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Edited by
Ivan Šprajc
and
Peter Pehani

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Slovene Anthropological Society
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Front-page: 3-Dimensional Computer Simulation of Dunamuck I Summer Solstice Sunrise 3500 BCE (image by David Fisher, 2012)

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PREFACE

Astronomy, archaeology and ethnology or social/cultural anthropology have always attracted public interest and spurred imagination, apparently because they all share the interest in something remote in space or time and, therefore, hardly – if at all – accessible. No wonder, then, that the astronomically-related concepts possessed by the archaeologically and ethnographically documented societies, profoundly different from what has been the mainstream of modern Western civilization, have not only inspired serious scientific research but have also fueled wild speculations. Recent years have witnessed a particularly remarkable increase in the production of unscientific theories, most of them somehow related to the year 2012 and its alleged importance for the ancient Maya. The authors of a large number of publications, websites, films and public lectures claimed that, for the winter solstice of 2012, the Maya foretold either devastating natural disasters of different kinds – even the end of the world – or a radical change in human consciousness leading to a new age of profound spirituality and social harmony. Most of these speculations were derived from arbitrary, bizarre or utterly fantastic interpretations of the Maya calendrical system, astronomical knowledge, and prophetic texts. In view of their expected (and confirmed) culmination in the year 2012 – coinciding, incidentally, with the first *katun* (20-year cycle of the Maya calendar) anniversary of the *Société Européenne pour l'Astronomie dans la Culture* (SEAC) – and considering that many other cultures have been victims of similar charlatanic and fraudulent theories, the 2012 conference of the Society was deemed an appropriate opportunity for their critical examination and confrontation with methodologically sound interpretations based on the available evidence.

Given this thematic focus of the conference, reflected in its rather provocative title 'Ancient Cosmologies and Modern Prophets', the participants were encouraged to present various popular but unfounded theories and interpretations and bring them under scientific scrutiny, as well as to discuss general theoretical and methodological issues relevant for cultural astronomy and its sub-fields, and to present concrete case studies exemplifying the utility of certain approaches for solving specific problems.

The 20th Conference of the European Society for Astronomy in Culture was held in Ljubljana, Slovenia, from September 24 to 29, 2012, and was attended by 55 participants from 19 countries. More than fifty talks and five posters were presented, among them the invited lectures given by Juan Antonio Belmonte, Nicholas Campion, César González García, Stanisław Iwaniszewski, David W. Pankenier, Fernando Pimenta, Frank Prendergast, Barbara Rappenglück, Michael Rappenglück, Clive Ruggles and Lionel Sims. Most contributions were submitted for publication and are included in this volume, while some did not pass the peer-review process. In keeping with the meeting program, the contributions are arranged in several thematic sections.

Acknowledgments

The conference was hosted by the City Museum of Ljubljana and the Research Center of the Slovenian Academy of Sciences and Arts (ZRC SAZU), Ljubljana. We are indebted to both institutions, as well as to the Slovenian Research Agency (ARRS), for granting financial aid, and to the National Museum of Slovenia, the Municipality of Ljubljana, the Municipality of Bled, and the Ethnogallery Skrina, for providing other kinds of support.

We wish to express our special gratitude to Dr. Oto Luthar, Director of ZRC SAZU, for various kinds of help during the preparation of the conference, as well as to Barbara Ravnik, M.A., Director of the National Museum of Slovenia, and Dr. Andreja Breznik, researcher of the same museum, Tine Kernc and Jure Kusetič, of the Ivan Michler Institute, Dr. Dimitrij Mlekuž, from the Department of Archaeology at the University of Ljubljana, and Janez Fajfar, Mayor of the Municipality of Bled, for their helpful collaboration in the organization of the half-day excursion to Bled and the full-day excursion to western Slovenia. The support offered both in preparatory works and during the conference by Gregor Meglič, co-chair of the Local Organizing Committee, was essential for a successful organization of the event and coordination of the activities. We are also grateful to other members of the Committee, who helped the conference run smoothly and assisted in a number of ways, and particularly to Melita Robič, Technical Secretary of the Institute of Anthropological and Spatial Studies of ZRC SAZU, who contributed to the solution of a variety of administrative and other issues.

Finally, we wish to thank the members of the Scientific Organizing Committee, and all the colleagues who have facilitated the preparation of this volume: various scholars provided valuable peer-reviews, while Marcia Butchart, Daniel Brown, Nick Campion, Roz Frank, Jarita Holbrook and Steven Renshaw kindly revised a number of papers for grammar and style.

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During the SEAC General Assembly, on September 28, 2012, Dr. Juan Antonio Belmonte Avilés received the Carlos Jaschek Memorial Award 2012 from Dr. Michael Rappenglück, President of SEAC.

Enigma of Time

The 2012 Phenomenon in Context: Millenarianism, New Age and Cultural Astronomy

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Abstract

The 2012 Phenomenon is one of the most recent versions of the ancient tradition of relating imminent, future, historical upheavals on earth, to the stars. The literary origins of this practice are found both in the Jewish Torah/Christian Old Testament, and in the works of Plato. The most familiar exemplar of this tradition in the twentieth century west was the belief in the coming New Age or Age of Aquarius, which are often considered to be identical. The 2012 Phenomenon is a direct adaptation of belief in the Aquarian Age into an American, New World context. This paper will examine the origins of the idea of the Aquarian Age in late eighteenth- and early nineteenth-century radicalism, and consider the 2012 Phenomenon's debt to Aquarian Age political and religious ideology. It explores the work of José Argüelles, suggests that the 2012 Phenomenon is best understood as a call to action for anti-capitalist, utopian environmentalism, and concludes with the suggestion that the study of Cultural Astronomy should actively encompass the culture of the modern west.

KEYWORDS: 2012 Phenomenon, millenarianism, New Age, cultural astronomy

POVZETEK

Fenomen 2012 je ena izmed najnovejših različic starodavnih tradicij, ki so povezovale prihajajoče zgodovinske preobrate na zemlji z nebesnimi pojavi. Prvi zapise o teh praksah najdemo tako v judovski Tori/krščanski Stari zavezi kot v Platonovih delih. V 20. stoletju najbolj razširjen primer te tradicije je bila vera v Novo dobo (New Age) oz. v Vodnarjevo obdobje, ki ju je zahodna kultura pogosto enačila. Pri fenomenu 2012 gre za direktno prilagoditev tega verovanja na kontekst Amerike oz. Novega sveta. Članek obravnava izvore ideje o Vodnarjevi dobi v radikalizmu poznega 18. in zgodnjega 19. stoletja ter vplive s tem povezane politične in verske ideologije na fenomen 2012. Prečuje tudi delo Joséja Argüellesa in povzema, da lahko fenomen 2012 najlažje razumemo kot protikapitalistični in utopični naravovarstveni poziv, zaključi pa se z mislijo, da bi se moral študij kulturne astronomije bolj aktivno posvečati moderni zahodni kulturi.

KLJUČNE BESEDE: fenomen 2012, milenarizem, New Age, kulturna astronomija

Introduction

The so-called ‘2012 Phenomenon’ (Campion 2011) began with the publication in 1987 of *The Mayan Factor*, by José Argüelles, the ‘best known teacher’ (Sitler 2011: 10) in the 2012 cultural milieu. It has attracted much attention from journalists, especially as the anticipated End of the World on 21 December 2012 approached, and has aroused a certain amount of anger amongst some astronomers and sceptics, who have devoted attention to refuting the phenomenon’s claims (NASA 2012; Plait 2008). These claims are that:

1. The Maya calendar comes to an end on 21 December 2012
2. This date should be marked by an apocalyptic transformation
3. The transformation may be either peaceful or violent.

Most, if not all, public attention on the 2012 prophecies focused on the supposed prediction of the end of the world, an event to be caused by possible comet collision, ‘pole shifts’ and other scenarios often associated with the destruction of civilisation. However, the prediction of a violent end of the world was a largely media-created event inspired by the disaster movie 2012 (Hoopes 2011a: 30; Lentini 2011: 70). The result was that much attention was devoted to refuting such cataclysmic expectations (Plait 2008; NASA 2012) which, by focussing on such claims, may have heightened their public profile and given the impression that the 2012 prophecies were exclusively concerned with a coming cataclysm. However, in terms of the 2012 Phenomenon as a whole, predictions of physical disaster appear to have occupied a marginal fringe. If the work of the principal 2012 theorists listed by Hoopes (2011a: 40) is considered, all are found to be vigorous opponents of the notion of a violent apocalypse (for example, Clow 2001: 25; Clow & Clow 2004; Calleman 2004; Jenkins 2009). Even Zecharia Sitchin, whose *End of Days* (2009) was unintentionally responsible for the idea that the extra-terrestrial Annunaki would return in their space-ships from the planet Nibiru on 21 December 2012, resisted any precise forecast of apocalyptic disaster in 2012. A message posted posthumously on Sitchin’s website in July 2011 by his niece, Janet Sitchin, carried the following unambiguous statement: ‘neither cataclysmic events on December 21, 2012 nor Nibiru come into play as a concern in 2012’ (http://www.sitchin.com/).

This paper examines the 2012 Phenomenon as the most recent example of an established feature of millenarianism, a strand of European thought which can be traced back in the literature for around 2,500 years, and which envisaged an end of the world or, at least, a radical break in history (Campion 1994). In so doing the paper draws on recent work by Gelfer (2011), particularly Hoopes’ (2011a, 2011b) view that the Phenomenon can be understood as a variety of modern New Age thought. It also builds on my work on Millenarianism (1994), New Age (2012), and the New Age context of the 2012 Phenomenon (2011). The paper will focus on the 2012 Phenomenon as a form of cultural astronomy, defined as ‘the use of astronomical knowledge, beliefs or theories to inspire, inform or influence social forms and ideologies, or any aspect of human behaviour’ (Campion 2004: xv). As Hoopes (2011a: 246) put it, ‘the 2012 phenomenon brings a fascinating intersection of astronomy and culture’. Hoopes added, though, that the promised end of the Maya calendar ‘is primarily an astrological and cultural event, not an astronomical one’ (2011a: 245) in that its connection any authentic Maya astronomy is tenuous. ‘Astrology’, he continued, 'was at the heart of the 2012 phenomenon' (Hoopes 2011a: 42), which then has the same relationship to astronomy as does the astrological Age of Aquarius: there is a referent in physical astronomical measurement, but the astronomically-derived cultural edifice of millenarian expectation (that is, the astrological component) is the most important feature (Campion 2011; 2012). This distinction is based upon a conventional distinction between astronomy as primarily concerned with measurement, and astrology as preoccupied with meaning.

The Historical Antecedents

The term New Age can be used in two senses (Campion 2012); it is both a future historical period characterised by spiritual enlightenment, and the matrix of ideas which has been encouraged and developed by believers in the coming Age. That New Age narratives are located within the European millenarian tradition has long been recognised (Campion 1994; 2012). There were two important strands which fed into European millenarianism. The first was Jewish and Christian apocalyptic (Cohn 1970), with its visions, alternatively, of a restored earthly Kingdom of David or a spiritual Kingdom of God. The Jews looked forward to a restoration of this world, the Christians to the creation of another world. In each case an astronomical component was present in the expectation that the coming eschaton, or end, would be forewarned by celestial omens. Cohn (1970) also noted that millenarianism inherently tends towards revolutionary politics and an aversion to established order. He described millenarianism (1970: 27) as a 'compensatory fantasy' in which sin and oppression will succumb to the final victory of righteousness as a substitute for justice in personal and political relationships. The second strand was classical historiography, with its vision of an astronomically-defined, cyclical, repetitive, alternating creation and destruction of the cosmos. Central to classical theory was the prophecy of the future return of a primeval, lost golden age, a theory first recorded by the poet Hesiod in his Works and Days (1923). The notion of current society as existing in a primitive state, sandwiched between two periods of great sophistication, one in the past and the other in the future, has become central to New Age narratives. As Joscelyn Godwin (2011: ix) observed, the key feature of one particular genre of apocalyptic thought is that, in his words 'there was a high culture in prehistoric times'. The astronomical basis of classical apocalyptic thought was articulated by Plato in the fourth century BCE:

> The complete number of Time fulfils the Complete year when all the eight circuits with their relative speeds, finish together and come to a head, when measured by the revolution of the Same and the Similarly-moving (Plato 1931: 39D).

History in Platonic cosmology is cyclical and, in theory, the alternation of past and future golden ages with current decline is infinite. A complete mythology developed from this idea, one which has the world experiencing periodic destructions when all the planets meet in a conjunction. According to Diogenes Laertius (1925: vii.139), Stoic cosmology claims that 'at stated periods of time [God] absorbs into himself the whole of substance and again creates it from himself'.

Significant for New Age thought is the composition of the Platonic cosmos primarily of psyche, which we may translate as soul or, better, as consciousness. In both Platonic and Stoic versions, the cosmos is 'a living being, rational, animate and intelligent' (Diogenes Laertius 1925: VII.142). Also central to New Age thought is the paradox, evident in Platonic theories of fate, in which humanity both exists within a deterministic state known as Necessity, which may be best seen as coincident with nature, yet is able to negotiate fate though such means as virtuous living, education or ritual. For the Stoics, on the one hand, 'all things happen by fate or destiny' (Diogenes Laertius1925: VII.149) and, on the other, 'he [the wise man] alone is free and bad men are slaves, [while] freedom is the power of independent action' (Diogenes Laertius 1925: VII.122). The need to respond to the cosmos within this paradox is central to classical cosmology. By willingly submitting to fate, the Stoic would be free and, if fate was coincident with nature, then the Stoic was required to live in harmony with nature (Long 1996: 164-5).

The Stoic-Platonic paradox in which individual action is required in order to bring a predetermined future into existence was termed 'activism' by Karl Popper (1986: 210, 244) and is a feature of most millenarian beliefs. In Popper's view, astrology is activist, functioning as a framework which enables the individual to freely implement the predetermined future. Popper's insight that millenarianism encourages active human participation in the historical process was also noted by Ninian Smart (1973: 93) who observed that,

> The authority of the original event helps to explain why it is that so many myths look back to primordial or founding events. But there is no reason in principle why the same 'real presence' should not flow from the future as well as from the past. Indeed this is the function of eschatological myths. The final overcoming of evil by God, for example, is a future event in which we can participate now.

To refer to previous eras, then, the European Renaissance and Reformation were both possible precisely because leading figures believed that it was both possible to renew the world and that their efforts to do so were supported by the flow of history (Campion 1994). The same phenomenon is present, as Popper (1957) pointed out, in Marxism, as it is in Progress Theory (Campion 1994: 458).

Greek cosmology, transmitted through the European world, therefore assumed that the cosmos fluctuated between periodic creation and destruction, was conscious, and could therefore be communicated with by humanity. Transmitted into the Renaissance, Eugenio Garin had this to say about astrological theories of history, noting the Popperian paradox of the combination of determinism with freedom to act:

> On the theoretical level one is dealing with the precise philosophy of history based on a conception of the universe, and characterized by consistent naturalism and a rigid determinism. On the practical level the acceptance of such a doctrine brings with it the attempt at an exact reading of the heavens to foresee the fates which await us, the one was always uncertain whether some kind of escape would be open to man into the area free from the contingencies which occur under the moon. (Garin 1976: 16)

Garin, continued, observing the survival of the Stoic-Platonic paradox in the Renaissance:

> The wisest of men is, then, he who reads human history and the stars; and some people hold that, precisely because the knowledgeable astrologer truly interprets the ways of the stars he, and only he, can establish that operative magic which allows one, by making use of the game of the heavenly configurations, to escape their harmful consequences, if they are foreseen in time. (Garin 1976: 16)

Keith Thomas added further context, suggesting that the astrological interpretation of long periods of history is sociological in character:

> During the Italian Renaissance astrological doctrines about the recurrence of planetary conjunctions had helped to form the concept of a historical 'period...In their [the astrologers] confident assumption that the principles of human society were capable of human explanation, we can detect the germ of modern sociology. (Thomas 1971: 386-7)

The failure of apocalyptic prophecies is a major problem for millenarian groups, as discussed in Stone (2000), and is a factor in the development of Desroche's (1979: 93-4) identification of two forms of Christian millenarianism. The first form, 'premillenarianism', or 'premillenialism' (Wessinger 1997: 48-9), sometimes known as 'catastrophic millenarianism', argues that Christ will come before the millennium, typically accompanied by the violent upheavals prophesied in Revelation. The second form, postmillennialism, assumes that the 'kingdom of God is progressively installed by an evolutive process' (Desroche 1979: 93), with no violent cataclysm. Wessinger (1997: 50-1) uses the alternative 'progressive' millenarianism. Although strict typologies are sometimes difficult to sustain when the phenomenological perspective is considered, the distinctions can still be useful.

Enlightenment Radicalism: 2012 as Secular

The term New Age originated in the context of late 18th century radicalism, particularly the millenarian expectations associated with the French revolution; it was used as the title for his chapter envisaging a new egalitarian world by François Volney (1795: 127-133). It then appears in the preface to William Blake's poem 'Milton', begun in 1804, which included the call, 'Rouze up, O Young Men of the New Age!' (Blake 1971: 480). Blake was familiar with the work of the Swedish religious reformer and mystic Emmanuel Swedenborg (1688-1782), the author of two major millenarian texts. The first, *On the Last Judgement and the Destruction of Babylon*, dealt with the destruction of the old world, while the second, *The New Jerusalem and its Heavenly Doctrine* (Swedenborg 1990), dealt with the creation of the new world, inspired by St. John's vision of the 'new heaven', 'new earth' and 'new Jerusalem' (Revelation 21: 1).

Swedenborg's teachings appealed to radicals who were not ready to embrace atheism, but rejected the dogma and authority of established churches. His followers in London formed themselves into 'The Theosophical Society Instituted for the Purpose of Promoting the Heavenly Doctrines of the New Jerusalem' and, after 1787, the 'New Church'. They thrived in the millenarian context of late eighteenth-century England in which, according to Garrett (1984: 67) 'Spiritual enlightenment and human regeneration would come about through events on this earth, including both natural and political, until the wicked had been defeated'. There was an emphasis on the transformation of the world rather than, in traditional Christian millenarianism (at least as a first stage), on its destruction, as well as a profound consciousness of the need for inner change. Garrett cites one Swedenborgian, Richard Clarke, who wrote in 1772, 'In our own inner man, lies the foundation of the new Jerusalem' (1984: 68). For a while, Swedenborg's vision of a new world aroused considerable enthusiasm and the scientist and political radical Joseph Priestly, wrote in 1791 'This kingdom of Christ, and consequently Swedenborg's doctrine, is speedily to prevail over the whole world, and to continue forever' (Priestly 1791: 6).

Enlightenment Astronomy

While Swedenborgianism was developing in the English-speaking world, a parallel challenge to the established churches, whether Catholic or Protestant, was taking place in France, where anti-clerical radicals and astronomers were developing the concept of the Age of Aquarius. They did this by showing that religious symbolism was not a guide to essential truth, but only to the movement of the constellations due to the precession of the equinoxes. The theory was this: all religion originated in star worship; the forms of religious worship changed as the constellations precessed over the vernal point; therefore, all forms of religious worship, including Christian, were relative, having no essential truth. These arguments were developed by the radical philosopher Jean Sylvain Bailly (1736-1793) in two major works, *Histoire de l'astronomie ancienne* (1775) and *Traite de l'astronomie indienne et orientals* (1787), *François Delaunaye in his* 1791 work, *L'Histoire générale et? particulière des religions et du Culte*, and Charles Dupuis (1742-1809) in his *Mémoire sur l'origine des constellations, et sur l'explication de la fable.* Dupuis' ideas were cast in what he himself called the framework of 'that singular Politico-Astrological Drama', the Apocalypse (Dupuis1873: iv).

Both the French radicals and the Swedenborgians were secular in their rejection of established religion and counter-cultural in their opposition to the political order. From the French came an updated version of the Platonic-Stoic concept of astronomically-defined historical periods and from the Swedenborgians the notion of a spiritual new age. All were familiar to H.P. Blavatsky, the founder of the Theosophical Society (1888: 1.658, II.436, 742), and from Blavatsky there is a smooth line of transmission of ideas to 20th century ideas of the astronomically determined Aquarian Age and the spiritual, enlightened, New Age (Campion 2012)

Modern New Age Culture

New Age culture has a number of key characteristics (Campion 2012: 37-8). The fundamental theological belief holds that the divine exists within each human being, rather than being purely external. The individual is, then, essentially spiritual and New Age religion is therefore fundamentally Gnostic, influenced by Blavatsky (see for example 1982: I. 1-54). It is also assumed that all religions share an inner, esoteric truth, no matter what the differences between their detailed theological claims and institutional identities, a claim also inherited from theosophy. The consequence is eclecticism and syncretism, in which ideas from many cultures may be adopted either individually, or combined to create new systems. The tendency to syncretism is linked to holism, a belief that the entire universe is one interdependent whole, and from this idea there develops a concern with the environment. Lastly, the universe is thought to be in a constant process of evolutionary spiritual development, an idea directly borrowed from Blavatsky.

Popperian activism is also central to the New Agers' desire to engage with the world. The astrologer Rupert Gleadow (1968: 137), who was profoundly sceptical of the Age of Aquarius, wrote that 'its only virtue is that it encourages us to look on the future, despite rebuffs, as something for which we must continue to do our best'. In other words, true or not, it is a call to action. According to David Spangler (1984: 84) 'The New Age offers action' and is a metaphor which galvanises people into action, 'an image of transformation and potential' which can endow people with the power to transform themselves and their society (1993: 88).

Linked to activism, meanwhile, is the transformation which will make the inauguration of the New Age possible. To quote Michael York (1995: 39)

> What unites all New Agers, however, is the vision of radical mystical transformation on both the personal and collective levels. In fact, the awakening to the potential abilities of the human self - one's individual psychic powers and the capability for physical and/or psychological healing - is the New Age springboard for the quantum leap of collective consciousness which is to bring about and constitute the New Age itself.

The emergence of two key features of New Age culture - its esoteric millenarianism and its use of precession of the equinoxes – leads to another feature identified by sociologists of religion – its secularism. Braden led the way by suggesting that astrologers who forecast the Age of Aquarius were 'humanists', noting that the key to the prophecy concerns 'long-term prospects for man' (Braden 1971: 17) rather than, as traditional millenarianism would have it, the inauguration of the kingdom of God. This theme was developed by Miller, who argued that New Age culture is broadly descended from Enlightenment secularism, especially in its humanism, naturalism and existentialism, although in a 'spiritualized' form (Miller 1990: 4; see also 20). This idea was developed by Hanegraaff, who argued that the New Age is 'characterised by a popular western culture criticism expressed in terms of a secularised esotericism' (Hanegraaff 1996: 409, 521). And, as Godwin has pointed out, Blavatsky's theosophy was as much a product of the Enlightenment as a reaction against it (Godwin 1994: xi).

The Aquarian Age: Alice Bailey and Dane Rudhyar

The two most influential New Age teachers in the 20th century were the theosophists Alice Bailey (1880-1941) and Rudolf Steiner (1861-1925). Of these Bailey is the most important for the 2012 Phenomenon, as her student, the musician, painter and astrologer Dane Rudhyar (1895-1985) was to became José Argüelles' mentor (Hoopes 2011a; 2011b).

The New Age, for Bailey, was the spiritual era made possible by the Aquarian Age, the astronomically defined historical period set to begin when the Sun rises in the constellation Aquarius at the vernal equinox. In the same way, the end of the Mayan calendar is not an end in itself but a means to spiritual evolution. Such evolution is both predetermined since the origin of the universe, but also requires human assistance in order to come into being.

Alice Bailey's view of the Age of Aquarius was couched entirely in terms of her apocalyptic, Swedenborgian, Christian millenarianism. She confidently identified signs of 'the time of the end' (1948: 187) and of the 'the reappearance of the Christ and the externalisation of the Kingdom of God' (1984: 185). Bailey's view of the transition to the millennium was that it depended both on the strength of superior spiritual beings she called the 'Hierarchy of Light' (1940: 217), and the willingness of human beings to actively support them. This action was as material as spiritual and, in 1940, when the USA was still neutral, she argued strongly against both neutrality and conscientious objection (1940: 216-7). For Bailey, the major crisis of her time was world war, and the Second World War, she wrote (1957), had been accompanied by a struggle on the spiritual plane. Some Adepts, Bailey claimed, believe that humanity's problems arose from the fact that, as a result of intense strain caused by the First World War, the web of etheric matter 'called the "veil of the temple" was rent or torn asunder' (1934a: 4), resulting in a speeding up of the anticipated unification of the of the physical and astral planes. The result, 'Esoterically speaking', she concluded, is 'a point of contact, an imminent moment of "spiritual intercourse"', out of which, 'a new world can be born (1934b: 21). However, this is obviously, therefore, bound to heighten the chances of crisis for, while 'the New Age (is) dawning' (1934a: 7) and enlightened individuals are absorbing positive energy, 'building 'the age of understanding, of brotherhood and of illumination', the letting loose of psychic forces amongst the ignorant and uncontrolled is potentially highly destructive. Bailey combined pre- and post-millennial qualities in her millenarianism, believing that a violent transition to the Aquarian Age was likely but not inevitable. She summed up her vision of the New Age as follows:

> The functioning of the Law of Loving Understanding will be greatly facilitated and speeded during the Aquarian Age which we are considering; it will eventuate later in the development of a world-wide international spirit, in the recognition of one universal faith in God and in humanity also as the major expression of divinity upon the planet and in the transfer of the human consciousness from the world of material things to that of the more purely psychic. (Bailey 1949: 47)

Bailey forecast that 'Humanity itself is rapidly arriving at the point where its united will will be the determining factor in world affairs and this will be due to the unfoldment of the mind through the success of the evolutionary process' (Bailey 1949: 36). Her vision, central to Aquarian Age thought, was the classically theosophical one of a cyclical evolutionary return of humanity to a more spiritual existence. Her prophecies though, were profoundly political, requiring the collapse of the established social, political and economic order. Though her followers are little in evidence in political activity, they do exist and know themselves as World Servers, and constitute the theosophical equivalent of a Bolshevik 'revolutionary vanguard'.

Dane Rudhyar, one of Bailey's most prominent students, promoted her ideas in a series of influential books. In 1938 Rudhyar opened his second book on astrology with an apocalyptic proclamation of the change of the astrological ages:

> Today is a new birthday for the ancient gods. New men call for new symbols. Their cry rises, beyond their logical intellects ashamed of mystical longings, for new gods to worship and to use in order to integrate their harrowing mental confusion and to stabilize their uprooted souls. Young gods, fresh and radiant with the sunshine of a new dawn, glorified with the 'golden light' of a new Sun of Power, ecstatic with virgin potentialities after the banishment of ancient nightmares. (Rudhyar 1938: xiii)

Rudhyar wrote further contributions to New/Aquarian Age millenarianism in the 1960s and 70s. *Astrological Timing: The Transition to the New Age*, which was first published in 1969, dealt with questions such as the dating of the Aquarian Age, while *Occult Preparations for a New Age*, which appeared in 1975, was a detailed discussion of the principles of theosophical cosmology as outlined in Blavatsky's *The Secret Doctrine*, and the transition from the Piscean to Aquarian Ages. Rudhyar also dealt extensively with theosophical material in his other books, including Blavatskyan racial evolution in *The Panetarization of Consciousness* (1977: 125 - 150). He regarded Blavatskyan evolution as providing a possible solution to the potentially catastrophic apocalyptic threats of the late-twentieth century, and wrote that,

> The basic question today is indeed whether or not the social, psychological and biological or telluric processes and modes of human response which we have known in our limited experience of the past may not be made obsolete and superseded by basically new developments. We can perhaps expect a totally new 'mutation' of mankind or a basic transformation of society. (Rudhyar 1972: 21)

Within this historicist framework, Rudhyar saw himself as taking a consciou-sly activist position. In 1911, while a teenager in France, he had been possessed by 'an incontrovertible belief in the impending deterioration of our Western civilisation' (1977: v). His life's work was devoted to finding a solution. In Rudhyar's version of Blavatsky's evolutionary theory, the world was beginning the return to pure consciousness. The entire cosmos was implicated in this process and was destined to reach, in the distant future, a state of pure spirit, with no physical matter whatsoever. To reach this point peacefully and without a major world crisis, it was necessary for all people to become spiritually self-aware and, ultimately, submit to higher cosmic, spiritual powers.

The notion of the coming Age of Aquarius became a commonplace amongst astrologers, and its revolutionary significance was set out by Cyril Fagan in 1951. Both capitalist and communist systems were to be overthrown in a revolution which was to be based on self-understanding:

> Nations, monarchies, sovereign governments, republics, communistic states, separate communities, clans and tribes will be things of the past. This desirable state of affairs will not be brought about by conquest; but by a complete psychological revolution taking place in the consciousness of all individuals. (Fagan 1951: 24)

However, while all astrologers might agree that the Age is coming, there are substantial differences about the date. While Rudhyar was in absolutely no doubt concerning the inevitability of the imminent arrival of the New Age, and humanity's resulting spiritual transformation, he recognised that there were difficulties in dating the Age's beginning. The start of the Aquarian Age varies depending on whether one uses either the constellations or a version of the sidereal zodiac, in which the twelve zodiac signs are located against the precessing backdrop of the stars. He suggested that the date of the Age's beginning is of secondary importance if one's focus is the human rather than the cosmic (1967: 12-13). Alexander Ruperti, a student of both Bailey and Rudhyar, went further and expressed a profound scepticism about the fixation with the Age of Aquarius as a fixed, astronomically-based period. In the early 1990s he claimed that, because the boundaries between the constellations are arbitrary, 'talking about the age of Aquarius beginning at such and such a date precisely is ridiculous because nobody knows, nobody can measure it'(Ruperti 2002: 2). He added (2002: 2),

> There is symbolism behind what we call the Aquarian age and so forth, but giving the name of Aquarius to this second phase of the polar cycle of the Earth is merely one way of explaining what is happening. The importance of the second phase is not necessarily linked to the imagery of the sign Aquarius, that's merely one way of looking at it. And it is not necessarily the deepest way of looking at it.

The New Age is therefore thrown into an existential, chronological uncertainty: it is coming, and coming soon, but nobody knows when. The precession of the stars can be measured with great precision, but there is no agreement on which of many measurable points indicates the Aquarian Age's beginning.

The Mayan Factor: José Argüelles

José Argüelles was introduced to New Age ideology and Aquarian Age historiography in 1969, when he read two important theosophical works, Alice Bailey's *Education in the New Age*, and Dane Rudhyar's *The Pulse of Life*. He contacted Rudhyar, who immediately saw that Argüelles was already implementing his vision of the New Age (South 2009: 133-6). The two men became friends and in 1971 Argüelles moved into Rudhyar's home, becoming totally immersed in the theosophical vision of the coming rise in global consciousness.

Argüelles adopted Bailey's view that humanity was in a state of unparalleled millennial crisis as a precursor to the beginning of the New Age, but reframed it within the environmental crisis; Blavatsky had been more concerned with the Second World War and the nuclear threat. Argüelles was overt about his counter-cultural credentials, referencing psychedelic art, 'The Doors of Perception' (without mentioning Aldous Huxley's mescaline-inspired book of the same name), and the visionary path on which he embarked before his visit to Mexico in 1968 (1987: 30). There are deep parallels here with the background and impact of Carlos Castaneda, the author of the Don Juan books and Terence McKenna. Between them, Castaneda and McKenna (more explicitly than Castaneda) did much to popularise the notion of a coming rise in consciousness facilitated by a shamanistic use of hallucinogenic (now more likely known by users as entheogenic) drugs (McKenna 1991). Argüelles was lecturing at the University of California, Davis, during the high point of radical hippy culture in the late 1960s, and was deeply influenced by it (South 2009: 112-6). The environmentalism which emerged out of the counter-culture was present in Argüelles' activism from the start, from his engagement with the First Whole Earth Festival on the University campus in April 1972 (South 2009: 113). From then on collective, Popperian, activism was to be central to Argüelles' work. Bailey's organisation, the Lucis Trust, had already popularised (and perhaps initiated) the concept of collective, global meditations, as a means of assisting the arrival of the Aquarian Age. Argüelles developed this concept in the 'Harmonic Convergence', the global meditation in August 1987 which brought his ideas to a wide audience. From the outset Argüelles had also adopted an astrological framework, dividing his students both into their zodiacal sun-signs and, for the purposes of the Festival, their four elemental groups, fire, earth, air and water. The astronomical impetus behind his work was provided by the Apollo photographs of the whole earth from space, and the visual demonstration of the planet as a single entity, in which social and political barriers were shown to be illusions.

Argüelles articulated his eco-apocalyptic philosophy in The Mayan Factor, denouncing the 'Faustian development of global industrialisation' (1987: 178) which has led to an 'unnecessary military economy and the production of wasteful and even toxic consumer goods' (1987: 190), language which aligned him with any left-leaning environmentalist. He couched the environmental crisis within Bailey's theosophical historiography, adding that such global industrialisation represented 'a turning away from the light – our guiding inner "soul-light" – to pursue the immediate power gains of a facile technology mastery over our material means. In truth this turning away is a surrender to the force of darkness, called by the ancient Mexicans, Tezcatlipoca, the Dark Lord of Time' (1987: 178; see also 190). All lost golden ages from which humanity has been alienated – or alienated itself – are equivalent. One version Britain – 'Arthur's ancient Albion' (1987: 179) – had been desecrated by coal-mining and the industrial revolution. A literal understanding of humanity's historical situation, though, is inadequate: 'According to the Mayan Factor', Argüelles wrote, 'we live at the bottom of an electromagnetic ocean' (1987: 179), like squid at the bottom of the watery ocean. He, understood, though, that such descriptions can be 'mythical' (1987: 178), and avoided literalism by referring, for example to 'what we call UFOs' (1987: 190), rather than to UFOs as if they were a technological fact. Once capitalism, consumerism and industrialisation have been rejected, he believed, the former golden age will be restored Argüelles' counter-culturalism did not require a rejection of technology, only of what he saw as destructive, materialistic, technology.

The problem with dating the beginning of the New Age on the basis of the Aquarian Age, as Rudhyar and Ruperti had found, was the impossibility of deciding on what basis the measurement should be made. Argüelles' masterstroke was to apply the Mayan calendar to the problem. It enabled him to make, in Garin's (1976: 16) words, an 'exact reading of the heavens to foresee the fates which await us', where precession of the equinoxes had failed. If, for Ruperti, the Aquarian Age was merely one way of measuring the beginning of the New Age, Argüelles was perfectly free to suggest another. In the Mayan calendar he found an alternative grid for measuring the beginning of the New Age, which had the same apparently objective timing as the precession of the equinoxes, but which was supposedly both more reliable and carried a new authenticity, being embedded as it was in Mayanism, the belief that the Maya were the carriers of an ancient, lost, superior knowledge (Hoopes 2011a). Argüelles predicted that

> Like the Maya who preceded us, we shall understand that the path to the stars is through the senses and the proper utilisation of our mind as the auto-regulatory control factor will help facilitate the passage to different levels or dimensions of being. (1987: 190)

This is well-understood by his followers. As Stephanie South (2009: 34) put it,

> For José, the meaning of December 21, 2012, has everything to do with shifting time-frequencies. This transition is anticipated as the transformation of the present material-industrial order of the planet into a full renewal of the human mind, where telepathy is universal.

Argüelles was therefore able to completely resolve uncertainty over the dating of the New Age by locating its precise inauguration to the nearest day, as well as reinforcing its authenticity by reference to Mayanism and reframing its function in the need to save the planet from environmental catastrophe.

The Mayan Factor in 2012

While public and media attention on the 2012 Phenomenon in late 2012 focused exclusively on pre-millenarian prophecies of a violent cataclysm, the majority of active apologists for the notion that the end of the Mayan calendar possessed a millenarian significance appear to have advocated a post-millenarian peaceful transition. There was no shortage of material on the 2012 prophecies on the web. Searching the web opens new problems for scholars, especially when considering the problem of assessing the relative importance of different texts. One simple method is to follow rankings in Google web searches. I conducted two searches, the first for 'Maya calendar 2012 violent transformation' and the second for

'Maya calendar 2012 peaceful transformation'. The first search produced in the first ranking only websites suggesting that the world would not come to an end, but that peaceful transformation was more likely. The second search produced the website '13Moon' as the first option. The opening statement is illustrative of the field as a whole, suggesting its activist, esoteric, post-millenarian, debt to Alice Bailey via Argüelles and Rudhyar and, through Bailey, to the 18th century radicals:

> December 21, 2012 marks the completion of the Great Mayan Cycle, and the beginning of a New World Age. There are many predictions of what might happen on this day that, if they do not occur, could mislead many to perceive this date as meaningless. By focusing too heavily on external events, one may be missing the true significance of this prophetic date. Regardless of what happens externally on this day, December 21, 2012 is a clear marker of the transition of World Ages. This synchronization is inviting all of humanity to open to imagining, envisioning and actualizing the possibilities of gradual, positive transformation of our human culture in harmony with the Earth. *As we internally align* with this grand shifting of cycles we can contribute our personal inspiration and commitment to being part of this collective transformation. (13Moon)

The same website continues:

> A central focus of the 2012 prophecy is that humanity must confront our severe disconnection from Nature, and re-establish our harmonious interconnection with all of life that we may awaken our human potential and align with the next evolutionary stage that Earth is entering into (13moon).

Several themes emerge from this text.

1. Mention of the Great Mayan cycle locates the prophecy in an objectively measurable framework: it is therefore inevitable
2. The reference to the 'New World Age' evokes the concept of the 'New Age'.
3. Inner transformation is more important than outer, external events may be irrelevant and the vital change is one of consciousness
4. Although the coming transformation is inevitable, active participation and personal commitment is required in order to bring about the coming transformation.
5. Such commitment builds and engages the individual with a wider community.
6. The goal is the restoration of a lost harmony with nature.
7. This is part of a re-alignment with the next evolutionary stage which unites both humanity and the entire planet.
8. Such commitment builds and engages the individual with a wider community.

A number of comments can be made on this text. First, in the sense that no divinity is evoked, it is secular and, second, as, by inference, the current world is rejected, it is counter-cultural. Both are features of Aquarian Age prophecy. In addition, the seven features listed above are also standard features of belief in the Age of Aquarius. The activist imperative is prevalent elsewhere on 2012 Prophecy websites, promoting opportunities for personal and collective spiritual transformation. For example the 'Birth2012' web site advertises the following:

> Join us for Activation Week and you can
> • Discover your unique contribution to the global path
> • Renew your hope for our world
> • Learn all the exciting initiatives that are coming together
> • Receive practical training on creating hubs, events and grassroots activities
> • Become part of a worldwide positive change movement
> • Receive potent wisdom from dozens of our world's most beloved teachers.

Of particular relevance to Cultural Astronomy is 13Moon's inheritance of Baileyite astrological activism. The website advertised a meditation in order to encourage peace and healing of the oceans at the 2012 autumnal equinox.

> In honor of the Equinox ~ all day Friday Sept 21 and Sat 22 around the globe synchronizations for peace are taking place - some at the exact moment of Equinox (PDT Sept 22 7:49AM), others all day, some at Sunset and Sunrise - including The International Day of Peace, The Solar Wave, EarthDance, Didjeridoo Meditations, Meditations for Healing the Ocean, ETC. SPREAD THE WORD! BLESSINGS, Eden Skywalker.

Thus astronomy becomes an aide to the millenarian activist imperative. And, as Mark Van Stone (2011: 23) put it, the entire Phenomenon is a call 'for us to contemplate-our-wicked-ways before it is too late'.

Conclusion

The 2012 Phenomenon needs to be understood in the context of views of time derived from both scriptural and classical cosmology. This paper has focused on the legacy of classical thought, particularly Platonic and Stoic concepts of a cosmos which was alive and conscious and experienced a repetitive cycle of creation and destruction, and the Stoic notion that freedom lies in living in harmony with nature. Argüelles and the other 2012 theorists gave a slightly different gloss to an established feature of western astrology; its sociological, to use Thomas's (1971: 386-7) description, analysis of history in terms of astronomical cycles, and its resulting radical political programme. As Garin (1976: 18) argued,

> As one can see, the theme of 'newness', of a new life, a new age, new worlds, new heavens, new earths - which would run so eloquently through the centuries of the Renaissance…was originally nothing more than an astrological commonplace.

The key paradox in such theories, as noted by Karl Popper, was their combination of an astronomically-justified determinism with a requirement to act. Transmitted through the Renaissance to the modern era, 18th century radicals located both the vision of a spiritual New Age, and an astronomically-determined periodisation, as the justification for their counter-cultural politics. In that astronomy, in the form of the Mayan calendar (as an alternative to the precession of the equinoxes), provides an apparently objective timing measure, and hence the supposedly objective proof that the New Age is beginning, the 2012 Phenomenon can be located as a modern form of 'cultural astronomy'. Argüelles' view of the New Age was adapted in turn from Rudhyar, Bailey, Blavatsky and Swedenborg, but whereas Rudhyar and Bailey had used the precession of the equinoxes as a timing measure, hanging their future utopia on the beginning of the Age of Aquarius, Argüelles found a new world authenticity in the Mayan calendar. And to borrow Stephen Sutcliffe's (2003, pp. 9-11) examination of difficulties relating to the term 'New Age', as 'New Age' is an 'emblem', so are 'Aquarian Age and 'Mayan Calendar'. The emblem 'Mayan Calendar' has therefore been attached to an astronomy – the calendar used by the historic Maya - to which it has only a tenuous connection.

Popper's theory of activism explains the enduring appeal of apocalyptic ideas. For Stuart Sutcliffe, then, 'New Age becomes a 'millenialist' or apocalyptic' emblem (2003: 9, 11) which encourages a focus on a particular strand of social or political action. Similarly, the term 'Maya Calendar' and the apocalyptic ideas associated with it, has become an emblem for the encouragement of a spiritual form of environmental activism.

To attempt to debunk the 2012 prophecies as a hoax is as pointless as dismissing the Torah, Koran or New Testament as hoaxes. First, to give the prophecies the status of hoax, is to argue that those who have promoted them do not believe in them, a proposition for which no supporting research is offered as evidence. Second, academics in the humanities and social sciences seek to understand rather than condemn. Worse, the debunkers were responding to a media creation.

The 2012 Phenomenon can be located within the history of western millenarianism. As I have argued, a key characteristic of New Age millenarianism is its Popperian activism. It is evident from Argüelles' politics, as well as those of the writers and websites which follow him, that his concern was with encouraging the anti-capitalist wing of the environmental movement. That he adopted theosophical, astrological historiography as an activist call to action, places him in that form of theosophy which once offered a spiritual alternative to Marxist materialism (Campion 1994: 458). Marx had used the promise of an earthly paradise to inspire revolution at the same time as Blavatsky was arguing for a spiritual one: they are different but parallel millenarian themes. The 2012 Phenomenon therefore has little to do with the end of the world, but, rather, its salvation, and is best understood as a form of eco-spirituality, combining the this-worldly hopes of Jewish millenarianism with the other-worldly expectations of Christianity. Argüelles' belief that the transition to the new period of history would be peaceful and characterised by inner transformation is Swedenborgian, and is therefore best identified as a form of progressive, or post-millenarianism. Finally, in that the 2012 Phenomenon clearly appropriates astronomy for cultural purposes, it supports the proposition that the discipline of Cultural Astronomy should move from the study primarily of the non-western and the pre-modern, to focus more on the modern west.

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'Great Year', *Hamlet's Mill* and the '2012 Maya Prophecy': the Charm of Cyclical Time

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Abstract
Evolution of the concept of time is briefly reviewed. The origins of the myth present in most ancient cultures throughout the world of a long cycle lasting some millennia after which all past events will be repeated in a more or less similar way and called by modern scholars the 'Great Year', is analyzed. A well known book by de Santillana and von Dechend, *Hamlet's Mill*, contains a hypothesis that the mythology connected to the 'Great Year' derives from precession of the Earth's axis discovered by an ancient civilization of unsuspected sophistication. This book was severely criticized by academic reviewers on a number of grounds. However, *Hamlet's Mill* is a well written and intriguing book and has fascinated thousands of readers. This has cleared the way for a number of hoaxes such as the so-called '2012 Maya Prophecy'.

POVZETEK
V članku podajamo pregled razvoja koncepta časa. Analiziramo izvor mita, prisotnega v večini starodavnih kultur, o dolgem ciklu, ki traja nekaj tisočletij in po katerem se vsi dogodki ponovijo v bolj ali manj isti obliki; sodobni učenjaki ga imenujejo 'Veliko leto'. Dobro znana knjiga de Santillane in von Dechendove *Hamletov mlin* navaja hipotezo, da mitologija v zvezi z 'Velikim letom' izhaja iz precesije Zemljine osi, ki jo je odkrila neka starodavna nesluteno visoko razvita civilizacija. Akademski krogi so delo ostro kritizirali z več aspektov, toda *Hamletov mlin* je dobro napisana in privlačna knjiga, ki je navdušila tisoče bralcev ter utrla pot drugim potegavščinam, kot je na primer 'majevska prerokba 2012'.

Inborn 'biological time'
The concept of 'time cycle' is inborn in mankind as well as in other living beings (see, e.g. Aveni 1989). Actually, most all living beings show behaviours regulated by 'circadian' cycles which are characterized by a period close to 24 hours (*circa diem* or 'about one day'). Examples of human circadian cycles are the waking/sleeping cycle, the secretion of melatonin, testosterone and other chemical substances, and the one of variation of body temperature and pressure. Since circadian cycles have a period similar to that of the Earth's rotation, they are probably due to the alternation of sunlight and darkness. Further, plants and animals have biological cycles connected to other periodical natural phenomena such as the seasons and tides.

On the other hand, mankind, most probably even before becoming Homo Sapiens, also had the concept of 'biological time' since men and women surely noticed that they were first a child, then an adult, and then an old man/woman. The innate concept of time suggested by human biology, the most natural one, is thus either cyclical or linear.

Invention of 'sacred' and 'physical' time

The fact that 'biological time' is inborn does not imply that the concept of 'physical time' (time as an external, measurable entity which in principle should be linear or cyclical) is also inbred in mankind. Actually, the anthropological study of the last hunter-gatherer tribes still extant just a few decades ago seems to show that these people do not have the abstract concept of 'physical' time.

A recent study (Sinha *et al.* 2011) revealed that the Amazonian Amondawa tribe, first 'discovered' by anthropologists in 1986, lacks linguistic structures that relate time and space such as the idea of 'working through the night'. Further, the Amondawa language has no word for 'time' or indeed for time periods such as 'month' or 'year'. Of course, Amondawa people, like any other people, can talk about events and sequences of events, but they have no concept of a physical time independent from the events.

Not all scholars agree with this hypothesis. For instance, Marshack (1972) interpreted a bone dated to 20,000 BP where a series of holes are carved to be used for lunar phase counting. This interpretation is not accepted by a large majority of anthropologists and archaeologists. However, if it were true, the quantitative counting of time could have started from the late Paleolithic, and the concept of physical time cycles would be at least coeval with the earliest forms of human thought if not innate.

In any case, it is apparent that the need for quantitative counting of time became mandatory after the 'Neolithic revolution'. In fact, nomad hunter-gatherers needed just a short warning of seasonal change in order to prepare to move their camps. Conversely, sedentary farmers needed to plan activity on the basis of at least an annual time scale. Thus, they needed an actual 'calendar' which would be a stable and reasonably reliable time reference system. This time reference was found in the astronomical cycles of the Sun and Moon and in the annual cycle of constellations in the night sky. These ordered cycles further reflected the repetitive, monotonous, and unavoidable cycles of everyday life of this time perfectly.

However, agriculture, sedentary settlement, and the production of food surplus involved a social structure which became more and more complex and necessitated someone to be on duty for coordination of the various activities. What was previously an equalitarian society thereby started to stratify. With the development and differentiation of economic activities and the increasing contact (sometime peaceful but often violent) between different communities, the 'chiefs' enforced their power even more and needed to develop ideological support to justify it. The original animistic religion was thus complicated until it was consolidated into a polytheistic religion with various gods organized in a stratified 'pantheon'.

For this reason, together with the 'civil calendar' which was connected to agricultural needs, 'sacred calendars' appeared in order to facilitate prayer to each god in the proper way, in the proper place, and at the proper time, following the indication of professional 'religion specialists'. Writing was invented at the beginning of the Bronze Age in Egypt and Mesopotamia, and there is evidence that codified calendars and instruments to measure time were used in that epoch. In Egypt during the Middle Kingdom (2125-1630 BCE), sophisticated calendars were used and day and night were divided into 12 hours each. Further, sundial and water clocks were invented. The fact that time started to be measured clearly indicates that it was conceived as a self-existing entity independent from events happening 'in' it. It is thus evident that the abstract concept of 'physical time' originated from this epoch. The calendar was developed for social needs. At that time, work for wages (though not yet money) first appeared and implied the need for a quantitative evaluation of working time.

The origin of 'historical time' and the 'Great Year'

Social needs also generated the concept of 'historical time'. At that time, society was organized into state-cities or actual kingdoms. As the power of rulers became stronger, the need to justify such power grew as well. Thus, they codified pre-existing myths into a cosmology that connected their power to divine origin. They did this through establishment of a genealogical chain that directly connected the king to mythical forefathers (see, e.g. Aveni 1989). This is how 'dynastic histories' and 'lists of kings', the first form of written history, were born. Time became a transcendent principle and was codified in the rules that not only regulated civil life but also justified the power of the king. The king was thus the only 'master of time' (see, e.g. Aveni 1989) and the only one allowed to modify the calendar in many civilizations; typical in this sense is the Chinese Empire (see, e.g. Needham 1959; Polcaro and Martocchia 2012)

However, if civil time was and remained for millennia a 'cyclical physical time' based on usual short-term astronomical cycles (such as the day, lunar month, and solar or sidereal year; see, e.g. Hesiod's *Works and Days*), 'historical time' was a 'sacred time' that was developed on a longer scale involving mythical ancestors. As Mircea Eliade (1959) states, sacred time must always be 'cyclical time'. A time cycle much longer than cycles used for the everyday life was thus needed. Many civilizations thus developed what modern scholars generally call a 'Great Year', a mythical cycle with a multi-millenarian period, such as the Mayan 'Long Computation'. At the end of the Bronze Age (at different dates in different geographical areas) time was thereby conceived as always 'cyclical' in shorter or longer periods.

Hamlet's Mill

Some scholars do not agree with the hypothesis of a social origin of the concept of 'Great Year'. In particular, Santillana and von Dechend (1969) in their well known book *Hamlet's Mill* hypothesize that all mythology connected to the 'Great Year' was derived from the precession of the Earth's axis. The essential premise of the book is that much mythology and ancient literature has been badly misinterpreted and generally relate to a sort of 'mono-myth' conveying significant scientific and specifically astronomical ideas and knowledge.

According to de Santillana and von Dechend, 'Our ancestors of the high and far-off times were endowed with minds wholly comparable to ours, and were capable of rational processes – always given the means at hand' (p. 68). These ancestors were fascinated by astronomical observations, and they made many discoveries. In particular, the precession of the Earth's axis was discovered long before the accepted date of Greek discovery (perhaps as early as in 4000 BCE) by an ancient civilization of unsuspected sophistication. Nevertheless, again following de Santillana and von Dechend, the expression of this proto-scientific vision of the cosmos was not mathematical but mythological. All the gods are stars, and mythological language makes exclusive reference to celestial phenomena. For example, 'earth' in myth means only 'the ideal plane laid through the ecliptic' (p. 58); all stories of global floods 'refer to an old astronomical image' (p. 57).

The book thereby tries to reconstruct a primordial myth referring to the precession of the Earth's axis. The authors claim that it can be recognized in a common myth, widespread all over the world, of a heavenly mill which rotates around the Pole Star and grinds out the world salt and soil. The millstone falling off its frame represents the passing of the pole star of one zodiacal age (symbolized by a ruler or king of some sort and his overthrow of authority), and its restoration represents a new star moving into the position of pole star (symbolized by the empowering of a new king and the establishment of a new order and of a new age). This myth was correctly interpreted by scholars and philosopher up to the first century CE. Its roots were then forgotten, and the related myths were transmitted only as popular tales.

The authors attempt to demonstrate their thesis and the influence of the hypothesized highly developed ancient civilization by analyzing world mythology using an enormous number of fonts ranging from Saxo Grammaticus (Denmark, 12th Century) and Snorri Sturluson (Iceland, 12th Century) to Firdausi (Persia, 11th Century), from Plato and other classical Greek philosophers to Cicero, Plutarch and other classical Roman and Greek historians of various epochs, and from Vedic and later Indian mythology to the Sumerian Gilgamesh Saga.

Critics and supporters of *Hamlet's Mill*

Some of the 'Great Year' cycles are manifestly linked to astronomical cycles. For example, the Sanskrit 'Great Year' cycle is 2850 years long, 150 times the Metonic cycle (see Aveni 1989). However, not all 'Great Year' cycles have an obvious astronomical meaning. Above all, the hypothesis that between about 4000 BCE and 100 CE a single archaic system prevailed throughout most of the civilized and proto-civilized world is hard to believe.

Though de Santillana was a respected scholar in the history of science, *Hamlet's Mill* was severely criticized by academic reviewers for a number of reasons (see, e.g., Leach 1970; Payne-Gaposhkin 1972; Davidson 1974) including: (1) tenuous arguments based on incorrect or outdated linguistic information, (2) lack of familiarity with modern sources (actually, half of the references were more than 40 years old when the book was published), and (3) over-reliance on coincidence or analogy and the general implausibility of a long lasting, widely spread and influential civilization existing and not leaving behind any solid evidence.

Regardless, *Hamlet's Mill* had an immediate and enormous success with the general public. This fact can be explained within the general political framework of the period when it was published. In fact, 1969 was a time of student uprisings and the spread of 'science demystification' (as in Marcuse and many others authors of the 'Frankfurt School' of philosophy). From a political point of view, *Hamlet's Mill* cannot be considered 'progressive' and even less a 'left-oriented' book. On the contrary, it can be considered to be highly 'conservative', because of its continuous reference to a past 'Gold Age' destroyed by the modern culture.

However, de Santillana and von Dechend book was dominated by a 'spirit of protest' directed against their colleagues (Jenkins 2012). On the jacket flap summary of the first hard cover edition, the authors state: 'Contradicting many current notions about cultural evolution, this exploratory book investigates the origins of human knowledge in the archaic, preliterate world'. In the Introduction, de Santillana and von Dechend state that they are well aware of modern interpretations of myth and folklore but find them 'shallow and lacking insight'.

Similar comments which stress that much 'modern' scholarship is biased and built upon 'sand castles' of past assumptions can be found throughout their book. This strong criticism of the 'current notions' of 'official science' was attuned to the 'hate' of the 1968 movement for the 'Ivory Towerism' of academic science, though in *Hamlet's Mill* there is nothing referring to the need of social justice that was the driving force of this movement.

The fame of the book further increased with the beginning much less political 'hippy' and then 'New Age' movements. The latter is a sort of 'spiritual materialism' developed in the last quarter of the 20th century. Its central precepts have been described as 'drawing on both Eastern and Western spiritual and metaphysical traditions' (Wikipedia 2012). New Age practices and philosophies draw inspiration from major world religions, with strong influences from East Asian religions, but also from Gnosticism, Neopaganism, 'New Thought', Spiritualism, Theosophy, Universalism, Western esotericism and astrology. In fact, the term 'New Age' refers to the coming astrological Age of Aquarius. Proselytes of New Age believe that Atlantis, Lemuria, Mu, and other lost lands existed. With 'evidence' such as crystal skull relics and monuments such as Stonehenge and the Great Pyramid of Giza that were left behind, they found in *Hamlet's Mill* a sort of scientific demonstration of their world vision.

As an example, though never explicitly citing the Santillana & von Dechend book, the ridiculous 'theory' of 'time waves' by Terence Mc Kenna (1992), one of the major 'philosophers' of the New Age and the man who 'rediscovered' the 'Mayan prophecy of 2012', shows manifest analogies with the hypothesis of *Hamlet's Mill* regarding a single ancient civilization of unsuspected sophistication, spread from China to Central America.

Merits and faults of *Hamlet's Mill*

Of course, *Hamlet's Mill* is not the same thing as the Mc Kenna 'theory' or any of the actual frauds that have been organized on the basis of New Age fantasies. However, the risk that is induced when 'traditional' science, based on a Galilean 'proving and challenging' method is left to follow a purely inductive method based on personal beliefs, with a 'swift, allusive, paradoxical exposition' must be stressed as Cecilia Payne-Gaposhkin (1972) states in her brilliant review of *Hamlet's Mill*. The method can be charming, but (citing Goya and Brecht) 'The sleep of reason produces monsters' and opens the door to pretenders ready to take advantage of common people who may lack actual scientific knowledge.

The de Santillana and von Dechend book is no doubt a very serious work with respect to New Age subculture. Though its final conclusions are wrong, and despite the undervaluation of the role of social needs in human cultures and the use of often unreliable fonts, *Hamlet's Mill* was an honest attempt to elucidate a valuable aspect of ancient science and myth previously overlooked. The authors never state that Plato's Myth of Atlantis is an actual description of historical facts but rather suggest that it is a memory of a previous culture based on a careful observation of the sky. Cosmological myths are understood to be stories that often come from careful observation of the movement of Sun, Moon, planets, and stars during the year.

However, some topics are discussed in a very weak and sometimes amateurish way, especially those of Mesoamerican myth. In this case, the reason may be the embryonic state of Mesoamerican studies in the 1960s. Other glitches can be explained when the context in which the book was written is considered. Giorgio de Santillana published a book of his own the previous year and was still lecturing at M.I.T., so his workload during the late 1960s must have been intense. Furthermore, he was ill and near death at the time (Jenkins 2012).

Despite the faults and erroneous conclusions, the authors thesis that there is an astronomical dimension to myth (not understood by most scholars) was later demonstrated to be quite correct, and 'social Darwinism' which supposed that an older culture is always more 'primitive' than a later one, was shown to be wrong. The discovery that much of humanity's oldest myths were derived from celestial observations is probably the most important contribution that *Hamlet's Mill* offered and still offers. The authors also demonstrated that the concept of 'cyclical time' from long ago had and still has an indisputable charm for mankind. Such may be seen in the irony that many modern cosmologists preferred a model of an 'oscillating universe' to one of 'endless expansion' without any significant scientific reason until experimental data finally ruled out the first hypothesis.

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Theory and Methodology

On the Possibility of an 'Astronomical Perspective' in the Study of Human Evolution

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Abstract
The 'Sapient Paradox' is the apparently unexplainable time delay of several ten thousand years following the arrival of *Homo sapiens* in Asia and Europe and before the introduction of impressive innovations with the agricultural revolution. Renfrew (2007) has suggested that the solution of the paradox has to do with changes in modes of thought that occurred with sedentism. According to Renfrew, this is a subject of study for cognitive archaeology where the final goal would be to understand the formation of the human mind. Several scholars, however, affirm that climatic change was crucial to such a revolution as it would have been very difficult to develop agriculture during the Palaeolithic. In other words, sedentism was not justified during the ice age, and that may be the solution to the paradox. It is widely accepted that climate variations were due to so-called orbital forcing, the slow periodic changes of orbital parameters of the Earth (known also as the Milankovitch theory). These and other astronomical effects on the climate are discussed along with the consequent impact on human evolution. The question then rises as to whether or not it is possible to adopt an 'astronomical' perspective instead of (or complementary to) the 'cognitive archaeological' one. Such would be possible by adopting a different point of reference (that is, from 'outside'), and a non-anthropocentric approach.

KEYWORDS: cognitive archaeology, palaeoclimate, orbital forcing, solar activity

POVZETEK
'Paradoks *sapiensa*' je do sedaj nepojasnjen časovni zamik, dolg nekaj deset tisoč let, med prihodom *Homo sapiensa* v Azijo in Evropo ter uvedbo velikih novosti ob agrikulturni revoluciji. Renfrew (2007) ugotavlja, da je rešitev tega paradoksa treba iskati v spremenjenem načinu razmišljanja, do katerega je prišlo s stalno naselitvijo. Po njegovem je to izziv za kognitivno arheologijo, katere končni cilj je razumeti, kako se je oblikoval človeški um. Po drugi strani pa mnogo znanstvenikov zatrjuje, da je za to revolucijo bila ključna klimatska sprememba – v paleolitiku bi bilo namreč zelo težko razviti poljedelstvo. Z drugimi besedami, stalna naselitev med ledeno dobo ni bila smiselna, v čemer bi lahko bil ključ za rešitev paradoksa. Splošno priznano je, da so bile klimatske spremembe posledica dolgotrajnih periodičnih sprememb parametrov zemljine orbite (Milankovićeva

teorija). V članku obravnavamo te in druge astronomske vplive na podnebje, skupaj z njihovimi posledicami za evolucijo človeka. Na koncu se sprašujemo ali lahko 'kognitivni arheološki' pogled nadomestimo (ali dopolnimo) z 'astronomskim'. To bi bilo možno, če privzamemo drugačno referenčno točko (t. j. od 'zunaj') in ne-antropocentrični pristop.

KLJUČNE BESEDE: kognitivna arheologija, paleoklimatologija, orbitalni ciklusi, Sončeva aktivnost

Introduction

The purpose of the present paper is to suggest the possibility of an astronomical perspective instead of (or complementary to) the cognitive archaeology perspective in the study of the human evolution that was proposed by Renfrew. He explained his approach clearly in papers and books (e.g. Renfrew 2007) and stressed the link between cognitive archaeology and cognitive science as an interdisciplinary science that includes neuroscience, psychology, and anthropology. His approach may be summarized as follows: 'the brain (mind) studies its own evolution'. On the 'Sapient Paradox', Renfrew (2007: 84) remarked:

> If the arrival [in Europe] of the new species, *Homo sapiens*, with its higher level of cognitive capacity […] was so significant, why did it take so long for the really impressive innovation seen in the accompanying agricultural revolution, to come about? What accounts for the huge gap from the first appearance of *Homo sapiens* in Europe 40,000 years ago (and earlier in western Asia) to the earliest agricultural revolution in western Asia and Europe of 10,000 years ago? This is a time lag of 30,000 years!

It is a central idea of Renfrew's work that the most decisive turn in prehistory came with an order-of-magnitude increase in the varieties of engagement between humans and the material world, mediated by the use of symbols, which began with the development of sedentism at the beginning of Neolithic. While sedentism may have triggered the turn, what triggered the sedentism? According to Renfrew (2007: 147), 'most commentators, including Lewis Binford and Jacques Cauvin (e.g. Cauvin 2000), accept that climatic change was crucial (global warming, and the establishment of more stable conditions with fewer oscillations in temperature).' So, it might be concluded that it was climate change that triggered sedentism. However, what triggered climate change? Before trying to give an answer, it should be noted that apparently Renfrew (2007) didn't give much weight to the effects of climatic change.

Orbital forcing

Effects on climate

It is important to recall some of the widely accepted results of studies in paleoclimatology. The trend of the mean temperature difference estimated from deuterium in ice cores of Antarctica (e.g. Petit et al. 1999) suggests that climate of about 130 thousand and 240 thousand years ago was similar to the present (Figure 1). Going back further in time, other warm peaks with similar time scales can be seen, so the trend can be interpreted in terms of periodic phenomena (e.g. Kawamura et al. 2007). Analogous results have been obtained for all the various proxies that were analysed in the past forty years (e.g. from palynological sediments and oxygen isotopes in ocean sediments). According to paleoclimatologists these periodicities have an astronomical origin and are usually called orbital forcing (the Milankovitch theory). The slight changes in solar insolation due to slow changes in the eccentricity of the Earth's orbit, obliquity of the ecliptic, and precession of the Earth's orbit, gave rise to strong climate changes that can be deduced from the analysis of proxies. It is impressive that within paleoclimatology, there are no alternative hypotheses to the astronomical one, even if it does not exactly explain all data. Orbital forcing is at the basis of any interpretation of paleodata for the last millions years.

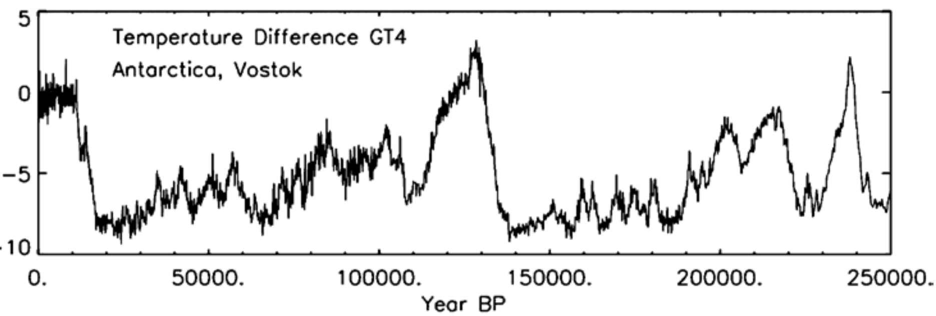

Figure 1: Temperature difference GT4 in Antarctica according to Petit et al. (1999) against the years before present (BP). One should note the short duration of warm climate phases compared to the long duration of cold climate.

From about ten thousand years ago to the present, the average temperature (not only in Antarctica) was rather stable, and the sea level significantly increased. Just few millennia before, the environment should have been completely different. The temperature was lower, and the sea level was very low, about 120 m below the present level (the late glacial maximum). Data on distribution of vegetation are extremely interesting (Figure 2). For example, on the mountains in southern Italy there were no deciduous woods as today, but there was a Siberian-like environment, a steppe (a lot of herbs), and the typical trees of cold climates. The very cold, dry, and unstable climate lasted at least fifty thousand years. Conversely, pollens suggest very stable and warm conditions during the last ten thousand years. This could be the explanation of the paradox. Indeed, it would have been rather difficult to imagine something like agriculture, at least at the latitudes above the tropic, during the long phase of cold climate. Actually, there was no reason for there to be a different economy from hunting and gathering during such a long period. Hence, there was no reason for sedentism, since it is generally supposed that the hunter-gatherer lifestyle was a nomadic one. Therefore one might conclude that it was orbital forcing that triggered the change in human evolution. As a logical consequence, it seems reasonable that in order to understand the human evolution, one has to know astronomy and its effects on climate.

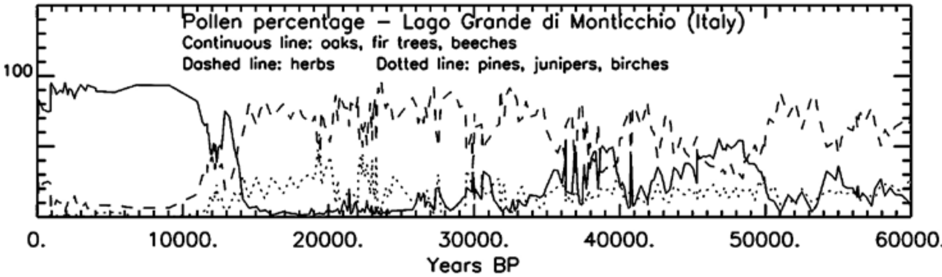

Figure 2: Pollen percentage from the Lago Grande di Monticchio in southern Italy (Allen et al. 1999) plotted against the years before present (BP). Continuous line: deciduous trees of warm-temperate climate such as oaks and beeches, and fir trees; dashed line: herbs; dotted line: trees of cold climate such as pines, birches and junipers.

Caveat

Of course the situation is not as clear-cut as depicted so briefly, and it is not possible to discuss it in detail here. Thus, some caveats are in order: *Homo sapiens*, our species, is supposed to have originated in Africa, and groups of *Homo sapiens* left from there about fifty thousand years ago (Mellars 2006). Some groups probably interbred with Neanderthals on their way to central Europe and with Denisovans in Asia (Gibbons 2011). The first farming economies appeared much later, about the ninth millennium BCE, and in the Near East (see e.g. Cauvin 2000). Recent data, however, from the New Guinea Highlands demonstrate exploitation of the endemic pandanus and yams in archaeological sites more than 40,000 years ago (Summerhayes et al. 2010). The sites contain stone tools thought to be used to remove trees, and this suggests that early inhabitants cleared forest patches to promote the growth of useful plants. In this case, however, *Homo sapiens* exploited wild (not domesticated) tubers and plants. This was not yet agriculture. In New Guinea, agriculture should have begun just 7000 thousand years ago with domesticated tubers, including taro, yams, sugarcane, and bananas. However, there are indications of forest clearance as early as 9000 years ago (Renfrew 2007: 61-62).

One could also wonder whether or not sedentism really began with climate change. Watkins (2010) pointed out that it probably began before, at least about 25,000 years ago (early Epipaleolithic) in the Near East (site of Ohalo II). Farming should have complemented rather than prompted the advent of permanent communities. There are also recent results regarding ancient pottery in China where vessels have been discovered dating back 20,000 years (Wu et al. 2012). There were probably hunters and gatherers living there in settlements. In any case, even taking into account these caveats, the basis of the evolution from Palaeolithic to Neolithic and the development of agriculture probably resulted from strong climate change due to orbital forcing.

Other effects on climate

Astronomical effects, however, also heavily affected the history of mankind at later times. For example, Wang et al. (2005) analysed sections of stalagmites of a cave in China. The general weakening of the Asian monsoon, i.e., progressively less rain during rainy seasons, was deduced by those authors for the last 9,000 years and corresponds with orbitally induced lowering of summer solar insolation (orbital forcing). Locally, during the Holocene Optimum Climate several thousand years ago, conditions were indeed wetter than present ones, for instance in the Sahara (Kuper and Kröpelin 2006). The general weakening trend is punctuated by eight further weak Asian Monsoon events, each lasting one to five centuries. Gupta et al. (2003) obtained analogous results from bio-sediments in the Arabian Sea. They correspond to so-called Bond events in the Northern hemisphere detected in ice cores (Bond et al. 1997). The causes are not clear, but paleoclimatologists are thinking about astronomical effects such as changes in solar output or in the long period of lunar tides (1800 years) along with the relative atmospheric response of Earth. Some of these events produced strong droughts. Here, an event of about 4000 years ago should be noted. It has been detected in the sediments of the Gulf of Oman as a sudden increase of dust indicating strong aridification (de Menocal 2001; see also Brooks 2006). The consequences should have been dramatic for people whose lives depended on the East Asian, South-West Asian and West African monsoon regimes. Aridification was one of the most severe climatic events, and it very probably caused the collapse of the Old Kingdom in Egypt (presumably there were no more floods of the Nile), of the Akkadian Empire in Mesopotamia, and of the Neolithic civilization in China. These are just some examples of the terrible effects that astronomical parameters seem to have had on climate and on timescales of centuries and millennia. The last Bond event corresponds to the so-called little ice age of three centuries ago which is usually ascribed to lower solar activity as indicated by the Maunder minimum, a lack of solar spots. The physical mechanism that has been proposed is related to the weak solar magnetic field during a lower activity phase; the field would be no more able to effectively shield the Solar System from the galactic cosmic rays. Their effect would be to change the cloud covering conditions in the atmosphere (for a critical review about the astronomical impacts on climate, see Bailer-Jones 2009).

An astronomical perspective

Astronomy therefore must be taken into account in order to understand the evolution and the history of mankind, and this suggests the possibility of adopting an ‘astronomical perspective’. It would consist of the study of evolution of mankind (and also of the history of Earth and of the evolution of life on Earth) as seen from ‘outside’, not from ‘inside’. Is it possible to adopt a different point of reference from that of cognitive archaeology and to study human evolution with a ‘non-anthropocentric’ approach? This may be more understandable by scholars that have an education in astronomy and/or astrophysics. In astronomy, the Earth is studied as a planet in the same way that other Solar System objects are studied, and it is not a special place apart from the fact that it is the only place where the peculiar phenomenon of life has been observed thus far. On the other hand, the approach of cognitive archaeology is the study of mankind's evolution as seen so to speak from 'inside' the mind itself. This seems an essentially anthropocentric approach.

For scholars that received a humanistic education, the astronomical perspective may not be as evident as for astronomers. Therefore, in order to help in understanding, an analogy from science fiction may be used. Imagine a large spaceship, even larger than Enterprise of Star Trek. It has a very long-term mission that will last about twenty years, and it consists in the exploration of some regions of the Galaxy. There are several hundred people on board. The spaceship is thus a small travelling town. During the long mission, children are born and are educated on board. One of them is a young scholar interested in the study of possible (if any) civilizations in planetary systems of the Galaxy. To him, the Sun is not at all a special star, and the Solar System is just one of the systems with a planet harbouring life. When at the end of the mission, he has the opportunity to land on the planet Earth and to visit it, he does not feel himself an earthling. He comes from space and feels himself to be an alien. His approach will be the study of the human population on Earth as seen from 'outside'. In a certain sense, this is the approach of a present day astronomer or astrophysicist.

Generally, an 'astronomical' perspective should allow a better global vision of the Earth's history. A better synthesis would be possible of what happened on this planet if an astronomical framework were used. Of course, this could be just a professional bias. Therefore, comments on this idea are welcome.

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Profiting from Models of Astronomical Alignments to Unveil Ancient Cosmologies in Europe and the Mediterranean

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Abstract
A new methodological system of procedures is proposed to make sense of the possible astronomical orientations of megalithic and other monuments. Such a system is based on a number of steps rooted in readings of the available data that limit the search for meaning to the last step, but are based on the results obtained in the previous steps. Such a methodology is experimentally applied to the orientation data collected for the megalithic tombs of the Iberian Peninsula. The result provides a new understanding of the orientations as a relation of time and space and a way to investigate the concept of time or temporality of the societies who built such monuments: how they possibly understood time as co-existent with space and how such a view was imprinted in their monuments and thus into landscape.

KEYWORDS: methodology, megalithism, orientation models, solar and lunar orientations, temporality and space

POVZETEK
Predlagamo nov metodološki sklop procedur za pojasnjevanje možnih astronomskih orientacij megalitskih in drugih spomenikov. Sklop sestavlja več korakov, izhajajočih iz tolmačenja razpoložljivih podatkov, pri čemer iskanje pomena omejimo na zadnji korak, baziramo pa na rezultatih iz prejšnjih korakov. To metodologijo smo preizkusili na podatkih o usmeritvah megalitskih grobnic Iberskega polotoka. Rezultati nam podajajo novo razumevanje orientacij kot relacij v času in prostoru, pa tudi način za proučevanje koncepta časa in časovnosti v družbah, ki so te spomenike zgradile: verjetno so razumele čas kot koeksistenčen s prostorom, ta koncept pa je bil vtisnjen v njihove spomenike in s tem v pokrajino.

KLJUČNE BESEDE: metodologija, megalitizem, modeli usmeritev, usmerjenosti proti Soncu in Luni, časovnost in prostor

Introduction

Much recent effort has been devoted to the acquisition of large numbers of orientation data in order to verify whether, within a given society, the orientation of monuments, – either tombs, temples or other cultic areas – shared common orientation patterns (see, e.g. Ruggles 1999; Hoskin 2001 for megalithic monuments or Belmonte & Shaltout 2009 for Egyptian temples). A single measurement considered alone (i.e. devoid of any archaeological or cultural background), regardless of how significant it may seem, does not provide sufficient confidence that such an orientation was intentional. The way to verify such intentionality is at the roots of the now supposedly superseded green and brown archaeoastronomies (Ruggles 2011). However, this effort has been necessary as it is important to show that orientations are meaningful data and valuable information can be extracted from them.

After this goal is fulfilled, a second step is identification of a possible astronomical culprit, if applicable. This could be a difficult task given the intrinsic degeneracy of solar, lunar or even stellar targets. Also, in many instances such as in the cases of the megalithic phenomena or Proto-historic societies, we lack any written account or possible ethnographic sources to enlighten the data; even when we have it, as for the classical temples, it is difficult to decipher the correct meaning.

One possible solution much explored in the last decade, is the use of different statistical and probabilistic techniques or direct modeling of the data. Such efforts have mainly used elaborate modeling techniques (Gonzalez-Garcia et al 2005; Gonzalez-Garcia 2009a; Silva & Pimenta 2012), Bayesian inference approaches (Pimenta et al. 2009) or clustering analysis (Gonzalez-Garcia 2009b; Gonzalez-Garcia & Belmonte 2010; Belmonte & Gonzalez-Garcia 2012). The main aim of such investigations was to break the degeneracy in many orientation patterns towards areas where both the sun and the moon could be identified as possible astronomical targets for megalithic astronomy.

However, even if a signal could be statistically significant, this is different from the fact that it could be archaeologically significant (Fletcher & Lock 2005: 12); during the last decade a number of authors have indicated a failure to understand the meaning behind monument orientation if using only a 'cold' statistical approach (see Iwaniszewski 2009 or for a recent review on the subject see Ruggles 2011). A number of alternatives are proposed, such as the phenomenological approach used by Sims (2007) or the hermeneutic spiral advocated by Rappenglück & Rappenglück in this volume.

Such methodologies are appropriate to the anthropological and archaeological work and indeed provide a way to step aside from the coldness of data and move into the interpretation and meaning of orientations. A problem with these approaches, however, is that in many instances although the discourse could be valid, the subjectivity of the researcher is not constrained by any logical limit and thus the conclusions are not based on facts but more on the logical track of their thoughts.

In the following we will propose a way in between both methodologies based on the statistical treatment of the data while trying to derive meaning from it using anthropological methodologies.

A Few Notes on Statistic

Before proposing a possible solution to or restriction for this subjective trap, we must introduce a few notes on the ways histograms, kernel density estimations (KDEs hereafter) or curvigrams are normally produced.

An appropriate smoothing of the azimuth histogram by a function called the kernel produces the azimuth KDEs. To do so, at each entry in azimuth we multiply the value of the number of occurrences of that azimuth in our sample by the kernel function with a given passband or width.

The key choices then are the type of function we use and the passband or the width of this function, i.e. the number of azimuth values we take into account in our function softening. For the first choice, there are several possible functions, although the Gaussian and the Epanechnikov kernels are the most commonly used. In this work we use the second one. For the bandwidth, although there are theoretical prescriptions in the literature as to the best choice (Rosenblatt 1956; Parzen 1962) these are not practical. A practical prescription for the optimal choice of the bandwidth is $h \approx 1.06\sigma n^{-1/5}$, where n is the number of data we have and σ is the standard deviation of the sample (Silverman 1998); however, this is only usable if we use a Gaussian kernel and the data behaves as a Gaussian distribution. It is important to note that for other kernels this is based more on a trial-and-error method; however, depending on the number of monuments, the spread in azimuths and the errors implied in the data acquisition process one may use larger or smaller values for the passband.

We have been using these tools to plot the results of our measurements of orientations in azimuth and declinations in our recent work. Azimuth is a circular magnitude, i.e. the largest value it may reach, 360°, equals the smallest 0°; when transforming this quantity into declination we must remember this fact. The implications when interpreting declination curvigrams, or KDDs, could be important, as we will show soon.

Histograms normally give the number of occurrences of a given characteristic – for example, an orientation towards a particular value of azimuth – however, that number is often given in terms of a relative frequency or a percentage.

When using any kind of histogram, it is important to provide a mean to assess the significance of the different maxima that might appear. When dealing with data from natural sources, this measurement might be affected by 'noise' sources and the 'signal' must be compared to the 'noise' in order to verify if it can be clearly distinguished from it. In our data, coming from measurements of orientations, i.e. not natural, we could not 'a priori' say that any measurement is noise.

To be able to say if a measurement is significant we have to compare it with respect to something, and see if the result is significant. Thus we should compare with respect to other instances. One such comparison could be against a random sample of the same size as our database. However this may pose a problem: a random sample with a small volume of data could give a rugged histogram to compare with, while a large sized random sample is not much different from a homogeneous distribution. This is why we propose to do this comparison with a homogeneous distribution in Azimuth of the same size as that of our sample. We normally use a normalized relative frequency to scale our

KDEs or histograms. To do so we divide the number of occurrences of a given azimuth by the mean number of occurrences for that sample; this is equivalent to dividing or comparing the results of a uniform distribution of the same size as our data sample and with a value equal to the mean of our data.

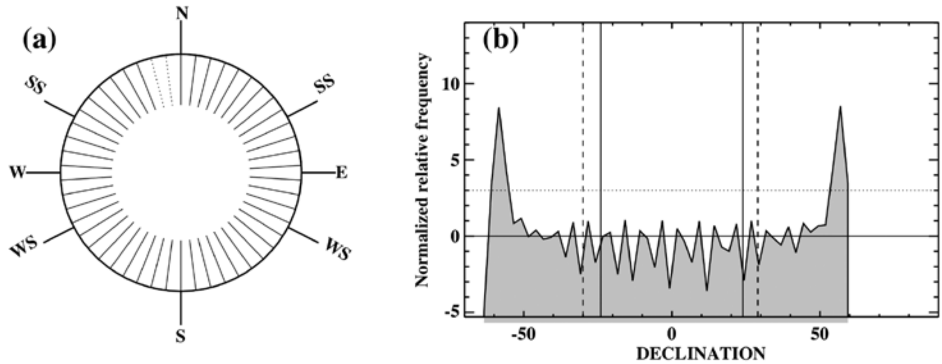

Figure 1: (a) azimuth distribution of a homogeneous sample. When we convert this into declination at any given latitude, the new magnitude is not homogeneously distributed (b). There are two maxima related to the accumulation areas at north and south. We must take this into account when finding large maxima towards north or south in our measurements. Solid vertical lines delineate the solar range, while vertical dashed lines indicate the lunar range.

When converting to declinations we would have a distribution of the shape presented in figure 1. Our comparison then will be made by plotting in the KDE the quantity: (f(obs)-f(unif))/σ(unif), where f(obs) is the frequency of the observed event, f(unif) is the frequency of the uniform event and σ(unif) is the standard deviation of the uniform distribution. What is the meaning of this? This will give a curvigram scaled with respect to the uniform distribution, i.e. we compare against it and see whether our data is significant against that distribution. The scale is given by the standard deviation of such uniform distribution; if our data has a maximum that rises up to a value of 3 this means that it is 3 times larger than that standard deviation, or 3 σ. This is usually a criterion to indicate that a given 'signal' is significant.

It is interesting to see that the homogeneous distribution in azimuth, which in that quantity would give us a flat line, presents a double peaked histogram. These two peaks correspond to the accumulation areas towards north and south. It is common, for certain groups of monuments, to find that a small number of monuments oriented towards north or south translate into huge peaks when considered in declinations. This is the reason.

Other distributions we may want to compare against are those of the movements of the sun or the moon on the eastern horizon.

Multivariate Techniques

Multivariate techniques are commonly used in archaeology and have been used in the recent past for archaeoastronomical data (see e.g. Gonzalez-Garcia & Belmonte 2010). These techniques produce some kind of graphical output and statistics that are descriptive, because they simplify the data and present possible patterns within them (Fletcher & Lock 2005: 139).

The techniques we will apply here are the Principal Component Analysis, Cluster Analysis and a representation of such called the dendrogram and, finally, the k-means clustering.

As part of multivariate analyses, cluster analysis and principal component analysis try to search for regularities in the data that may allow finding groups or clusters among them. Using a given distance-measuring algorithm, cluster analysis finds groups among the data and then finds distances among the clusters, building a hierarchy of distances. A plotting procedure of such a hierarchy is known as a dendrogram.

Principal component analysis or PCA tries to find the vectors of maximum variance among multivariate data. In other words, if we have our data in a multidimensional space, it tries to determine if the data could be well described by a combination of a number of those dimensions and thus allow us to lower the number of dimensions. A by-product of this method is that we may find groups among our data and that we may include models of the movement of astronomical bodies directly among the data and see if this data is more closely related to one model or another in that multidimensional space (see e.g. Lay 1994 for an introduction).

Finally, the k-means clustering (Everitt 1995) links the groups of monuments into clusters by comparing the shape of the kernel density distribution of each data group with a given seed. In each step, the method computes the distance of each distribution to the seeds and then does the grouping. The groups define a new seed by calculating the one in that cluster which is closer to the mean of the cluster, and the process is iterated until it reaches a convergence.

Now that all our statistical tools have been defined we may move towards the proposal for the new methodology to obtain the best results from these tools.

The Structuralism Stair

In a recent book, Criado Boado (2012) proposes a possible way forward to overcome the caveats described in the introduction when dealing with archaeological data, which could be applicable to archaeoastronomy also. It is based on a kind of structuralism stair. We start by investigating a given particular issue, a determined aspect, a common form of the archaeological record. For the sake of illustration, let it be the shape of a given pottery artifact found in a given excavation. After inspecting the data, the facts may prompt the researcher to propose a first hypothesis with regard to such shape. This is usually where we end our investigations and perhaps jump to conclusions regarding meaning of archaeological records, incorporating anthropological methodologies. However this new method proposes a number of steps before taking that leap.

A second step would be to research other characteristics of the archaeological object we are investigating, for example, the colors or the areas of deposition. By doing such further investigations and comparing the results against our first hypothesis we could expand it to a new level: a new hypothesis that may result in the postulation of an ideal model encapsulating all the information collected so far. We must bear in mind that such a model is still not complete and is not giving a 'meaning' to the archaeological object we are investigating; but by proceeding in this way we are accumulating different layers of significance (Garcia Quintela & Gonzalez-Garcia 2009).

The third step involves comparing our regional investigation to how that object appears in other geographical areas: how the shapes, colors and other characteristics of the pottery appear in other areas. If a common pattern arises, our ideal model could be expanded to a generic hypothetical model, something that could be applied on a general level to a variety of similar objects.

To finally attain a proper level of understanding, Criado-Boado proposes comparing such archaeological characteristics from different chrono-cultural contexts. By so doing, the shape of different pottery vessels may, for instance, indicate the persistence and changes derived by the action of time and culture; under a structural code we could then postulate an ideal generic model.

Up to now all steps are based on data, and thus up to now we may term this approach as mainly positivistic.

The final step is that of trying to identify the sense out of that archaeological problem. To do so we could have recourse to any of the current anthropological methodologies but we must always do it based on our previous steps on the stair; thus, the subjectivity would be much more constrained than if we try to jump into the fifth step without going through the other steps before.

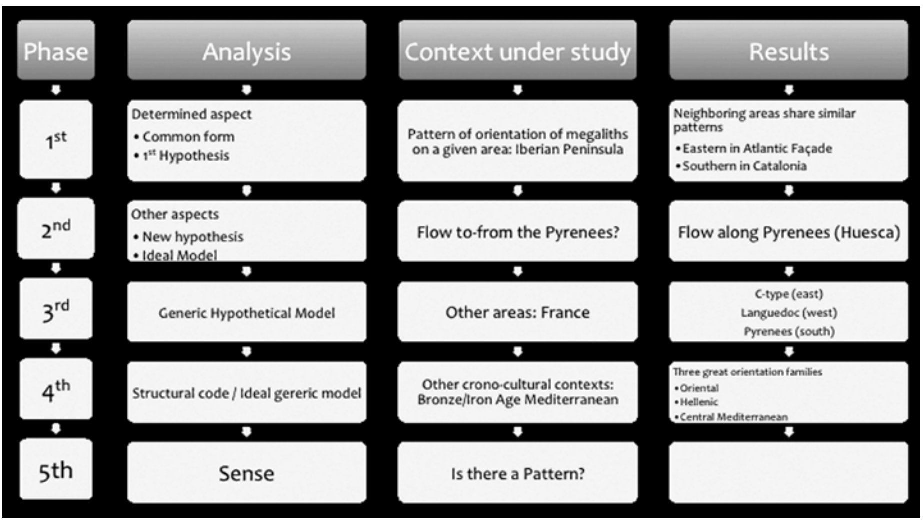

Figure 2: The structuralism stair. At each step a particular aspect of the record is inspected. The ever-growing evidence allows us to expand the models and hypothesis by testing them on different steps until we reach a level of sophistication that allows us to derive a meaning from such a record. See text for further details.

The Iberian Dolmens, a Test Bed for the Method

We will apply this method to the data sample of Iberian megaliths compiled by Hoskin (2001) and studied by Gonzalez-Garcia & Belmonte (2010).

We will start by acknowledging a list of facts:

- Although in all cases we have to decide a given direction that could be more or less justified, we can (and we do) measure the orientation of the dolmens.
- Dolmens built in a given area by a given society tend to share a given pattern of orientation, as demonstrated by several works in the past (e.g. Ruggles 1999; Hoskin 2001).
- The simplest way to explain such a pattern of orientation in many instances is by an astronomical target.
- Given the nature of the movements of the Sun and the Moon in the horizon, in most cases, it is not possible to distinguish which one is the possible target.

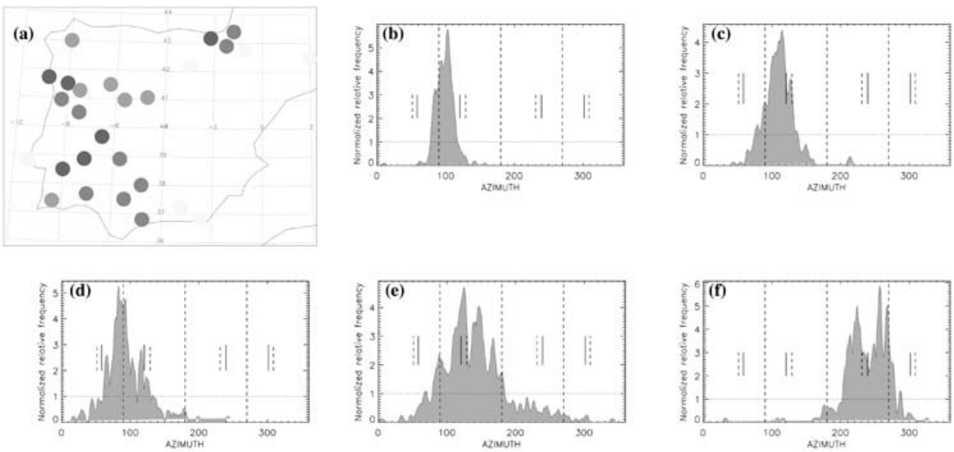

Figure 3: (a) K-means diagram for the megalithic monuments of the Iberian Peninsula and neighboring regions. This diagram should be compared with those in Gonzalez-Garcia & Belmonte (2010). The families that the k-means clustering derives are independent although consistent with those derived there by the dendrogram and PCA analysis. The group of Huesca dolmens is also included and falls in a transitional area along the dolmens of the Pyrenees. (b-f) Families of orientations derived by the three methods are quite consistent. If we group the orientations of the groups in each family we can derive a general shape for them. For the details, see text.

Step 1. Orientation patterns in the Iberian Peninsula

To overcome the problem of degeneracy for the dolmens in the Iberian Peninsula Gonzalez-Garcia & Belmonte (2010) attempted the use of cluster analysis to the pattern of orientations of 32 groups of megalithic monuments in this area. They defined a number of what they called 'genetic markers', a set of numbers derived from a first statistical treatment of the orientation data for each group. This set of numbers defined a data space where they tried two methods of cluster analysis, the dendrogram and the Principal Component Analysis.

The main results of their investigation were that neighboring regions within the Iberian Peninsula tended to share similar orientation patterns and that in some instances such orientations could be better explained by particular models of the movements of the sun or the moon.

We have tested their result through the k-means clustering algorithm. We find similar groups as those found with the other two methods, confirming the robustness of the result.

With the different methods we could identify five regions or groups according to the orientation of their megalithic monuments (Figure 3). The first one involves the monuments in the Atlantic façade of the Peninsula (Fig. 3b), with orientations mainly towards east or southeast, but generally inside the limits of the solar and lunar ranges. Then what could be transitional areas could be defined through the valleys towards the interior of the Peninsula, and the southeast (Fig. 3c). The southeast defines a third area (Fig. 3d), while the northeast part of the Peninsula along with the Mediterranean islands of Corsica and Sardinia define a new family with orientations centered on the southeast (Fig. 3e), while the last family includes dolmens from the Balearic Islands and the south of France (Fig. 3f).

These results will be used to explore the scheme devised above. The first step in our ladder will be comparing the orientation of these monuments and our first hypothesis that neighboring regions tend to share orientation patterns. In their paper, Gonzalez-Garcia & Belmonte also conclude that areas not yet investigated, where dolmens exist but had not been measured yet, should be used as a test bed for that hypothesis.

Step 2. Empty areas: testing and expanding the hypothesis

One such area was in the south part of the middle Pyrenees, in the Spanish province of Huesca. There, at a relatively high altitude there are around 30 megalithic monuments, mainly simple dolmens and a few stone circles. Belmonte & Gonzalez-Garcia (2012) investigated the 15 simple dolmens measurable in this area. It is interesting to note that the horizon altitude in most cases is large. When they performed a new dendrogram analysis for the Iberian Peninsula including now the middle Pyrenees dolmens, these dolmens fall within a group of neighbouring regions, although with transitional characteristics: the orientation pattern is similar to the dolmens in the east, i.e. they are oriented to the southeast, while the declinations, due to the horizon altitude, appear more similar to the dolmens in the west, staying inside the solar and lunar rising ranges (Figure 2).

After this first test we may modify our initial hypothesis to say that in certain instances the orientations seem to adapt to changing conditions and that what may be perceived as transitional areas display transitional characteristics in their orientation patterns.

A further conclusion is that apparently the Pyrenees were also communication areas along the mountain range. However it would be nice to see what occurs on the other side of the mountains, as the Roman roads and early medieval churches talk about a clear exchange of trade and ideas across the Pyrenees.

Step 3. Applying the hypothesis to other areas: France

In step 1, we have already seen that some of the megalithic tombs in southern France presented some similarities with the dolmens in the Balearic Islands and in northwest Iberia. However to see if such similarities hold, or are the product of a selection effect we must compare the orientations with those of other closer areas in France.

We have collected data for 22 areas in France and we have included those areas close by in the Iberian Peninsula, plus the Balearic Islands, Corsica and Sardinia. This amounts to a total of 31 areas, with over 1500 megalithic structures in total. The data are collected from the corpus mensurarum in Hoskin (2001), while those for Brittany come from Hoskin (2007a; 2007b), for central France from Hoskin & Higginbottom (2002) and for the Channel Islands from Le Conte (2008).

We have applied the same algorithms as in Gonzalez-Garcia & Belmonte (2010), plus the further statistical tool known as the k-means clustering.

The results are consistent among the three methods, indicating the robustness of the result. Figure 4 shows the results for the dendrogram analysis.

From this analysis, we observe that there are at least four to five clear families of dolmens according to their orientations. One would include the monuments form Provence and Languedoc together with those of the Balearic Islands. It is interesting to see that under the new conditions this family is the same that already appeared in our first analysis of the Iberian dolmens. This should not be a surprise, as these are the only groups displaying clear orientation patterns towards west in this area.

A second group includes the dolmens on both sides (north and south) of the eastern Pyrenees. A third group includes the Causses type dolmens in the south central areas of France. This group includes a large number of dolmens, mostly simple in their construction, which display a preference towards the eastern horizon, inside the solar and lunar ranges.

Group four includes those dolmens in the area east of the Causses and northwest of the Languedoc. Their orientation and placement in the dendrogram situate this group as some kind of transitional group.

Finally, group five includes dolmens at the western part of the Pyrenees. The second and fifth groups confirm something hinted at before, the communication across the mountain range. However, in the area just north of Huesca (Departement Hautes Pyrenees) the dolmens are scarce and still need to be measured, and indeed it would be an interesting test of these ideas.

The dolmens and passage graves in Brittany have too complicated a history; however some interesting patterns arise, like the differences between the south and north of the region, regardless of the dolmen types.

These results are widely similar to the ones obtained with the k-means clustering and the PCA, indicating that our model for the Iberian Peninsula seems to be applicable also, at least, to the south of France; neighboring regions do tend to share similar orientation patterns.

When we compare these orientation groups to models of the orientation of the sun and the moon at particular moments of the yearly cycle, as performed by Gonzalez-Garcia & Belmonte (2010) using the PCA analysis, we find that some monuments may be clearly modeled by using certain lunar models.

Such groups include the L-type and BR-type dolmens investigated by Gonzalez-Garcia et al. (2005). There it is shown that such dolmens could be modeled by orientations towards the first sight of the lunar crescent after the Spring Equinox, or the solstices.

Another group is that of the C-type dolmens in central France. Their orientation, whether we examine just those located in the Département of Lot or all the C-type dolmens, could be modeled with the Pascal Full moon (or all moons from one half of the year for all C-type monuments), a similar target to that advocated by da Silva (2004) for the Alentejo dolmens in the Iberian Peninsula.

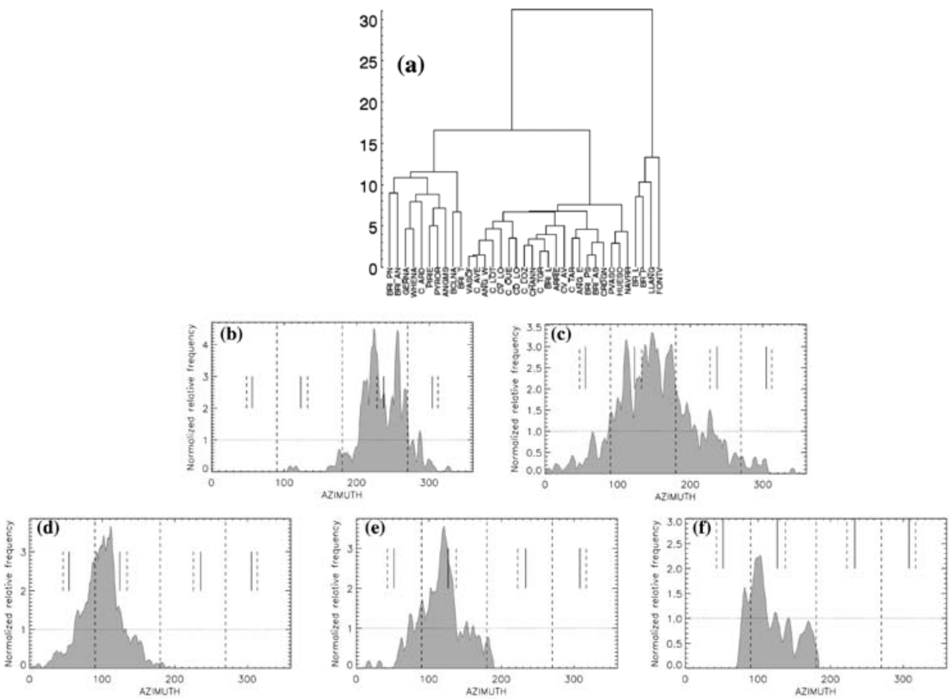

Figure 4: (a) Dendrogram analysis for the dolmens in France discussed in the text. We may identify five families. (b-f) The families identified by the three different methods are again widely consistent and we may stack the data together. Family (b) includes data from the southeast of France, (c) includes mainly groups from the eastern Pyrenees, (d) data from the Causses, (e) includes data from Brittany and the transitions between (b), (c) and (d). Finally (f) includes data from the western Pyrenees.

We may thus generalize our hypothesis to a generic hypothetical model, something susceptible to general application, at least in more areas than those which were investigated in the first place. In this sense it would be extremely interesting to apply this methodology to other areas, like the British Isles or the TRB areas in northern Europe or the dolmens in Northern Africa.

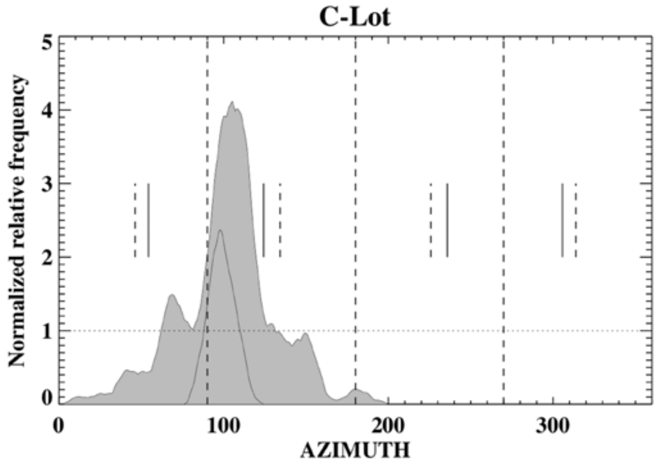

Figure 5: After the PCA analysis including a few models of the movements of the sun and the moon at particular moments of the year we have attempted a few models on some of the groups of dolmens in France. The figure displays the C-type dolmens from the region of Lot (shaded area) together with a model for the spring full moon (light solid curve inside this area); this is the first full moon after spring equinox. This model can describe the behavior of the mean maximum of the family.

Step 4. Other chrono-cultural areas: the Bronze and Iron Age Mediterranean.

In order to verify the extent and applicability of the ideal generic model, we will compare these results with those from a similar analysis performed with the temples and funerary monuments of the Mediterranean from the Bronze and Iron Ages (González-García & Belmonte 2013).

Data for the Egyptian temples were obtained from Belmonte, Shaltout & Fakri (2009) and Belmonte et al. (2010). Kushite data include 50 temples and were taken from Belmonte et al. (2010). Hittite and Phrygian orientations were obtained from the survey performed by González-García & Belmonte (2011). M. Blomberg and G. Henrikson measured the Minoan temples in several campaigns and the data were kindly provided by the authors − see Henrikson & Blomberg (2008) for further details. Data from the Hellenic temples in Greece were obtained from Boutsikas (2009), while data for those in Sicily and Magna Graecia were obtained from Salt (2009) and Aveni & Romano (2000), respectively. Maltese temple data are from Fodera-Serio et al (1992), while the Etruscan and Samnite temples were measured by Aveni & Romano (1994) and Ruggieri & Pagano (2010), respectively. Hoskin (2001) measured the taulas from Minorca and Aramburu-Zabala & Belmonte (2002) collected the data for the Square talayots from Majorca. Data for Sardinian nuraghe come from Zedda & Belmonte (2004). Esteban (2002) collected the data for the Iberian temples while Esteban et al. (2001) and Belmonte et al. (2007) did the same for pre-Roman temples in North Africa. These temples were divided in two groups, the first one including pre-Roman temples, presumably showing Libyan-Phoenician ancestry (Esteban 2003), while the second includes Roman temples founded ex-novo. Nabataean temples were obtained from Belmonte et al. (2013). Finally, temples from Lycia and Cyrene were presented by González-García & Belmonte (2013).

As a test group, together with these temples, they included a number of funereal structures with possible cultic functions such us the Thracian megalithic monuments (González-García et al. 2009), Tunisian dolmens (Esteban et al. 2001), Sardinian Tombe di Giganti (Zedda et al. 1996) and Punic hypogeal tombs (Gonzalez-Garcia et al. 2007).

In total they analyzed nearly 2500 cultic structures along the Mediterranean and for different epochs, from Old Kingdom Egyptian temples to North African Roman temples. In order to make a fair statistical comparison, they used declination measurements, as the different monuments encompass a wide range in latitude and in epochs. They followed the statistical approach explained above for the megalithic structures in the Iberian Peninsula and France, and thus their results could be directly applicable to the comparison with the ones derived above.

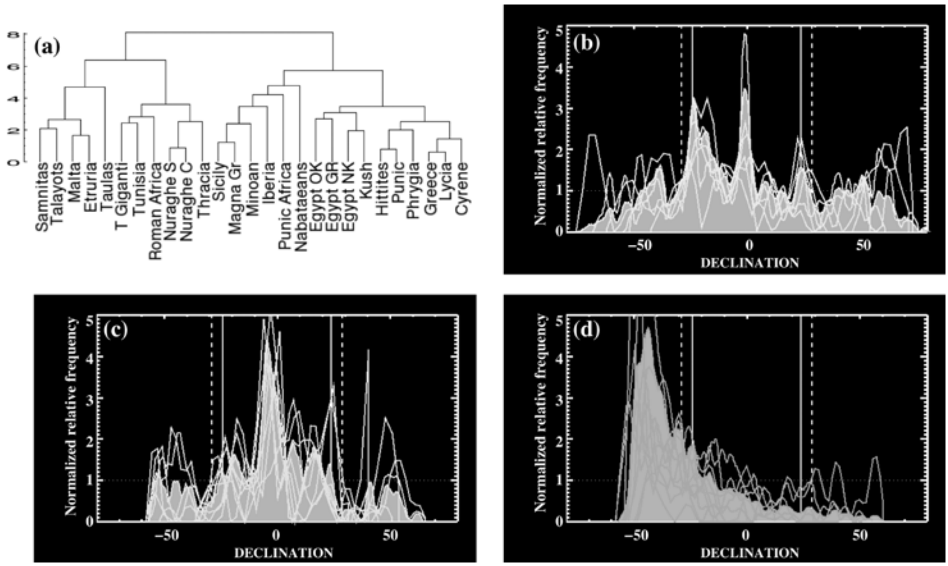

Figure 6: (a) Dendrogram analysis on the orientation of 27 groups of monuments from around the Mediterranean from the Bronze and Iron Ages. It is interesting that the k-means analysis again finds very similar results. Three broad families could be defined according to this analysis. One includes monuments from the Middle East plus a few interlopers (1), the second includes Hellenic temples (2) and the third includes monuments from the Central Mediterranean (3). (b-d) The monuments comprising the families found by the k-means analysis can be stacked together to define a general shape for the KDE of that family (shaded areas). Family (b) presents two maxima, which could be related to the winter solstice and the equinoxes. Family (c) presents broad off-centered maxima perhaps related to equinoctial alignments. Family (d) presents a broad peak towards southern orientations.

The results from the two methods, dendrogram analysis and k-means clustering, indicate that the monuments tend to cluster in groups that we may term 'culturally related'. They find a first group encompassing monuments from the Near East: the Hittites, Phrygians, Nabataean, Egyptian and Kushite monuments appear highly related. Although some small differences might arise, there is a clear homogeneity from the orientations mainly towards solstitial and equinoctial directions. It is interesting that both maxima for most of these families are quite sharp, and not broad as was the case for the megalithic monuments: perhaps indicating a better construction method, a finer intentionality or a more clear orientation towards solar orientations as opposed to perhaps lunar ones. A geographic and architectonic interloper is the group of Punic hypogeal tombs of the western Mediterranean. These display a similar orientation pattern to those of the Eastern Mediterranean temples, but are both located outside the 'area' of the Middle East and they are tombs, not temples. However, the link with the other structures is that they were built by a society with deep cultural roots in the Middle East and that seemed to have paid a great cultic attention to the dead.

A second group includes the Hellenic temples from Greece, Lycia, Cyrene, Magna Graecia and Sicily, together with those of the Minoans, Iberians and Libyan-Phoenician. The cultural homogeneity of the first five groups seems striking. Temples built at distant areas such as Lycia or Sicily share orientation patterns dictated by the cultural link between them. Temporal interlopers such as the Minoan temples or geographic and cultural ones like the Iberian or Libyan-Phoenician, call for a further study on Mycenaean and Phoenician temples to verify if the Bronze Age temples of Greece and Phoenicia also could follow the pattern of orientation of these groups of monuments, which seems dominated by a broad equinoctial maximum with other lower maxima at the solstices or lunastices. The maxima in this area seem broader than the ones of the Near East, perhaps indicating a preference for lunar orientations, although only proper modeling would verify this asseveration.

The third area includes the cultic structures from the central Mediterranean, which tend to display orientation towards the southern part of the horizon, with a more or less narrow range, depending on the group. The orientation for some of the groups, like the Taulas in Minorca, have been linked with the prevailing winds in the islands (REF); however the consistency of orientation in this area may point towards a common milieu of ideas in the Central Mediterranean towards southern parts of the horizon. If we must invoke an astronomical interpretation this could range from the culmination of the Sun (or any other luminary for that purpose) or perhaps to some specific group of stars. One star group that has frequently appeared in the literature is the group formed by the Southern Cross and the Pointers.

To summarize, the groups found by González-García & Belmonte (2013) indicate that orientation during the Bronze and Iron Ages seems to be driven by cultural relations. Groups of monuments that share a common cultural background, such as the Hellenic temples, tend to display similar orientation patterns in different geographical areas. This may indicate that although the local manifestation of the cults and the Hellenic culture could be widely different, the objects to which they were oriented are systematically the same. In other areas, like the Near East, more data is needed in order to draw firmer conclusions; however, it may indicate that different cultures, when faced with similar problems tend to find similar solutions, although a number of cultural links between them could not be discarded.

Astronomical implications could also be derived. We should keep in mind that a single model cannot explain all orientations (Boutsikas 2011); however we may see a preeminence of equinoctial and solstitial alignments in the oriental family, perhaps linked to the prominence of solar and stellar cults there. The Hellenic family seems to present wide and slightly off-centered equinoctial alignments, perhaps related to lunar and/or stellar cults, while the central Mediterranean family orientation towards the south seems to have been systematically linked with possible stellar cults.

Now, following our structural code, can we derive an ideal generic model? Comparing the situations in the megalithic families and the Bronze and Iron Ages' monuments it seems that orientations talk to us about cultural relations. While in the megalithic areas these seem to connect neighbouring regions culturally, the long trade and colonization of the Mediterranean in the late Bronze and Iron Ages seem to be the drivers for the common orientation patterns found.

Thus, we may postulate our ideal generic model on orientations as follows: that neighboring/culturally related areas tend to present similar orientation patterns. For the Megalithism this is based on geographical areas, i.e. culturally related areas are next to each other. So far, according to the results from the modeling techniques, these tend to be mostly Lunar for the areas studied to date. There are frontiers areas like the mountains, which could be perceived as a membrane rather than a strict barrier.

However, for the Bronze/Iron Age Mediterranean, culturally related areas are more extended. Orientation might travel together with other cultural traits.

With regard to the megalithic monuments 'equinoctial' (or non-solstitial) orientations seem to appear in several areas. These are characterized by simple distributions, which later expanded to neighboring areas, becoming more complicated.

Examples of such simple distributions, i.e. with only one maximum, are the groups of monuments from Alentejo (Portugal), Lot (France) or Fontvieille (France).

Southern orientations seem typical for Mediterranean groups that also tend to display more complex distributions. It is interesting to note that this area of the Central Mediterranean is also where we find that southern orientations are prevalent for latter epochs. Such orientations have been linked with the stars, the sun/moon in culmination, illumination, and winds. However, the fact that such orientations are so consistent through time might point to some more fundamental, possibly not yet identified reason. This makes the investigation of Northern Africa dolmens the more interesting.

Offset Equinox orientations seem to be the characteristic feature of Hellenic monuments, while a combination of both Equinoxes plus Solstices is more characteristic of the Middle East.

So What?

The fifth step in the structuralism ladder involves the identification of meaning within the archaeological record and its interpretation. We have been dealing with the orientation of monuments, in particular megalithic monuments in the Iberian Peninsula; we have further extended this study to the areas of southern France and to the Bronze Age and Iron Age Mediterranean.

We study orientations and these are no more than measurements in space; we are measuring a dimension, a direction. However, particular directions might have a special meaning on temporality. Particular areas of a given landscape might be important at certain periods of the year. For example, a meadow might be important in autumn when the harvest time comes, and a given culture might assign a temporal significance to that meadow; such significance could be highlighted if particular rituals have to be performed at that place precisely on that occasion. So, the spatially important area gains a temporal and ritual meaning (Gell 1992: 197-205).

At the same time we must bear in mind that temporality introduces order in space, and thus creates the Landscape, as a space thought and culturally built, where not only the natural features such as springs, mountains or woods are present but also artificial structures from the same or other societies which are thought or reinterpreted by a different culture (Garcia Quintela & Gonzalez Garcia 2009).

The societal practice of going to a particular part of the territory at a given moment or performing a given ritual at the correct moment and place, orders time and space.

Following this reasoning, an assumption on the astronomical significance of the orientation of monuments may give us information about time or, to be more precise, on the concept of temporality in a given society.

This is a difficult concept. Not all societies need to have acknowledged the apparent flow of time, and those who did might have done it in a wide variety of forms from cyclic to linear or other concepts based on the ancestor cults, the naturalistic cults, et cetera (Gell 1992: 37-77).

However, we might postulate that different orientations perhaps reflect a different concept of time or of the construction of time.

If this is so, and starting from the point in our sample closer to us in time, we might acknowledge that the Mediterranean Bronze and Iron Age societies had different calendric systems as a reflection of their different temporalities. The different orientation patterns might reflect precisely those differences in their calendric systems. The Near East and Hellenic societies had a need to regulate time (Cohen 1993; Hannah 2003). They needed a calendar, as it is understood today, as a system to compute and regulate time. Not only did they need to regulate civil time, but also - most importantly for our purposes - religious and cultic time, although most probably these concepts must not have been separate for most of them. This need is reflected in the different calendars that have reached us which pay great attention to particular moments of the year and the need to accommodate ritual and natural (i.e. astronomical) cycles. This might be reflected in the appearance of clearly solstitial or equinoctial related peaks with complex manifestations, as is attested to by the intricacy of the orientation distributions.

This is less clear in the case of the orientation distribution for the megalithic structures. One first aspect is that in most cases the orientation distributions are simpler than those of latter periods, perhaps indicating a different need to mark temporality.

It is possible that talking of calendars and calendar regulations in the Megalithism is not fully justified according to our data. Early state societies of the Mediterranean Bronze and Iron Ages had rather well defined calendrical systems, and this was reflected in the somewhat simple orientation pattern of their monuments. The fact that the megalithic monuments present more complex orientations, with larger spread in the orientation values, may point to a simpler method to mark the temporality in these societies. Such a method could be that of controlling, for example, when the sun is at the solstice, when is the first crescent that follows the equinox, or if the sun and the moon cross over at the horizon. This speaks to us more of a control of the ritual landscape through the correct time and the need to control time more than to regulate it (Aveni 2000: 325-339).

Of course, the need to regulate or control time would be reflected in the kind of rituals to be expected in one or the other instances, and would speak to us also of perhaps more complex beliefs.

Future Work

By no means this is a finished work, but a work in progress. Much effort must be devoted in order to find deeper meaning in the data. Also the meaning on temporality is not the only possible interpretation; it is an interpretation that first looks at the group of megalithic monuments as a whole and second looks only for an interpretation based on the temporality. Other meanings could surely be derived.

One interesting issue is the feasibility of the structuralism ladder method and the possibility it opens for the studies in archaeoastronomy.

Indeed, one ingredient for the future is to continue the modeling procedures, not only with those included here but also using Bayesian inferences (Pimenta et al. 2009, see Pimenta in this volume) in order to do more specific studies on the orientations of those groups of monuments explored here to find among a suite of models the one that better describes the data and see also if regional patterns concerning the celestial bodies appear as a result.

It will certainly be very interesting to extend the analysis to megalithic monuments of other areas in Europe like the British Isles, the TRB or North African areas and perhaps explore in further detail the case for Brittany.

It would be highly desirable to include other factors in the analysis, not just orientations, but also the architecture of megaliths, like the location of megaliths, space relations inside necropolises and other cultural aspects (ceramics, goods found, petroglyphs' location, etc).

Acknowledgements

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Myths and Motifs as Reflections of Prehistoric Cosmic Events: Some Methodological Considerations

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Abstract
The last three decades have seen a growing awareness that the planet Earth and human civilizations might be much more threatened by extraterrestrial objects than previously thought. It has been suggested on many occasions that the course of human prehistory has been remarkably shaped by big meteorite impacts, airbursts of meteoroids, or the load of the atmosphere with cosmic dust. Myths and motifs are interpreted to encode information of such events. This article brings to the fore a series of essential methodological steps which may strengthen such interpretations.

KEYWORDS: myth, interpretation of myths, prehistory, meteorite impact, hermeneutics

POVZETEK
V zadnjih treh desetletjih se vse bolj zavedamo, da izvenzemeljski objekti Zemljo in človeštvo ogrožajo precej bolj, kot se je včasih predpostavljalo. Često je bilo izraženo mnenje, da so na razvoj človeštva v prazgodovini močno vplivali padci velikih meteoritov, eksplozije meteoroidov v atmosferi in povečane količine kozmičnega prahu. Takšne pretekle pojave razbiramo prek interpretacije mitov in simbolov. Članek prikazuje najpomembnejše metodološke korake, ki izboljšujejo takšne interpretacije.

KLJUČNE BESEDE: mit, interpretacija mitov, prazgodovina, padci meteoritov, hermenevtika

Myths and motifs are an important part of cultural astronomy. Myths may reflect our ancestors' understanding of celestial processes, and motifs on artifacts – interpreted to represent the sun, the moon or stars – may deepen our insights into earlier worldviews. But often such interpretations are of a casual character. Myths[1] as well as motifs[2] are char-

[1] By the term 'myth' I will in the following also subsume traditions like folktales and legends; on the difficulties of defining 'myth' see Masse et al. 2007: 9-14.
[2] In the following I will use the term 'motif' in general for any iconographic symbols or motifs on artifacts as well as for allegoric motifs in oral or written traditions.

acterized by different facets of meaning, and without efforts for a solid methodological approach an interpretation may easily get lost among the products of the researcher's fantasy. A general method of interpreting myths or motifs does not exist. Interpretations of myths and motifs use a changing mixture of methods deriving from different disciplines in the humanities, as there are philology, ethnology, history of art, science of religions, sociology, or psychology etc. In practice, the particular mixture of methods follows from the concrete context of research. In rarer cases interpretation of myths and motifs gets involved with disciplines of the natural sciences and their methods, e. g. geology or astronomy. As in the current case of cultural astronomy, interpretation of myths and motifs can enter into close and fruitful interaction with such disciplines. In the last decades these interactions have intensified coalescing into a special subfield of cultural astronomy that addresses the question of whether cosmic events – i. e. meteorite impacts hitting the Earth, airbursts of meteoroids, or the Earth being affected by cometary dust – have influenced prehistoric cultures and whether such events are reflected in myths and motifs.

In the last three decades new research results have fostered the awareness that the Earth and human civilisations might be much more threatened by extraterrestrial objects than previously thought. The observation of the fragmenting comet Shoemaker-Levy hitting the planet Jupiter in 1994 and NASA's program for searching Near-Earth-Objects (http://neo.jpl.nasa.gov/) have contributed to this trend. And awareness is spreading, that the rate of meteorite impacts of at least regional effects should be estimated considerably higher than conventional calculations do. Events like the one at Tunguska 1908 which flattened ~2000 km^2 of Siberian forest, are now expected to occur at 'an overage of 100 to 1,500 years and yield an energy release of between 4 and 15 Mt' (Barrientos & Masse 2012: 5). Of late an expanding sector of scientific literature has adopted the idea that human prehistory during the Holocene epoch of the last 10,000 years was shaped by catastrophes triggered by cosmic objects: big meteorite impacts, airbursts of meteoroids, or the Earth passing through the debris of disintegrated comets. Complex scenarios were developed describing the presumed environmental and cultural effects of such catastrophes: Gigantic fires, ash rains, mega-tsunamis, rock-slides and climatic downturns are supposed to be the effects in nature. The cultural response of prehistoric humans to these apocalyptic experiences is assumed to be reflected in abrupt cultural change, in religious beliefs, in myths and in monuments (e.g. Stonehenge [Steel 1998; Tollmann & Tollmann 1993: 495f.]; the Egyptian pyramids [Tollmann & Tollmann 1993: 470ff.]). Prehistoric dates and periods which seemingly fit such scenarios were figured out and interpreted as evidence of some catastrophe induced by cosmic objects.

But these theories are in some conflict with the currently ascertained knowledge of prehistoric cosmic events. Airbursts or the accumulation of cosmic dust in the atmosphere are, in general, extremely hard to verify and are not yet attested for prehistory. Meteorite impacts are validated by the proof of certain mineralogical and/or geological criteria (Norton 2002: 291-299; French 1998: 97-99). Measured by these criteria, the number of confirmed prehistoric meteorite impacts is extremely small, namely, about 10 worldwide (see Earth Impact Database). Crater diameters range from mostly a few meters or some decimeters to the rare case of 600 m (Tüttensee/Germany). In the best cases, dating covers periods of several hundred years, and an even greater level of imprecision is common (Barrientos & Masse 2012: 30) More exact dating hitherto has failed because of uncertainty of dating methods and the problem of exact chronologies in prehistory. Conceivably accompanying effects of an impact like e.g. wildfires, earthquakes or acid rain, are hardly documented in the context of Holocene impacts (as an exception see Ernstson et al. 2010; Rappenglück et al. 2010). This fact may be due either to the circumstance that such effects do not exist, or to the preconceived opinion of researchers that small meteorite impacts should not cause remarkable secondary effects and that therefore such effects need not be looked for. Cultural effects can not yet be confirmed or they can only be modeled (Barrientos & Masse 2012). This is because of the small size of these meteorite impacts for the most part, the imprecise dating and poor archaeological databases. Hence, there is a remarkable divergence between the concrete data which can be contributed to the discussion by the relevant natural sciences on the one hand and the new modeling of impact rates, as well as the aforementioned scenarios of presumed environmental and cultural effects, on the other hand. The latter effects play a key-role to the interpretation of myths and motifs since they are the ones that allegedly provide information about prehistoric cosmic events which are otherwise hard to substantiate. Can the interpretation of myths and motifs serve this purpose? Which problems occur? Which essential methodological steps should be followed? These questions will be discussed in the following section, illustrated by few examples drawn from the relevant literature on this topic.

Mechanisms of perception

The most widespread trap in interpreting motifs in myths and iconography is the way that the researcher's main area of interest affects the interpretation of the data and the cognitive biases that are brought into play. The psychology of perception teaches us how our preferences and prejudices as well as other often unconsciousness inner and outer influences channel and confine even the most elementary process of perception, let alone further interpretations (Chabris & Simons 2010; Storch 2010). Picture puzzles e. g., like the famous 'All is vanity' of Charles Allen Gilbert (1873-1929) exploit this fact. Since the channeled perception suggests an unquestionable persuasiveness of an idea, the methods which every scientific discipline has for ensuring as well as for testing the potential of a theory, often are endangered to be widely neglected.

Distinct descriptions of motifs and the requirement of a solid database

Awareness of the mechanisms of perception reminds us that interpreting single motifs first of all requires a meticulous description as well as a rationalized distinction of the motif under study from other similar motifs. Only in this way it is possible to get a solid database for analysis and interpretation. For instance, in the literature discussed here an omega-shaped motif is often labeled to be a motif representing a comet. This interpretation was put forward by Ilse Fuhr in a book on omega-shaped motifs (Fuhr 1967) and was subsequently adopted by other authors (e. g. Clube & Napier 1990: 176ff.). But Fuhr's interpretation is founded on a database which uses an undifferentiated mixture of motifs (see Fig. 1). In the case of the omega-shaped motif it is essential to clarify whether e.g. the outwards curved spiral is an indispensable characteristic element of the omega-shaped motif, and hence cannot be mixed up with a motif showing an inwards curved spiral, or whether these two elements are mere variations. Such scrutinizing establishes a solid database but was not carried out by Fuhr. Following Fuhr, Clube and Napier labeled the Egyptian goddess Hathor as a comet (Clube & Napier 1990: 178) because at times her headdress shows spiral-shaped curls reminding one of an omega-shape. Of course other researchers have presented good arguments for entirely other interpretations of Hathor's headdress, e.g. as a gynaecological motif (Tassie 2005).

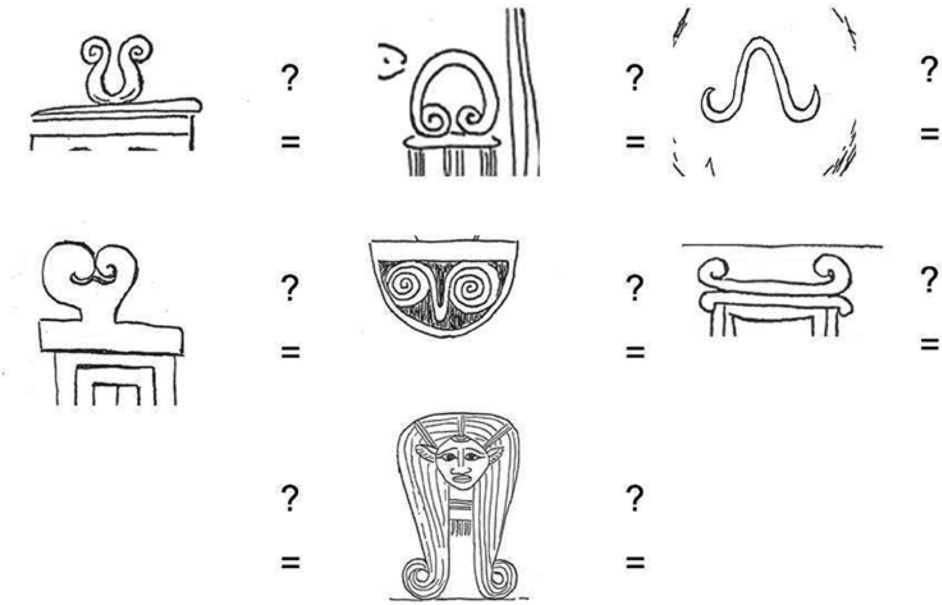

Figure 1. Variants of the omega-shaped motif or different motifs? Examples from the book of Fuhr 1967.

A similar procedure of distinction should be applied to motifs transmitted by oral or written tradition. Dragons e. g. are interpreted by Clube & Napier (1982: 198-206), the Tollmanns (1993: 455ff.) or Baillie (2001) as mythical analogies of comets. Mythical traditions worldwide ascribe very different meanings to dragons, be it their symbolism as bringers of good luck, symbols of resurrection, of wisdom, of the moon knots (*caput draconis* and *cauda draconis*), of destruction, or whatever (Stamer & Zingsem 2001). A separation and classification would clarify the database. A comparable generalization is noticed in Masse's interpretation of 'supernatural twins or companions' as allegories of fragmented comets (Masse 2007: 57). Again, such an interpretation should be carefully balanced against rivaling ones concerning twin myths from all over the world (Bianchi 1986: 99-107). For example, the fact that rare twin births which in ancient cultures provoked manifold questions and reactions (Rathmayr 2003: 858-860), could be an inducement for the creation of twin myths is a cultural factor worthy of serious consideration.

Being aware of definitions

The need for distinct descriptions and differentiations must be extended to the basic need to operate with clear definitions of the terms being utilized. Definitions deeply shape our elementary perception, the selection of data which we take as a basis of our research and finally the interpretation of these datasets. In the context of this topic this need becomes particularly evident in the case of the use of the term 'catastrophe'. The definition of the terms 'catastrophe' or 'disaster' – especially in connection with 'culture' – is fiercely disputed in the scientific literature. The least common denominator says that 'catastrophe' means an abrupt, violent event with human victims. Any further aspects, like perhaps changes in politics and societal coherence, abandonment of a region, changes in material culture, are controversially discussed in terms of their potential to define a 'catastrophe' (Torrence 2002). A substantial number of studies dealing with putative prehistoric meteorite impacts, airbursts or cosmic dust events do not give an account of their definition of 'catastrophe' and of 'cultural disaster'. For them it seems to be self-evident that the presumed cosmic event must have inevitably been disastrous, sometimes on a world-wide scale, and that such a disaster could not result other than in abrupt cultural change. Furthermore, another underlying theoretical assumption remains implicit: that abrupt cultural change is very probably caused by an external catastrophic event. Such not explicitly stated theoretical assumptions influence the data selected and considered to verify a cosmic catastrophe, including especially the willingness on the part of the researcher to accept myths and motifs from all over the world as the reflex of a single cosmic catastrophe. Together with the significant failure to fulfill the aforementioned need to carefully describe and distinguish the various motifs, the resulting database ends up being amorphous (see e. g. Tollmann & Tollmann 1993).

Controlling the quality of the database

A solid database with carefully described and differentiated elements still has to be checked for its quality. Clube and Napier speculate that the prehistoric rock carvings of the so-called Panorama Stone in Ilkley/England, showing circles and lines, might be cometary motifs, representing cometary nuclei, tails and striations (Clube & Napier 1990: 176f.; plate 20). Open-air rock carvings like the Panorama Stone are subjected to manifold alterations: they are exposed to the natural process of weathering, but also may have been altered by human activities, be it later supplements, intentional destruction, or subjective reconstruction. Such activities on rock-carvings depend on the changing interests, reinterpretations and affections of people across the millennia. Hence, it is important that the interpreter of rock-carvings check aspects like the age of the carvings, their simultaneity and the question of whether they form an intentional unity. In case of the Panorama Stone it is, at the same time, eye-opening and confusing to look at drawings from the 19th and 20th century, all of them representing the carvings of the Panorama Stone, and to compare them with the photo shown in the book of Clube and Napier. It is hard to figure out the supposed congruence between the carvings shown on the photo and the representations found in the drawings. The question arises: which representation shows the 'original' status of the carvings? Did such an 'original' status exist at all, i. e., is our concept of originality adequate in terms of ancient people's intentions concerning rock carvings? Can it be reconstructed at all? Considerations of such questions are missing from Clube's and Napier's interpretation of the Panorama Stone and fuel doubts about the quality of their database.

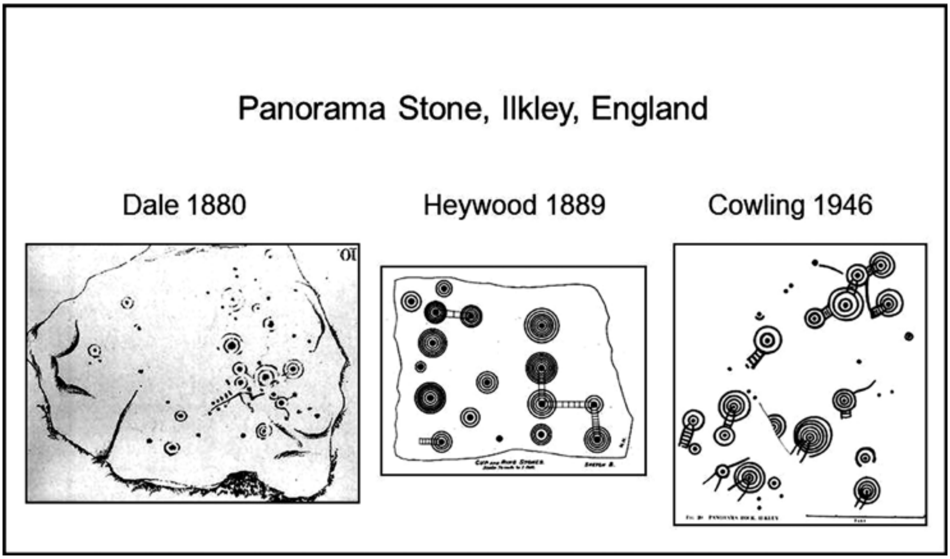

Figure 2. Panorama Stone (Ikley, England): drawings from the 19th and 20th century.

Comparable scrutinizing must be applied on written texts or oral sources. For such documents a number of other questions arise: Who transmits the tradition? Is the transmitted information part of his or her own cultural heritage or part of another culture? Which status does he or she have and which intention? Was it a missionary, who gave the story a Christian appearance, was it an ethnographer favoring the Jungian approach to myth or the one of Levy-Strauss, or was it a researcher influenced by nationalistic ambitions? What efforts were made to ensure an adequate translation? In mythology the available sources may be strongly shaped by the answers to such questions. Did the scientific identification of a meteorite impact location already exist when the story allegedly correlated to it was first recorded or was the story prior to the scientific explanation? Such questions concerning the quality of the database, which partly touch the methodology employed in textual criticism, have to be reflected before any interpretation of the text is attempted.

Check the cultural context of a motif

For any interpretation it is essential to check the cultural context of the motif. Omitting or neglecting to address the motif's contextualization is a common problem in the kind of literature treated here. Prehistoric rock carvings of the cup-and-ring-type are connected to comets by Clube and Napier as well as by the Tollmanns. The Tollmanns claim that the cup-and-ring-marks of Achnabreck (Scotland) illustrate meteorite impacts into the Northern Atlantic, which they connect to the biblical flood. They suggest that the carvings depict in detail the head of comets and their tails, as well as the rings of waves which were caused when the objects plunged into the sea (Tollmann & Tollmann 1993: 494 fig. 139). Clube and Napier claim that similar carvings from Ardmarnoch (Scotland) represent a 'family of comets moving through a star field' (Clube & Napier 1982: 263; fig. 30). In both cases considerations of the cultural context are missing. For example, the Tollmanns fail to substantiate their unusual claim that presumable Bronze Age rock carvings illustrate a meteorite impact ca. 6000 years before then. The fact that more than 100 different interpretations have been ascribed to this type of cup-and-ring engravings (Morris 1979: 16) illustrates the randomness of any interpretation when the context of the interpreted object is either unknown or neglected.

A strange example of the inadequate mixing up of the context of mythical motives is given by Allan & Delair (1997: 292). When speculating about the source of some cosmic bombardment of the Earth, they mention the Bifrost Bridge of Norse mythology, combine it with Mount Meru from Indian mythology, and falsely suggest by their phrasing that Mount Meru was mentioned in the Norse Eddas: 'The Norse Eddas state that this bridge [Bifrost Bridge] … existed near Meru …'. This confusion illustrates the problems which may arise when myths from all over the world are taken together and deliberately used as a basis of argumentation.

Considering the results of other sciences; respecting their scientific methods and criteria

When carrying out a research project, it is indispensable that myths and motifs be interpreted in concordance with the methods, results and criteria of the other disciplines involved in the investigation. Indeed, a truly interdisciplinary approach creates a minefield of possible traps because by necessity the investigator is forced to move beyond her/his own field of competence.

Masse hypothesizes that the mythical character of Humbaba, a demon from the Babylonian Gilgamesh epic, had been inspired by the formation of the planetary Owl Nebula in the Big Dipper. He compares Humbaba's face, as it is represented in a figurine of the 18th-17th century BC (Fig. 3), with 'telescopic photographs of the Owl Nebula' and speaks of a 'striking similarity' (Masse 1998: 76). The Owl Nebula M97 (http://messier.seds.org/m/m097.html) has a visual brightness of 9.9 mag and cannot be seen by naked-eye. Not even a telescope with small aperture can reveal details of its inner structure. Masse argues that the Owl Nebula had once been much larger than it is today, having the size of the full moon and temporarily being visible by naked-eye observation. He takes this assumption from several other myths which he also correlates to the Owl Nebula. Of course, the original nova or supernova temporarily produced remarkable point brightness. But this kind of brightness has to be distinguished from an extension in size and a surface brightness which would enable a naked-eye observation of the inner structure of the Owl Nebula. Absolute nothing is known from astrophysics that would support Masse's claim that at any time inner structures of the Owl Nebula would have been visible to the naked eye. Hence, Masses' argumentation and his statements about the Owl Nebula, being drawn from myths (Masse 1998: 70-76), are deeply undermined when the data of astrophysics are brought into the picture. This example illustrates the importance of being able to establish a good correlation between the interpretation of a myth or motif being proposed and the available data drawn from the other disciplines that are involved in the research project.

Figure 3. Clay mask of Humbaba (Sippar, southern Irap, ca. 1800-1600 BC) © Trustees of the British Museum / Telescopic photo of the Owl Nebula (camera: CANON EOS 60 D; telescope: Celestron ED 80/600; exposure time: 40 x 120 sec / ISO 1600 / IDAS-LPS-P2 filter) © Max Kiermayer.

In many scientific disciplines, especially in the natural sciences, there are criteria that are used to prove the correctness of a hypothesis. Meteorite impacts are proven e. g. by a mineralogical criterion, a special metamorphosis of quartz grains by shock pressure, the so-called Planar Deformation Features (Stöffler & Langenhorst 1994: 165). Scientists who put forth the claim of a meteorite impact have to provide evidence for this mineralogical criterion or of other criteria relevant in the case of impact research. One of the prevalent characteristics of the literature treated here is the fact that the existence of a meteorite impact is proposed, but the geological and mineralogical evidence necessary to support such a claim is not provided.

Bond & Hempsell, who claim that a meteorite impact caused the gigantic landslide at the Köfels mountain (Austria) in 3123 BC, suggest that before impact the object sculptured the nearby summit Gamskogel by clipping 'the ridge to give a 2 kilometre long cut with a 6 degree slope' (Bond & Hempsell 2008: 97). If Bond & Hempsell were right, such an intensive contact of the meteorite with the ground should have caused prominent mineralogical alternations in the rocks of the affected ridge. Hempsell & Bond base their claim solely on the nowadays crater-like morphology of the Gamskogel summit, ignoring the fact that morphology is not a relevant criterion in meteorite impact research. In short, they fail to discuss whether the Gamskogel summit shows mineralogical alterations which would be diagnostic for a meteorite impact.

Special problems arise with meteoroid airbursts in the atmosphere and cosmic dust events, which have a major role e. g. in the scenarios developed by Clube and Napier or Baillie. Such events are even more difficult to prove than meteorite impacts. Micrometer-sized cosmic grains found in ice cores may rank among the most qualified possibilities to substantiate a cosmic dust event. But the ongoing controversy about the character of the 536 AD environmental downturn – whether it was caused by (a) a cosmic dust event (e. g. Abbott et al. 2008) or (b) massive volcanic eruption(s) (e. g. Dull et al. 2010) – illustrates the problems which occur when drawing on this kind of evidence. Hence, claims that myths or motifs reflect meteoroid airburst and especially cosmic dust events can hardly be counterchecked by substantial chemical or mineralogical results.

The location

The need to provide geological/mineralogical and/or chemical evidence of a putative event of extraterrestrial origin is strongly tied to the question of where this event took place. In many cases a meteorite impact is alleged on the basis of a myth but no geographical location is even suggested (e. g. Clube & Napier 1982: 146, 184f.; Clube & Napier 1990: 186ff.), or at the proposed location no impact signature has ever been found (see e. g. Engelhardt: 1979; Baillie 2005: 102-114). In instances where statements, provided by a particular myth, concerning a specific location, can be properly correlated with a concrete existing meteorite impact site, this aspect of regional congruence greatly enhances the probability that the former reflects the latter. In contrast, it is highly problematic when putative meteorite impacts, suggested because of a myth but for which concrete physical evidence is missing, serve as the basis for developing detailed cultural scenarios of the past.

Furthermore, when myths from all over the world are interpreted as their origins could be traced back to one single meteorite impact or airburst, attempts to countercheck by regional congruence become severely hampered. The Tollmanns (1993) assume that in ca. 7500 BC the break-up of a comet caused several meteorite impacts worldwide, one of them located at the Köfels (Austria). Myths from all over the world are supposed to reflect this event. The criterion of regional congruence cannot be adapted to this hypothesis. A comparable scenario is developed by Masse (2007). He claims that the putative Burckle crater in the Indian Ocean was part of a multiple meteorite impact event in 2807 BC that caused worldwide mega-tsunamis. According to Masse, these impact-induced mega-tsunamis are reflected in a vast corpus of flood myths around the world. His study shows that constructing a theory on the basis of a corpus of world-wide myths creates another dilemma. It is described by Masse himself: 'What does not fit the model of a single large Indian Ocean impact is the presence of a number of mega-tsunami myths from Brazil, the western coast of North America, the Arctic Ocean and in other locations outside the Indian Ocean basin. … And … Burckle Crater itself cannot explain the large volume of rainfall indicated by worldwide mythology' (Masse 2007: 57). By assuming that all the cited myths refer to the same event, Masse must speculate that upon its approach the cosmic object broke up and that its fragments impacted the Earth at several locations, not only at Burckle Crater in the Indian Ocean. Hereby the possibility to countercheck the ascription of a myth to a meteorite impact by checking the regional congruence is thwarted. Indeed, the mismatch of the concrete scenario with the mythical evidence – that a meteorite impact in the Indian Ocean cannot be the trigger of a mega-tsunami myth in the Arctic Ocean etc. – might be understood as a caveat, a warning that not all the analyzed flood myths from all over the world trace back to the same event.

Dating

The dating of cosmic events

Since airbursts and cosmic dust events are complicated when it comes to substantiating, their dating is also problematic. Meteorite impacts are temporally isolated events and hence associated with a concrete date. Hence their correct dating is essential for gaining information about cause and effect in terms of meteorite impacts and their alleged cultural repercussions (Baillie 1998: 113f.). But despite all the modern methods of dating available – be it radiocarbon, OSL, dendrochronology or ice core dating – none of the confirmed prehistoric impacts have been adequately dated by now, rather they have an uncertainty of several hundred up to several thousand years (Masse 2007: 28). Such variance of date reduces any considerations of cultural consequences to hypothetical discussions (Rappenglück 2008; Rappenglück et al. 2009).

Nevertheless, the literature dealing with prehistoric catastrophes of extraterrestrial origin bristles with exact dates correct to a year. They originate from the application of different very dubious approaches to the dating of traditions.

The dating of traditions

It is a common characteristic of the kind of literature treated here that traditions from the Bible are rated as historical documents and that their allegedly chronology is used as an absolutely reliable framework for dating (e. g. Clube & Napier 1982: 247). A very popular example is the story from Exodus, which is repeatedly linked, albeit with very different dates, to presumed meteorite impacts or disastrous interactions of comets with the earthly atmosphere (Clube & Napier 1982: 251ff. [1369 BC]; Baillie 2001: 239f. [1628 BC]; Spedicato 2008: 373 [1447 BC]; etc.). Such interpretations ignore the fact that modern Biblical exegesis and archaeology fiercely disputes (Zenger 2008: 600-603) whether 'the exodus' was a historical event at all and – in case it was – whether it was one single event or some kind of longer-lasting process. Consequently, its eventual dating is controversial, too. In the context discussed here Biblical tales can neither serve to establish a chronological timetable nor as a suitable basis for scientific argumentation.

Another dubious approach is the failure to validate the age of a tradition: when did the mythical tradition supposedly originate? Does it provide time designations, which can serve to decode its age? The Biblical tale of the destruction of the cities Sodom and Gomorrah illustrates the problem. At least three different authors ascribe this catastrophe to a putative meteorite impact. The Tollmanns conclude that the date of the event corresponds to ca. 7500 BC (1993: 264) whereas Bond & Hempsell give 3123 BC (2008: 101) and Masse, 2188 BC (Masse 1998: 80). None of them asks about the age of the tale of Sodom and Gomorrah. All of them reconstruct the date of the event by elements that have nothing to do with the tale. Furthermore, the researchers, particularly the Tollmanns, do not care that the first reference to Sodom and Gomorrah in the Jewish tradition is several thousand years younger than the putative meteorite impact of ca. 7500 BC, the event which, according to their theory, was to be the trigger for the destruction of Sodom and Gomorrah.

Congruence of dating

When a tradition is supposed to reflect a concrete event, it is essential to examine whether there is any evidence for a congruence of the dating of the event and the chronological classification of the tradition. In a case from Australia the chronological discrepancy is even more distinct than in the just mentioned theory of the Tollmanns. Hamacher et al. (2010) claimed to have found a meteorite crater after 'using a combination of Google Maps and a local Arrernte Aboriginal oral tradition regarding a star that fell into a waterhole ….' They estimated the age of the putative crater to be several millions of years, i. e. that its origin was impossibly witnessed by humans. Hence, the claim that there is a connection between the tradition and the geological site is quite strange. At this point the appropriateness of labeling of the depression as a meteorite crater still cannot be confirmed (Hamacher et al. 2012: 138).

Adopting another approach Masse (2007: 48-54) deduced the date of the meteorite impact which should have caused the putative Burckle Crater in the Indian Ocean from a worldwide corpus of flood myths. From temporal indications in the myths he infers May 10, 2807 BC as the date of the event. Unfortunately, Burckle Crater itself has not yet been dated by conventional radiometric dating. That is to say, any independent confirmation of the suggested dating is missing.

In contrast to such approaches, Blomqvist (1994) looked for some congruence between the dates provided by a myth and the independent dating of a meteorite impact crater. He looked for time designations given by a myth itself and hence concluded a *terminus post quem* for its origin. Analyzing the Greco-Roman myth of Phaethon he concluded from the motif of the horse-drawn chariot and the earliest known archaeological evidence of such vehicles, that the myth of Phaethon should not have originated earlier than about 2000 BC (Blomqvist 1994: 9). He then compared the extrapolated age of the myth to the age of confirmed meteorite craters. Finding some chronological congruence of ca. 500 years with the Estonian Kaalijärv crater he suggested that the myth of Phaethon might be a reflection of this meteorite impact (Blomqvist 1994: 15).

Finally, the following fact should be taken into consideration: that a myth may 'float' in time, i. e., that an older narrative nucleus may be appropriated and re-actualized by the addition of narrative elements and/or by ascribing to it to a later specific cultural context or event.

Match of dating and location

The examples listed in the paragraph above illustrate that dating myths or similar traditions and correlating them with meteorite impacts, airbursts or cosmic dust events is a very challenging process. Hence, when seeking evidence to back up such a correlation, Blomqvist not only looked for a chronological congruence between the myth of Phaethon and some meteorite impact, but also for some congruence in terms of locality (Blomqvist 1994: 9-15). He analyzed the myth of Phaethon for clues to the region of Phaethon's fall and looked for a confirmed meteorite impact in the respective region, which also fulfills the demand for chronological congruence with the Phaethon myth.

Building on Blomqvist's analysis, Rappenglück et al. (2010) re-examined the myth of Phaethon and suggested that it reflects a meteorite impact in South-East Germany, which was discovered in 2004 (Ernstson et al. 2010). We established on the one hand a well-matching congruence between chronological aspects of the myth and the independent dating of the so-called Chiemgau impact, which had resulted from radiocarbon dating, OSL and archaeological stratigraphy. On the other hand we ascertained the congruence of locality. Furthermore, close parallels between details described in the myth and geological phenomena which can be observed in the affected region strengthen the hypothesis, that the myth of Phaethon reflects the Chiemgau impact. By this means it is the central thrust of our study to ensure the interpretations by checking the match between chronological and regional data as well as other phenomena both in the myth and in reference to the concrete meteorite impact itself.

The 'hermeneutic spiral'

Myths and motifs are multi-facetted expressions of the human world of thought which, consequently, require a complex process of interpretation. 'Hermeneutics' is the theory and praxis of interpretation and the term 'hermeneutic circle' labels the process of scientific cognition in the humanities as well as in the natural sciences (Stegmüller 1996). It deals with the processes of understanding and assumes that understanding starts with the pre-knowledge and presuppositions of the interpreter (see '1. mechanisms of perception'). 'Hermeneutic circle' means that the interpretation cannot proceed straight ahead to the intention(s) and meaning(s) of the interpreted object but rather must take a spiral-like path. After a first approach one's own presuppositions have to be reviewed, then follows a new approach on another level of cognition, another review of one's own assumptions and so on. This process of the 'hermeneutic circle' is more appropriately called the 'hermeneutic spiral' (Stegmüller 1996: 69). Due to the multi-facetted character of myths and motifs their interpretation is especially prone to failure in terms of successfully accomplishing all the steps required by the hermeneutic spiral. Interpreters who do not respect the necessary methodological steps for ensuring the scientific quality of the research being carried out will easily miss the path of the 'hermeneutic spiral' and are in danger instead of ending up locked within a kind of circular reasoning.

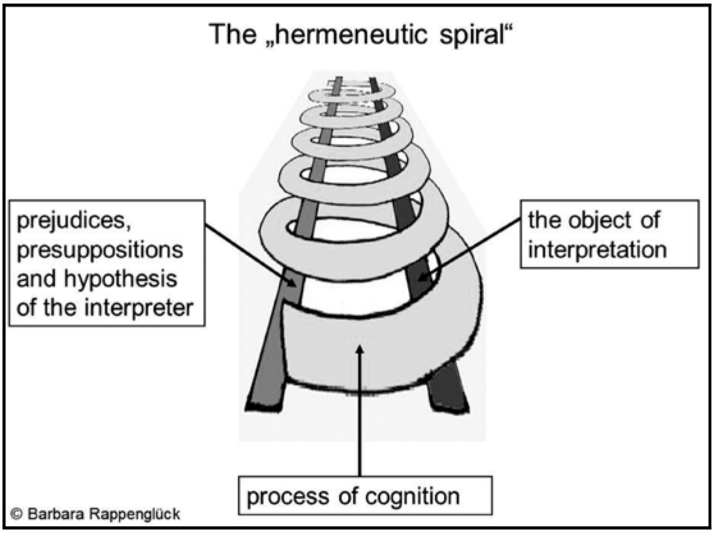

Figure 4. Hermeneutic spiral.

Conclusion

In this study a number of problems have been discussed, which refer to the way myths and motifs are interpreted. The discussion has had as its goal to contribute relevant input to the interpretation of complex scenarios of prehistoric catastrophes triggered by cosmic objects. There are still important obstacles facing researchers, such as the absence of a general method of interpretation, multiple meanings, or the difficulties involved in deducing the age or the date of a tradition, but also unfamiliarity of the researcher concerning impact phenomena in general as well as the lack of an in-depth understanding of the geophysical aspects of such processes (Rappenglück et al.: 2011). It is clear that myths and motifs cannot stand alone. They need to be backed up by the kind of solid data that can be contributed by the relevant natural sciences, especially in the case of verifying putative cosmic events. Furthermore, caution is advised because of the fact that for none of the known prehistoric meteorite impacts are the cultural effects archaeologically palpable. In the absence of such data it would be advisable for now to abstain from the claim of extensive cultural consequences.

Nevertheless, there are some promising approaches that could be employed to ensure that myths and motifs do indeed reflect some cosmic event and also to enhance the chances that they reflect in some fashion the cultural effects of such an event. For instance, Masse & Masse (2007) analyzed a set of 284 South American myths ‘that have as their primary motif a single major cataclysm’ (Masse & Masse 2007: 43). They proceeded to define five categories of cataclysm which are described in the myths, investigated their geographical distribution and compared the result with the geological facts of the respective region. From this analysis they concluded that a number of myths might reflect volcanic eruptions, others are considered to depict meteorite impacts, some of them potentially related ‘to the Campo del Cielo and Río Cuarto cosmic impacts’ (Masse & Masse 2007: 193).

Another approach has been chosen by von Engelhardt (1979), Blomqvist (1994) and Rappenglück et al. (2010). They all analyze not a corpus of different myths, but a single one, namely the Greco-Roman myth of Phaethon. Von Engelhardt (1979), who was a prominent expert in meteorite impact research and well acquainted with the physical phenomena related to such an event, has presented an exemplary analysis of this myth as a general reflex of a meteorite impact. Even when he ascribed this event to a location, the Po-Delta (Italy), where until now no meteorite impact has been verified, his general comparison of impact phenomena with details depicted in the myth of Phaethon is a pioneering study. Blomqvist (1994) pushed ahead the analysis of the myth significantly by stressing the aspect that details of the myths should be in congruence with the location and dating of a concrete, known meteorite impact. This claim could be extended and satisfied by Rappenglück et al. (2010) because of the close congruence of mythical details even with geological phenomena in the affected region. The approach utilized by von Engelhardt, Blomqvist and Rappenglück et al. to deal with one single myth was facilitated by the fact that the myth of Phaethon has been handed down in many variants. Such a lucky circumstance will often not be given and may narrow future possibilities of analyzing one single myth.

Nevertheless, the innovative approach of von Engelhardt which involved carefully analyzing myths for impact phenomena could be applied also to some of the myths collected by the Tollmanns. Although admittedly the Tollmanns get lost and end up constructing a rather confuse cultural scenario, they have collected quite a number of traditions that seem to depict the details of a fall and impact of a meteorite in an intriguing manner. At least some of those descriptions must be considered to reflect a cosmic event. A thorough analysis like von Engelhardt’s might substantiate this assumption. Additionally, looking at a broader corpus of traditions like Masse & Masse did, could serve to extend the number of variants or to find related traditions. By combining this with Blomqvist’s criteria of congruence, it is possible that in the future more myths can be ascribed to concrete verifiable meteorite impacts.

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Palaeolithic Stargazers and Today´s Astro Maniacs - Methodological Concepts of Cultural Astronomy focused on Case Studies of Earlier Prehistory

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Abstract
The paper discusses the demarcation problem between non-science, fringe-science and science by considering methodological issues of cultural astronomy when interpreting the Palaeolithic archaeological inventory. The research focuses primarily on various astronomical assessments of cave art at Lascaux and at some other locations, as well as on case studies of the artefacts.

KEYWORDS: Palaeoastronomy, Palaeomathematics, methodology, Palaeolithic measurement tools

POVZETEK
Članek razpravlja o problemu razlikovanja med ne-znanostjo, mejno znanostjo ter znanostjo, pri čemer upošteva metodološke izzive, s katerimi se sooča kulturna astronomija pri interpretaciji paleolitskega arheološkega inventarja. Raziskava se prvenstveno osredotoča na različne astronomske razlage jamskih slikarij v Lascauxju, pa tudi na nekaterih drugih lokacijah, ter na posamezne študije artefaktov.

KLJUČNE BESEDE: paleoastronomija, paleomatematika, metodologija, paleolitska merska orodja

Introduction
Since the beginning of the 20th c. a number of studies have been dedicated to an astronomical interpretation of different parts of the Palaeolithic archaeological inventory. An overview is given in Rappenglück (1999, 2008). While astro-maniacs enthusiastically announced in the inventory they had discovered evidence for an incredible level of astronomical knowledge among archaic people, scientifically trained researchers faced serious problems of methodology proving such hypothesis and formulating consistent theories concerning the kind of archaic astronomy encountered in Earlier Prehistory, which could best be called *Palaeoastronomy*.

Frequently, whereas the authors often insist on taking full credit for their alleged discoveries, they do so without feeling obliged to bring forward a careful and methodological basis for their views. At the same time they do not allow their theories to be subjected to detailed scrutiny nor do they engage in scientific discussions concerning them.

Quite a lot of fancy ideas and feeble constructions, partially or entirely unsubstantiated, are circulated and popularised by the mass media in an unaudited form. In particular, web-based media like Wikipedia, blogs, Facebook, and others, although they offer additional ways of disseminating information and allowing for critical debates, likewise they provide vehicles for vague talk, a raft of obscure notions, and bias. In this environment, science journalism faces serious problems when it attempts to be fair when covering competing claims. Moreover, the mass media, which economically are forced to simplify the complexity of scientific approaches and results to satisfy claims of the vast majority, influence the credibility of scientists and scientific findings with regard to public and also expert opinion. Moreover today's fast moving media landscape can foster sensationalism on the part of the scientific staff, by picking up and presenting odd ideas quickly, while neglecting to do the necessary background research.. Frequently, fascinating pictures rapidly replace content. Subsequently, within the field of Palaeoastronomy there is an on-going discussion concerning how to go about demarcating and evaluating the borders between pseudosciences, amateur science, bad science, pathological science, and even popular science. The time-robbing analysis and evaluation of such scatter brained constructs are left in the hands of few interested researchers, who painstaking have to find a way to communicate to both the scientific community and the public, why a suggested approach and point of view are not based on solid evidence and lack reasonable demonstration. Thus, it is necessary to discuss, explicitly, the methodological problems Cultural Astronomy confronts when dealing with Earlier Prehistory.

How do we know what people of the Upper Palaeolithic might have known about astronomical phenomena?

The archaeological record of the Upper Palaeolithic is relevant, in particular for certain astronomical interpretations. In general the artefacts can be divided into two categories: fixed and mobile objects. The first type consists of rock art – paintings, engravings, or sculptures – found within caves, at rock shelters, and at special places (e.g. along rivers). In addition, built-in fitments in caverns, and dwellings as well as other structures at open air sites count among this class. The second type includes movable two- or three-dimensional artworks, pieces of jewellery, and tools. Manifestations of people's ideas are found in fixed as well as mobile objects. Moreover there exist two kinds of representations, which can appear isolated or combined: abstract signs and naturalistic depictions.

The integral methodology

Scientific research dealing with possible archaic astronomical knowledge along with mathematical abilities of Upper Palaeolithic and Epipaleolithic/Mesolithic people needs an appropriate methodology (Bialas 1989). Though Pásztor (2011) has mentioned the problem again (see Rappenglück 1999), she, however, failed to discuss the variety of approaches utilized in the field and offered no methodological improvement to the current approaches/check the different approaches in the field and offered no methodological enhancement. Ideas have already been put forward about the need for such a systematic approach (Rappenglück 1999). Most approaches are focused on partial interpretations, which for example are grounded economically, technically, socially, psychically, artistically, or religiously (Rappenglück 1999; 2008). Until recently researchers have been little interested in methodological issues and consequently, often neglected the need to integrate different readings and methodologies. The constitutive base of any paleoastronomical reading is given by the scope of all obtainable archaeological hard data, including, when feasible, measurements of the alignments of the object under study.

Multidisciplinary and interdisciplinary data gathering is required which would rely on a general phenomenological approach and on the knowledge of applied methodologies, measurement errors, and supporting theories as well as the prejudices behind them. At this elementary stage screening of the data is not recommended given that later on data previously seeming insignificant can become crucial for the interpretation.

Based on the classic semiotic triangle of reference (syntax, semiotics, and pragmatics) one can think of a syntactical, semiotic, and pragmatic aspect of such a methodical approach in cultural astronomy, including paleoastronomy.

1. The syntactic factor refers to the construction and arrangement of symbols. Appropriate measurement instruments and techniques, the forming of feature classes and formal relationships are required for data acquisition. Structural, logical, statistical, and measurement methods are applied in data preparation.

2. The semantic factor denotes the relations of symbols and the meanings assigned to them. The social sciences, following a diversity of methods, e.g. anthropology (especially cultural, biological, linguistic anthropology), ethnoscience, mythology, religious studies, psychology, can provide data.

3. The pragmatic factor bears on symbols and their respective application by their users. Thus, the life world and life praxis of the respective culture has to be appropriately taken into consideration. Archaic people were highly capable of integrating several aspects and multiple levels of meaning in the cultural conceptualizations making up their world view, by making intensive use of symbolic, mythic, and ritual language. Thus, cultural astronomy requires understanding the special mindscape and coherent worldview of archaic cultures, consisting of ideas, procedures, and valuations, with which for the most part we are unfamiliar today, e.g. divination, astrology, and certain religious concepts.

4. In addition, the practices of native peoples who use various tools for carrying out astronomical measurements are another area that needs to be investigated. While it is important for palaeoastronomical research, for the

> most part is has been little studied. Experimental archaeology which would concentrate on studying such astronomical tools could be viewed as experimental archaeoastronomy for it can contribute to the reconstruction of early observing practices, methods and measurement techniques, allowing for the assessment of their range of applications as well as their limitations.

Thus to identify, substantiate and evaluate traces of astronomical knowledge in the archaeological records of Earlier Prehistoric cultures, a multifaceted and broadly conceptualized approach is necessary. It could be best termed an *Integral Method* (Rappenglück 1999): the combination of methods and disciplines, fitting together, interdisciplinary, at each level, increases the probability for the overall coherence and correctness of the argumentation and assertions being made. Therefore, the methodology follows the so-called Hermeneutic Spiral as a process of assuring integrative comprehension (Stegmüller 1996). Such a rigorous scientific approach should contain observe at least the following components:

- Phenomenological description, detecting presuppositions and avoiding prejudices
- well-formed definitions
- psychology of perception and pitfall of cognitive illusions
- iconographical unambiguity
- in depth analysis of details and sufficient exactness
- concurrence of syntactic, semantic and pragmatic aspects
- quasi- and exact astronomical points of view
- context
- recognition of multiple levels of meaning and their relationships
- consistency, mutual intelligibility, support and complementariness of methods, hypothesis, and conclusions
- testability of hypothesis
- problem of circular reasoning
- explanatory value of a hypothesis
- integrity of an object and the problems of reconstruction
- different dating methods and problems of age determination
- astronomical evidence
- statistical processing of data; hypothesis and significance tests
- life world and praxis of the respective culture
- cultural comparison
- data and diversity of methods, observing strictly the peculiarities of each approach from mathematics, natural sciences (e.g. astronomy, geosciences, zooarchaeology, palaeoethnobotany, chronobiology, surveying, archaeometry, neurobiology), and social sciences (e.g. cultural, biological, linguistic anthropology, ethnoscience, mythology, religious studies, psychology)
- possible sources and propagation of errors, concerning observations, measurements, calendrical calculations, data processing (including software features and limits), transfer of records, disclosure of information

Integral Methodology consists of a multiplicity of approaches, each critically evaluated, but combined together to achieve mutual intelligibility. Thus its employment increases the plausibility of a hypothesis or a theory. Therefore interdisciplinarity as the suggested methodology for Cultural Astronomy does not translate as simply bringing together results and methods from several sciences and linking them together by analogous conclusions. Rather it means integrating the methodical elements of archaeological reconstruction, astronomical analysis and historical comparative interpretation to achieve a seamless synthesis.

Problems to face and to overcome

Astro-maniacs working on questions related to Paleoastronomy arrive at their conclusions either wittingly or unwittingly, but always by avoiding an in depth study of the actual archaeological and astronomical data. Moreover, they often cast doubt on the relevance of pre-existing scientific results and methods. This can also happen because of the mere fact that we are dealing with individuals who are scientifically uneducated concerning the respective topic. They do not take into consideration any of methodical requirements discussed above. Some examples are given here for clarification.

Andersen (1993: 11, 12, 58-62) acts as if he were a well-trained number cruncher, discovering fine-tuned calendars everywhere. He counts all of what seems to be countable, without defining any feature classes. Though slightly better Kocher (1979: 16-21, 58-62; 1985: 10) goes along the same track. Bornefeld (1994) reads the depictions in cave art as a proto-writing, reconstructs the corresponding proto-language, and derives certain astronomical content (eclipse reckoning) from them, without any compelling evidence or without any logical structure to his arguments.

Laričev, a well-trained archaeologist, meticulously discovers, describes and counts sets of marks on bones, which he believes to be intentionally engraved (Laričev 1999a, b; 2004; 2005). He is aware of some of the methodological requirements, cited above (Laričev and Anninckij 2005). Thus, some of his research work deserves closer attention and should be checked in detail directly on the object or on approved replicas. Nevertheless, concerning some Upper Palaeolithic artefacts studied by him, he is in danger of overdoing the counting (Laričev 1999a: 45-51). For instance, Laričev's derivations of the synodic periods of Mercury, Venus, Mars, Jupiter, Saturn, of eclipse cycles (Laričev 1990), and of a Palaeolithic zodiac (Laričev 1999a: 255-278; 1999b: 255-262, 281-330) are debatable. This is because he bases his arguments solely on counting sets of marks, with only sparse or no additional context that would permit attaching such values to the reckonings. Laričev takes the view that a depiction first should be interpreted of its own accord, without any other semantic information coming from social sciences (Laričev 2005: 85). Thus, he considers numbers as the royal road to achieve objective interpretations (Laričev 2005: 85). But without anyway to justify units being describe, units which conceptually might have been used by the producer of the depiction, analysing counting sets sometimes leads to 'adding up apple and pears'. Additionally, the unwitting anticipation—or presumption of astronomically relevant numbers by the researcher can bias a result, too.

What counts? First one has to ensure that the object with the proposed counting set is complete. Working on a reconstruction is fraught with problems. An ivory plate (13.6/14.1 x 8.2/8.5 cm), from the campsite of Mal'ta (Russia), ca. 18-15 BP, is often cited as an example of a lunisolar calendar (Frolov 1979: 88) or even for the depiction of the synodic periods of Venus, Mars, Jupiter, Saturn, rounded to integers (585, 780, 399, 378 days) together with a solar year of 365 days and a lunar year of 354 days (Laričev 1999a: 256-262). The object shows one big spiral and several small serpentine or convoluted rows made of buckles. The mathematical concept of spirals is clearly recognizable. There is, however, a serious problem in terms of being able to count the buckles: ¼ of the plate is missing and had been reconstructed as a wax replica (Marshack 1991: 336-337), without any documentation concerning the criteria used for representing the additional buckles was done. A valid interpretation seems to be impossible.

Another example is given by a piece of an elephant's tibia (A1) from a much earlier site dating to the Lower Palaeolithic, namely, a Homo erectus campsite in Bilzingsleben (Germany), ca. 400-350 ka BP. On the bone a set of intentional parallel cuts is found and 7 + 14 (= 21), can be recognized. A reconstruction by Mania (Mania and Mania, 1988; A1) suggests a completed set of 7 + 14 + *7* (= 28) cuts, which establishes symmetry. Beside this essentially aesthetic argument, no real archaeological basis or justification for the reconstruction is given. Schößler (2003) suggests a lunation and Schmidt-Kaler (2012) constructs a sidereal lunar month, both using the reconstructed sequence of cuts on the bone. This would make the object the oldest lunar time-reckoning notation hitherto known. But the validity of the reconstructions has not been established. Nonetheless, there exists another much older object, bearing a complete sequence of cuts, which can be interpreted as a record of 27 days (a sidereal month). Guadelli (2004) excavated a bovine bone from the cave of Kozarnika (Bulgaria), at least 1.2 Million BP, showing just 27 cuts, which had been intentionally made by Homo erectus.

Jégues Wolkiewiez (2005: 57-58) has re-examined the bone of Blanchard des Roches (France), ca. 37-27 ka BP, which had been classed by Marshack (1991) as an example of observational, positional, but non-arithmetical lunar time-reckoning. Four marks in the sequence don't fit her concept. Thus, she decided to exclude them from her interpretation and to explain doing so by saying that sequence in question was a mistake on the part of the original sky watcher.

Finally one has to show that a pattern, which is purported to be read as a kind of counting, isn't a pure decoration or that the pattern could be explained by another reasonable interpretation. Laričev (2004), for example, counts periods of moon, sun, on a bone ('commando staff') from Sungir (Russia), ca. 27.7-15.6 ka BP. However, according to another view of the small sculptures from Mal'ta and Buret (Russia), ca. 18-15 ka BP, the pattern indicates nothing more than a fashionable protective fur clothing (Libor Balák 2012).

In any case, it is necessary to define feature classes of counting sets on the respective object that bears the code and keep in mind the type of the object under study. Then additional semantic input coming from social sciences allows the researcher to set up a model, which, in turn, has to be verified through the analysis of comparable objects. This requires a statistical approach. For example, Frolov (1978-1979) has built up a small database of objects showing counting sets. Patterns of numerable units depicted on pebbles from the Azilian (ca. 12-10 ka BP), have a significant clustering from 21 to 29 and multiples of these reckonings (Couraud 1985). This indicates a certain possible preference for lunar time-reckoning. The databases, however, are still poor and statistical approaches remain hitherto unsatisfying. Preliminary work concerning databases of signs and depicted animals as well as other beings (humans, chimeras etc.) used in Upper Paleolithic cave art, including statistical analysis and semantic interpretations, has been already carried out (Sauvet, Sauvet, and Włodarczyk 1977; Sauvet and Sauvet 1979; Sauvet and Włodarczyk 1995).

With respect to the field of Palaeoastronomy, researchers are interested in another related topic. If some knowledge of stars and asterisms is posited, what was its usage and relevance in the respective Palaeolithic culture? Since the beginning of the 20th c. astronomical depictions in Palaeolithic rock art have been proposed. Most of the approaches, as discussed in Rappenglück (1999, 2008), are deficient in that they lack a rigorous interdisciplinary methodology including careful analysis of available archaeological data, the imposition of astronomical exactness, and an awareness of the importance of ethnological semantics.

As a heuristic first step into creative problem-solving (Holyoak and Thagard 1995), it has been suggested that intuitions and conclusions by analogy are useful. Nevertheless there are serious problems and dangers, too.

Already in the twenties and thirties Baudouin (1916, 1921, 1923) believedthat asterisms had been identified in several depictions on portable artefacts and on rock walls. He thought that a kind of a zodiac was present in the Mousterian, 120-40 ka BP. At the beginning of the 20th c., scientific methodologies and knowledge of the archaeology and dating of Upper Paleolithic artefacts were poor. Thus Baudouin's ideas are inspiring, but cannot be asserted with the same confidence as when he originally put them forward/in the original sense he believed.

Kaurov (1999: 471-472) reads engravings in a stone from the Neanderthal burial of La Ferrassie 6 (France), 75–65 ka BP (Langley, Clarkson, and Ulm 2008: 297), as the Big and Little Dipper asterisms. He, however, conducts no in depth scientific analysis to support his hypothesis. This is done by Van Binsbergen (2004). He thoroughly examines the sepulchre stone from La Ferrassie (France), 75–65 ka BP, and the Aurignacian block La Ferrassie XVI, 29 ka BP and concludes that in both cases the holes refer to Orion's belt and stars around it. Though such studies, depending on the exact verification of artificial 'holes' and a distinct description of the object's feature classes, in principle are to be taken very cautiously, Van Binsbergen's approach did follow many of the principles of integral methodology.

Eelsalu (1985), Antequera Congregado (1991, 1994), and Edge (1997) conclude by pure analogy that in the cave of Lascaux, Hall of Bulls, aurochs' and dots are somehow related to the Pleiades. They widen their conjectures and identify several rock pictures, showing certain species of animals (or chimeras) with asterisms, which they think to be congruent with combinations or parts of today's constellations. They, however, base their arguments only on similarities between rock pictures and asterisms, the selection of certain star patterns according to the possible sky view corresponding to the images' age, and the relations between each of them (topographic argumentation). Thus, their research remains at the heuristic level of discussion for they fail to substantiate their ideas in a convincing fashion, according to the presented methodological framework discussed previously. Some examples illustrate the procedure: Antequera Congregado (1991, 1994) applies her heuristic approach to the 'Great Panel' of the Altamira cave (Spain). In that case the problem of maintaining such an approach is quite obvious: According to her, the 'Big Bison' (N# 46) is an asterism built up by stars of today's Hercules, the Northern Crown, and Bootes. She, however, doesn't take into account the proper motions of the stars. Concerning the most recent 14C age of the rock pictures of 13.1 ka BP, the movement especially of Arcturus (Bootes) cannot at all be neglected.

There is, also, the so-called 'unicorn' in the 'Hall of Bulls', Lascaux (France), 18.8-6.9 ka BP. Antequera Congregado (1994), for example, entirely identifies the animal's shape with today's Scorpio and the circular figures 'inside' the chimera's body with the Milky Way's dark zones. She doesn't offer any conclusion beside the formal analogical idea. Equally, she assigned the so-called 'inverted horse' in the Axial Gallery to the constellation 'Pegasus'.

Edge (1997) recognizes Taurus and the Pleiades in the 'Hall of Bulls'. He identifies the round of animals with star patterns (from Bull #18 [Taurus, Cetus, Fornax, Eridanus] to the #2 the 'Unicorn' [Libra, Scorpius, Sagittarius]) grouped along the ecliptic, visible at summer solstice ca. 15,000 BC, from dusk to dawn, and running from west to east. Edge thinks that the course of the moon is connected to the animal asterism represented. He suggests that especially full moon at summer solstice had been important for the people of Lascaux during the Magdalenian. Edge is fully aware of the different artistic styles in Lascaux. He takes the stars' proper motions into account. Edge however selects and omits identifications of the animals with asterisms (combined parts of today's constellations) according to his principal leading idea, starting with the identification of the Pleiades at the bull #18 and extending the interpretation on the complete round of depictions. Though this approach is not far difficult to apply by reconstructing the sky at the Lascaux epoch using a planetarium software, it is ambiguous: He would have to offer reasons for the direction used in reading the depictions with respect to the different parts of the 'Hall of the Bulls', the affiliation of images in the 'Axial Gallery', and the gap given by the entrance into it.

Jégues Wolkiewiez (2000) takes full credit for having measured the azimuth angles of the rock pictures in the 'Hall of Bulls', including the 'inverted Horse' at the terminal of the 'Axial Gallery', and in the 'Shaft of the Dead Man'. Measurements have to be done reasonably, verifiably, and fully according to techniques and mathematics of surveying. She, however, doesn't inform the reader about the specific angle measurement devices used, the respective measurement errors, the origin point of measurement in the cave, certain measurement points in it and the reasons for their selection, and the surveying plan employed. She also doesn't setup any feature classes of animals and signs, which she accepted or omitted from the object set. There are for example a tiny bear #17 and horse #1 in the 'Hall of Bulls', which do not attract her interest (Ruspoli 1986: 200-201).

In addition she doesn't acknowledge that research has shown a sequential making of the pictures: The bulls belong together and had been depicted before the horses (Apellaniz 1984; Bahn 1994). According to her measurements she superimposed today's constellations onto the cave paintings, without taking into consideration the stars' proper motions, following a rough allocation of some animals' parts with azimuths. She doesn't give sufficient evidence, e.g., why just these assignments, syntactically and semantically, are permitted. Thus, it is possible to project any preferred constellations onto a decorated cave wall, depending on the archaeological framework of dating (frequently some thousand years), which with a few exceptions, offers multiple astronomical interpretations. Instead it is necessary to set forth the conditions for restrictions which make the conclusions clearer. Moreover, Jégues Wolkiewiez (2000: 1-5) states that at summer solstice the setting sun illuminates (!) the back part of the aurochs 14# and also penetrates the Axial Gallery up to the 'inverted horse'. First, she tested her idea by looking into the entrance of the Lascaux cave, which had been artificially built and which opens onto a corridor equipped with four airlocks leading to the Hall of Bulls: At summer solstice sun set this portal is lit by the sun. This is purely heuristic and not an argument that can be used to substantiate her hypothesis. She then bases her explanation on a geological and archaeological section made at the entrance of Lascaux (Vouvé 1979: 39, fig. 18). In fact, the archaeological and geological stratigraphy, if reading much more detailed graphics (Leroi-Gourhan 1979: 47, fig. 25; Aujoulat 2005: 32, fig. 17), shows that when the sunbeam enters, in the very best case, if ever, it may have touched the back part of aurochs #14. The sunbeam, however, never could have penetrated the Axial Gallery up to the inverted horse, because of the original rock nose that was situated at the entrance at the end of the Upper Paleolithic and the protruding rock walls, which only leave open a small part beneath the ceiling (Aujoulat 2005: 31, 32, fig. 17). Jégues Wolkiewiez doesn't read the geological section carefully enough. Moreover, she doesn't make clear that the sun only at an altitude of about 7° is able to illuminate the cave, and then only just a little bit. There is no summer solstice sunset at the horizon visible.

Jégues Wolkiewiez (2007), moreover, associates the depiction of the two crossed bison #65 in the 'Ship' with a linear presentation of the azimuths of the rising and setting sun at summer and winter solstice, as well as at the spring and autumn equinox. She assigns the point of the equinoxes at the horizon with the bison's crossed hind legs. Why doesn't she use the crossed tails of the animals? This is also reasonable. But then the overlaid diagram she used would have needed to be shifted some degrees to the right. Moreover, there is no indication of the position from which she did her measurements. Thus, her statements are completely insufficient.

Finally many researchers have been busy interpreting the enigmatic rock art panel in the 'Shaft of the Dead Man' of Lascaux. The discussion of almost all the different approaches and results, including the evaluation of the hypothesis up to the year 1999, can be found in Rappenglück (1999). Some general problems are cited here. For instance, Laričev (1999) takes angle measurements between parts of the animals and geometrical elements in the rock art panel, just from a photo, without respect to measured points according to photogrammetric standards, including possible image distortions. Eelsalu (1985), Congregado (2001), and Laričev (1999) associate the arrangement of rock pictures with the area of the sky, set out by the today's constellations Orion (bird-man), Taurus (bison), Gemini (woolly rhino), and Sirius (bird-on-the-stick). William Glyn-Jones (2007) considers Taurus to be the bison. Gemini and Orion (down to the belt) should represent the bird-man. Procyon is the bird-on-the-stick and Leo illustrates the back part of the woolly rhino. They arrive at that interpretation, because of their familiarity and preoccupation with these constellations offered by the younger traditions of antiquity. Except their techniques of overlaying rock pictures with stars and constellations, adjusted and often distorted to fit the idea, they do not offer reliable proofs drawn from archaeological data, painstaking analysis of the artwork, exact measurements on the walls and sufficient support by interdisciplinary research according to the integral method presented above. The authors often disregard the computation of proper motion, which in some cases is not negligible. Laričev (1999) for example, identifying the bird-on-the-stick with Sirius (α CMa), doesn't take the movement of this star, which is significant, into account. Some additional pitfalls: Weiss (cited in Rappenglück 1999) works upon copies of the rock images and derived their widespread astronomical conclusions partially from copy inaccuracies. Kuhn (cited in Rappenglück 1999) doesn't consider the shifting of the calendar date referring to the sun's position, if one's goes back to the Magdalenian epoch. In the case of Jégues Wolkiewiez' (2000: 19, and 27, fn. 49), personal preferences prevail in her attempt to achieve a thoroughly scientific approach. Knowing the work of earlier researchers (Rappenglück 1999), she decided to superimpose it by using an inconsistent variant. Concerning the rock art panel in the 'Shaft of the Dead Man' she construes a complete sky view of the northern sky. Using planetarium software she suggests that the panel depicts the night sky at autumn equinox 18.73 BP (uncalibrated), a single date, which falls in the scope of 14C radiometry of the archaeological layers (Rappenglück 2004: 102-104). To put flesh on the bones she reconstructs a funny scene, which would imply that the observer lies face-up on the ground while the person's head is tilted back to view the bird-man constellation in the south. But the star Deneb (α Cyg) somehow troubles her preferred interpretation. Thus, without hesitation she decided to eliminate him from the Magdalenian sky. According to her Deneb did not exist before the advanced civilizations of Mesopotamia, Egypt, and Crete. She confirms her statement assigning Deneb the spectral class K or M, which proves her complete ignorance of the relevant astronomical facts: In fact α Cyg belongs to A2 Iap. It is estimated that Deneb came into being more than 10 Mio years ago and changed from spectral class B (or O) into the actual one (Kaler 2009).

Rhawn (2011) follows the 'projection' procedure of his forerunners, without citing them, and identifies some of today's constellations with Palaeolithic artwork. He doesn't give any evidence for his hypothesis and bases all his reading on a few analogies.

Astro-maniacs like Glyn-Jones (2007) and Cunningham (2011-2012) map certain asterisms, which they thought to be depicted on the northern wall in the 'Shaft of the Dead Man', onto parts of the Earth's surface (Nile River delta and Giza; Eurasia). They interpret this as an illustration of incredibly high level of astronomical and geodetic knowledge of Upper Paleolithic cultures. This is completely plucked out of the air.

How then does one evaluate the possible astronomical knowledge of Paleolithic cultures?

When doing research in the field of Palaeoastronomy, the first pitfall to overcome is given by the variety of ways human perception and cognition works. Normally, scarcely anybody cares about the properties of cognitive illusions, one's hidden preferences, prejudices, and epistemological interest (Chabris and Simons 2010). It is the duty of science to bring these to the fore, think about them and to discuss the preconditions of the respective approaches, assumptions, and kinds of personal preferences and bias. Therefore, training is necessary in order to recognize ambiguous illusions, separation from the ground, figure-ground reversals, fictions, and problems of context. Astronomers are familiar with various kinds of such cognitive illusions. Depending on the context (semantic, pragmatic) of respective cultures, a certain star pattern (syntax) is interpreted in different ways. To crown it all, Upper Palaeolithic people themselves intentionally used just a lot of these cognitive illusions for illustrating multiple levels of meaning in single depictions (Olins Alpert 2008: 119-192). This increases the number of traps to fall in. A further important step is a meticulous phenomenological description, defining feature classes and respecting any percept. This requires the researcher to abstain from prejudging the data and to employ an open-minded approach, as well as a disposition to be receptive for the object's properties.

In addition, there is evidence that at least during the Upper Palaeolithic those who created the artwork had a certain spatiotemporal perception that differed from the average of people today. They were especially skilled at observing and depicting animals' special behaviours (Rappenglück 1999, 2008; Azéma and Rivère (2012), sometimes much better than in the modern era (Horvath et al. 2012). Being hunter-gatherers, they had a special sense for dynamical processes, which they illustrated in their artwork, for example, by dissolving continuous movements into a superposition of succeeding images, producing a kind of *photo kinetic* sequence. Moreover, three-dimensionality was experienced by motion, which creates the concept of a hodological space (Rappenglück 1999). These specific cognitive abilities of Upper Palaeolithic peoples would have deeply affected their perception of astronomical phenomena (Rappenglück 1999).

Another very serious problem involves the question of dating intentional depictions in Upper and Middle Paleolithic times as accurately as possible. In most cases there is no way to get a direct and definitive result. Though rock pictures in a composition are stylistically similar, their age differs significantly (Lorblanchet 2001: 267-284). In the cave of Cougnac (France) direct 14C dating of parts of one depicted male big stag results in two dates separated by ca. 5,500 years: 25.51-24.73 ka BP and 19.77-19.23 ka BP. It is possible that the errors in dating arise because Palaeolithic artists used already old material. But the differences of dating within the same depictions are not really understood (Fortea 2002: 28). Recent research concerning different radiometric methods amplifies the dating problem (Pike et al. 2012). Up to now there was no real agreement about the unambiguity of dating methods and results. Therefore, dating based on different, preferably independent methods, like radiometric, stratigraphy, pollen analysis, style etc. and calibration procedures is necessary and helps in delimiting the range of possible dates assigned to the object. As an example, a discussion of dating techniques that are relevant for astronomical interpretations in the cave of Lascaux is presented in Rappenglück (1999). Hence, only the multiplicity and evaluation of archaeological dating offer a certain time frame for astronomical statements.

It is also necessary to take into account the characteristics of Palaeolithic people, their life world and life praxis, in order to develop the cultural framework in which astronomical knowledge may have been an issue. This context also permits one to draw some conclusions about the kind of abilities they possessed as sky watchers. It is well-documented that hunter-gatherers much the same as farmers had been able to carefully watch celestial phenomena and to pass the astronomical knowledge on (Rappenglück 1999; Hayden and Villeneuve 2011).

As hunters, Palaeolithic people were well aware of the life cycles of wild animals (mammals, birds, reptiles and even insects): They carefully watched the diurnal and nocturnal activities, the mating seasons, the gestation periods and breeding times, the change of fur, development and dropping of antlers, the fledging of the sub adults, the specific growth stages, and the annual migration of the animal species (Rappenglück 2008). As gatherers, in addition to collecting berries, nuts, mushrooms, and certain plants they were also familiar with the seasonal growth of wild flora especially the particular time of blossom and fructification, a fact, which is well known from studying both, mobile and parietal depictions (Rappenglück 2008). Since the Aurignacian (40-31 ka BP) phenological depictions on mobile artefacts and fixed (parietal) on rocks in caves and at open air sites are evidenced by several studies (Marshack 1991; Rappenglück 1999, 2008), though there also had been criticism of the interpretation of these depictions (Robinson 1992; D'Errico 1989; D'Errico and Cacho 1994).

New evidence concerning the need for certain astronomical knowledge is given by the recent analysis of communal hunting in the Middle and Upper Palaeolithic. Already in the late Middle Paleolithic (300–40 ka BP), at least 71 ka BP ago, Neanderthals seasonally preyed upon certain faunal species and organized communal hunting (Niven et al. 2012; Rendu et al 2012). After 34 ka BP, in the early Aurignacian, networking and logistically developed human groups controlled large areas up to 100,000 km^2 (Djindjian 2012). During the Upper Paleolithic, people were already engaging in well-organized and long-standing seasonal hunts, starting from selected base camps and returning to them (Niven 2007; Schwendler 2012). There is some evidence for the existence of peculiar aggregation places like the Côa Valley (Portugal), 31-12 ka BP (Aubry et al. 2012). Such areas were frequented at certain times each year by local and regional groups, which came together for holding social events, including conducting specific rituals.

Communal hunting and the periodic assembly of human groups reflect their ability to carry out actions in common, such as social events, including in particular the meeting of sexes. These actions, in turn, required a specific perception and approach to spatiotemporal processes. Furthermore, such activities required a type of social organization that would have relied on well-trained individuals with specialized knowledge, communicating and cooperating together (Rendu et al 2012). People also visited cave-sanctuaries following the rhythm of the seasons (Rappenglück 2008). The creation and renewal of some depictions were done in accordance with special time periods, accompanied by the corresponding icons, myths and rituals. Certain kinds of time-reckonings were needed to determine hunting or fence seasons and to start the local or even regional gathering of hunting specialists and those people who were in charge of took care of processing the kill. Periodic logistics of sourcing, storage, processing, and related meetings resulted in cyclical concepts of time – a year-round pattern –, which would have included observing and synchronizing astronomical with biological and sociological rhythms. Upper Palaeolithic people illustrated the annual round or certain subdivisions of it on mobile artefacts and in rock art (caves / open air sites). They frequently combined phenophases of fauna and flora as well as the woman's biological cycles (menstruation, pregnancy) with astronomically significant dates and periods related to the course of the moon, the sun, and some asterisms. This kind of representation best of all could be referred to as a *palaeo-almanac,* which combines time-reckoning and important information originating from different spheres of life (Marshack 1999; Rappenglück 2008). Such palaeo-almanacs consist of naturalistic depictions of mostly faunal, but also at time floral elements and include abstract counting aids (e.g., series of dots, notches, certain geometric figures etc.).

They set the framework for a more elaborate time-reckoning leading to calendars. From the records on bones, antlers, and stones it can be derived that people carefully watched the course of the moon, notating its position over the natural horizon and the change of its phases up to a period of some synodic or sidereal lunar years (Marshack 1991; Rappenglück 1999, 2008, 2009; Utrilla et al. 2012). First, research found the renditions only to be observation-based, mnemonic, narrative, and non-arithmetical (Marshack 1991). Further analysis (D'Ericco 1989), however, showed that on some artifacts the markings had not been accumulated for days or months, but rather within a shorter time frame. From that result researchers argued that the idea of Upper Paleolithic calendars had been refuted. In fact, this is not conclusive evidence. People keep observation-based calendars geared to certain counted real-time periods. However, they also represent time cycles in their entirety. This is evidenced by depictions of time periods combined with images of animals, plants, and abstract signs found in deep caves (Rappenglück 2008), whose making obviously is not synchronized with the course of sun, moon, and stars outside. In addition, further research done by the critics themselves notably weakened the argumentation against the existence of calendars in the Upper Palaeolithic (D'Ericco and Cacho 1994). Nevertheless, some of the following conclusions are still under discussion, because of the scarcity of the hitherto available finds and the fact that they have not yet been subjected to a fully statistical analysis.

The synodic as well as the sidereal lunar month and year, with subsets and multiples, show up on Upper Palaeolithic artefacts (Marshack 1991; Rappenglück 1999, 2008, 2009; Utrilla et al. 2012). The fortnight and the double synodic month can frequently be found. Partitions ($^1/_2$, $^1/_4$, $^1/_6$, $^1/_8$) of an approximated solar year of 360 days are recorded. The sum of days from autumn to spring equinox or from autumn to summer solstice and from spring to autumn equinox is depicted. In addition, the woman's pregnancy period, counted in multiple of sidereal or synodic months, plays an important role in the Upper

Palaeolithic. There exist some kinds of lunisolar time-reckoning, too. Evidence is given for synchronizing and intercalating of different biological and astronomical time periods. This is especially true if longer periods are noted where a clearly structured arithmetic notation of astronomically significant time units has been used.

Through the application of some of the principles of integral methodology, outlined above, concerning the Upper Palaeolithic (40-12 ka BP), one finds that astronomical depictions, like phenological almanacs, a kind of lunar time-reckoning, certain asterisms, and manifestations of cosmovisions probably are present (Frolov 1977-1979; Marshack 1991; Rappenglück 1999, 2008, 2009).

A difficult but important field of study within paleoastronomy deals with the possible alignments of caves, rock shelters, dwellings, and burials. In that case it is indispensable to apply the integral methodology, with particular focus on building up feature classes and noting the context. Statistics may be considerably biased by the natural alignment of rock shelters and caves along river systems, elementary human needs for certain intensity values of light, the sun's warmth, and security. It is important to think about the intentionality of specified viewpoints, the natural horizon, the alignments of rock shelters, cave entrances, galleries (at several levels), the linkage with certain rock pictures and the cultural affiliation of the artefact under study. In any case such detailed studies have to be made for each object, before doing a statistical analysis. There seems to be one well-reasoned study concerning the entrance gallery of the cave of Parpalló (Spain), 21.4-13.1 ka BP, which is illuminated up to the terminal by the winter solstice sun (Esteban and Tortosa 1998).

At first appearance a statistical analysis of sites (decorated caves and rock shelters), by Wolkiewiez (2011) seems to reveal evidence of the intentional selection by humans, according to the exact position of the sun at the horizon (caves: preferred sunset at summer solstice, sunrise at summer solstice, sunrise at winter solstice; rock shelters: preferred sunrise winter solstice, sunset winter solstice, south, sunrise summer solstice). But this approach lacks a rigorous scientific basis. The localities are not attributed to certain feature classes except the rough type (cave, rock shelter): there is no real classification (respective epoch, area of cultures, structure of caves and rock shelters, natural horizon, measurement points, kind of depictions etc.). The same problem exists when evaluating a preliminary analysis of alignments of caves, rock shelters, open air sites, made by Fabio Silva 2011 (personal communication) using the PACEA 2011 database (D'Errico et al. 2011). Though an intentional selection of the caves with respect to rough cardinal alignments in a given case cannot be ruled out, at this point there is still not sufficient proof to make such an assertion.

Research (Binant 1991; Smirnov 1991) indicates that Homo sapiens neanderthalensis burials on average are aligned (body axis) East–West and European Early Modern Humans interred the dead North – South. There are some hints that the alignments follows feature classes (male- female / old – young), too (Binant 1991).

A necessary and very important context for Palaeoastronomy is given by paleomathematics (Rappenglück 1999, 2009, 2010, 2012; Pletser 2012). Seminomadic Palaeolithic hunter-gatherers already were able to measure qualities quantitatively. Many examples of evidence for measuring instruments and methods as well as proto-mathematical concepts are found such as the preparation of plane surfaces and levelling technics, the constructions of tents and huts including the adjustment of architectural elements, scaffolding in caves, the cut of clothing, the making of hunting weapons, the mixing ratios of dye stuffs used for cave paintings, purposes of orientation in space and time, including elementary map sketches of local regions and celestial areas, and basic systems of time-reckoning. During the Upper Palaeolithic people constructed geometrical figures like the line segment, the rectangular cross, the isosceles, equilateral, and right-angled triangle, different kinds of quadrangle (rectangle, square, trapezium, rhombus), the pentagon and hexagon, the circle, the ellipse, the spiral and the Greek fret, grid and tessellation (using triangles, lozenges, and hexagons). Moreover, 3D figures like cuboids, spheres or even screws were known and manufactured. There are hints about mental imaging methods, for example, translation, rotation, or projection, the use of templates, scaling procedures, design principles, natural and artificial measuring instruments, e.g., body parts, the measuring cord and rod, the plumb bob, a simple protractor, and the use of the shadow stick. People also utilized certain counting methods, displayed on rock faces inside and outside of caves or on mobile stone or bone objects. Results of ethnomathematical and ethnoastronomical studies further substantiate that comparatively simple measuring instruments and methods are well-suited for obtaining perfectly good results and satisfying the needs of the populations in question.

Finally, researchers should take into account the perception and meaning of caves and their topological structure as they relate to archaic early cosmovisions and ecosystems (Rappenglück 2007, 2009). That rounds off the scientific approach to paleoastronomical issues.

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European Prehistory

Solar Symbolism of 'Horns of Consecration'?

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Abstract

The paper examines a tentative hypothesis according to which the so-called horns of consecration found at the Eneolithic site of Vučedol in eastern Croatia offer support for the existence of horizon solar observations in the Vučedol culture. The support, if any, could only come from the context of the find, rather than from the comparative material adduced in the paper. In the first place, the Minoan 'horns of consecration' are usually derived from certain Egyptian hieroglyphs, especially the *akhet*-sign. It was further argued that they were actually used as a crude instrument in solstitial observations, but their symbolical function is also emphasized. Yet the iconographic sources do not substantiate their connection with the sun, let alone the solstices. Concerning the *akhet*-sign in the context of Egyptian culture, the evidence similarly does not seem to support its association with the solstices. Several such associations have been proposed, both referring to linguistic and iconographic sources, as well as landscape arrangements and much later religious-calendaric considerations. However, none of them seems convincing. The same can be said for Mesopotamia, where a similar symbol is found and analysed in iconographic and literary sources. In conclusion, it is maintained that the postulated context of the finds is the only supportive evidence for any solar connotation of the 'horns of consecration' in the Vučedol culture. Therefore it cannot convincingly be argued that this object actually played any part in the horizon solar observations at Vučedol.

KEYWORDS: Vučedol, horns of consecration, *akhet*, solstice

POVZETEK

Članek raziskuje hipotezo, po kateri naj bi t.i. konsekrativni rogovi, najdeni na eneolitskem najdišču Vučedol na vzhodnem Hrvaškem, dokazovali, da so v vučedolski kulturi opazovali Sončevo gibanje po horizontu. Kakršna koli podpora tej hipotezi bi lahko prišla le iz konteksta najdbe, ne pa iz primerjalnih dejstev, navedenih v članku. Razširjeno je mnenje, da minojski konsekrativni rogovi izhajajo iz določenih egiptovskih hieroglifov, posebno iz znaka *akhet*. Nekateri tudi menijo, da so jih dejansko uporabljali kot okoren inštrument za opazovanje solsticijev, čeprav so imeli tudi simbolni pomen. Vendar pa v ikonografskih virih ni najti temeljev za njihovo povezavo s Soncem, kaj šele s solsticijem. Tudi v kontekstu egiptovske kulture ni trdnih dokazov o povezavi znaka *akhet* s solsticiji. Nekaj poskusov v tej smeri je bilo – le-ti so se opirali na lingvistične in ikonografske vire,

ureditve pokrajine in kasnejša verska in koledarska pojmovanja –, vendar se noben ne zdi prepričljiv. Enako velja za mezopotamsko kulturo, ki pozna podoben simbol. Lahko zaključimo, da so kontekstualni podatki o najdbi edini dokaz v prid povezave konsekrativnih rogov vučedolske kulture s Soncem. Zatorej ni možno z gotovostjo trditi, da so v Vučedolu te rogove dejansko uporabljali za opazovanje Sonca na horizontu.

KLJUČNE BESEDE: Vučedol, konsekrativni rogovi, *akhet*, solsticij

Introduction

In an earlier paper (Bilić 2013, forthcoming) I have argued that the complicated entrance complex on the Gradac (hill fort), the 'acropolis' of the Vučedol settlement, which consisted of two structures in front of the house itself, doors that led to the antechamber, and doors to the main room, could have been oriented towards the summer solstice sunset. The entrance complex is constructed in such a way so as to preclude the entrance of the sun's rays in the 'megaron-house' during the entire year, except for 31 days before and after the summer solstice. Also, 12 days before and after the summer solstice the sunlight would only enter the interior chamber, no longer illuminating the interior wall of the antechamber of the 'megaron-house'; this was perhaps combined with the longer period of illumination in order to obtain the precise day of the solstice. I have argued that a Vučedol observer could have kept tally of the number of days between the sun's 'entrance' into the inner chamber and its 'exit' from it, a total of sixty–two days, perhaps also the tally of the number of days between the sun's 'complete entrance' into the inner chamber and its 'complete exit' from it, which takes a total of twenty–four days, and the midpoint between these two – or four – events would have given him the day of the summer solstice. Standing alone, this hypothesis is hard to defend, but it does gain some support based on the additional evidence adduced below.

However, this evidence does not decidedly point towards the importance of the solstices in the context of the Vučedol culture, but rather to the presence of horizon solar observations in general. Thus a preliminary analysis of eight houses from the Streim Vineyard at Vučedol (after Forenbaher 1994, 1995) has shown that seven of them (objects 1, 2, 3, 4, 8, 9, 10) were indeed oriented upon the arc of the horizon between the summer solstice sunrise and the east (or the winter solstice sunset and the west), while the eighth (object 5) was less that five degrees off to the north (or south) if measured by its walls, but inside the arc if measured by its axis. This suggests that the position of the sun at the horizon played some part in the orientation of Vučedol houses. It does not, however, point to any special importance of the solstices.

As a comparison, the Neolithic Linear pottery complex long houses are in general oriented upon the arc of the horizon between 90 and 180° (Marshall 1981: 115; Hodder 1990: 170). On the other hand, the majority of eastern causeways of circular earthworks of the late Neolithic Lengyel culture, whose function was perhaps ritual, are generally oriented upon the sunrise points at the horizon between the winter and summer solstice (Pásztor, Barna & Roslund 2008: 916-918, 921-922), while 80% of the entrances of the analysed Late Neolithic houses on the Orkneys lie on a NW-SE axis, similar to the orientation of local passage graves. Most of these have east-facing entrances, although the most notable, Maes Howe, is oriented upon the winter sunset), while the orientation of central hearths is predominantly towards solstice sunrise and sunset points (Parker Pearson & Richards 1994: 40-2).

The results of the analysis of Vučedol houses thus provide some – but not decisive – support by contextualizing the previous hypothesis concerning the orientation of the megaron. Furthermore, the horizon solar observations were probably a part of ritual performances in the Vučedol settlement, which is corroborated with the ever present solar symbolic on Vučedol pottery. The elaborate pottery decoration has been adduced as another type of evidence for the performance of horizon solar observations in the Vučedol culture (on this see also Bilić 2013 with earlier literature). It was argued that the decoration of the ritual vessels of the Vučedol culture reflects the importance of the horizon observations of the sun and that precisely this position of the sun had some special significance for the Vučedol population. However, this additional contextualizing evidence still does not point decidedly to the solstices.

'Horns of consecration' and solar interpretations of their origin

During the original excavations of the Vučedol Gradac, the excavators found a specimen of the so-called horns of consecration in the basement II D, in a layer containing Vučedol material, dating from the 1st half of the 3rd millennium B.C. (Schmidt 1945: Fig. 22 on p. 33, 36, 106, Pl. L.3; Durman 1988: 148 cat. nr. 37; Milićević Bradač 2005: 192 and Fig. 21) (Figure 1).[1]

Figure 1. 'Horns of consecration' from Vucedol (Schmidt 1945: Pl. L.3).

Considering the postulated importance of solar observations in the Vučedol culture it seems appropriate to discuss the meaning of the so-called horns of consecration both in the context of solar observations and by keeping in mind the presence of solar elements in the Vučedol cult. The solar origin of the Minoan 'horns of consecration'[2] was suggested rather early in the history of their discovery and the initial attempts to explain them. The concept arose, it seems, through an association with certain Egyptian hieroglyphs that

[1] This is not the only specimen of the 'horns of consecration' in the context of the Vučedol culture, but it is the only one from the Gradac.

[2] Cf. the Minoan hieroglyphic sign no. 37 ⊔ (Evans) (Marinatos 2010: 103-4).

were attributed solar connotations. Thus Newberry (1908: 27-8) associated the Cretan 'horns of consecration' with hieroglyphic signs N35 (), denoting foreign country, desert, desert country, and land of Retjenu and N36 (), denoting mountain.[3]

To the best of my knowledge, it was Gärte who, after repeating Newberry's claims (1922: 81-2), first associated a representation similar to the Cretan 'horns of consecration' on a stele from Cartage, actually the upper part of the Tanit-symbol, and this part of the symbol in general, with the Egyptian sign for horizon, N 37 () (Gärte 1922: 93, cf. 92-4; cf. Nilsson 1950: 187-8, 1967: 274; Powell 1977: 72; D'Agata 1992: 247 n. 6; MacGillivray 2004: 331; Milićević Bradač 2005: 193 with n. 4; Banou 2008: 28; Marinatos 2010: 106).[4] It was Hazzidakis (1934: 102-3), though, who first suggested the possibility that Minoan 'horns of consecration' were derived from the Egyptian signs for mountain () or horizon, *akhet* (, 'solar mountain', according to him) (cf. Banou 2008: 28), adding that they were symbols of a Minoan solar deity. Nilsson (1950: 189), although acknowledging the 'undeniable' similarity between the 'horns of consecration' and the *akhet*-sign, still rejected this thesis (cf. Powell 1977: 72; Marinatos 2010: 106).

The notion was not further discussed until Powell published an article in 1977 strongly arguing for the derivation of the 'horns of consecration' from the hieroglyphic sign for the horizon (see esp. 1977: 72, 74; cf. D'Agata 1992: 247 n. 6; MacGillivray 2004: 331, Banou 2008: 28; Marinatos 2010: 106). In 1984, Makkay argued for the similarity of the mountain-sign (N26) with a depiction resembling the 'horns of consecration' on a Middle or Late Neolithic ceramic object from Knossos (Makkay 1984: 22, 24 with Fig. 1.2b on p. 23; cf. Milićević Bradač 2005: 193). A possible connection of Minoan 'horns of consecration' with the Egyptian hieroglyphic signs for the mountain[5] or horizon[6] was only occasionally mentioned.

The closest approximation to the *akhet*-sign I have managed to find in Minoan representations is a snake tube from Gournia, which has the 'horns of consecration' with a (slightly off-centre) disk between them topping the handle (Gesell 1976: 248, 256, cat. no. 3, Pl. XLI.3; cf. Gärte 1922: 76 with Fig. 5, Hazzidakis 1934: 102 with Fig. 17). Hazzidakis (1934: 104) attempts to explain the fact that the disk is rarely depicted together with the horns of consecration by arguing for the superstition of the Minoans, which is a rather desperate interpretation. More recently, three authors have approached the issue from a somewhat different angle, although still retaining the old notion of the association between the *akhet*-sign and the so-called horns of consecration, and their arguments are of a special importance to us. MacGillivray (2004: 331, cf. 2000: 129) has argued for the derivation of the Minoan 'horns of consecration' from the Egyptian hieroglyphic signs for mountain and horizon, retaining the meaning of 'mountainous horizon' (cf. Banou 2008: 29; Marinatos 2010: 106). Moreover, he has argued for their practical use in solar observations (MacGil-

[3] Cf. Nilsson 1950: 187, 1967: 274, Powell 1977: 72, MacGillivray 2004: 331.
[4] Nilsson 1950: 187, cf. 1967: 274 n. 7, on the other hand, cites Kristensen 1913 as suggesting the similarity of the 'horns of consecration' with the Egyptian sign for the horizon (cf. Marinatos 2010: 106).
[5] Watrous 1998: 23-24. Cf. Banou 2008: 29; Marinatos 2010: 106.
[6] MacDonald 2005: 68-9; Moss 2005: 160, 210-3. Cf. Banou 2008: 29.

livray 2000: 129, 2004: 331; cf. Banou 2008: 35, 40), more specifically, for the observation of solstices (MacGillivray 2000: 129). Thus he believes that they were used as devices for the standardization of the position of the solstice points, substituting the non-existing undulating horizon (MacGillivray 2004: 331; cf. Banou 2008: 29, 41). In this way, he specifically associates the so-called horns of consecration with the observation of solstices. Furthermore, he also believes that primary function of peak sanctuaries were astral observations (cf. MacGillivray & Sackett 2000: 169 for Petsophas, where the 'horns of consecration' device would have had to been used, and cf. Henriksson & Blomberg 1996: 103, 112, 114, who argue for astronomical observations as one of their functions), more specifically, the sun's annual path along the horizon (MacGillivray 2004: 331; cf. Banou 2008: 34). In this connection, Banou (2008: 34) argues that the clay model of 'horns of consecration' from the peak sanctuary of Petsophas represents a symbol analogous to the Egyptian sign for mountain. Moreover, it has been argued that the peak sanctuary of Petsophas was used as a solar observatory, more specifically, for the observation of the summer solstice sunrise (Henriksson & Blomberg 1996: 104-5, 109, 1997-8: 147-51, 2001: 611-2; Goodison 2004: 348, opting for the winter solstice sunrise; cf. Banou 2008: 34). Thus at Petsophas we would see the connection between the so-called horns of consecration and solstice observations. Finally, Banou (2008: 40) sees in the 'horns of consecration' both the symbols of mountain peaks from which astronomical observations were made and practical instruments for solar observations and she further suggests that their edges could have indicated the solstice points on the horizon (Banou 2008: 41). Last but not least, Marinatos (2010: 106-7, 109-10, 113, 115-6) has spoken in favour of a cosmological interpretation of the 'horns of consecration', recognising in them a symbol denoting 'the twin peak mountain depicting the east and west points of the horizon' or 'the gate of the cosmic mountain of sunrise and sunset', analogous to the Egyptian *akhet*-sign (which she refers to as 'cosmic mountain'). On balance, based on the evidence discussed above, attempts that have been made in the past to connect the Minoan 'horns of consecration' with the sun, let alone the solstices, are weak. The connections are extremely hypothetical and, consequently, the thesis remains unproven, regardless of the arguments that have been put forward in favour of the (again hypothetical) derivation of this object from the *akhet*-sign.

The *akhet*-sign – the Egyptian origin of 'horns of consecration'?

To this point I have presented a short review of opinions concerning the solar origin of the so-called horns of consecration. In that review a tentative picture emerged of an object whose morphology was derived from Egyptian hieroglyph(s) with certain solar connotations and which was used as a symbol of annual solar movement, more precisely, its extreme points, and perhaps also as an object that functioned as a practical instrument for the observation of solstices. This is arguably the context in which they were found on the Vučedol hill fort: next to a structure generally oriented towards the summer solstice sunset and used to determine the day of the summer solstice with the 'halving the difference' method in the context of a culture known to have performed horizon solar observations and utilized them in decoration of their ritual vessels. However, since the Minoan evidence remains at best tentative, it does not seems possible to draw from it such a strong conclusion regarding the situation at Vučedol, especially since any notion of the *solstice* observations at Vučedol remains entirely hypothetical.

The suggestion that the *akhet*/'horns of consecration' symbol, or its edges, represented the extreme points in the annual solar motion has to be examined more thoroughly. The *akhet*-sign possesses undeniable solar associations, both in its graphic appearance and in cosmological notions associated with the concept underlying its appearance. Yet a more specific reference to the solstices seems to be absent. It might be as old as the Naquada I period (ca. 4000-3500 BC). Thus Piankoff (1957: i.31 Fig. 11) reproduces a decoration on Amratian pottery depicting a double mountain surrounded by waters with two solar disks on each side of the mountain (cf. Giedion 1962: ii.129 Fig. 69; Smith 1987: 89 Fig. 4.38). There are no depictions of the *akhet*-sign during the dynastic periods predating the New Kingdom; however, in *PT* 685.2064 the king's birth (accompanying Re in the Netherworld?) is described as the splitting apart of two mountains, which might suggest that the concept apparent in the later sign could have been in circulation much earlier (cf. Piankoff 1957: i.31 n. 6). Finally, *CT* 305.iv.59 mention 'the two great mountains on which Re appears'.[7]

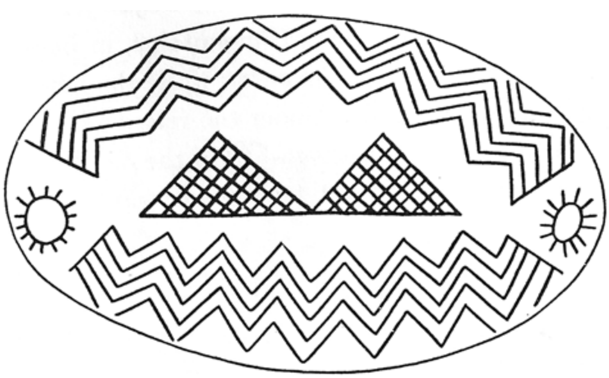

Figure 2: Amratian vessel, Naquada I period (Piankoff 1957: i.31 Fig. 11).

Banou (2008: 32) cites several Egyptological discussions relating to the fact that the towers flanking the central east-facing entrance of the New Kingdom temples might represent the horizon-sign, marking the position of the solstices on the eastern horizon. Yet all that the authors she cites say is that those towers either symbolize 'the twin mountains of Bakhu and Manu between which the sun god rose daily' (Aldred 1987: 165), which has no reference to the solstices, or 'the two peaks of the horizon between which the sun rose' (Wilkinson 1992: 135). Wilkinson further adds that the pylons 'symbolized the gate of the eastern horizon (N27)'

[7] On the concept of *akhet* in general see especially Kuentz 1920: 140 *passim*, esp. 189-90; also Breasted *ARE* ii, p. 132 n. *c*, v, p. 132; Piankoff 1934: 58, 59; Faulkner 1962: 4-5; Goelet in Dassow 1998: 143; Assmann 1980: iii.3-7 s.v. *Horizont*); Assmann 2003: 58; Allen 1988: 6, 2003: 27.

(Wilkinson 1992: 139), which also refers to the sun's diurnal path. Furthermore, it is claimed that 'the pylon, with its two pylon towers and the recess between them within the gateway, represents the horizon' (Redford 2001: iii.372), which again bears no reference to the sun's annual movement. In another work R.H. Wilkinson more explicitly stated that 'the pylon mimicked the shape of the *akhet* or horizon hieroglyph' (Wilkinson 2000: 60, cf. p. 77, figure caption), 'on which the sun rose each day' (Wilkinson 2000: 77), adding that the pairs of obelisks placed on each side of the entrance pylons may have functioned 'to some degree as a form of the two mountains of the horizon upon which the pylons themselves were modelled' (Wilkinson 2000: 78). Still, there is no implicit or explicit reference to the solstices.

A reference to the sun's annual path associated with the *akhet*-sign can perhaps be recognized in a representation on the papyrus of Khonsu-mes A from the 21st dynasty (Piankoff 1957: i.145 Fig. 62). Here the hoeing of the ground is represented inside a circle, together with two disks on both sides of the east-west axis of the circle, joined together by nine dotted lines; outside the circle, on its eastern (upper) side, is a large *akhet*-sign, while two goddesses, 'The One of the North' (on the left) and 'The One of the South' (on the right), pour out a fiery liquid from two vases, which forms two concentric circles around the circle, indicated by dotted lines. The points where the liquid touches the circle correspond to the ends of the horizon-sign, in this way forming the southern and northern limit of sunrise.

This is a rather speculative suggestion, but it is not impossible that the tips (summits) of the *akhet*-sign might have represented – during this late period of Egyptian history (10th-9th c.) – the limits of the sun's annual movement. A similar suggestion was offered by Kuentz, who claims that the dual form *akhty* can be understood as the section of the eastern horizon within the extreme points of annual solar movement, rather than in its usual meaning of 'eastern and western horizon' (Kuentz 1920: 170-2); thus, we could suppose that the word could have also been applied to the section of the western horizon within the extreme points of annual solar movement. This is precisely the meaning of the expression 'two easts and two wests' (*Quran* 55:17) as understood by the Islamic commentaries cited by Kuentz (Kuentz 1920: 169-70, cf. Minorsky 1970: xlix n. 5 and the identical explanation in Tabari, Rosenthal 1989: i.234 and in *Tafsir Ibn Kathir*, *Tanwīr al-Miqbās min Tafsīr Ibn Abbās* and *Tafsīr al-Jalālayn* ad 55:17). Thus, according to Kuentz, *akhty* could occasionally actually mean 'the summer solstice and the winter solstice' from the perspective of horizon observation ('*l'orient entre le lever d'hiver et celui d'été*').

A much more spectacular hypothesis associates the *akhet*-sign to the Giza pyramid complex in the context of solstices. When observed from the eastern niche of the Sphinx Temple, the sun sets almost exactly halfway between the pyramid of Cheops (Khufu) and that of Chephren (Khafra) on the summer solstice, thus forming a huge *akhet*-sign (Lehner 1985: 141, 1997: 130; Shaltout, Belmonte & Fekri 2007: 417-8; Magli 2011: 28; Magli 2009: 41 takes for the point of observation the NW corner of the Chephren's Valley Temple). Since the Egyptian name of Cheops' pyramid – probably also of the entire Giza complex – was actually *Akhet Khufu* (Lehner 1985: 142, 1997: 130; cf. Kuentz 1920: 147, also Simpson 2003: 18, P. Westcar vii.8), while the Sphinx's name was *Har-em-akhet*, it is possible that the horizon on which this Horus was placed was precisely Cheops' horizon (Shaltout, Belmonte & Fekri 2007: 419, 436; Magli 2009: 48 n. 8). Wilkinson (1992: 135, 1994: 159, cf. 166 and Ill. 120) further adds that the Giza Sphinx (*Hor-em-akhet*) can be understood as a representation of Horus on a horizon formed by Cheop's and Chephren's pyramid (cf. Shaltout, Belmonte & Fekri 2007: 417, 418 Fig. 13). According to this theory, the *akhet*-sign would be a symbol for the summer solstice. But how can this be reconciled with the fact that the symbol denoting the horizon was depicted differently in the earlier period? We might further add that the word 'solstice', together with the notion of solstices in general, does not appear in Egyptian texts,[8] while a description of the sun's annual movement from the Ptolemaic period – an inscription on the statue of the astronomer-priest Harkheby (Daressy 1916: 2-4; Clagett 1995: ii.495; Lehoux 2007: 121) – mentions 'the northward and southward motions of the sun', which is simply a description of solar movement, rather than a technical term which would be used in a scientific description of the observation of solar phenomena.

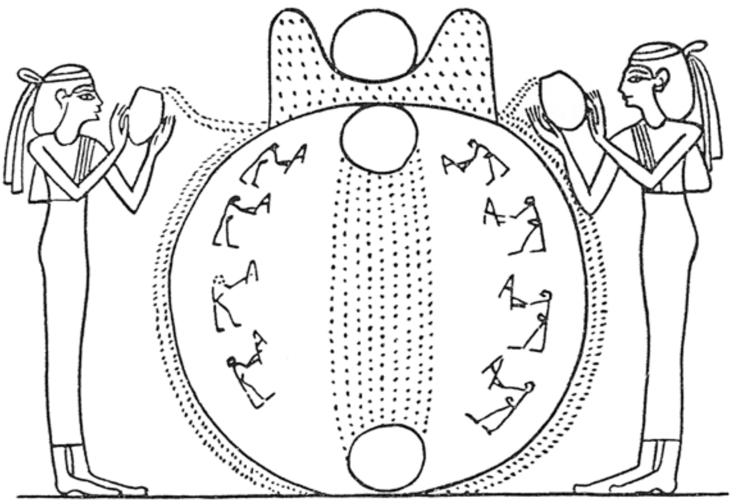

Figure 3: The hoeing of the ground on the papyrus of Khonsu-mes A, 21st dynasty (Piankoff 1957: i.145 Fig. 62).

During the late period of Egyptian history certain suggestions indicating an Isis festival associated to the winter solstice appear. Thus Plutarch described a festival that was held on Athyr 17-20, according to the reformed calendar, when the sun is in Scorpio

[8] If we do not take here into account the enigmatic description from the New Kingdom Book of Nut discussed in Bilić 2013, where the region 'outside' the sky, inaccessible to the sun is described. Another tentative example is to be found in Meyer 1875: 3, who translated the expression šént n aten found on a stele in Tombos, dating from the reign of Thutmose I, as 'solstice/tropic' and found further references to the northern and southern tropic in the continuation of the text (cf. Heidel 1937: 3 n. 7), yet Breasted (ARE ii.70, p. 29), on the other hand, translated the expression without any reference to the solstice (cf. WÄS iv.412; Faulkner 1962: 261).

(*De Is. et Os.* XIII.356C, XXXIX.366DE, XLII.367EF; Neugebauer 1975: ii.580; Jones 1999: 261-6; Evans & Berggren 2006: 18-22). A passage in Achilles Tatius describing the *Isia* festival is often connected to this unnamed festival (*Isag*. 23): when the sun 'descends' from Cancer to Capricorn and the days become shorter the Egyptians mourn, and they celebrate when it commences its return towards Cancer (Jones 1999: 266-7). Furthermore, Geminus described how the Greeks believe that the Egyptian festival of Isia corresponds to the date of the winter solstice as determined by Eudoxus (*Elem. Astron.* VIII.20, 22 = fr. 214d Lasserre; cf. Neugebauer 1975: ii.579),[9] although this only applies on the period 120 years previous to Geminus (VIII.21, 24), more precisely, the winter solstice fell on Athyr 19 in 179 BC (Evans & Berggren 2006: 19). Since the winter solstice fell on Athyr 19 or 20, according to Eudoxus (fr. 214b) and Democritus (68B14.2) (P. Par. 1 col. 22.21-23), while the *Isia* were celebrated in Athry (more precisely, on Athyr 17-20) both before and after the calendar reform (Jones 1999: 264-6), it seems that this important festival was associated to the winter solstice in the period from the 3rd c. BC to the 2nd c. AD.[10]

In sum, the Egyptian evidence does not seem to support the association of the solstices with the *akhet*-sign. Several such associations were proposed, both referring to linguistic (the dual *akhty*) and iconographic sources (the hoeing of the earth scene), as well as landscape arrangements (the Giza plateau) and much later religious-calendric considerations (the *Isia*). Yet none of them seems convincing.

A similar concept in Mesopotamia?

The iconographic motif found in the so-called horns of consecration and the Egyptian *akhet*-sign is also found in Mesopotamia.[11] Moreover, it was here, precisely as in Egypt, associated with sun's (diurnal) movement, more accurately, with the moment of its rising, the appearance at the horizon. Furthermore, these figural representations are analogous to the concept as expounded in literary sources (cf. Horowitz 1998: 97 n. 3, 266, 331). In short, according to both, Utu/Šamaš rises at dawn from the mountain of sunrise and sets into the corresponding mountain at sunset (Black & Green 2000: 184). Thus the solar deity Šamaš appears on numerous Akkadian cylinder seals depicted as rising behind or out of a double mountain, a mountain with two prominent summits with a deep breach between them. Occasionally he is represented thrusting upwards by propping himself with his hand(s) placed upon the two mountain tops; sometimes he is depicted, as if climbing, with a raised leg and his feet resting upon one of the summits. He wears a horned crown,

[9] An alternative translation suggests that the Greeks believed that the date of the *Isia*, according to both the Egyptians and Eudoxus, fell on the winter solstice (Evans & Berggren 2006: 179 n. 10). According to [Gemin. *Elem. Astron.*] *Parapêgma*, Aujac p. 104.4 = fr. 214a Lasserre, Eudoxus' winter solstice fell on the fourth day of the sun's sojourn in Capricorn (according to Euctemon and Callipus the winter solstice fell on the first day of Capricorn, Aujac 103.23-104.2).

[10] Böckh 1863: 203-4 associated a hemerology dating from the New Kingdom (19th or 20th dynasty), where a festival held on Athyr 16-19 is described, the component of which was a mourning for Isis and Nephthys, with the *Isia* festival, but this should not be taken for granted (Jones 1999: 265 n. 14).

[11] The analogy was also recognized by Marinatos 2010: 107-12, 115.

designating his divine nature, and usually holds in his hand a serrated knife or a pruning saw, with rays emanating from his shoulders (Frankfort 1934: 20, 1939: 98-100, 105-8 with Pl. XVIIIa, c, g, XIXa; Van Buren 1955: 1-14; Böhmer 1965: 71-6 with Taf. XXXII.377, XXXIII.392-XXXVI.439, XXXVIII.464-5; Black & Green 2000: 184 with Fig. 152 on p. 183; Woods 2004: 55, 57, 58, Fig. 21-4). This iconographic motif can be recognized in literary sources. Thus in the *Gilgamesh Epic* the sun sets into the western mountain Mašu, 'Twins' (George 2003a: i.492, 669, ii.863, 865), associated with the daily rising and setting of the sun (*EG* IX.39, 45; George 2003a: i.669, 2003b: 71); the *Epic* also mentions 'the gate of the mountain' Mašu (IX.42, 135; George 2003a: i.669, 671, 2003b: 71, 73), through which Gilgamesh passes following the path of the sun. In general other literary sources corroborate the concept from the *GE*. Thus, to give several examples, according to *Third house prayer,* Utu rises from *kur-gal*, 'Great Mountain', *kur-idim*, '(subterranean?) Mountain of the Spring', and 'Holy Hill' (*du$_6$-kù* = *apsû*?), from the place where heaven and earth embrace at 'the base of heaven' (an.úr = *išid same*, i.e. the horizon) (Borger 1967: 3-4, l. 1-4; Horowitz 1998: 235, 315-6, 331), while according to *Tigi song to Inanna* he rises from the Cedar Mountain (cf. Kramer 1944: 20-1; Horowitz 1998: 331), and according to BA 10.1, 11ff he rises from the interior of heaven and crosses over the mountains of Hašur(-tree) (cf. George 2003a: ii.864 and a prayer K.3333+ and Nabonidus' inscription, OECT 1.27.iii.10-1; at *Incantation of Utu*, OrAnt 8.8:33-5 Utu owns both the Cedar and Hašur mountains) (cf. Kramer 1944: 20 n. 9). George (2003a: ii.864) further cites the *Enki and the World Order* (373, ETCSL 374-5, cf. Black, Cunningham, Robson & Zólyomi 2004: 223) and a Sumerian hymn to Ninurta (TCL XV.7.13) for the sun rising from Hašur/hašur trees, while Albright (1919: 179, 190) identifies the mountain of Hašur with Masios, which, in its turn, he identifies with Mašu. In a lament for Dumuzi (CT XV.26.22) cedar is described as 'the consecrated of Hašur, the shade/dark tree/black wood of Dilmun' (Albright 1919: 181; Kramer 1944: 21, 1963: 281-2; Jacobsen 1976: 70; Livingstone 1986: 110), while Dilmun, 'the place where Utu rises', is further mentioned in the *Eridu Genesis* (CBS 10673, Nippur Segment E, l. 11 (col. vi l. 11 = v. 260 or 261); Kramer in *ANET* p. 38, 1944: 18-9, 1956: 81, 1961: 98, 1983: 121; Heidel 1949: 105; Jacobsen 1981: 525, 1987: 250; Civil 1969: 145, West 1997: 167; Caspers & Govindankutty 1978: 139; Horowitz 1998: 329; George 2003a: i.275 n. 141, 496, 519; Black, Cunningham, Robson & Zólyomi 2004: 215). Furthermore, the Akkadian translation of the twelfth tablet of the *Utukku lemnutu* series explains that the Dark and Bright Mountains are precisely the mountains of Sunset and Sunrise, respectively (Heimpel 1986: 143-5; Horowitz 1998: 332; George 2003a: i.493 n. 169, with another similar passage in KAR 24.5-7), while a Sumerian hymn to Enlil places the mountains of sunrise and sunset at the edges of heaven and earth (Horowitz 1998: 331, cf. George 2003a: i.493 n. 169). Sumerian literary work *Inanna and Sukalletuda* also mentions the mountains of Sunset and Sunrise (Horowitz 1998: 249, cf. George 2003a: i.493 n. 169), and a *lipšur* litany, type I.1.4, claims that Šamaš enters Aja (his consort) through the Buduèudug Mountain (Reiner 1956: 132-3; cf. George 2003a: ii.863, litany derived from SB *Hh* XXII.5, also the Emar version, Msk 74115 obv. 28'). George (2003a: ii.864) quotes several additional references to the mountains of sunrise (a hymn to Nungal, a hymn in which the mountain is called Nergal's) and sunset (*Udugḫul* IV.61). Thus, the literary sources suggest that the sun both rises from and sets into a cosmic mountain, most probably the double mountain of Mašu, which is depicted in iconographic sources as a variant of 'horns of consecration' symbol.

Figure 4: Akkadian cylinder seal (Black & Green 2000: 183 Fig. 152).

Yet nowhere is this Mesopotamian concept associated with solstices, although the latter were, naturally, well known there. Thus in the mulApin (II.i.9-24) the solar year is defined by the solstices, in their turn defined, among other things, by the position of the sun at the eastern horizon and the change in direction of the course of the position of successive sunrises at the eastern horizon (II.i.11-2, 17-8, cf. II.ii.3; Hunger & Pingree 1989: 72-3, 75, 92). The word used in the mulApin is GUR (*târu*), 'to turn (around)' (see *CAD* 18.256-7 t s.v. *târu* 3a1'), which probably means that the expression definitely refers to the 'turnings' at the horizon, since the normal term for the solstice in Akkadian is *šamáš* GUB (*izziz(a)*), where GUB (*uzuzzu*) means 'to stand' (Rochberg 1998: 43, 157, 2010: 194-6; cf. Gössmann 1950: 184.373). In *Enuma Eliš* VII.127 there appears a term KUN.SAG.GI (Akk. *rēš-arkat*), literally 'front-back' (Landsberger & Kinnier Wilson 1961: 173; cf. Deimel 1912: 58, *tempus praeterlapsum et futurum*),[12] but is sometimes translated as 'turnings' (Speiser in *ANET*, p. 72), 'turning point' (Horowitz 1998: 115), or 'Wendepunkt, solstice point' (von Soden 1942: 17; Heidel 1942: 59).[13] This translation seems plausible, but due to the unsolved problem of the nature of *nēberu* associated with this concept, it is not possible to discuss it any further.

[12] *CAD* r 14.285-8 s.v. *rēšu* 4, a2 1.2.274-6 s.v. *arkatu* 1.

[13] *Kunsaggû*, an Akkadian loan word, is translated as 'turning point' on the basis of identification KUN.SAG.GA = *muḫru*, 'street chapel marking the turning point of a processional circuit' (*CAD* m2 10.2.177 s.v. *muḫru* 2, k 8.542 s.v. *kunsangû*; Horowitz 1998: 115, n. 12).

Interestingly, a Kassite lapis lazuli seal from the reign of king Burnaburiash (1359-1333 BC) found in Thebes (in a LH IIIB context, 1300-1200 BC) depicts a curious pastiche of elements characteristic of both Šamaš and Ea: a deity is represented emerging from between two triangular mountain tops in a characteristic Šamaš-pose. But he holds in his outstretched hands two jars from which he pours out water, which is a recognizable characteristic of Ea (Müller-Karpe 1980: iv.2 p. 782, iv.3 Taf. 254C; Porada 1981). The seal confirms that the 13th c. Mycenaeans in Thebes could have been familiar with the concept of the sun between 'the horns of consecration' in their Mesopotamian version. However, no direct association with the solstices is evident.

Conclusion

The analysis of Egyptian evidence for the association of the solstices with the presumed predecessor of the Minoan 'horns of consecration', the *akhet*-sign, did not reveal any significant results. Moreover, it does not seem that the solstices, apart from the evidence adduced from the orientations of a not inconsiderable group of temples,[14] played a significant role in Egyptian cosmology in general. The evidence adduced in support of the thesis according to which the Minoan 'horns of consecration' represented either a symbol of or a practical instruments used for the observations of the solstices is similarly tentative, to say the least (the Petsophas sanctuary).

It seems that it is possible that the Minoan 'horns of consecration' were indeed derived from Egyptian hieroglyphic signs for 'mountain' or 'horizon', and that the latter's solar character was indeed recognized by the receiving society. However, the association with the solstices is non-existent in both cultural complexes. Similarly, a corresponding iconographical motif was well-known in Mesopotamia, in the same way associated with sunrise, horizon and two-peaked mountain. And yet in this region there are still no apparent associations with solstices.

Consequently, it is not possible to reach any substantiated conclusion concerning the relatioship between the 'horns of consecration' and the solstices in the Vučedol culture. It could be argued that the postulated context in which they were found on the Vučedol hill fort and the larger context of the Vučedol culture in general could suggest a possible association of the so-called horns of consecration with the observation of the solstices, whether as symbolic representations or practical instruments.The immediate context is a structure possibly oriented towards the summer solstice sunset and used to determine the day of the summer solstice with the 'halving the difference' method, while the larger context is that of a culture known to have performed horizon solar observations and utilized them in the decoration of their pottery. However, the hypothetical nature of the megaron-solstice association, together with the rather speculative nature of the evidence adduced in support of any association of the 'horns of consecration' with solar observations, let alone the solstices, decidedly speaks against such a strong conclusion.

[14] Numerous Egyptian temples were oriented upon the winter solstice sunrise (Belmonte, Shaltout and Fekri have classified those in their group II-, 'the solstice group'), and also, less frequently, upon other solstice points (see Shaltout and Belmonte 2005, 2006; Shaltout, Belmonte and Fekri 2007, 2008).

Thus, it must be concluded that, based on the evidence presently available, the Vučedol 'horns of consecration' cannot be interpreted as either symbols or instruments for the observation of the solstices.

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Malady or Vanity: A Minoan Peak Sanctuary Figurine

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Abstract
The Uppsala archaeoastronomical group has shown that there are indications that the structures of the so-called peak sanctuaries on the hilltops Petsophas and Traostalos were used for astronomical studies. Other studies have also shown that Classical and Hellenistic Greek literature in part describe the sky as it was during Minoan times, i.e. around 2000 BCE. Earlier I have shown that the terracotta figurines found on those two peaks most likely represent constellations. However, an earlier interpretation of the figurines as gifts in a healing cult still lingers on. In this respect, the figurine most often cited is a seated female with one 'thick' leg. However, it appears that the normal, bare leg is carefully sculpted while the thick leg and the body are formed as a clay cylinder and seem to be of minor interest. The bare leg on a sitting woman, seen in profile, reminds us of Cassiopeia, the Ethiopian queen that, due to her vanity, was doomed to be a constellation. This paper will discuss that figurine, arguing that it depicts Cassiopeia, and also another figurine that has been used to motivate the hypothesis of a healing cult, showing that it can be understood as the constellation Andromeda.

KEYWORDS: Minoan, peak sanctuaries, constellations, Cassiopeia, Andromeda

POVZETEK
Člani uppsalske arheoastronomske skupine so pokazali, da so strukture svetišč na vrhovih Petsophasa in Traostalosa verjetno služile za astronomska opazovanja. Nekatere druge raziskave pa so pokazale, da klasična in helenistična grška literatura opisujeta nebo, kakršno je bilo v minojskem obdobju, t. j. okoli 2000 let pr. n. št. V preteklosti sem že pokazal, da terakotne figurice, najdene na obeh omenjenih vrhovih, najverjetneje predstavljajo ozvezdja. Kljub temu še vedno živijo starejše interpretacije, ki figurice razlagajo kot predmete zdravilskega kulta. V tej zvezi se največkrat navaja figurica sedeče ženske z eno 'debelo' nogo. Vendar se pri njej zdi, da je bila tista normalna, suha noga zelo skrbno izdelana, medtem ko sta bila debela noga in tudi telo oblikovana kot glinast valj in se zdita manj pomembna. Če pogledamo figurico sedeče ženske iz profila, njena suha noga spominja na Kasiopejo, etiopsko kraljico, ki je bila zaradi svoje nečimrnosti kaznovana tako, da je sedaj v ozvezdju. Poleg te figurice članek obravnava še eno, ki je v preteklosti prav tako vzpodbujala hipoteze o zdravilskemu kultu, a jo lahko razumemo kot upodobitev ozvezdja Andromede.

KLJUČNE BESEDE: Minojci, svetišča na vrhovih, ozvezdja, Kasiopeja, Andromeda

Background

Research carried out previously by the Uppsala archaeoastronomical group has shown that the surviving structures of the so-called peak sanctuaries on the hilltops Petsophas and Traostalos indicate that they were used for astronomical observations, for calendaric and navigational purposes (Henriksson & Blomberg 1996).

The sites are rather close to each other on the east coast of Crete, overlooking the sea to the east. Both sites are so-called peak sanctuaries within 1-2 km, from major Minoan settlements situated at sea level. Traostalos is 515 m above sea level and Petsophas is at about 255 m. There are no indications of ancient roads leading up to the peaks; they were reached by foot, Petsophas being reached in about half an hour and Traostalos, a rather more demanding climb, in about an hour for a young healthy person. Neither of the sites has any water source and they are exposed to the weather. These are not places that a sick person would find easily accessible. The climb to Traostalos, where the figurine with, and I quote, 'a swollen leg' or 'an oedematous leg' was found would have been very difficult and could have caused further health problems to the individual in question. Moreover, it would appear that the small structures at these sites were not suitable for more than overnight visits to study the stars and as lookout points towards the sea. These two sites are not situated 'on the lower and more accessible summits', as are the sites described in a paper on healing cults in Minoan times (Arnott 1999: 2).

There have also been studies showing that Classical and Hellenistic Greek literature, e.g. Aratos' *Phaenomena*, contain partial descriptions of the sky as it appeared during Minoan times, i.e. around 2000 BCE. This means that there seems to have been a long tradition concerning the stars, the sun, the moon, and the constellations, as well as the knowledge of how these could be used for keeping track of time, a tradition going back to the time when those two structures were originally built (Blomberg, P.E. 2003, with further references).

More than 2400 figurines in total are found on the two sites, dated to the time of the construction of the hilltop buildings (c 2000 BCE). The function of these figurines is still debated. Earlier I have shown that they are most likely representations of constellations, used for educational purposes (Blomberg 2000 and 2006). However, there are those who interpret them as gifts in a healing cult.

For example John Myres was the first to suggest this interpretation of the figurines when he published his excavation on Petsophas in 1902 (Myres 1902-1903). His interpretation was based on a number of terracotta figurines depicting parts of the human body, which reminded him of the votives found in Hellenistic Greek healing cult temples as well as in the modern churches of Greece. However, the majority of the terracotta figurines depict small animals: bulls, ibexes, along with human figures. The figurines representing animals dominates**;** while bulls are especially numerous.

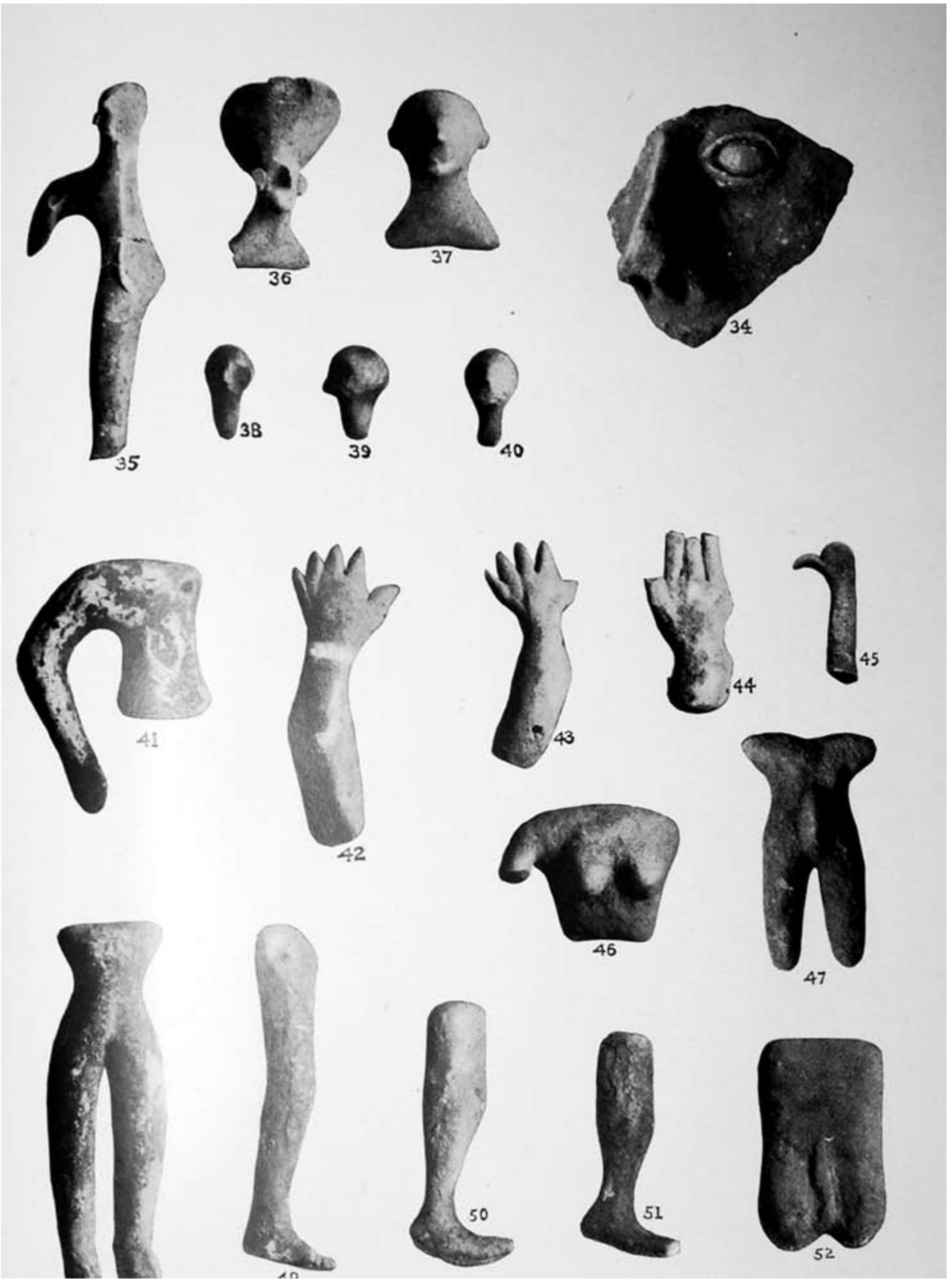

Figure 1: Finds from Petsophas (Myres 1902-1903).

Healing cult?

Myres, the excavator of Petsophas, interpreted the detached limbs as offerings given in thanks for healing, seeing them a parallel to the offerings we see in modern churches on Crete (Myres 1902/1903). Martin P. Nilsson, however, doubted that the terracottas on those peaks were parts of a healing cult (Nilsson 1968: 74) and raised serious questions referring to missing human parts common to known Hellenic healing cults (Nilsson 1968: 74 note 60: Blomberg 2003). Robert Arnott (1999) in an article, 'Healing cult in Minoan Crete', was well aware of Nilsson's doubts, but was still convinced the figures belonged to a healing cult. He refers to a small number of human figurines that in one or another way seem to show a defect that can have been caused by some disease or accident. In total he refers to five types of figurines:

- a deformed hand (Davaras 1976: fig 139)
- arms and hands that may have been deformed by arthritis and a female torso with thickened legs
- a seated female (HM 16443) with one 'thick' leg (Fig 2 and Davaras 1976: fig 138) that is elsewhere described as 'oedematous' (Arnott 1999: 4), this figurine is the one most often cited as indicating a healing cult.
- a group of human figurines, with reference to Myres, bisected vertically from groin to the top of the head and thought to show a human with some internal disease, 'an attempt to depict an internal disease or ailment', see fig 1:35.
- a figurine understood as a paraplegic (Rutkowski 1991: item 3.1.24 HM 4863)

We shall here remember that Aratos describes how Andromeda's right side begins to rise divided lengthwise at the same time as the Fishes begin to rise, 'So too the tragic arms and knees and shoulders of Andromeda extend all divided, one side ahead, the other behind, when the two Fishes are just emerging from the ocean' (Aratos: ll. 704-706). She is thus bisected vertically from groin to the top of the head (as Fig 1:35).

This means that out of about 2400 figurines, Arnott identified about a dozen figurines with defects that can be interpreted as showing medical problems for which the figurines were offered in a healing cult. After the presentation of these figurines, Arnott (1999: 4) states, 'but due to their crude rendering, the pathology in all these cases is uncertain.' The figurines are, in almost all museums, called votive gifts.

The sitting female figurines

Three of the figurines discussed in this connection are sitting humans, but there is one (HM 16443) that is emphasized and is in rather good condition. It was found on Traostalos and depicts a woman sitting on a chair. The head is similar to the standing female figurines, while the body and her left leg are formed by one clay cylinder; her left foot is missing. Her right leg is carefully formed, as if it were intended to be accentuated. Her breasts are clearly shown, to indicate a female. Her hat differs from that of other standing female figurines; it looks like a crown. Her arms, what remains of them, are outstretched (Figs 2a and b).

Figure 2: a) Figurine HM 16443, frontal. From Traostalos. Photo and permission to publish by 'Heraklion Archaeological Museum, MERACS-TAP. b) Figurine HM 16443 side view. Photo by the author.

In studying Aratos (ll. 188-196, 653-658, esp. the commentaries to those lines; Allen 1963: 142f, s.v. Cassiopeia) and the illustrated manuscripts of the *Phenomena* or other illustrations of that constellation, you will recognize the sitting lady with outstretched arms as Cassiopeia (many good pictures are available on the Internet s.v. Cassiopeia and then Pictures).

When we look for early pictures of the constellations, we find the Farnese Atlas which is a 2nd century Roman copy of a Hellenistic sculpture. It is the earliest complete map of the sky that we have and most likely is the earliest picture of the constellations with Cassiopeia positioned correctly amongst the other constellations.

Figure 3: Cassiopeia on the Farnese atlas. Roman copy of a Hellenistic sculpture.

According to the Greek myth, the Ethiopian queen Cassiopeia offended the Nereides by boasting that she was more beautiful, which was viewed as an offence. Due to her vanity she was doomed to be a constellation and there she remained, chained to a chair, looking at her daughter Andromeda who, in turn, was chained to a rock, expecting Cetus to come and kill her.

Early illustrations of Cassiopeia in Aratos manuscripts show her as a sitting lady with minor variations when compared to the terracotta figurine from Traostalos, a female figure depicted most often with a bare leg. If we look for the constellation Cassiopeia on star maps we recognize the arms, the bare breasts associated with a major star and then a star on her bare leg, see e.g. on a star map from 1822. The star Cassiopeia epsilon, Segin, on her leg can be on either leg, but that leg is portrayed as bare and exposed.

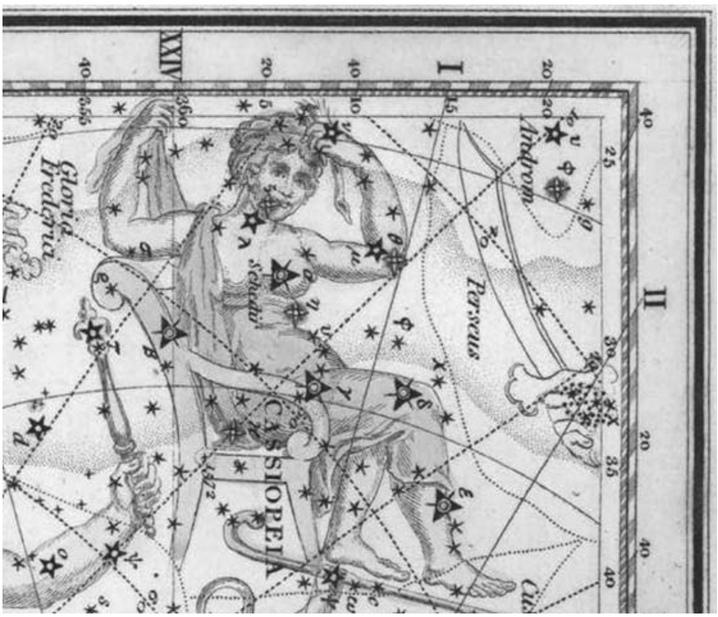

Figure 4: Cassiopeia on a star map from 1822. Alexander Jameison 1822.

A support for the interpretation of the symbolism of the sitting woman would arise if we should find similar figurines at sites that have no connection to a healing cult. Thus, a very interesting little figurine was found at Agia Triada, a site with no indication of a healing cult, but with indications of an interest in the heavenly bodies (see the article by M. Blomberg and Henriksson in this Proceedings). It is situated almost at sea level on the south coast of Crete. The constellation Cassiopeia appeared above the major mountains to the north of the site.

Figure 5: Sitting lady from Agia Triada, HM UNN. Photo and permission to publish Heraklion Archaeological Museum, MERACS-TAP.

Other sitting ladies have been found, for example in graves in that area (see e.g. Nilsson 1968: 296ff.).

Conclusions

When studying the terracotta figurines found on Crete, not only in peak sanctuaries but also at other sites such as graves, it seems that the figurines depict constellations or parts thereof. Although the symbolism of the figurines is in question, it is most likely that their use was connected in some fashion to calendarics and the movement the heavenly bodies, knowledge that would have been important for the passage of time and navigational purposes during the night. Understanding the figurines as depicting constellations does not contradict their possible religious meaning, as it could very well be that the stars and constellations had some spiritual significance in Minoan culture.

It seems clear that the sitting lady most likely depicts the constellation Cassiopeia and do not indicate that the hilltops were places for healing cults. She is another indicator of the Minoan interest in the stars and constellations, and the fact that our western map of the constellations in the sky derives from the Minoans.

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Oriented for Prayer: Astronomical Orientations of Protohistoric Sacred Buildings of the South Iberian Peninsula

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Abstract
This article presents the results of an archaeoastronomical study carried out in several protohistoric religious buildings of the southern half of the Iberian Peninsula, most of them located in modern-day Andalusia. The sites date from IX to V century BC and belong to the Tartessian or Iberian cultures. All sites show evidence of direct influence by Phoenician colonisation and most of them have even been interpreted as true Phoenician temples. An element commonly associated with some of these buildings are the bull hide-shaped altars, which have been interpreted as dedicated to the Phoenician deities of Baal and Astarte. We find that these sacred buildings are oriented to the same azimuth of 55°, indicating the importance of orientation in the design and ritual use of the sanctuaries. In discussing the astronomical targets of such an orientation pattern we find several possibilities – Sun, Moon or Venus – and the need to interpret the results in the light of current knowledge about the Phoenician religion as well as ancient written references.

KEYWORDS: Archaeoastronomy, temples, Phoenicia, Tartessos, Iberian Culture, solstices, Venus

POVZETEK
Članek predstavlja rezultate arheoastronomske študije, opravljene na več protohistoričnih religioznih objektih južnega Iberskega polotoka, večinoma v sedanji Andaluziji. Najdišča so iz časa med 9. in 5. stol. pr. n. št., pripadajo pa kulturi Tartessos oz. iberski kulturi. Na vseh najdiščih so vidni neposredni vplivi feničanske kolonizacije; večina jih je bila celo interpretirana kot pravi feničanski templji. Pogosti v teh zgradbah so oltarji v obliki bikove kože, ki naj bi bili posvečeni feničanskim božanstvom Baalu in Astarti. Ugotovili smo, da so vsa ta svetišča usmerjena z istim azimutom 55°, kar kaže na pomembnost usmeritve pri njihovem načrtovanju in obredni rabi. V razpravi o možnih astronomskih tarčah tega vzorca usmeritev podajamo

več možnosti – Sonce, Luna ali Venera – ter izražamo potrebo po interpretaciji rezultatov v luči sedanjega poznavanje feničanske religije ter starodavnih pisnih virov.

KLJUČNE BESEDE: arheoastronomija, templji, Fenicija, Tartessos, iberska kultura, solsticiji, Venera

Introduction

At the beginning of the first millennium BC, Phoenician sailors and traders reached the shores of the Iberian Peninsula. These foreigners founded *Gades* (modern Cádiz, probably the oldest city in Western Europe), and a dense chain of settlements in the south of the Iberian Peninsula. By the sixth century BC, because of the fall of Tyre, the Punics had taken over control of these Phoenician colonies. Almost at the same time, the Greeks appeared in the northeast of the Peninsula, founding *Emporion*, their westernmost colony. These alien colonists influenced the mosaic of Bronze Age indigenous cultures that inhabited the Peninsula, changing profoundly and forever their economy, social structure and perhaps even their religion. This epoch of strong acculturation has been traditionally called the Orientalizing Period, lasting from the ninth to the sixth centuy BC. Through contact with foreign traders the Tartessians developed their own script, introduced iron-working, large-scale silver mining, and the use of potter´s wheel (see Blázquez 1975; Harrison 1988).

Very few works have discussed the astronomical aspects of the religious and funerary worlds of the Orientalizing Period in south of Spain. Ramos Sainz (1986: 32) indicated that most burials of the Early Phoenician period in the Iberian Peninsula are arranged with their longitudinal axes close to the east-west line. In particular, this author noted that the entrance doors of the chambers at the necropolises of Trayamar and Puente de Noy are always oriented to the east. Similar orientations are also found in the hypogea of Villaricos (Belmonte 1999: 186) and Málaga (González García et al. 2007), with a pattern showing two peaks one at the equinox sunrise and other at the winter solstice sunrise. Esteban (2012) has analyzed the orientation pattern of burial pits in the necropolises of La Angorrilla and Cerrillo Blanco and found that the major axes of the tombs show a similar orientation pattern, covering the arc of the horizon where the rising of the Sun or the Moon takes place. Finally, Escacena (2007; 2009) has addressed the possibility of solar rituals being held in the sanctuaries and altars of El Carambolo and Cerro de San Juan.

In this paper we present the main results of an archaeoastronomical study of three sanctuaries located in the lower Guadalquivir Valley and dated to the Orientalizing Period along with an additional site located south of the present-day province of Alicante in southeast Spain (see Fig. 1). This last sanctuary is dated to the end of the Orientalizing Period and the beginning of the Iberian Period (V BC). An extended version of this work, written in Spanish, can be found in Esteban & Escacena (2013).

Methodology

The fieldwork was carried out in two campaigns, one in April 2006 where we visited the sites in the Guadalquivir Valley and a second one in April 2010 dedicated to investigating the temple at El Oral. In most cases, we were able to count on the advice of the archaeologists responsible for the excavations of the sites. The instruments used were a precision compass, a hand-

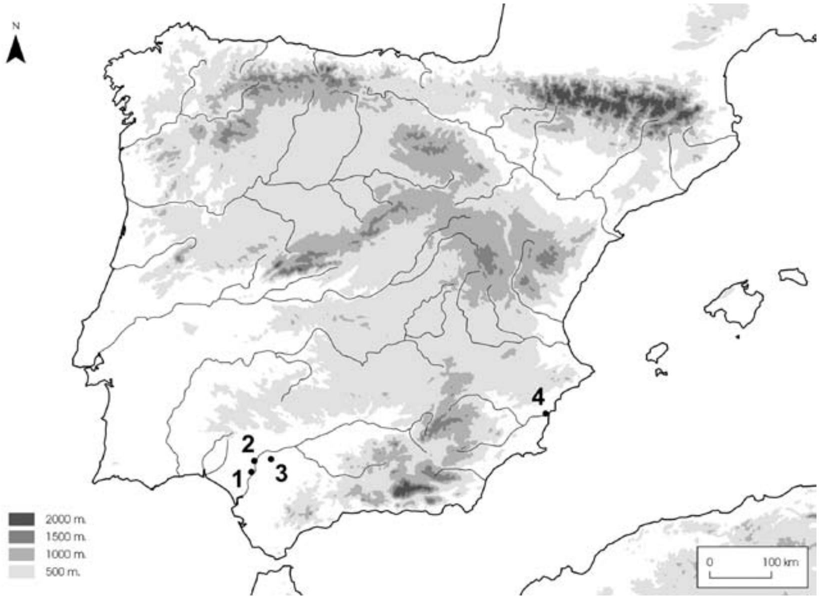

Figure 1: Location of the archaeological sites discussed in this work. 1-Cerro de San Juan, 2-Carambolo, 3-Saltillo and 4-El Oral. Adapted from Esteban & Escacena (2013).

held clinometer, a portable theodolite, a global positioning device (GPS) and a digital camera. The methodology used in the data collection is described in detail in Esteban & Moret (2006), and summarized briefly below.

The GPS was used to obtain the geographic coordinates of the sites, as well as for timing the measurements of the position of the solar disc to correct for the zero level of the horizontal angles provided by the theodolite. This was made centering the solar disk in the reticle of the viewfinder of the theodolite several times (usually three) during each visit to the site. We also used this instrument for measuring the azimuth and height of the topographic features on the horizon around the sites, keeping in mind that the instrument's accuracy is 0.045° sexagesimal for both axes. Height measurements were corrected for the atmospheric refraction effect near the horizon. The orientation of the buildings was measured with a precision compass, which provides an uncertainty of about 1°. The magnetic declination was determined by comparing the horizontal angle given by the compass with (a) the azimuths provided by the theodolite for different topographic features; or (b) the azimuths of the lines conecting the sites with those topographic features on detailed maps of the Servicio Geográfico del Ejército or the Instituto Geográfico Nacional at scales of 1:50,000 or 1:100,000.

Sanctuaries of the Lower Guadalquivir Valley

Most of the temples studied in this paper are located in the lower Guadalquivir Valley and belong to the present-day province of Sevilla: Cerro de San Juan (Coria del Río), El Carambolo (Camas) and Saltillo (Carmona). The geography of this area was very different in the first millenium BC. In fact, the present-day marsh lands at the south of the city of Seville once formed part of the wide estuary of the Guadalquivir River, the ancient *Lacus Ligustinus* (see Arteaga et al. 1995). Two of the sites studied here, Cerro de San Juan and El Carambolo, were located in coastal settlements at the top of hills and near the mouth of a river, as this was the common location chosen for Phoenician colonies in the Western Mediterranean (Aubet 1987: 257).

The archaeological work in Cerro de San Juan, a hillock on which stood the old town of *Caura*, has revealed that the settlement of the first millennium BC included a small Phoenician community (Escacena 2001). At the top of the hill, Escacena & Izquierdo (2001) found the remains of a sacred building showing the superposition of five structures with similar design, which suggests that they all had the same function. From the oldest (I) to the latest (V) phase there were some changes, but not significant enough as to make one think the site had been abandoned as a place of worship. The structure that shows more clearly its ritual function corresponds to phase III of the sanctuary, dated to the seventh century BC. It has a red soil, a mud bench attached and parallel to the perimeter wall of the temple and an altar in the center with a bull hide shape (see Fig. 2). These altars are relatively common in Spanish Protohistory as well as in other places of the Mediterranean and are also known as 'Cyprus ingot'. During the Bronze Age, the representations of the 'Ingot God' – an armed god standing on a ingot shaped like a bull-hide – were rather usual in Cyprus.

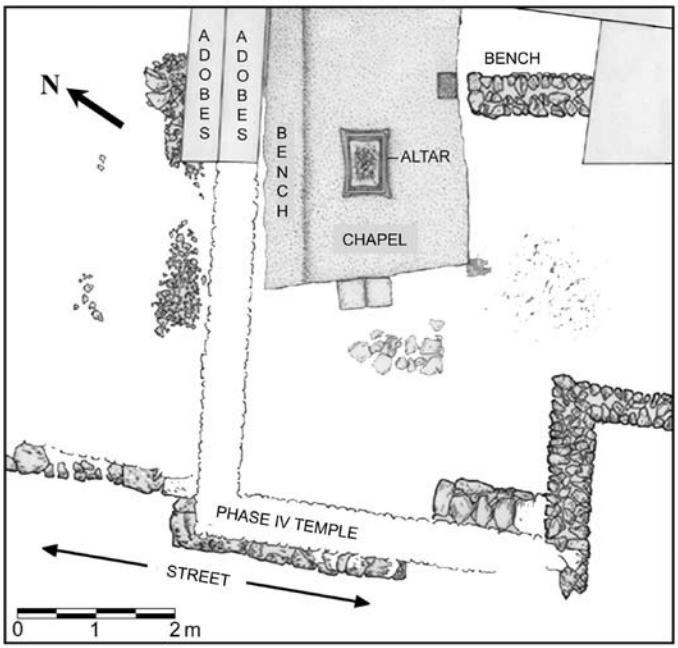

Figure 2: Plan of the phases III and IV of the sanctuary of Cerro de San Juan and its different architectural elements. Adapted from Esteban & Escacena (2013).

The sanctuary of Cerro de San Juan was an open area enclosed by a wall. It could have its main entrance at the east facade, but there are some indications of a second entrance in the western side. The orientation of the longitudinal axis of the altar of the phase III seems to be the same as the first building (phase I). The different phases of the temple construction exhibit a slightly different orientation perhaps due to the limitations imposed by the topographic and urban development of the religious complex inside the settlement. The bull-hide-shaped altar has a protuberance at its east side with a cavity for placing an offering and/or blood of the sacrificial victim. In addition, also in this area, but outside the altar proper, a circle of dark earth was found and interpreted as the *asherah* or sacred tree (Escacena & Izquierdo 2001: 134). So the eastern flank can be considered the most important area of the altar from a ritual and symbolic standpoint. In order to protect the remains of the sanctuary of Cerro de San Juan, they were reburied after their excavation in 1997-98. Therefore, our work on the site was limited to measuring modern architectural elements that were also present in the detailed plans of the excavation and estimating the orientations of the relevant archaeological remains with respect to those modern features. The estimated error for the measurements of the orientation of the modern walls is 1°. Considering the eastern direction as the relevant one, we find that the major axis of phase III and the original temple of phase I show an azimuth of 55.5° ± 2° (Fig. 2). According to archaeological evidence, the view of the eastern horizon was obstructed by other adjacent buildings at the time of construction of the phase III. By contrast, the western horizon was more likely to be clear, which is true even today. In any case, the distant horizon is very flat around the site (h = 0°).

Since 2002, archaeological fieldwork carried out on the top of the hillock of El Carambolo has confirmed the clear presence of Phoenician archaeological and religious elements at the site (Fernández Flores & Rodríguez Azogue 2007). The finding of a bronze statuette of Astarte indicated the possible consecration of the temple to this Phoenician goddess (Blanco Freijeiro 1968: note 5). The first building – dated to the ninth century BC – began as a humble rectangular structure divided into three spaces: an entrance courtyard, room A-29, and two roofed rooms at the back, A-45 and A-46 (see Fig. 3). The gate of the building was located on the eastern side. In the later phases, this original building was converted into the central backyard of a large complex. To the north of the backyard there is a chapel – room A-1 – with benches against the longitudinal walls that has been interpreted as a chapel dedicated to Astarte. But the best conserved chapel – room A-40 – is located to the south of the central backyard. This space has been interpreted as a chapel dedicated to a male deity (Baal/Melqart) and a large bull-hide-shaped altar was found on the floor, in the center of this room.

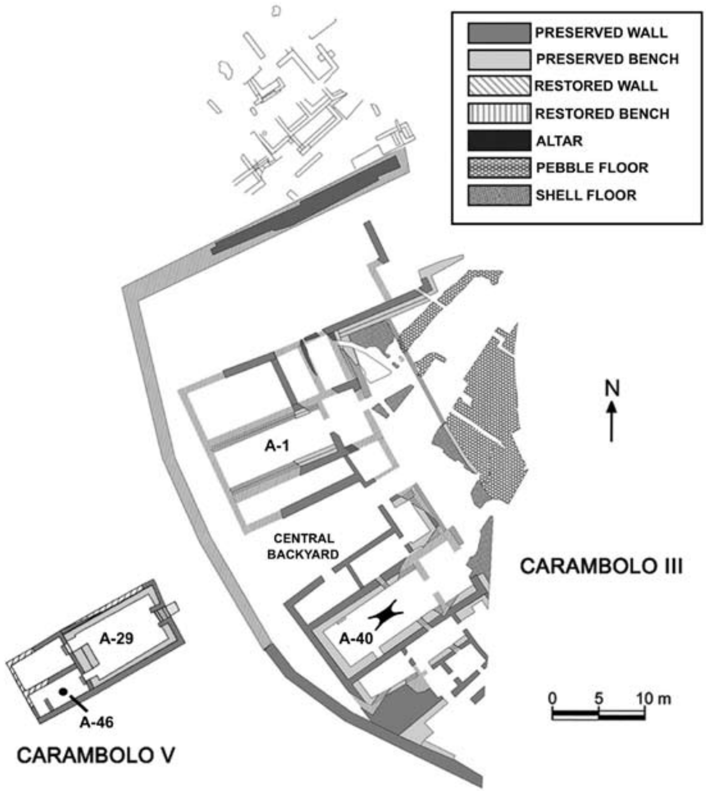

Figure 3: Plans of the phases III and V of the sanctuary of El Carambolo. The original building (Carambolo V) is beneath the area later turned into a central backyard in Carambolo III phase.

We measured several chapels at El Carambolo before they were reburied at the completion of the excavation process. The fieldwork focused on taking the orientation of the most important rooms: A-40, containing the bull-hide-shaped altar, A-29 and A-46. Room A-46 is in the back of the yard A-29, and it is interpreted as a chapel for the male deity Baal/Melqart pertaining to this phase of the sanctuary construction, while attached to it on the north, poorly preserved but supposedly parallel to it, A-45 would be the location of the sanctuary dedicated to Astarte. The orientation of A-45 and A-46 should be considered as the one representing the orientation of the original sanctuary. In El Carambolo, we chose eastward orientations because (a) the entrances of all the chapels are in this side and (b) a hole for the *asherah* is located at the east of the altar of A-40. In the case of the original temple, chapels A-45 and A-46 are oriented to an azimuth of 59°, while the yard A-29 points slightly to the north: 55.8°. All angles above have an associated uncertainty of about 1°. The walls of A-40, as well as the main axis of the altar, are oriented to

54.6°, with a standard deviation of 2°. Finally, the orientation of chapel A-1 (estimated from aerial photographs of the complex) is 63.5°. The geoarchaeological report of the site indicates that the sanctuary was not at the exact top of the hill in Tartessian times (Borja 2010: 197-200). In fact, toward the east, the true horizon had a height of about $h \approx 2°$ as seen from the chapels.

The temple of Saltillo (see Fig. 4) was found under the buildings of the modern city of Carmona. We can distinguish three different phases of construction between the second half of the seventh to the mid of fifth century BC. The archaeological findings indicate that this site was a place of worship of a Phoenician community (Belén 2000). Since the temple was reburied after excavation, our fieldwork was limited to measuring the azimuths of the walls of modern constructions represented in the detailed maps from the excavation and inferring the orientation of the ancient buildings. The entrance of the temple was not found during the excavation of the site, but its major axis shows an azimuth of 53.5° ± 2.0°.

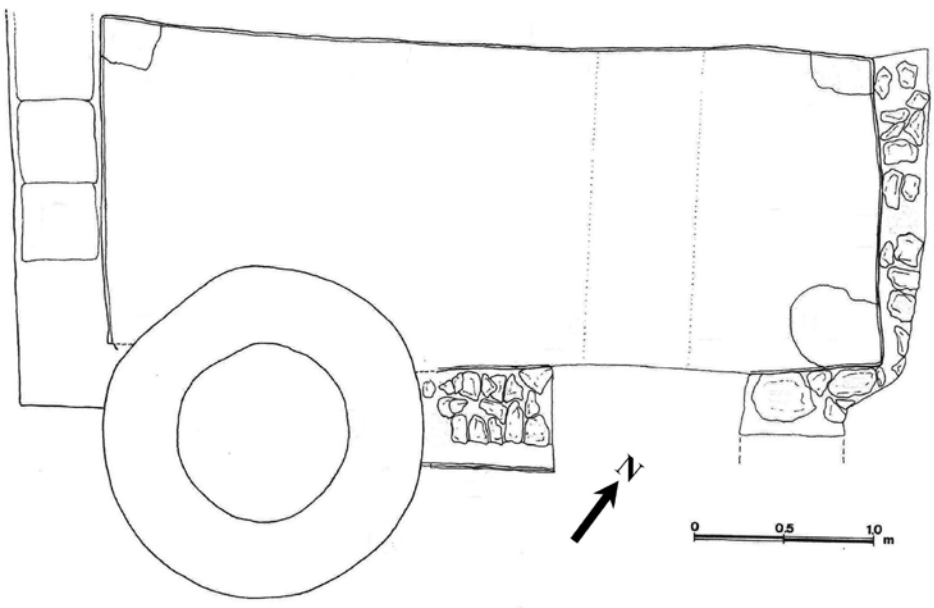

Figure 4: Plan of the temple of Saltillo.

The Iberian Temple at El Oral

El Oral is one of the earliest settlements of the Iberian culture found in southeastern Spain. It is dated to the first half of the fifth century BC (Abad & Sala 1993: 239). Numerous architectural details found in El Oral show close links with Mediterranean building traditions, which, in turn, can be directly related to the Phoenician and Punic world (Sala & Abad 2006: 25). The room named IIIJ1, located at the centre of this coastal settlement, has been interpreted as a temple (see Fig. 5). We decided to include this building in our sample because it contains a bull-hide-shaped altar similar to that of Carambolo. The temple has two entrances, one in the east and another in the west side. Assuming again eastward orientations, our measurements revealed that the major axis of the building points to an azimuth of 54.4° ± 1.0° and h = 0.4° over a nearby featureless hill located between the site and the sea.

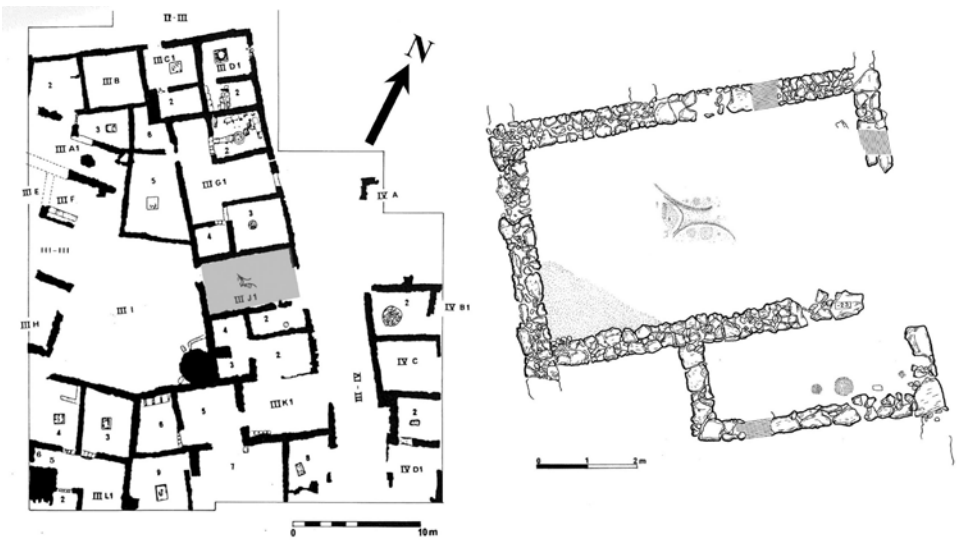

Figure 5: Left: general plan of the sector III of the Iberian settlement of El Oral. The grey area corresponds to room IIIJ1, the sanctuary. Right: detailed plan of room IIIJ1. Both plans are adapted from figures 40 and 139 of Abad & Sala (1993). Figure reproduced from Esteban & Escacena (2013).

The analysis of the horizon visible from El Oral provided interesting results in the western direction for the long walls of the building IIIJ1 point exactly towards a conspicuous topographic feature (Fig. 6), which corresponds to the summit of the Sierra de Pujálvarez, at a distance of about 30 km.

Figure 6: Part of the western horizon seen from room IIIJ1 of El Oral. The white arrow indicates the orientation of the south wall of IIIJ1, which coincides with the position of a distant peak. The box on the top right shows an enlargment of the horizon around the peak, the black arrow indicates the path of the setting of Venus at its maximum southerly extreme position (VSMSE). The black triangle indicates the point where sunset at winter solstice takes place. Figure reproduced from Esteban & Escacena (2013).

Discussion: The 55° Family

In Table 1 we show a summary of the results of this paper. The different columns include the site name, elements studied (altars and other architectural structures), direction considered for the orientations (eastward or westward, i.e. risings or settings), azimuth and height of the location on the horizon to which the element is pointing, the corresponding declination and the astronomical event that fits such orientation. We have only considered possible linkages to the Sun, Moon and Venus, the brightest celestial bodies visible to the naked eye and those that a priori might have had more symbolic importance.

Table 1: Orientations of the temples.

Sanctuary	Element	Horizon	Azimuth (°)	Height (°)	Declination (°)	Astronomical Event[a]
Cerro San Juan	Altar and original temple	East	55.5 ± 2.0	0	+26.4 ± 1.5	MRNMS?, VRMNE?
		West	235.5 ± 2.0	0	–27.2 ± 1.5	VSMSE
	Temple phase IV	East	62.0 ± 2.5	0	+21.6 ± 2.0	SRSS?
		West	242.0 ± 2.5	0	–22.3 ± 2.0	SSWS
Carambolo	A-29	East	55.8 ± 1.0	0	+26.2 ± 1.0	
				2	+27.7 _ 1.7	MRNMS
		West	235.8 ± 1.0	0	–26.9 ± 1.0	VSMSE
	A-46	East	58.8 ± 1.0	0	+24.0 ± 1.0	SRSS, VRMNE
				2	+25.5 _ 1.7	SRSS? VRMNE
		West	238.8 ± 1.0	0	–24.7 ± 1.0	SSWS
	A-40	East	54.6 ± 2.0	0	+27.0 ± 1.5	MRNMS
				2	+28.5 _ 2.2	MRNMS
		West	234.6 ± 2.0	0	–27.7 ± 1.5	VSMSE, MSSMS?
	A-1	East	63.5 ± 2.0	0	+20.4 ± 1.5	
				2	+21.8 _ 2.2	SRSS
		West	243.5 ± 2.0	0	–21.1 ± 1.5	
Saltillo	Temple	East	53.5 ± 2.0	0	+27.8 ± 1.5	MRNMS
		West	233.5 ± 2.0	0	–28.5 ± 1.5	MSSMS, VSMSE?
El Oral	Room IIIJ1	East	54.4 ± 1.0	0.4	+27.2 ± 0.6	MRNMS?
		West	234.4 ± 1.0	0.7	–27.1 ± 0.6	VSMSE

Notes:
[a]Events with question marks are marginally consistent with the given declination.
Acronym list and declinations of astronomical events between the ninth and fifth century BC:
SRSS – SunRise at Summer Solstice ($\delta = +23°.7$).
SSWS – SunSet at Winter Solstice ($\delta = -23°.7$).
MRNMS – MoonRise at Northern Major Standstill ($\delta = +28°.2$).
MSSMS – MoonSet at Southern Major Standstill ($\delta = -29°.7$).
VRMNE – Venus Rising at Maximum Northerly Extreme ($\delta = +24°.6$).
VSMSE – Venus Setting at Maximum Southerly Extreme ($\delta = -26°.5$).

Our most remarkable result is that the orientations of four religious buildings studied in this work (the altar and original temple of Cerro de San Juan, chapel A-40 of El Carambolo, temple of Saltillo and room IIIJ1 of El Oral) are identical within the uncertainties, showing and azimuth of about 55°. Undoubtedly, this finding suggests a well-defined orientation pattern that we will call the '55° family'.

As we can see in Table 1, to the east, the sanctuary of Cerro de San Juan is oriented slightly south of the moonrise at the northern major standstill (MRNMS) but also slightly north of the rising of Venus at its maximum northerly extreme position (VRMNE). On the contrary, if we consider the west as the relevant direction, then the relationship is more accurate and possibily linked to the setting of Venus at its maximum southerly extreme position (VSMSE). The temple of the later phase IV of Cerro de San Juan is oriented to the sunrise at the summer solstice (SRSS) when we consider the eastern horizon but to sunset at the winter solstice (SSWS) – with higher precission – westward. As we can see, in Cerro de San Juan, the astronomical orientations are more precise when considering the settings as the relevant phenomena: the altar and original temple facing the setting of Venus at its southernmost position (VSMSE) and the later temple (phase IV) oriented to the sunset at winter solstice (SSWS). If the precise orientation of the buildings was really a relevant aspect of their design**,** this result would suggest a possible evolution of the astronomical orientation (and perhaps the ritual) in the sanctuary: Venus initially and then the Sun.

For El Carambolo, we have also considered the eastward and westward directions. Eastwardly, we consider two values for height: a) $h = 0°$, assuming risings on the distant horizon, which is basically flat, and b) risings on the summit of the hill, with $h \approx 2°$. Eastwardly, A-46, which indicates the orientation of the original sanctuary, points toward the sunrise at the summer solstice (SRSS) and/or Venus at its maximum northerly extreme position (VRMNE) for both values of height (less precise to the SRSS in the case of $h \approx 2°$). Westwardly, the building would look to the sunset at winter solstice (SSWS). Looking to the east, chapel A-40 along with its bull-hide-shaped altar shows an orientation consistent with the moonrise at the northern major standstill (MRNMS) independently of the height of the horizon considered. However, westwardly, the relation with the moonset at southern major standstill (MSSMS) becomes marginal, but more precise with Venus at the VSMSE. The last chapel, A-1, shows an astronomical relation only eastward and when considering $h \approx 2°$ to the sunrise at the summer solstice (SRSS).

The building of Saltillo is oriented towards the moonrise at the northern major standstill (MRNMS) eastwardly but to the moonset at southern major standstill (MSSMS) and/or to the VSMSE – with lower precission – westwardly.

Finally, to the east, room IIIJ1 of El Oral is only marginally oriented to the moonrise at the northern major standstill (MRNMS). However, to the west, the orientation is more precise with the setting of Venus at its southernmost position (VSMSE). It is very striking that the point on the horizon toward which the temple is oriented – and where the VSMSE takes place – is the aforementioned conspicuous mountain (Fig. 6).

Escacena (2009) has proposed that the orientations of the bull-hide-shaped altars of Cerro de San Juan and El Carambolo are only approximate and, therefore, symbolic in nature. According to that author, they were used in annual rituals associated with the cycle of dying and resurrection of the god Baal at the summer solstice sunrise, a deity that would represent the solar disc, which dies and is resurrected on the third day. Its 'death' would correspond to the stand still of the solar declination at the solstices and its 'resurrection' to the recovery of its daily variation of declination on the third day after the solstice. This interpretaion would be in accordance with the celebration of annual festivities based on a solar calendar in the sanctuaries and the importance of eastward orientations. Very recently, Polcaro et al. (2013, this volume) studied the orientation of the Bronze Age temple of Pella (Jordan) dedicated to the god Baal, finding that it faces summer solstice sunrise, a result which they also interpret in the light of the rituals of the dying god Baal.

Alternatively to the aforementioned solar hypothesis based on the interpretation of the orientations as aproximate and symbolic, there is the fact that four similar temples with common elements share the same orientation within the uncertainties – the 55° family. This suggests that precision was important in the design of the buildings. Another open issue is the prominence of eastward or westward orientations. There are several reasons that favor eastward orientations: (a) the presence of distinctive features in the eastern sides of the altars of Cerro de San Juan and El Carambolo (receptacles for libations and holes for the *asherah*), and (b) the fact that the entrances of the chapels of the best excavated site (El Carambolo) are at the east sides. Centering our attention on precise eastward orientations, the results gathered in Table 1 suggest that the prominence of lunar aspects helps to explain the 55° family, in particular, the moonrise at the northern major standstill (MRNMS). It is well known that Canaanite religion had celebrations associated with the Moon, although its cycles were mostly used to sort the months and to inaugurate the official year (Del Olmo 1995: 282), which coincided with the opening of the agricultural year during the October Moon (Stieglitz 2000: 695). However, the long duration of the cycle of regression of lunar nodes does not correlate with what we know about the Phoenician liturgy, which is of much shorter periodicity.

Considering now westward orientations, it is clear that the 55° family should be connected with the the setting of Venus at its maximum southerly extreme position (VSMSE). Westward orientations would be favored if we consider: (a) that only the western horizon was clear enough to permit – in principle – celestial observations in Cerro de San Juan and settings on the distant horizon in the case of El Carambolo, and (b) the room IIIJ1 of El Oral shows a marker of the VSMSE on the distant horizon. Attending to the excellent description of the cycle of visibility of Venus by Šprajc (1996: 17-29, 139-153), the maximum southerly extreme position of this planet occurs every eight years, between October 29 and November 6 in 81% of the cases during the last four milennia (Šprajc 2013), and its setting takes place just a few degrees south from the winter solstice sunset. Unfortunately, as in the case of the Moon, the periodicity of the cycle of visibility of Venus is difficult to relate to what we know about the Phoenician liturgy.

The relation of the temples of the 55° family with Venus has some additional support considering the aforementioned finding of a bronze figurine of Astarte at El Carambolo. As it is well know, Astarte was the Phoenician goddess of nature, life and fertility, as well as the companion of the god Baal. She had strong celestial attributes, represented by a star symbol and identified with the planet Venus. Several ancient written sources refer to places and temples dedicated to Venus/Aphrodite on the coast of the Iberian Peninsula, sites that have traditionally been linked with Astarte (Pérez López 1998). Strabo (III 1, 9) refers to the existence of a temple dedicated to *Phosphoros* – the carrier of light – at the mouth of the Guadalquivir river. Strabo also uses the Latin epithet *lux dubia* – dubious light or twilight – to describe *Phosphoros*, while many authors have linked *Phosphoros* with Astarte, then assimilated to the Roman Venus and personified in the eponymous planet (Tovar 1962: 814).

As we have discussed, there are several hypotheses we might utilize to interpret our results, however, they are not necessarily mutually exclusive. Although the uniform orientation of the 55° family can be better explained with the Venus hypothesis, the finding of orientations related to the sunrise or sunset at solstices (phase IV temple of Cerro de San Juan or the original temple A-46 and chapel A-1 of El Carambolo) suggest the possibility of double Sun/Venus rituals. In fact, this has already been suggested by Escacena (2010: 111), who has examined the importance of the worship to the god Baal/Melqart and the feminine deity Astarte, Phoenician personifications of the celestial couple formed by pairing the Sun and Venus. At El Carambolo, this dual worship would have been reflected in the existence of two chapels used simultaneously at the different stages in the ritual life of the sanctuary (Fernández Flores & Rodríguez Azogue 2007: 228-229) and with different orientations.

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Employing 3-Dimensional Computer Simulation to Examine the Celestial Dating of Scottish Megalithic Sites

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Abstract
The initial progress of the research of applying the combined disciplines of: Geographic Information Systems (GIS), computerized 3-Dimensional modelling, and astronomical formulae (Meeus 1998; Chapront-Touze 1991; Bretagnon 1986) to Scottish Megalithic stone rows was presented at the 2010 SEAC Munich conference. The current phase of the inductive-deductive approach has come to an end, and new hypotheses have been derived as to astronomical orientations of the stone rows under investigation. The accepted viewing perspective from only along the face of the stones has been expanded to include observations orthogonal to the stone faces; whereby the phenomena of rising and setting of Sun, Moon and stars across the deliberately shaped stone tops that form false horizons, have been exposed. Self-indicated positions as to where to stand to witness the phenomena are some of the examples to be presented in this brief summary which reinforces the deduced hypotheses of stellar events at Ballochroy, and the false horizon of slanting stone tops, at both Dunamuck and Nether Largie initially presented in Munich (Fisher, in preparation). The simulations also enables one to deduce that a viable construction date 800 years earlier than previous research estimates, revising the construction date to circa 2500 BCE.

KEYWORDS: megaliths, dating, orientation, 3-dimension, simulation

POVZETEK
Začetni izsledki raziskav na škotskih megalitskih vrstah kamnov, pri katerih smo kombinirali geografske informacijske sisteme (GIS), računalniško tri-dimenzionalno modeliranje ter astronomske enačbe (Meeus 1998; Chapront-Touze 1991; Bretagnon 1986), so bili predstavljeni že leta 2010 na SEAC konferenci v Münchnu. Trenutno zaključujemo induktivno-deduktivno fazo; za proučevane vrste kamnov smo postavili nove hipoteze astronomskih orientacij. Splošno sprejeto perspektivo gledanja vzdolž sprednje strani kamnov smo razširili tako, da smo vključili smer, pravokotno nanjo; pri tem smo odkrili, da Sonce, Luna in zvezde vzhajajo ali zahajajo nad umetnim horizontom, ki ga tvorijo namensko oblikovani vrhovi kamnov. Pozicije, na katerih je treba stati, da opazimo navedene pojave, so samoumevne – nekaj jih navajamo v tem članku, v katerem podkrepimo

tudi nekatere hipoteze, predstavljene že v Münchnu (Fisher, v pripravi): o zvezdnih pojavih pri Ballochroyu ter o nagnjenih vrhov kamnov pri Dunamucku in Nether Largieju. Simulacije omogočajo tudi to, da verjetni datum izgradnje kamnov prestavimo za 800 let pred prejšnji predpostavljeni datum, torej okoli leta 2500 pr.n.št.

KLJUČNE BESEDE: megaliti, datiranje, orientacije, tri dimenzije, simulacija

Shaping the Stones

Two facets of what appears to be deliberate shaping of the stone tops have been revealed from this research, i) shaping of the stone tops to imitate the distant horizon and ii) shaping to create a false, sloping horizon, along which the Sun, Moon or stars are observed to ascend or descend the slope, at a selected time of the year.

Figure 1: Carnasserie Northern Stone Top Mirrors the Distant Hill.

In the first instance, that of shaping the stone top to match the distant horizon, the site at Carnasserie, comprising of a pair of stones, is an excellent example. By examining the photograph in figure 1, the top of the northern most stone, when viewed from the western side, is shaped to reflect the exact contour of the hill in the distance, this shaping includes the incorporation into the centre of the stone's top a depression or 'notch' that replicates the same 'notch' in the matching position in the peak of the distant hill. The land to the west of the stone, slopes up and away from the stone, enabling the viewer to position them self to facilitate the 'marrying' of the stone top with that of the hill including aligning the notches; Mackie (1974: 171) expresses this approach to witnessing the selected phenomena as, self-indicating or inferred. At the time of summer solstice sunrise, between 3500 BCE and 2200 BCE, the Sun could have been seen to rise from both the notch in the stone and the hilltop, see computer simulation image in figure 2. In order to illustrate the orientation of stone with hill, the viewpoint in figure 2 has been offset slightly.

Figure 2: Carnasserie 3500 BCE Summer Solstice Sunrise.

Dunamuck I

The site at Dunamuck farm combines both the shaping of a stone top to replicate that of the horizon, and the second instance as stated above, that of creating a false horizon. The shaping of the stone top to the horizon, performs the same indicator as occurs at Carnasserie, that is, by aligning the shape of the top with that of the horizon causes the observer to be positioned correctly, again self-indicating. This site however, was arranged so a second stone in the configuration is the stone upon which the phenomenon is observed. The second stone has a top that slopes, and at the time of the summer solstice sunrise (again within the date range of 3500 BCE to 2200 BCE), the Sun ascends along the sloping top of this second stone. Figure 3 illustrates this arrangement; the stone to the left in the image is made semi-transparent to demonstrate how the top is shaped to match the horizon. A number of other sites have a similar pairing of flat and slanting tops, further research is needed to determine if these other sites are designed with analogous properties.

Figure 3: Dunamuck I Summer Solstice Sunrise 3500 BCE.

Stellar events

Dunamuck II

The second arrangement of stones at Dunamuck comprised of 1 fallen and 2 standing megaliths (a second stone has fallen since the initial survey). The centre, fallen stone, was sufficiently exposed to enable the recording of its dimensions, and the determination of the most probable upright position for the stone. Modelling the arrangement with 3 upright stones presented an arrangement with two almost identical sloping tops. To record either lunar or solar events, only one sloping top would be required; the investigation into why there were two sloping tops uncovered the potential for a stellar-solar association.

Figure 4 illustrates the interrogation findings. At the time of the vernal equinox the heliacal setting of Aldebaran, rides down the sloping top of the larger stone to the left of the image, whilst The Pleiades rides down the slope of the centre stone. As the stars 'fall' off the end of their respective sloping tops, twilight turns to dawn, as the equinoctial Sun rises above the horizon. Moving to the western side of the stones the Sun can also be seen to rise along the slopes.

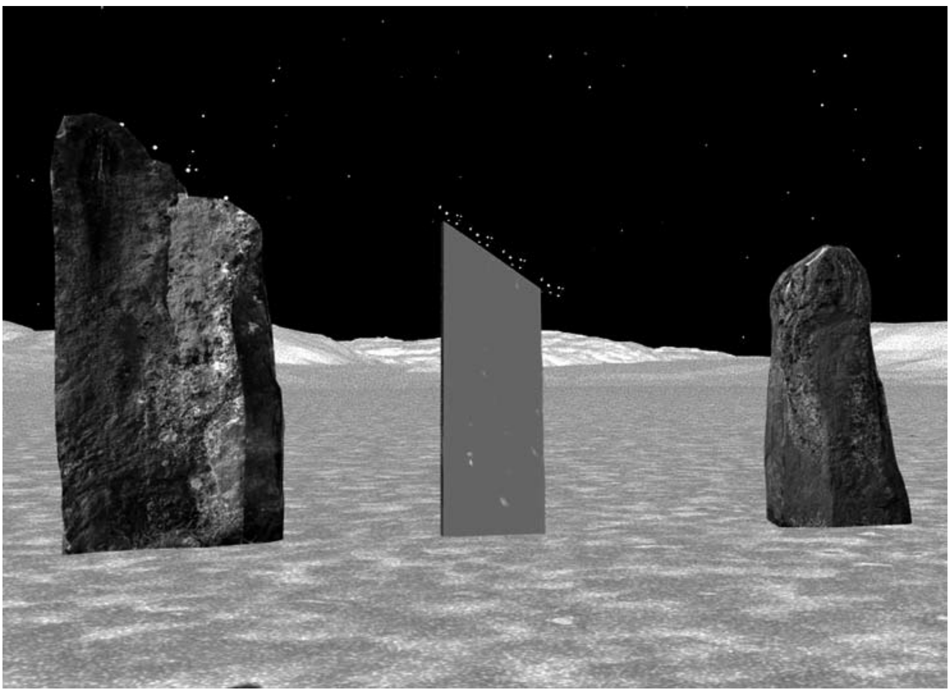

Figure 4: Heliacal Setting of Aldebaran and The Pleiades at Dunamuck.

Sun and Hill

The menhir at Tiraghoil, on the island of Mull, was designated ethnocentrically by Rev McLauchlan (1863: 49) as a pilgrimage marker between Iona and the bishopric at Inverness. This stone does not possess a slanting top as exampled above, but rather it possesses a somewhat rounded top. The simulations provide two solar-hill orientations across the top of the stone; in a similar manner to that illustrated at the 2010 SEAC conference for the site at Ballochory, whereby the top of the centre stone is oriented to the central peak of the Paps of Jura. One of the Tiraghoil orientations is a pronounced hill-stone-Sun combination, marking the summer solstice sunrise, see figure 5, the other more circumspect orientation, is to a diminutive bump in the horizon for the winter solstice sunrise.

Eight of the twelve sites investigated that indicated solar orientations, demonstrated that all observations are in relation to the stone's top, be that top sloping or somewhat pointed! Initially, one of those solar orientations was found not to be associated with a hill! Although not all sites are presented in detail here in this paper (the other sites being Escart, Brainport Bay, and Ballochroy), the Sun is either appearing out of, or sinking into, the top of a hill. The one solar oriented site that caused the initial deviation, having not indicated an association with a hill, was that of Dunamuck I as the interrogation was focused on the shaping of the stone tops. In revisiting the modelling software for the site, the coloration of the landscape to the north east was modified to distinguish it from the landmass nearby. This modification exposed a hill within the nearby topology that previously blended into the distant landmass in the original interrogation. This exposed hill is where the solstice Sun could be considered to rise, see Figure 3.

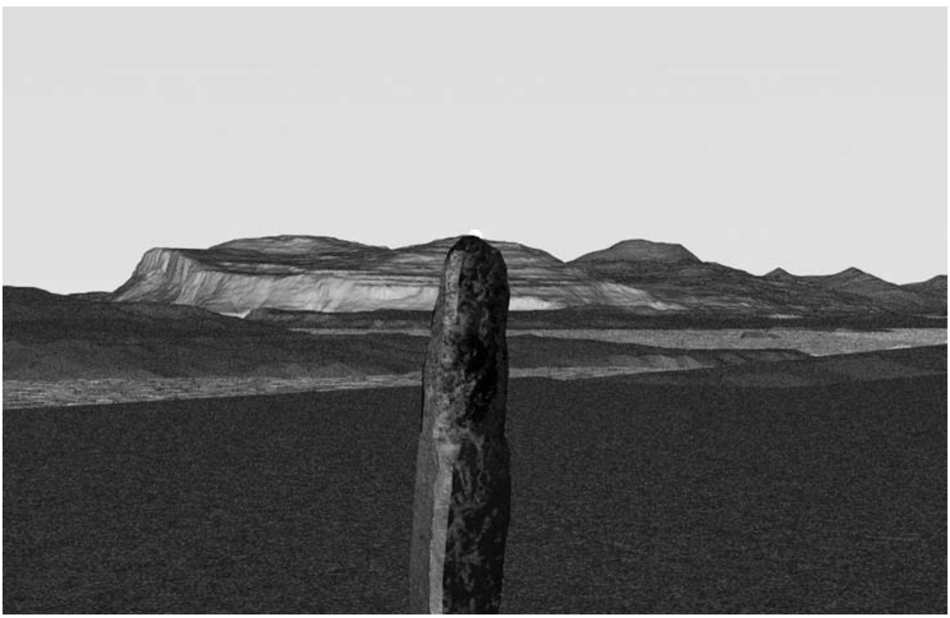

Figure 5: Summer Solstice Sunrise at Tiraghoil.

Kintraw

Thom (1978: 38) hypothesised that the menhir of Kintraw commemorates the green flash of the Sun being visible in the Col between the Paps of Jura, as it sets at the time of the winter solstice. Much discussion and investigation has transpired as to whether or not this event did indeed occur as Thom suggests in 1800 BCE, examples being, McCreary (1982: 183-190), Krupp (1983: 36), Wood (1980: 85-90) and Ruggles (1999: 25-29). The association of Sun with the Col is counter to the hypothesis posited in the previous discussion of the Sun-hill relationship. The employment of the Ordnance Survey of Great Britain Digital terrain models (DTM's) employed in the simulations, brought to light that the isle of Islay with its own 450 meter peaks, lies directly between Jura and the Sun at the time of the winter solstice, the Islay peaks being a natural barrier to the event as well as causing atmospheric disturbance; where a stable atmosphere is more suitable for Thom's

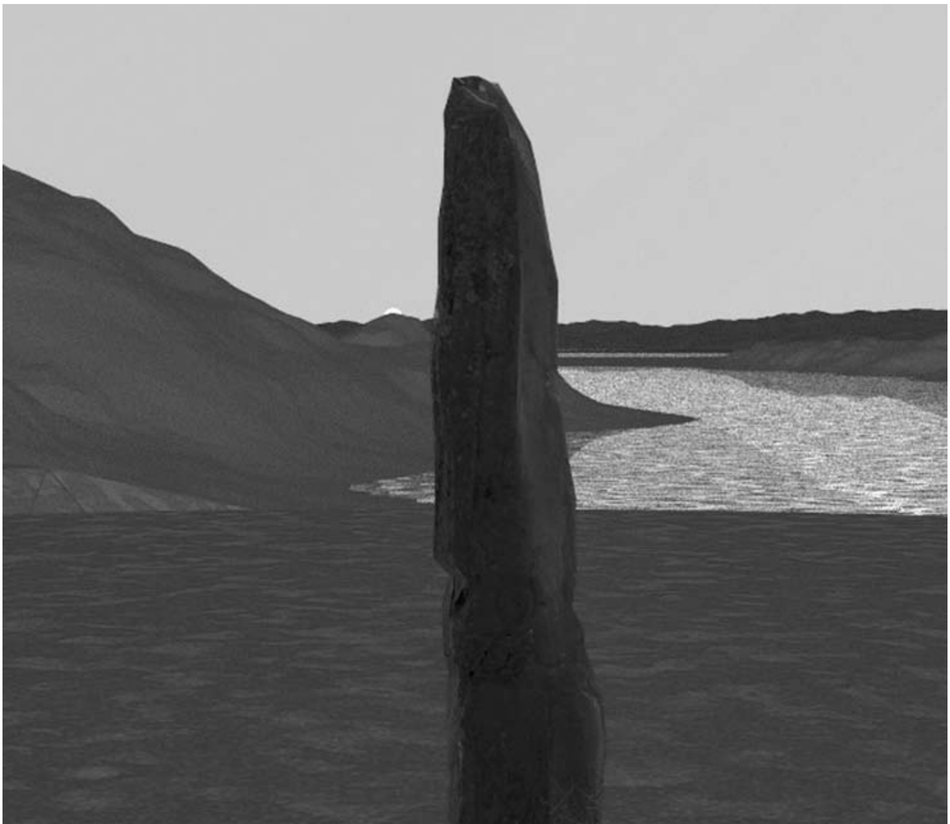

Figure 6: Kintraw Winter Solstice Sunset 2600 BCE.

hypothesis. However, with the obvious importance placed in the Neolithic to the Kintraw site itself, by the construction of multiple cairns and the erecting of the menhir itself, what, if any, celestial event could be associated with the location?

Foliage, in the form of pine trees, has obscured the landscape for previous investigators of the site for the past 40 years. The simulations conducted for the site is able to eliminate the foliage with the result that a knoll on the mainland becomes exposed, behind which the winter solstice Sun sets, see figure 6. Although observable from the location of the menhir no orientation could be associated with the stone itself. In fact the vista is best observed from the viewing station investigated by MacKie (1974: 181), which is located across the gorge that runs to the north of the area upon which the menhir stands. Depending on whether the viewing station or the platform upon which the menhir and cairns stand came first would place the construction of the viewing station prior to the Kintraw collection. This possibly suggests migration from the viewing station to the platform as the Suns declination changed over time. The results of the 3-D simulations reinforce the Sun-hill relationship.

Lunar Associations

New lunar orientations at Ballochroy and Nether Largie were presented in the 2010 SEAC paper (Fisher, in preparation). Two of the sites that were investigated which expand upon the potential for lunar orientations are those of Tiraghoil on Mull and An Car in Argyll. As well as the theorized sunrise orientation provided above, the simulations for the menhir at Tiraghoil, generated two moonrise orientations along two faces of the stone, 1 at the time of the northern major extreme, the other, the southern major extreme, see figure 7.

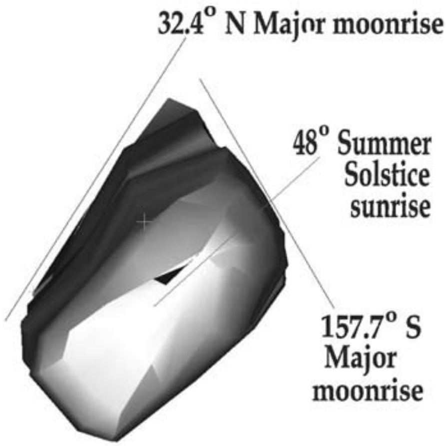

Figure 7: Tiraghoil Mull, Orientations.

The tall menhir at An Car, being the second site where lunar associations were found, sits in the next valley to the east of Nether Largie and leans to the north by 10º. Setting the stone to an upright position in the modelling software, the simulations exposed the four major extreme rising and setting horizon points of the Moon, and the southern minor moonset, figure 8. These orientations emulate those disclosed with the centre Stone at Nether Largie (Fisher, in preparation) notwithstanding the fact, that the horizons for the two sites are distinctly different.

One feature that rises from the research of these Scottish sites is the differentiation of lunar events from that of solar events as they relate to the stones. The demarcation for the Moon tends towards using a viewing perspective along the faces of the stones, whereas for the Sun it is the top of the stone that is used.

Why the Lunar Extremes?

One could consider the marking of the solstices as a calendrical requirement for the Neolithic, but with the 3-D simulations inducing 8 probable and 3 possible lunar orientations existing at Nether Largie, 3 probable orientations at An Car, plus 2 more at Tiraghoil, begs the question why mark the lunar extremes?

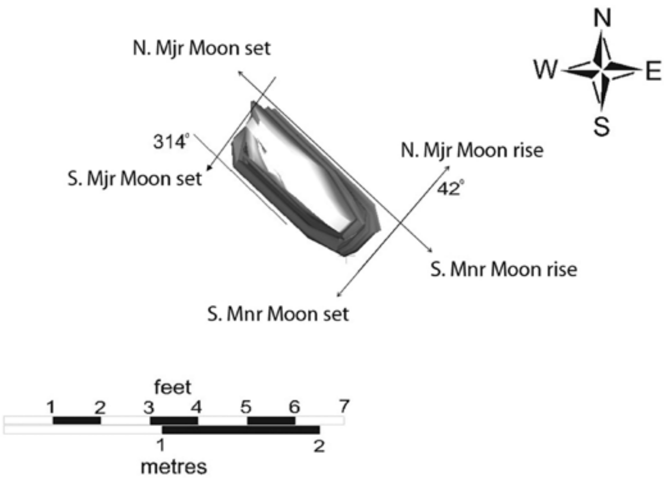

Figure 8: An Car Orientations.

Feasible Date Ranges

Conducting the investigation for the sites surveyed across a time span from 3500 BCE to 1500 BCE this method of 3-dimensional simulation enables a feasible construction date range for each individual site to be generated. In addition, for the sites that demonstrate similar date ranges, they may be considered as a local group. As such, a general construction date may be assessed for the group to circa 2500 BCE, see dashed line in the table below. This date, allows for a period for the event to be recognised, assimilated into social norms, requiring memorialising in stone; and finally, allowing for time for the sites to be functional. The table below also records that Ballochroy could not have functioned in 1770 BCE as Thom (1978: 37) conjectured as this research deduces that the sites are older than he originally hypothesised.

Table 1: Construction Date Assessment.

Site	3500	2500	1500	Means of dating
Ballochroy	3100	2200	1750	Stars, Solstices
Escart	3100	2200		Ballochroy, Sun
Nether Largie (NL)		2600 2200		Moon, cairn's archaeological record
Dunamuck		2600 2200		Stars, Sun, NL proximity
Kintraw		2600	1500	Sun
Ballymeanoch & An Car - Not possible to date by this method				
Brainport	3500	2300		Sun shadows
Carnasserie	3500	2500		Sun
Tiraghoil		2300	1800	Sun and Moon

Table 2 identifies the astronomical associations that may be comfortably hypothesised as they relate to the sites investigated. It can be seen from the table that there are twice as many major lunar extremes as there are minor extremes. This could be due to i) the greater difficulty in making such observations, as the Moon passes this points twice a month anyway, ii) that they were of less interest to the Neolithic, or iii) marker stones are missing from the sites. And yet, observations of the southern minor extreme were established. No evidence was found for the rising Moon at the time of the northern minor extreme, even at Nether Largie which could be assumed to be an extensive lunar observation site. Alternatively, as the northern and southern lunar extremes are only separated by 14 days, they could be treated as mirror images of each other, requiring only to mark one or the other, not necessarily both; thereby diminishing the need to mark the 'twin', other than reaffirmation of the first. This consideration would apply if the exact event is not the point of interest, only the seasonality, albeit the season only repeats itself every 18.6 years.

Only one site, Dunamuck is conjectured to have an equinoctial orientation and that is in conjunction with a proposed stellar observation. This could be due to a longer period of time required to associate the events through observation, which fits with the dating of the site as indicated in Table 1.

Table 2: Celestial Summary of Sites.

	Shaped Top	Solar						Lunar								Stellar
								Southern				Northern				
		Winter		Equinox		Summer		Mjr		Mnr		Mjr		Mnr		
Rise-Set		R	S	R	S	R	S	R	S	R	S	R	S	R	S	
Site																
An Car									Y	Y	Y	Y	Y			
Ballochroy	Y		Yh				YH		Y		Y				Y	Yrise
Ballymeanoch																
Brainport Bay			Zenith ?			Yh	?									
Carnasserie	Y						YH									
Dunamuck I	Y					YH										
Dunamuck II	Y			Y	Y	Yh										Yset
Escart			Yh													
Kintraw View Station			YH													
Nether Largie	YY6							Y Y	Y Y	Y ?	Y	Y Y6	YY ?		Y	
Tiraghoil						YH	Yh					Y	Y			
Torbhlaran	?															
KEY	**H**	Definite Hill association				**h**	possible hill association					**a**	artificial hill			
	Y	Shaped top view				**Y**	Stellar view					**?**	possible			

The last main observations from the Table 2 is i) the lack of winter solstice Sun rise, and ii) an even distribution of the setting Sun at both the winter and summer solstices; plus, the aforementioned association of Sun with hill.

Interpretations

There are several interpretations that may be derived from this computerised 3-D simulation research approach. First, as the date range can extend over a 900 year period, the archaeological dating of celestially oriented sites by the term *circa* is more appropriate than astronomical precision of ±50 years.

Considering the variation that atmospheric refraction may induce, plus a change in horizon altitude, for example from a sea level horizon to 2º of altitude refraction may range from ~35 to ~18 arcminutes (and that is without taking temperature variations into account). The 3 arcseconds of plate tectonic & isostatic shift, means that there is no need for archaeoastronomers to consider these land motions in computing celestial orientations at sites within the British Isles.

The singular megalith observations of solar and lunar events demonstrated through this modelling technique strongly supports Ruggles determination that only low-precision orientations exist (1999; 49-67). With the association of Sun-hill-megalith a directional indication by a stone's face need only be within ±1º with observations made at a distance from the stone. Likewise, when the slanting top of the stone is used to witness either the rising or setting of a celestial object, observations are made at a distance and, should the observers height vary, adjustment is automatic as it would require repositioning by a small amount closer or further away from the megalith to maintain the self-indicated position. Therefore, only low precision orientation between megalith and phenomenon being observed is required and Thom's level 3 and 4 orientation accuracies are unwarranted.

Although the hypotheses developed in this research (listed below) are supported by repeated results, only by combining similar investigations into other sites in the vicinity of Argyll with the results determined here, can a parsimonious evaluation be conducted as to any astronomical (or sky-lore) intent of the sites! There is one exception. The time period hypothesised need not depend on expanding the current research approach, but could be more solidly determined by archaeological excavation of the stones themselves, in order to reaffirm or refute the proposed construction dates. Particularly at Dunamuck and Ballochroy where the potential of stellar-solar association exists which is not demonstrated elsewhere; marking these megaliths as rare and precious sites, in need of greater protection.

The following list comprises of the evolving hypotheses exposed by this inductive-deductive approach.

1. An observational association of Sun with hill.
2. Self indicating positions as to where to stand to witness celestial phenomena.
3. The site investigations strongly indicate sites are older than Thom's (1978: 38) determination by 800 – 1000 years i.e. dating to the mid third millennium BCE - *circa* 2550.
4. Deliberately shaped stone tops to form false horizons employed to indicate the phenomena of the rising and setting of Sun, Moon and stars.
5. An orthogonal viewing perspective to the stone faces, as well as, viewing along their faces.

6. Observations of stars are a distinct possibility when linked to solar events.
7. Use of the stone faces as a directional indicator, are more associated with the Moon, whereas the tip of the megalith is associated with the Sun.

Whether the opportunity arises, or not, for the expansion of this research, three main points exist:

1. The date range adjustment is consistent across all sites.
2. The Sun-hill association is consistent where the solar sphere is the celestial object of interest (Ponting found such association at Callanish (1984: 52).
3. The shaped tops requiring an orthogonal viewing perspective not only adds the new dimension of creating a false horizon to witness the phenomena, but functions without a high-precision orientation.

With these points identified, the stones rows, and possibly circles, within Scotland and specifically those in the Argyll area, have to be reassessed as to their possible date of construction and function. This reassessment should impact not only the astronomical record, but as the date of construction is almost 1000 years earlier than previously considered the reassessment impacts upon the anthropological interpretation as well.

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New Evidence for Precise Lunar Alignments in Argyll, Scotland in the Early Bronze Age

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Abstract

In the 1960s and 70s Alexander Thom proposed the existence of precise alignments for the sun and moon circa 1700 BC. The proposal was contentious but the study was also open to criticism as it used sites selected from a wide area. Thom's results were reassessed by Clive Ruggles who concluded that the methodology used was flawed. By 1985 it was widely accepted that site selection could have caused inadvertent bias and that the alignments found could have been chance.

The present investigation[1] acknowledges the specific criticisms of Thom's work by choosing a limited region, considering only standing stones (but not circles), reporting on all sites in the region, and examining the likelihood of chance alignments occurring. Other matters related to alignments are discussed. The results demonstrate that planned precise lunar alignments occur in this region. This would seem to require a hierarchical society.

KEYWORDS: Precise lunar alignments, megalithic, Scotland

POVZETEK

V šestdesetih in sedemdesetih letih prejšnjega stoletja je Alexander Thom domneval obstoj natančnih poravnav s Soncem in z Luno okoli leta 1700 pr. n. št. Domneva je bila sporna, deležna pa je bila tudi kritik, saj je temeljila na najdiščih na zelo širokem območju. Njegove izsledke je ponovno ovrednotil Clive Ruggles, ki je pokazal, da je bila Thomova metodologija napačna. Do leta 1985 se je uveljavilo splošno mnenje, da je izbor najdišč morda povzročil nenamerno pristranost in da so bile ugotovljene poravnave lahko naključne.

V pričujoči raziskavi upoštevamo kritike Thomovega dela, tako da se omejimo na manjšo regijo, obravnavamo izključno stoječe kamne (ne pa krogov), poročamo o vseh najdiščih v regiji ter preučimo možnosti naključnih poravnav. Razpravljamo tudi o nekaterih drugih vidikih poravnav. Rezultati kažejo, da se v tej regiji pojavljajo namerne natančne poravnave z Luno, ki navajajo na obstoj hierarhične družbe.

KLJUČNE BESEDE: natančne poravnave z Luno, megalitski, Škotska

[1] Further information is available on the website http://www.lunarsites-scotland.net, where full results are given.

Introduction

This study endeavours to resolve whether, in the Early Bronze Age (EBA), long base line observations with horizon features were used to record key lunar positions. Many earlier Stone Age structures show an interest in the sun or moon. Passage grave entrances for the winter solstices and recumbent stone circles for the extreme southern moon are examples. These structures are generally not able to indicate a direction with a precision of better than 1^{o}.

The idea that some megalithic remains had been for astronomical purposes was suggested by Sir Norman Lockyer in 1906 (Heggie 1981: 179-82) and was popularised by Gerald Hawkins in *Stonehenge Decoded* (Hawkins 1965). Alexander Thom was the first to both propose and to give what he believed was evidence for precise lunar alignments[2] dated about 1700 BC. These were mainly sited in Scotland. His book *Megalithic Lunar Observatories* (Thom 1971) together with a number of papers (Thom and Thom 1980; Thom A.S. 1981**)** appeared to make a strong case for their existence. His belief was that the alignments were intentional and were not due to chance.

Heggie (1981: 170-79) after examining Thom's data concluded that it was unlikely that the claim for precise lunar alignments was justified. Clive Ruggles carried out a detailed reassessment of Thom's work (Ruggles 1982; 1983; 1999: 49-67) and found problems with it including: many lines not properly indicated; errors of identification; selection of horizon features; and variable types of backsight. In addition the sites chosen had a wide geographical spread. Ruggles therefore concluded that the results could be due to chance. Ruggles has said that his work did not prove that planned precise lunar alignments did not exist. Only that Thom had failed to prove that they did (Ruggles 1981: 172, 189). Later (1999: 67) he went further, stating: 'Taken together, these factors lead us to the unavoidable conclusion that lunar motions were not in fact observed and recorded to high precision in prehistoric times.'

Nonetheless I felt that the matter was not absolutely settled. It is, after all, expected in science that it is hard to prove a negative.

Thom's methods and preselection

There is good evidence that the foresights used by the Thoms (Thom 1971; Thom & Thom 1980; Thom A.S. 1981) and claimed to be for precise lunar alignments were not selected fairly. As Ruggles found in his reassessment of their work, 11 of the 44 lines given were not indicated (Ruggles 1982: S36; 1999: 61, 63). In addition, since the lines were from sites with a wide geographical spread, it is difficult to carry out any meaningful analysis of the claims of the Thoms regarding precise alignments.

Matters that need to be addressed

Ruggles (1999: 58-67) also raised many other issues that challenged the Thoms' claims including refraction, chance alignments, lunar parallax, extrapolation, weather, vegetation on foresights and ground/stone movements.

[2] An alignment consists of a backsight and a sufficiently distant foresight. The backsight typically consists of a flat sided standing stone (or two or more stones in a row) marking the observing position and indicating the direction to the foresight. A precision of 1′ arc is possible as shown by the results (Heggie 1981: 134).

These important topics require careful examination as they could be expected to preclude the possible existence of precise alignments. This is done after the presentation of the results when they can be discussed in the light of those results.

Investigation Outline

The objective of my study was to investigate a group of sites in a limited region for possible precise lunar alignments seeking new evidence regarding the existence or otherwise of such alignments. The region surveyed[1] was a coastal area of western Scotland, mainly Argyll, between latitudes 56º 0′N and 56º 45′N, which embraces Kilmartin Glen, a compact area rich in standing stones and Neolithic remains. Criteria for alignments are discussed by Heggie (1981: 136-45).

The present investigation acknowledged the above criticisms of Thom's work and sought to address them as follows:

- Choose one area only (A number of observers have made this point.)
- A backsight is a standing stone, pair or short row[3], with an indicated direction and (within this group)
- NO selection
- Assess the likelihood of chance alignments

In this study, the opposite direction was checked in all cases with null result. It seems that no investigation of possible precise alignments fulfilling these criteria has been done before.

Lunar Band

The moon's orbit and its apparent movement as seen from earth is not simple. It is explained elsewhere (Thom 1971: 15-27; Wood 1978: 66-70; North 1996: 553-68). Suffice to say here that the declination of the moon at a lunation maximum varies over an 18.6 year period and, *c.*1700 BC, between ±29° 03′ and ±18° 45′. Also the moon does not come smoothly to the maximum ('major standstill') and minimum ('minor standstill')[4], but in a series of small waves of amplitude about 9′ arc and period about 173 days termed the lunar perturbation or 'wobble' (Figure 1).

[3] Nine single stones (two stones fallen), two pairs (in one case, one stone fallen), one three stone row (two stones fallen), one four stone row.

[4] In place of 'standstill' the word 'lunastice' is sometimes used.

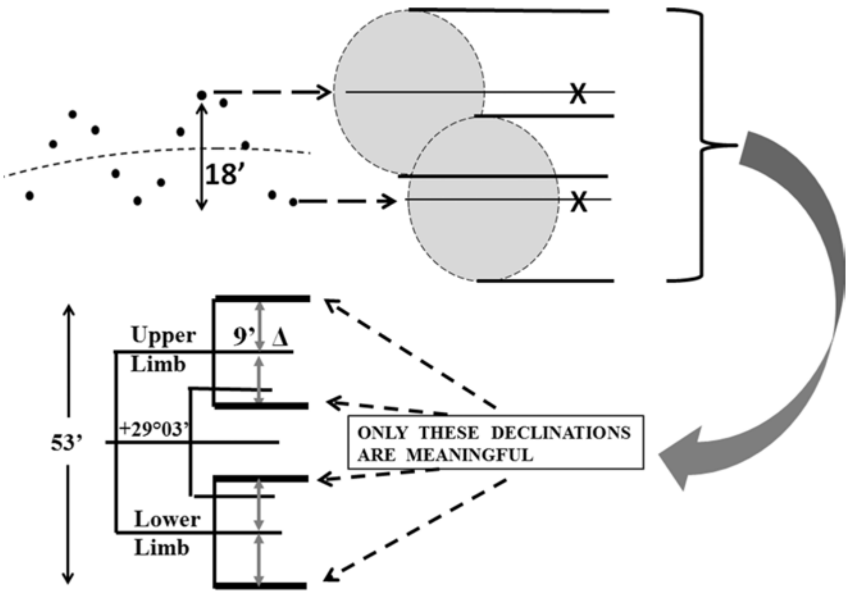

Figure 1: The Lunar Band. The dots represent the declination of the moon's centre at each lunation near the major standstill. Note that the only meaningful declinations are for the limbs of the moon with positive or negative 'wobble'. None of the other possible five declinations (moon centre or limbs of the moon with no 'wobble') are unique and/or measurable. There are 8 lunar bands: rising/setting, north /south, major and minor standstills.

Method

Figures 2 and 3 explain the method used to find indicated foresight features if they exist. It is important to emphasise that the foresight features have not been 'chosen'. If they are there, then the method finds them, i.e. the features originally used are rediscovered**.**

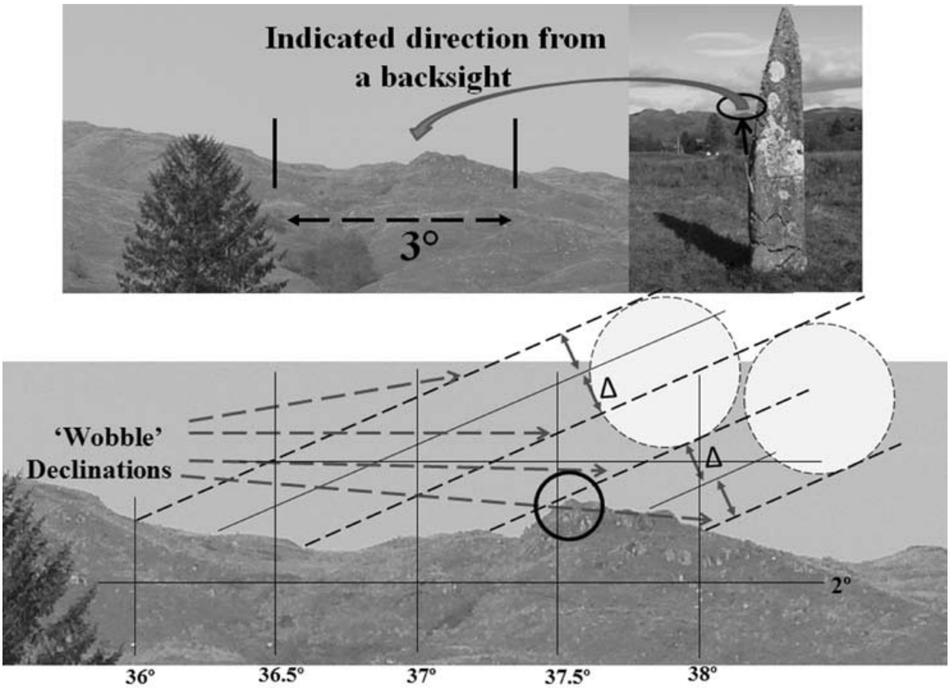

Figure 2: The horizon region indicated by the (typically) flat side of the stone is identified. A theodolite is used to make measurements of the sun (timed to the nearest second) and of the azimuth and altitude of skyline features. A levelled photograph is taken and the field results used to calculate and draw the relevant lunar declination lines as shown. This has been facilitated by the advent of the electronic era. An alignment is found if there is a distinct foresight feature which has the same declination (±2' arc) as one of the four key lunar declinations. (2' arc is sufficient to identify a key declination without being over restrictive). There was no basis to define an acceptable foresight before the survey began. However examination of the foresights found that they:
a. are a slope parallel to the moon's path or a distinct point, e.g. a peak or notch.
b. would enable warning of the moon's approach.
c. are well separated from any other usable and distinct feature which might be confused with the foresight intended.
(This definition was applied in the chance alignments investigation.)

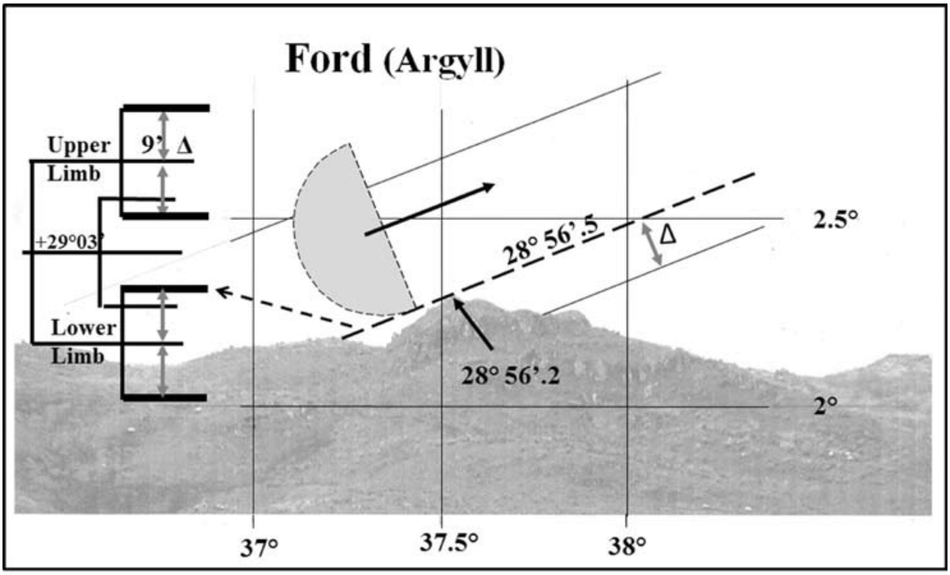

Figure 3: The final diagram is drawn (the rising moon would be at the 3rd quarter[5] (September)).

Summary of the results

After this summary three more alignment diagrams are given. In the region examined there are 34 sites. Of these:

- At 14 sites the stones have fallen, trees obstruct etc. and are not surveyable
- 5 of the stones have no indicated direction and/or have other plausible explanations e.g. waymarkers
- one remains of a stone circle
- one accepted as calendrical (Strontoiler (10)[6]

This leaves 13 sites. In accordance with the earlier statement, within this group there has been NO selection. They ALL gave a precise lunar alignment. Two alignments are for the minor standstill (Sluggan (12) and Glennan (18)) (see Table 1 and 'Discussion on Ritual, Culture and the Results Found' below).

Figures 4, 5 and 6 show three examples.

[5] It is sometimes erroneously believed that at the quarters, both cusps of the moon will not be lit leaving only one available. This is incorrect. At the equinoxes, although the moon will be severely tilted when only 2 or 3 days old it 'straightens up' so that at both quarters the position angle is always close to 90º or 270º.

[6] See website and Bailey et al. 1975.

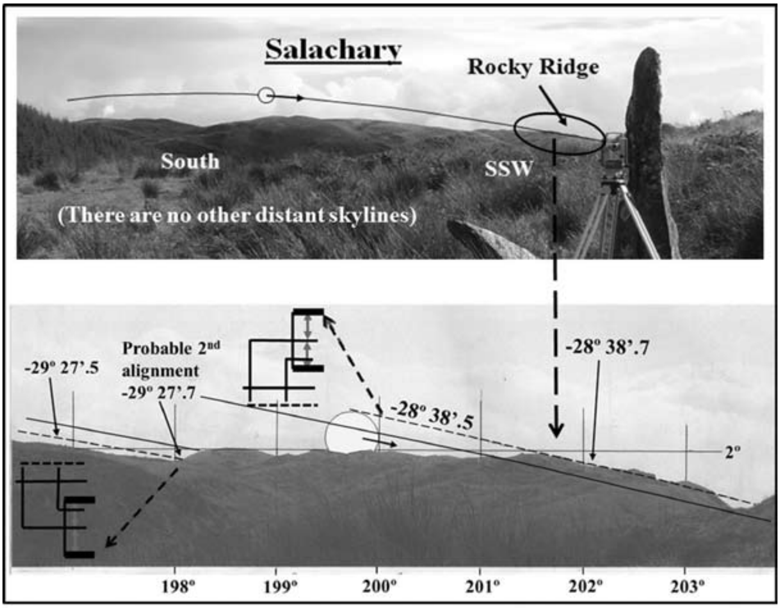

Figure 4: With the 'wobble' to the north as shown, the upper limb of the moon in the extreme south would, during the major standstill, have twinkled down the rocky skyline on the right. There may be a second alignment at 198° for the 'wobble' in the opposite direction. This would have occurred about 86 days before or after the main alignment.

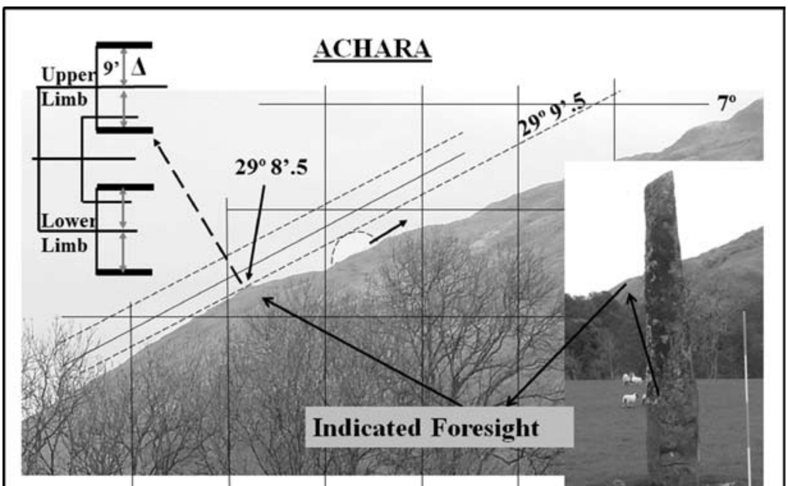

Figure 5: Achara.

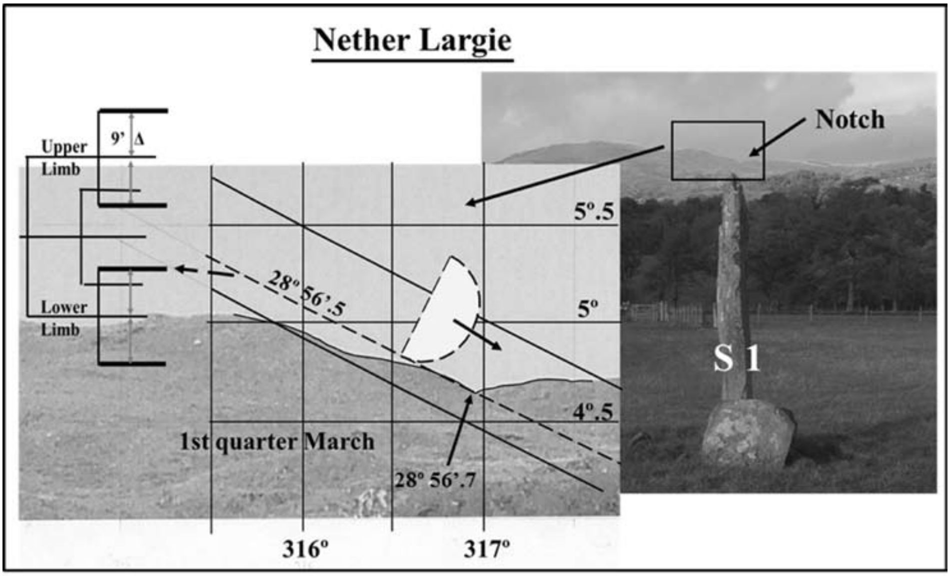

Figure 6: Nether Largie.

Alignments found at the Major Standstill with ±Δ

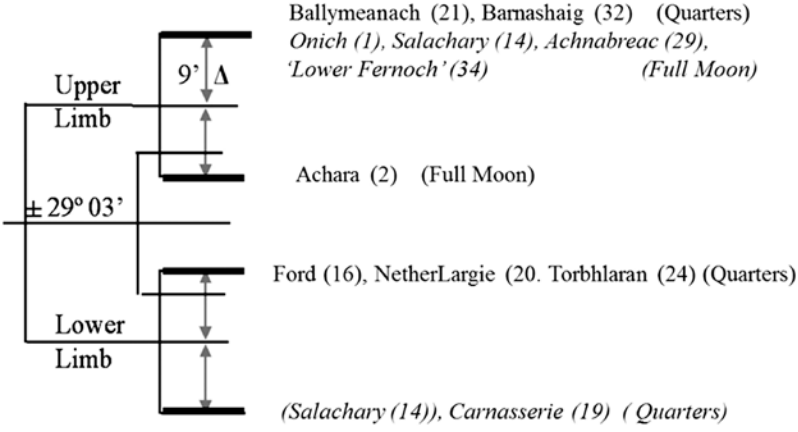

Figure 7. Regular font - North declination; Italics - South declination (the numbers refer to the site numbering from the north for all 34 sites in the region).

Declination values found

Refraction values as given in the Nautical Almanac and mean lunar parallax (57′.04) are applied. The value for the lunar perturbation, Δ, is often approximated to ± 9′ arc, more accurately ± 8′.6 or ± 10′ as follows:

		At the Major Standstill	At the Minor Standstill
Moon to the north	+ Δ	quarters +8′.6	full moon +10′
Moon to the north	- Δ	full moon -10′	quarters -8′.6
Moon to the south	+ Δ	full moon +10′	quarters +8′.6
Moon to the south	- Δ	quarters -8′.6	full moon -10′

The value of ±9′ arc for Δ was used. It was found that using the more correct values for Δ makes little difference. All of the measured declinations fall within ±2′ arc of a theoretical value, which, from the start, was taken as the limit of acceptable error (see 'Method' above). Nearly all sites had multiple visits for the purpose of declination measurement[7]. On each occasion three or four sets of timed sunsights were made and the azimuths found averaged (Table 1).

Table 1: Declinations found for alignments at the standstills ± Δ.

Site	Declination found	Theoretical Value - for Δ (a) ± 9'	Theoretical Value - for Δ (b) ± 8'.6/10'	Differences – from:- (a) ± 9'	Differences – from:- (b) ± 8'.6/10'
Onich (1)	-28° 38'.7	-28° 38'.5	-28° 37'.5	-0'.2	-1'.2
Achara(2)	+29° 08'.5	+29° 09'.5	+29° 08'.5	-1'.0	0'.0
Sluggan (12)	-18° 19'.7	-18° 21'.1	-18° 21'.5	+1'.4	+1'.8
Salachary(14)	-28° 38'.7	-28° 38'.5	-28° 37'.5	-0'2	-1'.2
Salachary(14)	-29° 27'.7	-29° 27'.5	-29° 27'.1	-0'.2	-0'.6
Ford (16)	+28° 56'.2	+28° 56'.5	+28° 56'.1	-0'.3	+0'.1
Glennan(18)	-18° 21'.4	-18° 21'.1	-18° 21'.5	-0'.3	+0'.1
Carnasserie(19)	Approx. (-29° 28'.5)	-29° 27'.5	-29° 27'.1	(-1'.0)	(-1'.4)
Nether Largie (20)	+28° 56'.7	+28° 56'.5	+28° 56'.1	+0'.2	+0'.6
Ballymeanach (21)	+29° 27'.6	+29° 27'.5	+29° 27'.1	+0'.1	+0'.5
Torbhlaran(24)	+28° 56'.2	+28° 56'.5	+28° 56'.1	-0'.3	+0'.1
Achnabreac(29)	Approx. (-28° 38')	-28° 38'.5	-28° 37'.5	(-0'.5)	(+0'.5)
Barnashaig(32)	+29° 28'.9	+29° 27'.5	+29° 27'.1	+1'.4	+1'.8
'Lower Fernoch' (34)	-28° 37'.1	-28° 38'.5	-28° 37'.5	+1'.4	+0'.4
			RMS	0'.78	0'.95

[7] Only Lower Fernoch had limited visits for reasons explained on the website. Also on the website is a list of the main visits in 'Analysis of Results', theodolite measurements. (Note that Barnashaig had many preliminary visits – see website).

Schematic diagrams of lunar phases/alignments found

In diagrams in Figures 8 and 9 the moon size has been reduced for clarity.

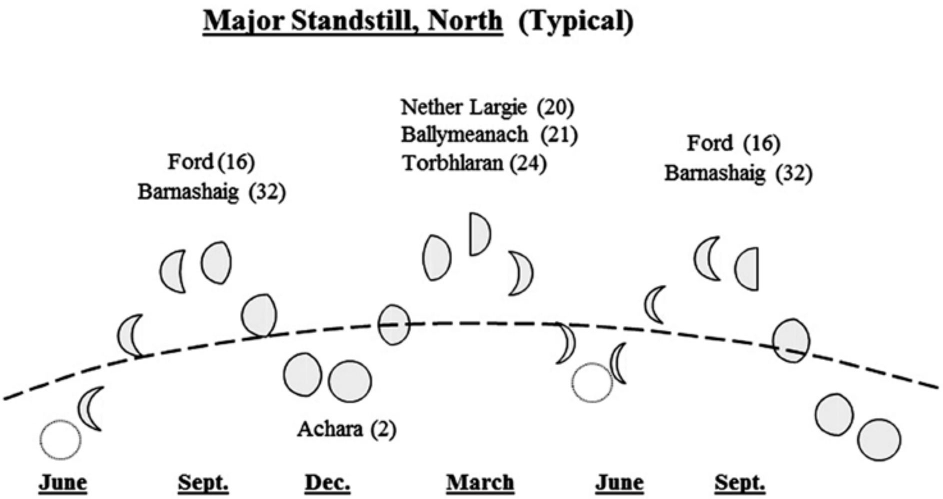

Figure 8: Maximum Standstill, North (Typical).

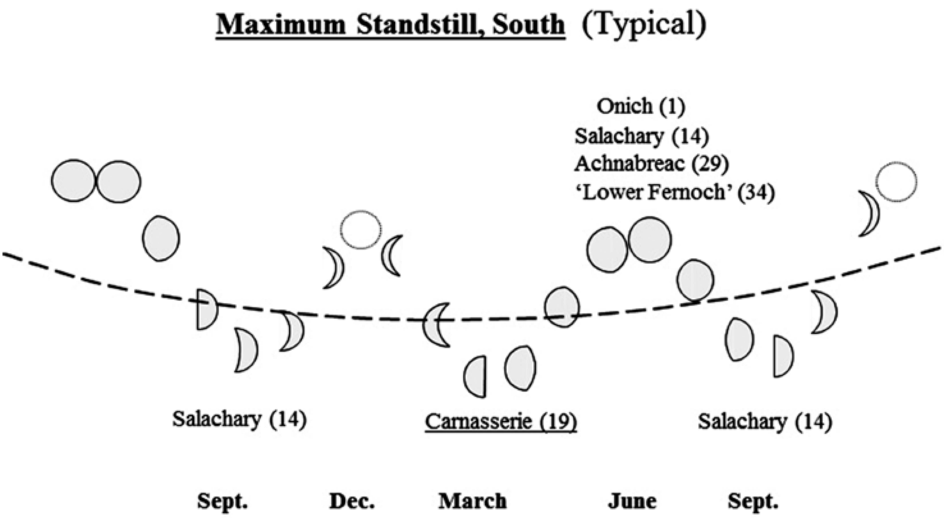

Figure 9: Maximum Standstill, South (Typical).

Evidence that the alignments were intended

- All 13 stones with an indicated lunar band gave a precise alignment for one of the 4 key declinations.
- There are several 'pairs' of stones with opposite 'wobble', for example Onich/Achara, Carnasserie/Achnabreac, and others.
- For 9 of the 13 alignments the foresight is a stone or is rocky (see 'Conclusions regarding the results found' below).

In addition the diagrams show that foresights were chosen with care to avoid doubt about the intended foresight, e.g. Achara (2), Salachary (14), Ford (16), Barnashaig (32).

Chance Alignments

In hilly country some chance alignments are to be expected (Heggie 1981: 136-45; Ruggles 1999: 59). Ruggles (1999: 42) illustrates this by analogy to a blind marksman who would sometimes hit a target. What we need is some assessment of the likely occurrence of chance alignments. This was done by examining a total of some 1500 degrees of random hilly horizon in the surveyed region from identifiable backsight positions. This contained 30 lunar bands and so potentially 30 alignments.

Three chance alignments were found. Therefore in this study 1 in 10 random Lunar Bands contained an alignment. Since the 13 sites are independent of each other, the probability of them all being chance is vanishingly small (0.1^13). There is no reason to suppose that the sample used was abnormal.

Conclusions regarding the results found

The following has been found:

a. The 13 sites that could be fully assessed all gave a precise lunar alignment in the indicated lunar band.
b. The declinations found were all within 2′ arc of a key declination.
c. There is internal consistency in the results found (see 'Evidence that the alignments were intended' above).

When the results of the Chance Alignment investigation are included the evidence tells us that the alignments are real and were planned.

The criteria for this study were heavily dependent on the criticism by Ruggles and Heggie of Thom's investigations, because they effectively specified what was required to resolve any debate.

The result of all acceptable backsights having precise alignments is remarkable and, given that chance alignments were not very common, fully justifies the claim that precise lunar alignments in this region were deliberately set up. No opinion is involved. The measurements are empirical and the calculations are routine, if laborious. The stones are there for anyone to measure.

The existence of precise lunar alignments and the arguments that such alignments could not be set up are mutually exclusive. The results of this study mean that issues surrounding refraction, parallax, extrapolation, weather etc. need to be revisited to answer the question ‘How were the alignments set up?’

What follows below should be the beginning of a new area of thought. I have no expectation that this will be the final word, and indeed hope that it is only the beginning of a productive debate. Previous issues on the feasibility of establishing precise alignments are discussed. Ways in which the difficulties may have been overstated, and ways in which they could have been worked around are suggested.

Refraction

Astronomical refraction is a known issue. It is accepted that refraction at very low altitude may vary considerably from the standard value. A study by Schaefer and Liller (1990) for the setting sun found widely varying refraction values with a RMS deviation of 0º.16 and a probable range of 0º.64. In the same paper there is mention of a brief study by Seidelmann for altitudes in the range 0º.2 to 3º.0 where the RMS deviation of three sets of measurements was 3′.0. The authors conclude that:-

> The historically important claim by A. Thom that the British megalithic sites were used as accurate observatories is shown to be wrong because the needed accuracy is much greater than can be obtained for long averaging intervals.

However the study by Schaefer and Liller was for an altitude of 0º using observations of the sun setting over the sea. The large deviations found are of particular significance in precise archaeoastronomy only when altitude measurements are made below 0º.5. The range of altitude in precise archaeoastronomy is usually 1º to 5º.

To add to the available information, I made three sets of timed measurements of the altitude of the setting sun (both limbs) to as low an altitude as possible; to below 1º where the horizon permitted. The altitude from these measurements was calculated (H_c) and compared with that observed (H_o), the difference giving the deviation.

Two different locations were used (one inland site (two sets), one near the sea). The total range of altitude was from 0º.24 to 4º.0. There were 57 observations and the mean deviation was |0′.6|.

Range of Altitude	Number of observations	Range of Deviation	Mean Deviation
0º.24 to 0º.5	7 observations	+ 0°.1 to −3°.0	|1′.7|
0º.5 to 1º.0	11 observations	+0°.4 to −2°.5	|0′.8|
1º.0 to 4º.0,	39 observations	+0°.8 to −0°.4	|0′.29|

These values are much smaller than those found by Schaefer and Liller which is to be expected because of the difference in altitude, but they are also much smaller than those found by Seidelmann whose observations were for a similar altitude range. Reijs (2001) gives a graph of altitude vs. refraction combining the results of Schaefer et al., Seidelmann and others which suggests that serious refraction problems are mainly to be expected at altitudes below about 0º.3. The results given above suggest that at altitudes above 1º.0 there is not a serious problem and that even down to 0º.5 difficulties may be manageable. In this study one site had a very low altitude: Lower Fernoch (34) (0º.19). The lowest of the remaining twelve was 1º.70.

Terrestrial refraction also occurs but the evidence shows that this does not seem to be an issue:

1. Most of the sites in Argyll have had multiple visits. The declination values found rarely varied by more than 0′.5 arc.
2. In his reassessment Clive Ruggles reported: 'Resurveys of 38 of the 44 sight-lines produced general agreement with the Thoms' declinations to within about 1′' (Ruggles 1983: S32).

Parallax

Changes in lunar parallax (54′ to 60′ arc) would be expected to make it very difficult to set up an alignment to the precision found. The assumption by Thom which others accepted was that it would be necessary to average results over 100 years or more (Thom 1971: 81-82; Heggie 1981: 178; Ruggles 1999: 66).

The following might offer a partial solution:

Declination transfer by use of the stars does not seem to have been previously considered. This could be achieved as follows: From the observing position of a known alignment, observe by how much any suitable star[8] 'misses' the foresight (a finger width at arm's length? or more precisely with a simple tool) – amount X. Having previously found a potentially suitable new horizon feature at a different site, use amount X from the same star to find the backsight position. (Change of latitude has only a small effect). This could be checked on any clear night when the star is suitably placed, and fine tuned at the next standstill. During the eighteen years between standstills a small group of skilled observers could set up many precise alignments by, in effect, copying the declination of a known alignment to a new site. The value of the lunar parallax during the prehistoric standstills is known and it was sometimes close to the mean value. If the method described above was used then it is possible that by chance it was done during a period when the lunar parallax was close to the mean value which would help to explain the high precision achieved, i.e. about any of 1760 BC, 1670 BC, 1570 BC (Thom 1971: 82). (This would not resolve how the original sites were established.)

It is also possible that changes in parallax were known and allowed for.

[8] See website www.lunarsites-scotland.net Discussion, Some New Ideas, Table 1.

Extrapolation

To determine the extreme value at any given lunar maximum, extrapolation would presumably be required but the evidence to date is very limited. Thom gives the theory of a method (Thom 1971: 83-90) and Wood explains how it could be done with a rope and pegs (Wood 1978: 114-139). The enigmatic stone rows in northern Scotland may have been used for extrapolation purposes (Myatt 1988; Thom 1971: 91-105).

Before any extrapolation method could be devised, it had to be recognised that it was necessary. This could have arisen from careful observation of the setting position of the moon at the major standstill - perhaps casual at first but later using posts. In the north for example it would have been noticed that the moon did not come smoothly to its maximum position but for about a year was always in the same region[9]. Further observations could eventually lead to the knowledge that the position of the moon on the horizon during a lunation maximum was generally erratic, occasionally reaching what seemed to be a maximum position. Hence to the need for extrapolation. '…it is possible to develop a detailed knowledge of astronomy using the simplest of technology' (Parker Pearson 2005: 128).

The evidence that extrapolation in some way was done lies in the results found in this study as stated in 'Conclusions regarding the alignments found' above.

Then we have:

a.) The alignments were intentionally set up.
b.) This could only be achieved by determining in some way the maximum lunar position to high precision.
c.) Except by chance the moon does not rise/set at the extreme north/south.
d.) To determine the maximum position three or more observations near the maximum must be made and the actual maximum found from these observations.

The small RMS residuals for the declination values found means that some method for determining the extreme position of the moon from the observations made was used. We therefore reach the conclusion that either extrapolation in some way was done to enable the sites to be set up or they were set up using some unknown method.

Other considerations

Weather preventing observation. There is evidence that the climate in northern latitudes was nearly 'Mediterranean' in the EBA with clearer skies (Wood 1978: 182-184).

Vegetation at foresights.

a) Pollen analysis suggests that there was less tree cover than now (Wood 1978: 182-184).
b) Grass and bushes would have been likely to be present. The fact that in this study 9 of the 13 sites had rocky foresights may be relevant to this.

[9] The ±9′ arc 'wobble' would not itself be initially found because the moon does not, except by chance, rise or set at its maximum north during any given lunation. However on about 50% of occasions it is within 3′ arc of the lunation maximum and rarely as much as 10′ arc from it. Since the overall 'wobble' is 18′ arc, it would be possible to observe that there was something 'wrong', leading to further investigation.

Changes in ground height/movement of stones. The results found imply that any changes in ground height are not sufficient to significantly affect the alignments. A stone that is no longer upright, or a row with fallen stones, may still fulfil the backsight criteria by giving an acceptable indicated direction, depending how it is leaning, or has fallen and/or what usable skylines are visible. This applies at Salachary (14), Achnabreac (29), Barnashaig (32) and Lower Fernoch (34). There is precedent for this (Ruggles 1993; 1999: 113-14).

Sun/Moon knowledge in the Late Neolithic

There is evidence from a wide variety of Neolithic structures (long barrows, cursuses, passage graves, stone circles, stone rows etc.) that many were orientated on the sun, moon and possibly the stars (North 1996; Ruggles 1999: 125-143; Burl 1982; Thom 1967: 96-104). In particular there is found to be a significant interest in solstices and lunar standstills. This interest is not limited to northwest Europe, but is also found in the Pacific (Edwards and Belmonte 2004; Edwards and Edwards 2010) and in North America the Hopi Indians' calendar (Renfrew 1973: 263-65) and the Hopewell sites in Ohio.

Between *c.* 3000 BC and 2500 BC there were significant changes in the structures at Stonehenge culminating in the stone sarsen trilithons and the lintelled sarsen circle. Elsewhere, a number of timber structures were built about or before 2500 BC including Arminghall, Woodhenge and Durrington (Parker Pearson 2005: 60-61; 2007; 2012: 80-91; North 1996: 345-392; Bradley 2007: 122-42). North proposed that these were probably lintelled[10]. North (1996: 436-40, 456-58) discusses the Q- and R-rings and the probability that some stones were lintelled. This seems to be confirmed by reshaping of some of the bluestones (Gibson 2005: 143-51). Parker Pearson (2007; 2012) has shown that the south circle at Durrington and the sarsen structures at Stonehenge are both dated to about or soon after 2500 BC.

There are multiple indications that a feature of all these structures was alignments for solar and lunar observations, particularly solstices and lunar standstills (Renfrew 1973: 261-65; North 1996; Parker Pearson 2012). North applies the ideas of lintelled rings of posts to the final phase at Stonehenge involving the lintelled sarsens. He shows that when approaching the monument from the northeast up the avenue, the uprights and lintels would have prevented the passage of any light rays until the region of the Heel stone was reached when two 'windows' would have opened up. The lower window would have allowed viewing of the midwinter setting sun[11] and the upper one the moon at its

[10] North considers possible arrangements at Woodhenge, Durrington Walls (south circle), Mount Pleasant and Arminghall, and shows how adding lintels to the uprights greatly increases the possibilities for targeted observation of certain positions of the sun and moon. By careful choice of the heights of the posts and the sizes of the rings, very limited regions of the sky would have been visible from a given viewing point. In addition the lintels could have been used to block most of the sun's disc (North 1996: 345-92).

[11] The idea that Stonehenge was primarily intended for viewing the rising midsummer solstitial sun has long been disputed. Instead the approach up the avenue from the northwest towards the midwinter solstitial setting sun is much more likely (North 1996: 440-41; Pearson 2005: 66; Sims 2006: 194-95).

monthly southern limits during the year long period of the minor standstill (North 1996: 441-65, 470-75; Sims 2006). The position of the moon in the upper window each month would have varied erratically because of the 'wobble' and because the moon would rarely be close to its monthly extreme at the time of observation. It is possible that these erratic movements alerted the observers to some previously unknown property of the moon. Whether or not this is so, knowledge of the 'wobble' would have been a necessary precursor for the establishment of the Argyll alignments 800 years later.

Evidence for a Hierarchical Society

The developments in the Stonehenge area around 2500 BC suggest a stratified society. The major construction phase at Stonehenge and Durrington Walls must have been carefully planned which in itself suggests a leadership of some sort. Parker Pearson has found that the workforce lived at Durrington Walls and probably numbered about 4,000. Such a workforce would have required significant organisation with a chain of command (Parker Pearson 2012: 109-127). That a hierarchical society existed or developed about this time has previously been suggested by a number of observers (Mackie 1977: 146-49; Renfrew 1973; Whittle 1981: 297-342).

It seems likely that the inner spaces of Stonehenge would have been used by a relatively small number of people (Bradley 2007: 141-42).

> Would the architects of Stonehenge, having gone to such pains to plan this extraordinary series of monuments, not have kept permanent control over its use? The necessary knowledge had by this time become very sophisticated, and it is hard to believe that it was shared by the population as a whole. (North 1996: 468)

It is therefore reasonable to suppose that a hierarchical society of some sort existed when the Argyll alignments were set up.

Discussion on Ritual, Culture and the Results Found

It seems likely that many Neolithic structures were intended to reflect on earth what was observed in the heavens for ritual or ceremonial purposes, when we expect that no great precision would have been required. It is a mistake to assume that we should interpret any astronomical indications in our present day terms; instead it is necessary to try to determine what such indications may have meant to the people who set them up. For example an alignment on the winter solstice could show a desire to 'turn the sun round' (Ruggles 1999: 148).

The reason for the orientations of long barrows, cursuses etc. towards certain positions of the heavenly bodies was doubtless ritual/religious and there is no suggestion that this did not remain the primary purpose even in the later structures: Stonehenge, the timber circles at Durrington, Woodhenge etc. as discussed above.

However perhaps astronomical reasons might eventually develop:

> It can hardly be doubted that the motivation of those responsible for Stonehenge was of an essentially religious character. To explain Stonehenge entirely in terms of religion, however, would be only to escape from astronomical enthusiasm by embracing its religious counterpart. (North 1996: 519).

> By and large, the rules by which the gods are believed to operate will be human rules, … When the gods are celestial objects, however, sooner or later it will be found that they are more predictable than are creatures of emotion. And in such ways as this, religion may nourish astronomical science, and in doing so need not lose its ascendency. (North1996: 520)

Nonetheless, North (1996: 10) adopts a religionist model for interpreting monumental alignments.

The investigation described in this paper found strong evidence for planned precise lunar alignments *c*. 1700 BC. The following is an attempt to show how this development might be related to earlier beliefs.

The monumental structures built earlier were just that; monumental, and intended to dominate the landscape (Thomas 1999: 34). This should be contrasted with lunar alignments which cannot be considered monumental in the above sense.

The high fidelity lunar alignments only appear some 800 years after Durrington, the sarsen phase at Stonehenge etc., and seem to have arrived fully developed. Perhaps earlier less successful attempts were removed or modified.

But why mainly in northern Europe and especially Scotland? There are two possible reasons: First, because of the high latitude, the moon at its southern extreme would be seen passing low across the horizon and be very obvious (Wood 1978: 188); and second, the rugged terrain is suitable for foresight features.

So what evidence is there that ritual or religious purpose might have influenced or even determined the setting up and or use of the precise lunar alignments in Argyll?

a.) Of the thirteen alignments found only two are for the minor standstill. This contrasts with the importance of the minor standstill at Stonehenge (North 1996: 441-451, 470-75) and the marked emphasis found at the West Kennet avenue by Sims (2010): 58 alignments for the minor standstill, 30 for the major standstill. A possible explanation is that although the minor standstill is obvious as an event it is more difficult to clearly identify any of the key lunar positions at the minor as opposed to the major standstill. This arises because the moon is not in a unique position; all other lunations pass the minimum point (Thom and Thom 1980: S80; Thom A.S. 1981: 17). The fact that there are so few precise alignments found for the minor standstill in this investigation could imply that the part any ritual considerations played in setting up the alignments was a small one.

b.) Four alignments are for the midsummer southern full moon (Figure 9). In Britain many monuments of the late Neolithic and EBA show an orientation towards the southwest; e.g. recumbent stone circles, Clava cairns and stone rows (Burl 1981; Ruggles 1999). These alignments focus on the winter solstice sunset and the southern major and minor moonsets thereby pairing sun and moon which could be in the same region of the sky. Ruggles links the full moon in this pairing. There is however no full moon in the southwest in winter and so Sims believes that Ruggles is mistaken to emphasise full moon. As Sims has pointed out, at midwinter sunset it would be 'dark moon'[12], not full moon (Sims 2006). Thus Stonehenge shows a clear association of 'dark moon' and the midwinter sunset. Sims also shows that from an anthropological standpoint, 'dark moon' was considered important.

These ideas are compared to the lunar alignments found:

There would be no 'pairing' with the horizon setting position of the southern standstill full moon as the sun could never be so far south. While the 'dark moon' does pair with the winter solstice, there is no evidence from this study that that was recognised. The relevant alignment could only be set up at full moon and the alignment at dark moon thereafter assumed. The four southern full moon alignments are associated with the other nine alignments and two of them are apparently paired with alignments for quarter moons (Achnabreac with Carnasserie and Lower Fernoch with Barnashaig). (Opposite 'wobble'; geographical and/or structural relationships). Thus their associations may lie elsewhere than dark moon.

The argument for lunar alignments in this region does not require corroboration by any ritual matters, interesting though that would be. Whatever their purpose, the case for their existence stands on its own empirical evidence.

Future Work

Several groups of stones in other regions in Scotland are currently being assessed using the same criteria. The results when available will be published on the website mentioned earlier.

Final Comments

Tycho Brahe, the Danish astronomer, is credited with identifying the lunar perturbation ('wobble') in AD 1595, though there is evidence that Arab astronomers suspected it in about AD 1000 (Wood 1978: 104). However the evidence presented here shows that the 'wobble' was very likely to have been known about in prehistoric times.

Julius Caesar and other Roman writers apparently knew that in Britain there were men who had a great knowledge of the movements of the sun, moon and stars (MacKie 1977: 228). This included the Druids – possible meaning of Druid is 'thrice wise' (MacKie 1977: 227). It is possible that this knowledge had its origins in the EBA.

I wish to thank the anonymous reviewer for a number of useful comments.

[12] 'Dark moon' implies death with the possibility of rebirth. It is not the same as new moon.

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The Archaeoastronomical Results of Three Bronze Age Buildings at Agia Triada, Crete

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Abstract
This is the final site report from the Uppsala archaeoastronomical project of ancient Crete. The project comprised a careful selection of the most important Bronze Age buildings from 15 archaeological excavations and 23 buildings at those excavations (Fig. 1). A list of our publications of the project can be found on our webpage (http://minoanastronomy.mikrob.com/?page_id=2), which is under construction. Such a study has not been done before. We use the standard methods of archaeoastronomy which, in short, are measuring the orientations of foundation walls and their opposite horizons, analyzing the measurements statistically, and comparing the results with digital reconstructions of the positions of celestial bodies for the time when the walls were built (Blomberg & Henriksson 2001a). We discovered that all of the buildings had orientations towards major celestial events such as sunrise or sunset at the equinoxes or the solstices, moonrise or moonset at the standstills, the heliacal rising or setting of a distinctive star, or sunrise on the first day of the twelve solar months of the Minoan calendar. The study also led to a new way of recognizing Mycenaean from Minoan buildings through their orientations (Blomberg & Henriksson 2001b). Agia Triada is one of the four sites in our project where this distinction is demonstrable.

KEYWORDS: Minoan astronomy, Minoan calendar, Minoan villa, Mycenaean megaron

POVZETEK
To je zaključno poročilo uppsalskega arheoastronomskega projekta o starodavni Kreti. Projekt je obsegal skrben izbor najpomembnejših bronastodobnih zgradb s 15 arheoloških izkopavanj, skupno 23 zgradb (slika 1). Pregled naših publikacij o projektu je na voljo na naši spletni strani v nastajanju (http://minoanastronomy.mikrob.com/?page_id=2). Takšne študije do sedaj še ni bilo. Uporabljamo standardne arheoastronomske metode, s katerimi merimo usmeritve temeljnih zidov in njihovih nasprotnih horizontov, meritve statistično analiziramo ter rezultate primerjamo z digitalnimi rekonstrukcijami položajev nebesnih teles v času izgradnje zidov (Blomberg & Henriksson 2001a). Odkrili smo, da so vse zgradbe usmerjene proti pomembnim dogodkom na nebu, kot so: Sončev vzhod ali zahod ob ena-

konočju ali solsticiju, vzhod ali zahod Lune v skrajnih legah, heliakalni vzhod ali zahod izstopajoče zvezde in Sončev vzhod na prve dneve dvanajstih solarnih mesecev minojskega koledarja. Študija je pripeljala tudi do novega načina razlikovanja mikenskih in minojskih stavb na podlagi njihove orientacije (Blomberg & Henriksson 2001b). Agia Triada je eno izmed štirih najdišč v našem projektu, kjer je to razlikovanje razvidno.

KLJUČNE BESEDE: minojska astronomija, minojski koledar, minojska vila, mikenski megaron

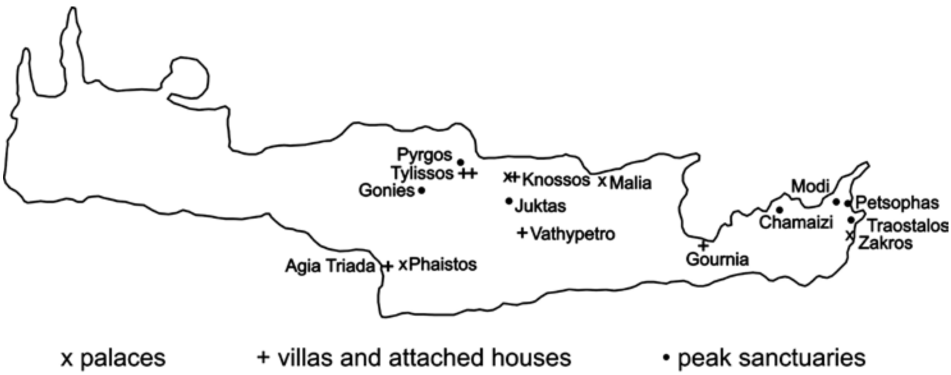

Figure 1: Map of the sites on Crete.

Introduction

Crete was settled in the seventh millennium BCE, and Agia Triada was an important settlement from at least the Final Neolithic until late in the first millennium BCE, a period of over three millennia. The site was excavated by the Italian school at Athens from 1902-1914, with supplementary studies made in the 1970s, and it is located a little over two kilometers from Phaistos, one of the four large Minoan palaces (La Rosa & Rizzo 1985).

At the end of the Middle Minoan period, about 1700 BCE, which is the beginning of the high point in the Minoan culture, a large sumptuous villa was built over an earlier house. It had all of the typical features of grand houses of the time, large suites of pillared chambers, stone floors, frescoes, fine objects, and large store rooms. Many of the objects found are of the highest quality and some are unique, e.g., exquisite vases carved from serpentine. Furthermore, the largest assemblage of Linear A documents in Crete was found in the villa. These were temporary economic records jotted down on unfired clay tablets. They were baked unintentionally by the fire which destroyed the villa. Permanent written records are assumed to have been documented on perishable materials. The villa was destroyed at the end of Late Minoan I (ca. 1450 BCE), but it was not ransacked. The time of destruction was widespread in the island and coincides with a period considered by many to mark the takeover by the Mycenaeans, who were Greek. It is not known how the Mycenaeans came to power, but they seem to have been present on the island for some time. Their original home was mainland Greece and their culture had been heavily influenced by the Minoans for centuries.

After the destruction a large megaron was built directly above the villa and a small megaron was built in the southeast corner of the site. The megaron is the most characteristic Mycenaean architectural form and the large example at Agia Triada is their most monumental structure in Crete. For the most part, the Mycenaeans only took over the Minoan buildings. The objects found in them identify their owners as Mycenaeans. The buildings from Agia Triada that are including in the Uppsala project are the Minoan villa, and the small and large megara.

We have presented our study of the small megaron at Agia Triada with two other contemporary Mycenaean buildings from other sites that have the same orientation in Blomberg & Henriksson (2005) and now present the Minoan villa and the large megaron. The orientation of the villa, especially the upper levels, is difficult to study because of the later construction of the large megaron directly over it. From our measurements we could determine the orientation of the bench room on the lower level. This and the adjoining rooms were an important part of the villa, used either for ceremonial or cultic purposes. Opposite them in the west is the sea. The long northern wall in this area is oriented to the equinoxes. Since the altitude of the terrain increases towards the east, we can conclude that the sunset alignment was intended. A wall appears to have been to the west, making it likely that the alignment was only visible from the upper rooms in this part of the villa. Additionally, there is a corridor in the lower level that has an alignment to the west peak of Mt. Ida. The large megaron built above the villa is also oriented towards the equinoxes, but likewise due to the terrain, we can conclude that a sunset alignment was intended (Fig. 2). The small megaron, which we presented earlier (Blomberg & Henriksson 2005), is oriented towards sunset at the summer solstice. This orientation is marked by the natural foresight of a hilltop in that direction.

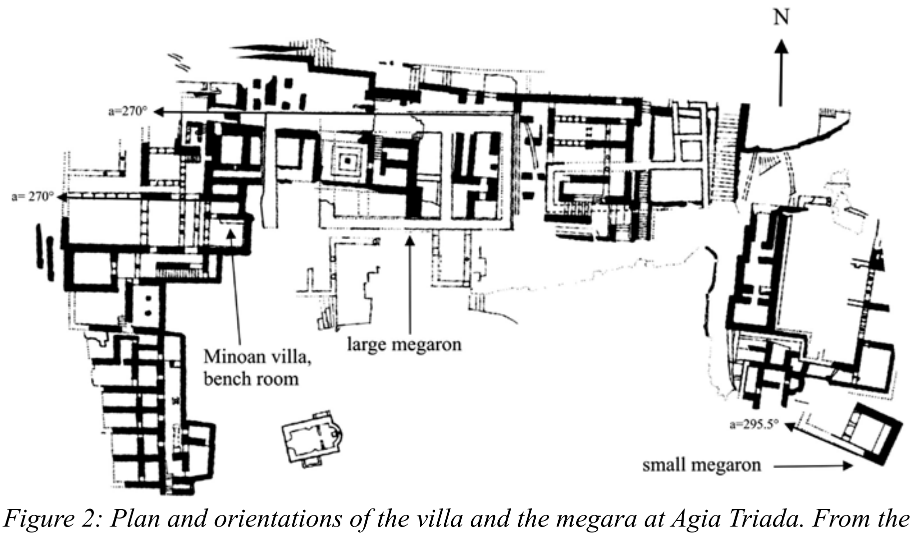

Figure 2: Plan and orientations of the villa and the megara at Agia Triada. From the Aerial atlas of ancient Crete (Myres et al 1992), with permission.

Now that we have measured the orientations of all of the buildings in our project we can point to consistent alignments to major celestial events arranged by both the Minoans and the Mycenaeans (Table 1). These events are sunrise and sunset at the equinoxes and the solstices, moonrise and moonset at the major standstills and the heliacal risings and settings of bright stars. Seven of the 18 Minoan buildings are oriented either towards sunrise or sunset at the equinoxes, six towards sunrise at the winter or summer solstice, and one towards moonrise at the southern major standstill. Five of the remaining six Minoan buildings are oriented towards sunrise or sunset on the first day of one of the eight solar months not marked by the equinoxes or solstices. The sixth remaining building, Traostalos, has orientations only towards the heliacal rising and setting of Arcturus. Several of the buildings have more than one orientation: The peak sanctuary on Petsophas has four, the palace at Phaistos and the villa at Vathypetro have three and the peak sanctuaries at Chamaizi, Pyrgos and Traostalos have two. All of the five Mycenaean buildings are oriented towards the west, either towards sunset at the equinoxes or sunset at the summer solstice.

Table 1: Orientations of the buildings in the Uppsala archaeoastronomical project.

Site	Orientation	Foresight
Agia Triada, villa LMIII megaron LMII megaron	sunset equinoxes " sunset summer solstice	 natural
Chamaizi, peak sanctuary?	sunrise winter solstice heliacal setting of Arcturus	artificial artificial
Gournia, MM IA house LM I house LM III house	sunrise one month before and after equinoxes " sunset winter solstice	 artificial
Juktas, peak sanctuary	sunrise equinoxes	natural
Knossos, palace south-east house	sunrise equinoxes "	artificial artificial
Malia, palace LM II megaron	sunrise one month before and after equinoxes sunset summer solstice	natural
Modi, peak sanctuary	sunrise two months before and after equinoxes	
Petsophas, peak sanctuary	sunrise summer solstice sunset equinoxes heliacal rising of Arcturus heliacal setting of Arcturus	natural natural
Phaistos, palace	sunrise equinoxes sunset equinoxes heliacal rising and setting of Canopus	 natural natural
Philioremos, peak sanctuary	sunrise summer solstice	natural
Pyrgos, peak sanctuary	sunrise summer solstice heliacal setting of Arcturus	 natural
Traostalos, peak sanctuary	heliacal rising of Arcturus heliacal setting of Arcturus	 natural
Tylissos, villa A Tylissos, villa C	sunrise summer solstice sunrise one month before and after solstices sunrise one month before and after equinoxes	artificial artificial artificial
Vathypetro, villa tripartite shrine	sunrise equinoxes sunrise one month before and after equinoxes sunrise winter solstice sunset summer solstice	artificial artificial artificial artificial
Zakros, palace	moon southern major standstill	natural

The palace at Knossos and the peak sanctuary on nearby Juktas also had orientations to mark the eleven days after the autumn equinox and these were emphasized by foresights. This indicates that the Minoans had used a lunisolar calendar that began in connection with the autumn equinox. There was also a calendar regulator at the palace at Knossos that kept track of the solar cycle making it easy to know when to add an extra day every four years. This regulator might mean that the Minoans also had a solar calendar. It is probable that the Minoans regularly related their important buildings and shrines to celestial phenomena, since the orientations are repeated and foresights are used at more than two-thirds of them. All but two, the palace at Zakros and the peak sanctuary on Traostalos, were oriented to the beginning of a month in the solar calendar (Table 2). The former was oriented towards moonrise at the major standstill, an event which could have had significance in calendar; the latter had orientations to the bright star Arcturus.

Table 2: Orientations of Minoan buildings to the beginning of a solar month.

Site	Months
Petsophas, Phaistos, Knossos (2), Juktas, Vathypetro, Agia Triada	first (autumn equinox)
Malia, Vathypetro	second
Modi	third
Chamaizi, Vathypetro	fourth (winter solstice)
Modi	fifth
Malia, Vathypetro	sixth
Petsophas, Phaistos, Knossos (2), Juktas, Vathypetro, Agia Triada	seventh (spring equinox)
Gournia (2), Tylissos Villas A and C	eighth
Tylissos Villa A	ninth
Philioremos, Petsophas, Pyrgos, Tylissos Villa A	tenth (summer solstice)
Tylissos Villa A	eleventh
Gournia (2), Tylissos Villas A and C	twelfth

We have further evidence of the existence of a solar calendar by the orientations of seven of the Minoan buildings to the first days of the months that were not marked by the equinoxes or solstices. One of the buildings was the important palace at Malia, and its orientation was marked by a natural foresight (Fig. 3). This alignment marked the start of the second and sixth months, if the year began at the autumn equinox. One orientation of the villa at Vathypetro was also to the beginning of the same two months and it was also marked by a foresight (Blomberg, & Henriksson 2005).

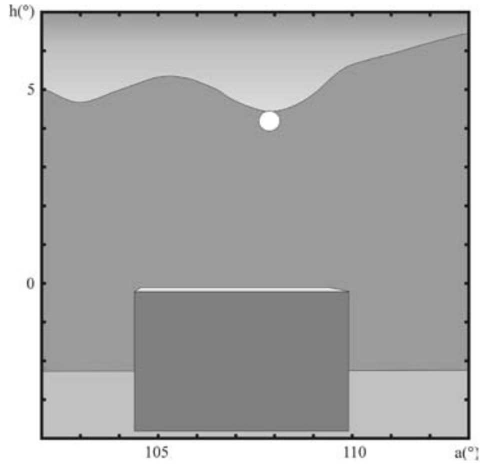

Figure 3: Orientation from the central shrine at Malia over the altar in the center of the central court to sunrise on the 22nd of October, one month after the autumn equinox and before the spring equinox.

For the palace at Phaistos, the emerging appearance of Canopus in the south seems to have resulted in the realignment of the new palace and the central court (Fig. 4, dark shaded areas). The star became visible behind the mountain in the south from the hill just west of the palace ca. 2080 BCE and its heliacal rising occurred three days before the autumn equinox (Fig. 5A). A new orientation of the central court was chosen towards the peak of the mountain in the south. The star would not have been visible from the central court while the palace was in use (Fig. 5B), but it would have been common knowledge to the Minoans that it rose behind the mountain just before the autumn equinox (Blomberg & Henriksson 2007).

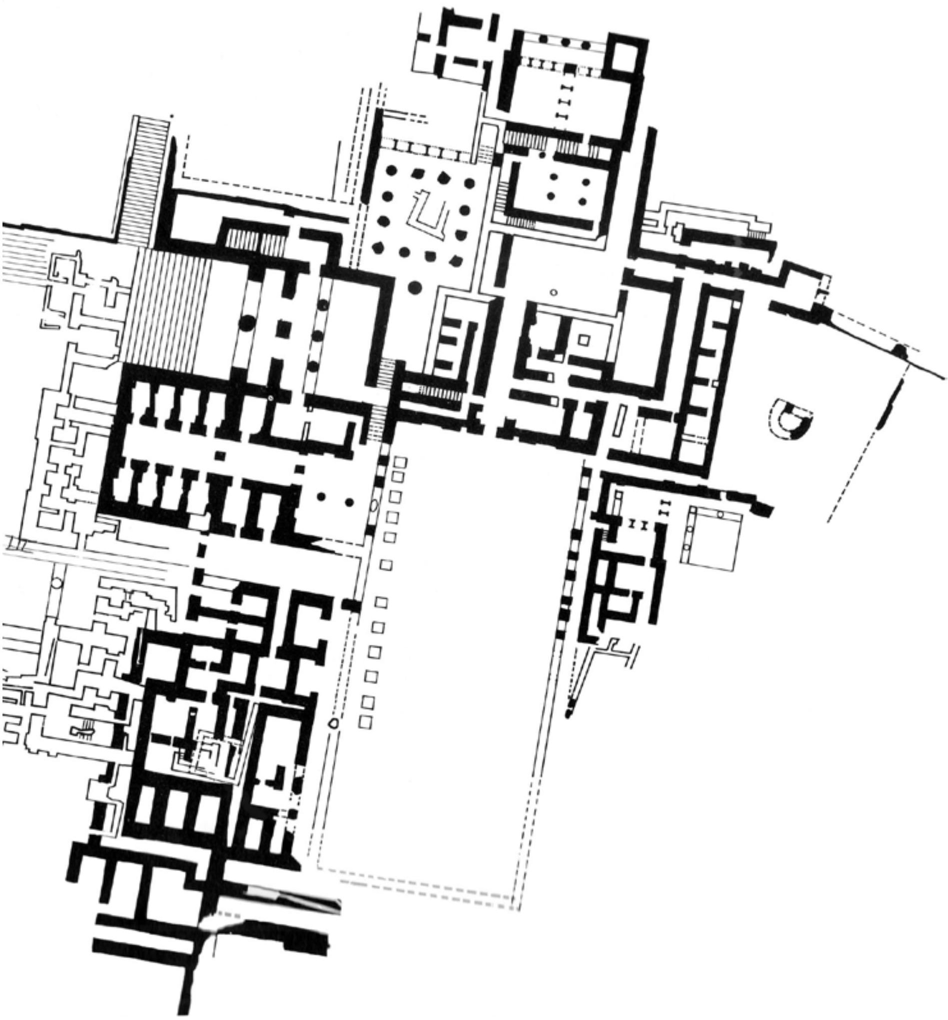

Figure 4: Plan of the palace at Phaistos. From Myers et al 1992, with permission.

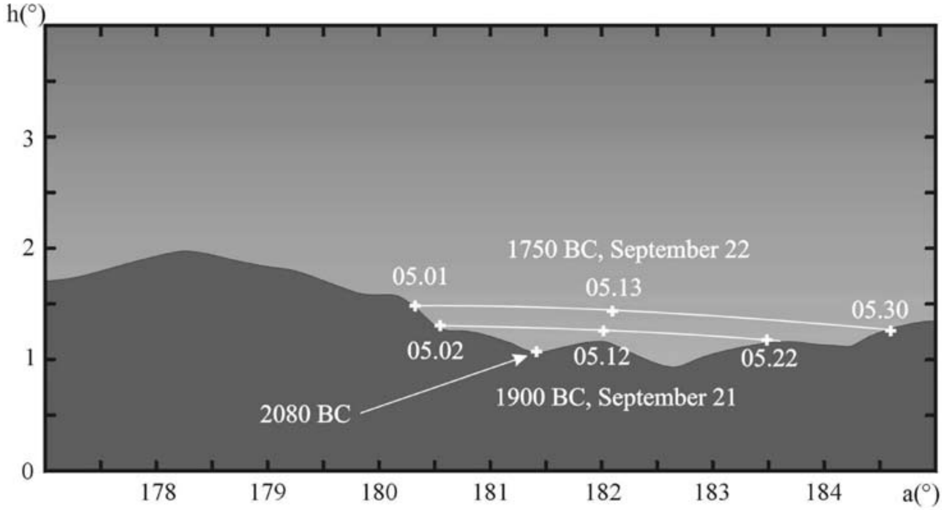

Figure 5A: After ca. 2080 BCE, Canopus would have risen and set behind the mountain south of the central court of the palace at Phaistos. It would have been seen for a few minutes only from the hill west of the palace.

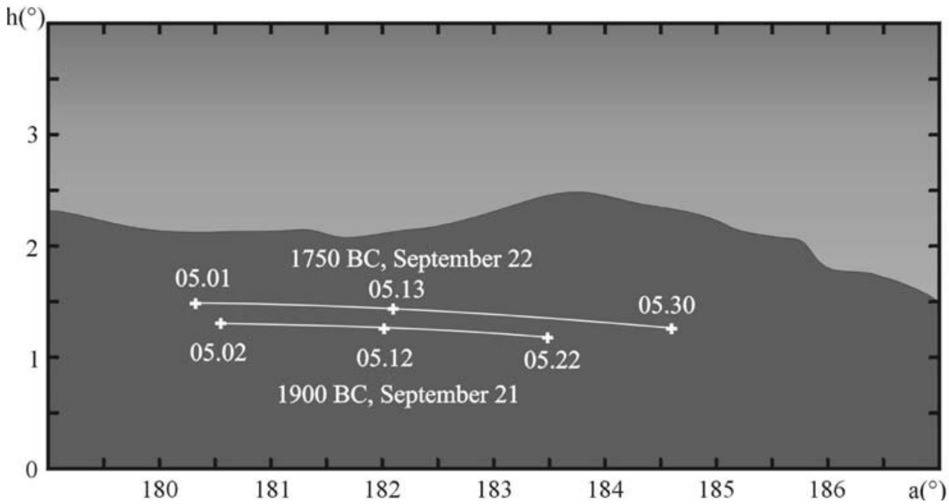

Figure 5B: Canopus would have remained above the horizon for less than half an hour, but would not have been visible from the palace itself.

This fact of the reorientation of a major monument to a new bright star stresses the importance of the meaning of celestial phenomena for the Minoans. They were much more than practical signs to mark the passing of the year and the progression of the seasons. They had extraordinary symbolic meaning that was essential for Minoan religion. Michael Hoskin reported an extreme reaction linked to the symbolic meaning of alignments at the sanctuary of Son Mas in Mallorca at about the same time. When the last star of the Southern Cross disappeared from sight due to precession, the site was abandoned (Hoskin 2001: 50f).

In Minoan Crete, each month probably was important for the places that marked the first day of that month, most likely celebrating a key event in local and national religious traditions such as an important event in the life of a divinity or hero, or times for sacred celebrations. Each place probably had its part to play in the wider context of Minoan cosmology and could have shared in a common responsibility for marking the vital annual events of human life, such as the rituals for rulers and priests, times for honoring the gods and goddesses, for sowing and harvesting, for sailing, and for national religious celebrations. All of these are echoed in later Mycenaean and Greek myths and rituals. We may take these as evidence that the second goal of our project, the influence of Minoan astronomy on Mycenaean and Greek culture was in some measure realized.

Acknowledgements

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Mnajdra Was Not Built in a Day

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Abstract
Based on archaeological evidence the Mnajdra complex, which consists of three distinct structures, seems to have been built and used throughout the Ggantija (3,600 – 3,000 BC) and Tarxien (3,000 – 2,500 BC) periods. As chronology is mainly based on typological and not on stratigraphic evidence, the precise dating of the Mnajdra buildings is not free of difficulty. It is generally acknowledged that the small trefoil temple was the first to be built, due to its simplicity, and that the middle temple was the last. The lower temple would have been constructed in a time span between the other two. However, this temple shows signs of more than one building phase and part of it could have been constructed before, or contemporarily to, the small trefoil temple. Based on field observations and horizon astronomy, this paper proposes a redefined building sequence for the lower temple, which was conceived of and built over a thousand year period. Where archaeology alone does not provide any conclusive evidence or indication, archaeoastronomy can provide supplementary data to help establish a possible building chronology.

KEYWORDS: archaeoastronomy, Malta, Neolithic, temples, orientation, chronology

POVZETEK
Na podlagi arheoloških dokazov se zdi, da je bil kompleks Mnajdra, ki ga sestavljajo tri ločene strukture, zgrajen in uporabljan v obdobjih Ggantija (3600 do 3000 pr. n. št.) in Tarxien (3000 do 2500 pr. n. št.). Ker kronologija temelji ne tipoloških in ne na stratigrafskih dokazih, je natančno datiranje zgradb v Mnajdri težavno. Splošno mnenje je, da je bil – glede na njegovo preprostost – najprej zgrajen mali tridelni tempelj, nazadnje pa srednji. Spodnji tempelj naj bi bil zgrajen v obdobju med obema. Vendar pa so v spodnjem templju vidne različne gradbene faze, zato je bil morda deloma zgrajen hkrati z malim tridelnim templjem ali celo pred njim. V članku na podlagi terenskih opazovanj in horizontske astronomije predlagamo spremenjeno zaporedje izgradnje spodnjega templja, ki je bil načrtovan in grajen skozi tisočletno obdobje. Kjer sama arheologija ne daje dokončnih dokazov ali podatkov, si pri ugotavljanju verjetne kronologije izgradnje lahko pomagamo z arheoastronomijo.

KLJUČNE BESEDE: arheoastronomija, Malta, neolitik, templji, usmerjenost, kronologija

Introduction

This paper aims to investigate whether archaeoastronomy can provide supplementary data to establish a possible building sequence of the Maltese Mnajdra temple where archaeological excavations and observations seemingly fail to provide clear chronological evidence. The question of whether Mnajdra was intentionally constructed to face specific predetermined objects in nature or aligned to celestial bodies is addressed. This study is based on archaeoastronomical fieldwork and photographic documentation. Distances were measured via a hand-held GPS (Garmin 12), whereas given azimuths and horizon altitudes were measured using a Suunto compass and clinometer tandem. Naked-eye astronomy at certain times throughout the year, close to the equinoxes and solstices, proved to be of special importance throughout this study.

Mnajdra is probably the most atmospheric of all the temples on Malta (Trump 2002: 148). It is situated in a gentle depression formed by converging hill slopes on the southern cliffs in the south-eastern sea lines. There are no modern buildings or constructions in sight and it has a scenic view over the sea and the rocky islet of Filfla. A first impression might be that the landscape where Mnajdra is built is barren and inhospitable; however, it offered all the resources necessary for a community 5,500 years ago (Stroud 2010: 5). The temples are built from both the harder Lower Coralline Limestone which one finds on nearby cliffs dropping into the sea and the softer Globigerina Limestone which is available less than 200 meters from the site. Mnajdra, like the nearby Hagar Qim temple, has never disappeared since the time it went out of use in prehistory, though it seems to have suffered disorder and damage, as can be seen in old photos and drawings. Mnajdra has gone through considerable restoration work since the first known excavations in the beginning of the 20th century. However, its central features are fundamentally well preserved and the overall feeling one has when visiting it, is of an archaic structure (Evans 1971: 96).

The temple period in Malta goes from the Early Neolithic (4,100 BC) until the Early Bronze Age (2,500 BC), however, when it comes to the Mnajdra complex the core time frame is the Ggantija (3,600 – 3,000 BC) and the Tarxien (3,000 – 2,500 BC) phases (Trump 2004: 230). The Mnajdra temple complex consists of three distinct temples or structures, as seen in figure 1.

The first decision that the prehistoric builders would have taken was the orientation of the axis along which the portal structures were to be erected (Torpiano 2004: 360). As it seems the builders put considerable work, effort and skill into the axis of orientation of their enduring megalithic temples, it could indicate a directional intentionality and Torpiano concludes that the concave façade present in most temples confirms the importance of the axis of orientation. Evans (1959: 125) on the other hand, claims that orientation seems not to be an important factor to the temple builders, though he maintains that mostly the entrances face in some direction between south-east and south-west. When it comes to the Mnajdra temple complex, Trump (2002: 148-51) agrees with Evans' point of view on temple orientations and only goes as far as stating that an 'astronomical alignment has been suggested'. The first authors to mention a possible celestial orienta-

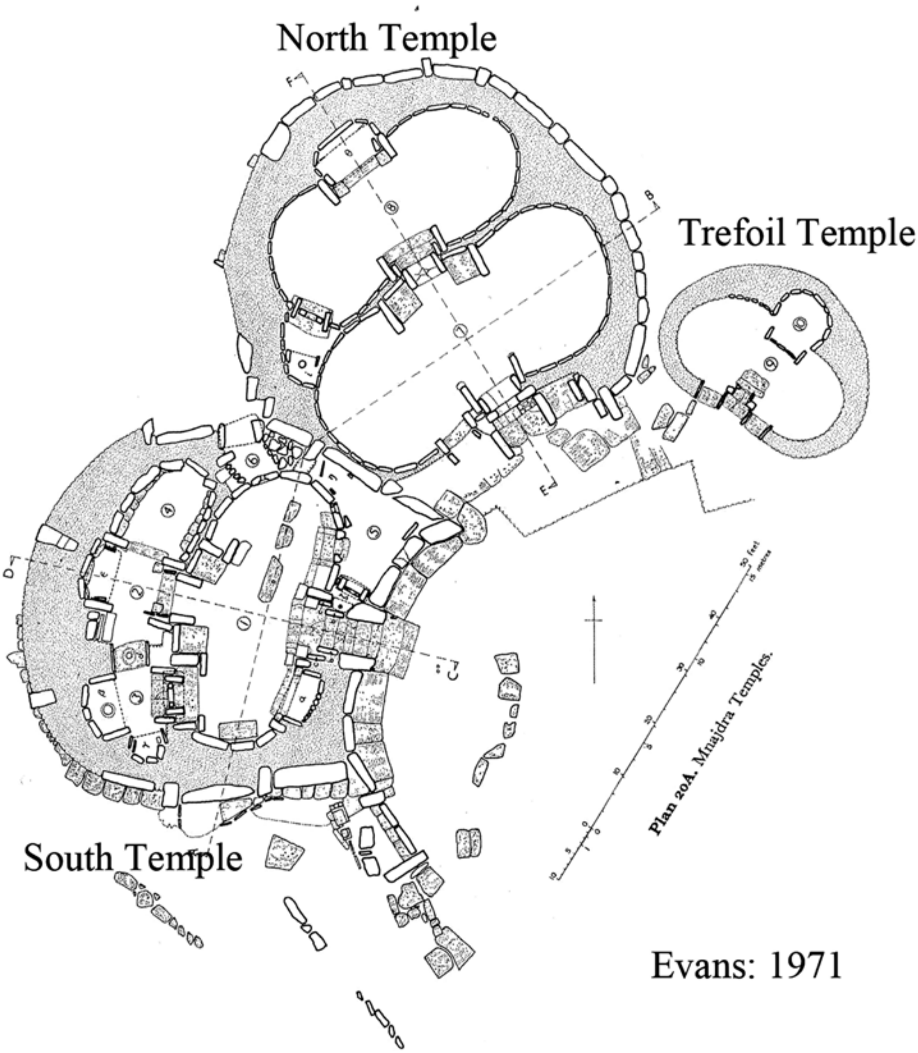

Figure 1: Plan of the Mnajdra temple complex, with the small trefoil temple at the right, the north temple at the top, and the south temple in the bottom-left. Adapted from Evans (1971).

tion were Ugolini (1934: 128, translated from Italian by the present author) and Zammit (1929b: 13). Studies conducted by Agius and Ventura (1980: 9) and by Cox and Lomsdalen (2010) concluded that most temples are in the south-east to south-west orientation range and show consistency of bearing, suggesting that some temples were intentionally constructed to face particular directions. On a survey of 14 orientations, Ventura *et al.*

(1992) found them all within the range 125.5° to 204°, less than a quarter of a circle, and concluded that, 'such a concentration of axes cannot have come about by chance.' When it comes to the Mnajdra complex this author (2011) argued that the three temples seem to have a well-defined orientation along the central axis. The small trefoil, or East temple, has a southerly orientation, whereas the five-lobed middle, or North, temple is orientated towards south-east. The five-lobe lower, or South temple, is oriented towards an eastern horizon that slopes down towards the sea which is 500 meters away as estimated by the present author through GPS readings. The South temple is atypical in the sense that it is the only extant temple on Malta with a well-defined orientation towards the east.

Building Chronology

Firstly one should emphasise that the chronology of Mnajdra is, according to Grima (2012), 'on shaky ground'. Its construction chronology is mostly based on typological observations and not on stratigraphic trench excavations (e.g Evans (1971: 102). The first person to have considered chronology was Fergusson (1872: 41) who maintained the middle, or North temple, to be the earliest due to its simple architecture and the fact that it was placed on higher ground than the other two. Mayr (1901: 663) agrees with Fergusson that the Mnajdra complex is not constructed within a single architectural layout, but instead claims the lower building, the South temple, to be the oldest.

Ashby (1913: 93) agrees with Mayr that the North temple is younger than the South one as the foundation of the former is piling up against the northern external wall of the latter and is thus structurally supported by the South temple. This strong argument is fully in accordance with Evans (1971: 102-3) who stated that the North temple was clearly added later in the Tarxien phase, constructed all at once and not subsequently altered. Evans dug only a single trench in the North temple, in room 7, where a large number of pottery shards, all of advanced Tarxien types, were recovered. This indicates that the temple was being used during the Tarxien period and, since no pottery from previous phases was found, suggests that it would have been built in the same period. Since the beginning of the 20th Century the archaeological consensus has therefore been that the North temple is the most recent one and that it was built and used in the Tarxien period.

The small trefoil temple does not feature in these chronological debates until well into the 20th century, after Ashby (1913: 91) re-erected the Western fallen pitted central pillars and reconstructed part of the temple wall (Ashby *et al.* 1913). Extensive restoration work was also completed by the Museum department in 1952 and 1953 (Pace 2004b: 129). According to Evans (1971: 101) as the monument stands today, it gives an impression of a trefoil temple, but it might have originally consisted of two pairs of apsidal rooms, of which the front has completely disappeared. The whole area around the trefoil temple seems to be part of a non-standard building lay-out with an irregular collection of rooms of which an overall plan is difficult to establish. Nevertheless, Evans (1971: 103) suggests that the small trefoil temple was the earliest to be constructed and this point is generally acknowledged by scholars today (Trump 2002: 148). In effect, Evans retrieved Ggantija type pottery in a trench excavated in front of this temple (1971: 103). However, it must be noted that this doesn't constitute clear evidence that the trefoil temple was first to be built. Shards from the earlier Zebbug and Mgarr periods (4,000 – 3,600 BC), in addition to Ggantija pottery, were retrieved in front of the entrance to room 3 in the South temple which, following the same reasoning, would suggest an even earlier building stage for this temple (Evans 1971: 102).

The most complex temple to assess the chronology of is the lower South temple as it shows sign of more than one building phase. Mayr (1901: 663) claims that 'the south building is the most important and so the oldest' (translated from German by the present author). Pottery shards from the Neolithic Zebbug (4,100 – 3,800 BC) up to the Bronze Age Borg in-Nadur (1,400 – 800 BC) periods have been retrieved there (Evans 1971: 102). According to this author this does not necessarily mean that the temple had been constructed during the Zebbug period, neither that it was completed about 2,500 year later in the Borg in-Nadur phase. The earlier pottery might indicate that the site was used as a dwelling or religious site prior to the construction of the temple, much like the 'shrine' at Skorba from the Red Skorba period (4,400 – 4,100 BC). This was in use as a sacred hut within a village compound prior to the erection of the temple itself (Trump 1966: 50-1). The later Bronze Age pottery suggests that the site was still in use, or reused, in this period. As no bronze material has ever been found on Mnajdra and there are no indications of metal items being applied or implemented in the temple construction, it is suggested that the temple was completed before the Bronze Age. According to Pace (2004b: 129) the current version of the South temple was built during the Ggantija phase and it is 'highly probable that much of the original Ggantija temple still stands intact'.

There is evidence that the South temple was not built all at once, but either in phases or that, at least, changes were made throughout its usage history. According to Evans (1971: 102), Fergusson had already noticed that an apse had previously been altered to make space for room 3 with its niches (Fig. 1). Mayr (1901: 663) agrees with Fergusson on this point and further suggests that the back central room, room 2, with its original two apses (3 and 4) are the remains of an earlier structure. Room 3 would not only have been refurbished later, but, due to regularity in style and the presence of the same drilled and pitted decoration, this would have occurred at the same time that the front apse (room 1) was added on. Ashby largely agrees with Mayr's claims, but suggests that the back wall of the rear and left hand apse (room 3, β and y) still stood and formed the back wall of the rear left-hand niche (Ashby *et al.* 1913: 97). Based on this, it may be argued that room 3 could belong to the very earliest part of the temple. During Evans' 1954 campaign he excavated a total of ten trenches in various parts of the lower temple 'with varying successes'. He claims to have cut an important trench in front of the threshold of room 3 running to the south wall of room 1 which contained a mixture of shards, some of the Ggantija type and others appeared to belong to an underdeveloped stage of the Tarxien period (Evans 1971: 102). He further suggests that the front apse (room 1) was constructed in an early Tarxien phase and that rooms 2 – 3 are probably the oldest part, 'though now, unfortunately, unprovable,' and concludes that the presence of Ggantija type of pottery 'seems to show that there was a building on the site in the previous phase' (1971: 103). The northern walls of the L-shaped room 5 are supporting the foundation walls of the front apses (room 7) of the middle temple. Pace (2004b: 131) claims room 5 to be from the Tarxien period, that the room was fashioned out of the wall of lower Mnajdra and that megaliths from the older building were used to structurally support the middle temple. Evans (1971) on the other hand, does not mention any possible refashioning of the wall of room 5. Evans(1971: 102) cut two trenches (E and F) in room 5 both containing Tarxien type pottery, whereas in one of them (E) Ggantija potshards were found at a deeper level. This author suggests that as: i) room 1 was built sometime in the Gganija period; ii) the Ggantija pottery was found in room 5 close to the outer wall of room 1; and iii) the room itself is most probably from the Tarxien period, as stated by Pace, this could indicate that the Ggantija pottery was there before the floor of room 5 was constructed and consequently the façade wall. Evans (1971: 103) on the other hand suggests, due to the presence of Ggantija pottery in the black level in trench E that there was a 'building on this site in the previous phase'. Due to its uncertainty, a guided and comprehensive analysis of the excavation data is needed before any conclusions can be drawn.

Although the precise dating of the Mnajdra building is not free of difficulties (Pace 2004b: 128), based on excavations, reports and the opinions of the archaeologists referred to above, the following chronology for the construction of the Mnajdra complex can be suggested:

1.) the small trefoil temple was built, probably in the Ggantija period as suggested by Evans;
2.) rooms 2, 3 and 4 of the South temple were built at some point in the Ggantija period (it is unknown whether this occurred before, during or after the small trefoil temple was constructed);
3.) the apses of room 1 may have been completed in later Ggantija or early Tarxien period and room 3 may have been refurbished at the same time. Room 6, however, could have been constructed in the first stage, and room 5 in the latter stage, of building the North temple in the Tarxien period, contemporarily with the concave façade of the South temple;
4.) the North temple was completed sometime into the Tarxien period.

Archaeoastronomy and Building Chronology

As the Mnajdra complex architecture stands today, it is primarily the South temple with its eastern orientation which has attracted most astronomical interest and speculation on whether it was intentionally constructed to face celestial bodies, especially the Equinox, Winter and Summer solstices sunrises (Ventura *et al.* 1992). Since the 1980's scholars, authors and enthusiasts have addressed the possibility that the temple was intentionally built as a calendar (Micallef 1990), an astronomical observatory (Micallef 2000: 3) or a time device to keep track of religious festivals and other events throughout the year (Cox & Lomsdalen 2010, Lomsdalen 2011). Some work on astronomical alignments has also been done on the North temple (Albrecht 2004: 50-9) and more extensive investigations were conducted by Ventura *et al*. (1993) regarding the two tally stones centrally placed in the small trefoil temple, which they suggest may have been used as a calendar for heliacal rising of the Pleiades and other stars and asterisms, registering significant astronomical sequences of annually occurring events. An astronomical factor to take into consideration when comparing alignments towards celestial bodies in the temple period and today is that the heavenly bodies have changed positions, and due to the tilt of the Earth's axis, the Sun rise and set horizon range is about 3/4 of a degree further north and south than what it is today (Agius and Ventura 1980: 16).

The small trefoil temple

As this temple stands today it has a central axis of about 210°, however, due to heavy reconstruction and refurbishment, it is dubious whether this accurately reflects its original axis. It is too far off for claiming a true south alignment, but it may be close enough to intentionally be oriented towards the small islet Filfla, at about 220°, which can be seen from within the main apsis of this temple. That it probably was a sacred island is indicated by the finds of pottery, jars and bones of animals belonging to the temple period (Farrugia Randon 2006: 43). In 1343 a chapel dedicated to the Assumption of Our Lady was erected after a fierce storm that caused much damage on the mainland. During a 2011 survey, conducted by the present author and Fabio Silva, it was found that also one of the chambers of the nearby temple Hagar Qim, is also oriented towards Filfla island, a fact that was also noted by Tilley (2004: 130).

Assuming that the tally marks previously mentioned are contemporaneous to the temple period, this further indicates an awareness of heavenly events affecting human actions and behaviour on Earth. Further evidence comes from what is tentatively called a 'solar wheel': a small pottery shard retrieved at nearby Hagar Qim (Ventura 2004: 312). Another example may be the tal-Qadi Stone found at the temple site of the same name, suggesting stars and a crescent moon (Micallef 2001). Orientation arguments can't here help with the construction chronology for this temple, however it suggests that sea, land and sky with the islet Filfla as a horizon marker were important components of an islander's cosmology (Grima 2001: 48-65).

The middle, or North, temple

The middle temple is oriented towards south-east, with a central axis of about 140°, which could indicate that the builders intended to align it halfway between the central axis of the trefoil temple (210°) and the lower temple (93°). As stated above, there are many indications that the middle temple is the last to be constructed and belongs to the Tarxien phase. Evans (1971: 102) claims that this temple was constructed all at once due to its thoroughly homogeneous architecture. Nevertheless, it is here suggested that it could consist of two building periods: the first consisting of the back apses (room 8), which was subsequently extended at a later stage. This was a procedure that was commonly used by the temple builders (Evans 1959: 125-6). Room 8 has two altars, a small one at the left hand apse reachable through a porthole entrance in the temple wall with a central axis about 0° or true north, which is confirmed by Albrecht (2007: 29). The other, apparently the main altar, is the back niche of room 8. Standing at the south edge of this altar, two orientations were measured through the approximately one-meter wide entrance (Fig. 3). Following an imaginary line through the north side of the entrance gives an azimuth of about 118° (declination of -22.4°). Following a line through the south side of the entrance gives an azimuth of about 126° (dec. -29.1°). This means that the Winter Solstice sunrise would be framed by the temple's entrance, as seen from the niche in room 8. In the same way, the major lunar standstill sunrise would be seen to rise close to the south side of this entrance. Cox (2009) made observations of the 'Far-Southerly Moonrise' of three Maltese temples from 2005 to 2007, however he did not include Mnajdra in his research programme, nevertheless, discussed in private conversations such a possibility. Consequently the present author's hypothesis cannot be observed and validated before around the years 2023 to 2025 when the far-southerly moonrise will again be visible. However, cross-jamb illumination of an altar seems to be a commonly desired feature used by the temple builders (Cox and Lomsdalen 2010). According to research by Vasallo (2000), a left hand cross-jamb illumination of demarcated areas inside the temples at Winter solstice sunrise seems to be prevalent in megalithic Malta.

When the temple was extended with the front apses, it would consequently block the illumination of the back altar and especially so if the temple was roofed (Trump 2002: 150). With the new apses, the major lunar standstill alignment continues through the north side of the 1.25 by 1.60 meter wide main porthole entrance to room 7, which is now partly destroyed. On either side of the entrance to the passage leading from room 7 to room 8 there are the usual altar-like arrangements (Evans 1971: 99). The present author can confirm that, at Winter solstice sunrise, the altar on the left hand side of the passage is illuminated (Fig. 4), a fact that was already noted by Albrecht (2007: 26). Based on archaeoastronomical considerations, it may then be suggested that the builders started with the back apses and at a later period extended the temple. In doing so, they would have intentionally kept the original astronomical alignments towards the sun and the moon intact, which would certainly suggest intentionality of directionality.

The lower, or South, temple

Most literature on astronomical alignments regarding the South temple seems to assume that the building was constructed all at once and only takes the present architecture and lay out into consideration. There are archaeological indications, as previously mentioned, that this temple might have expanded from the rear apses outwards. The question now is which part of the back apse was the very first to be erected. This paper argues that room 3 might be the first freestanding structure and the rest of the temple consequently has expanded from there. This hypothesis finds archaeological support from the trenches excavated by Evans, already discussed above. Further to this, Ashby suggests the back walls of the niches of this room are original and not refurbished. In addition, from this author's point of view, this structure does have all the elements of a free standing Maltese prehistoric temple in its own right: it has its own porthole entrance with rope holes for door closure, three niches, and a dressed altar stone for ritual purposes and received cross-jamb illumination during sunrise at the Solstices.

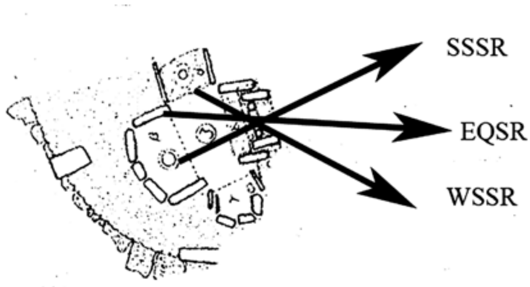

Figure 2: Room 3 of Mnajdra South temple. The three arrows indicate alignments to the Summer Solstice sunrise (SSSR), Equinoctial sunrise (EQSR) and Winter Solstice sunrise (WSSR).

Astronomically room 3 has alignments to the equinoctial and solstitial sunrises, during which specific areas inside would be illuminated (Fig. 2). These alignments are not as precise and demarcated as later parts of the South temple and may indicate an earlier period of horizon astronomy knowledge. The extension of this temple might have first been towards room 2 and 4. Astronomically room 4 seems to be of little interest, however, room 2 is highly central to the temple's overall axis of about 93° (dec. 0°) which aligns with the Spring and Autumn Equinoxes, fully illuminating the altar at its back niche (Campion and Malville 2011, Lomsdalen 2011). However, Ventura *et al*, (1992: 118) suggest the alignments might have been to the rising of the Pleiades and not the equinoctial sunrise. The altar of room 2 is also aligned to both Summer and Winter solstice and would receive cross-jamb illumination from both the Summer and Winter Solstice when room 1 was not yet constructed (Fig. 3).

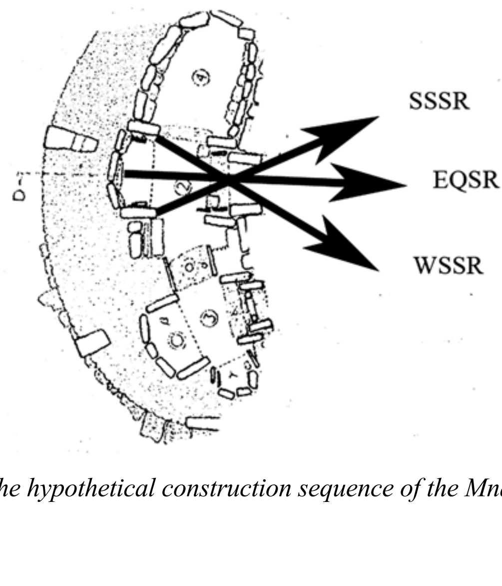

Figure 3: Stage 2 in the hypothetical construction sequence of the Mnajdra South temple.

The next construction phase in the sequence would be the extension to room 1 and the font apses, which seemed to be a normal temple building procedure as already mentioned. Room 1 has a similarity to the later built room 7 in which there is an altar on each side of the passage into the back room. At Summer and Winter solstice sunrise, the two altars in room 1 would receive a cross-jamb illumination before the building of the façade and the extension of the main entrance (Fig. 4). This is when also the rear part (room 8) of the North temple might have been constructed.

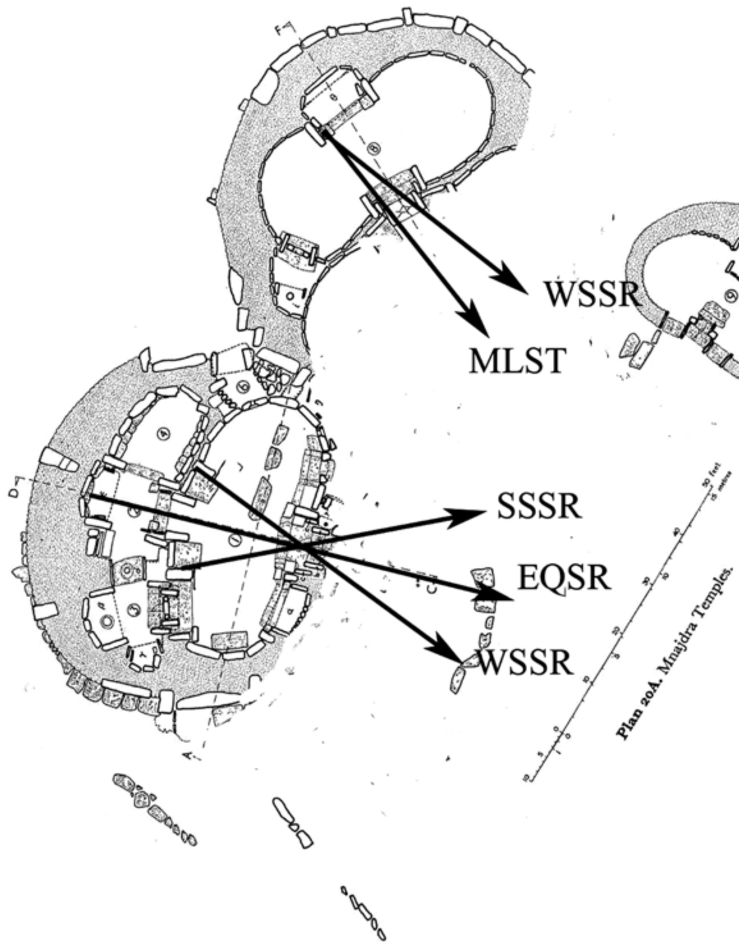

Figure 4: Third stage in the hypothetical construction of the Mnajdra South temple, and first stage of the North temple. The arrow MLST indicates the Major Lunar Standstill.

By building room 5 and completing the North temple (room 7), setting up the concave façade of the South temple and prolonging and narrowing its main entrance, the two altars just mentioned would be closed off from the sunlight at time of the solstice (Fig 5). It is here suggested that this was when the two vertical orthostats were placed on each side of the altars in order to receive the cross-jamb illumination at the Summer and Winter solstices, as can be observed today (Lomsdalen 2011).

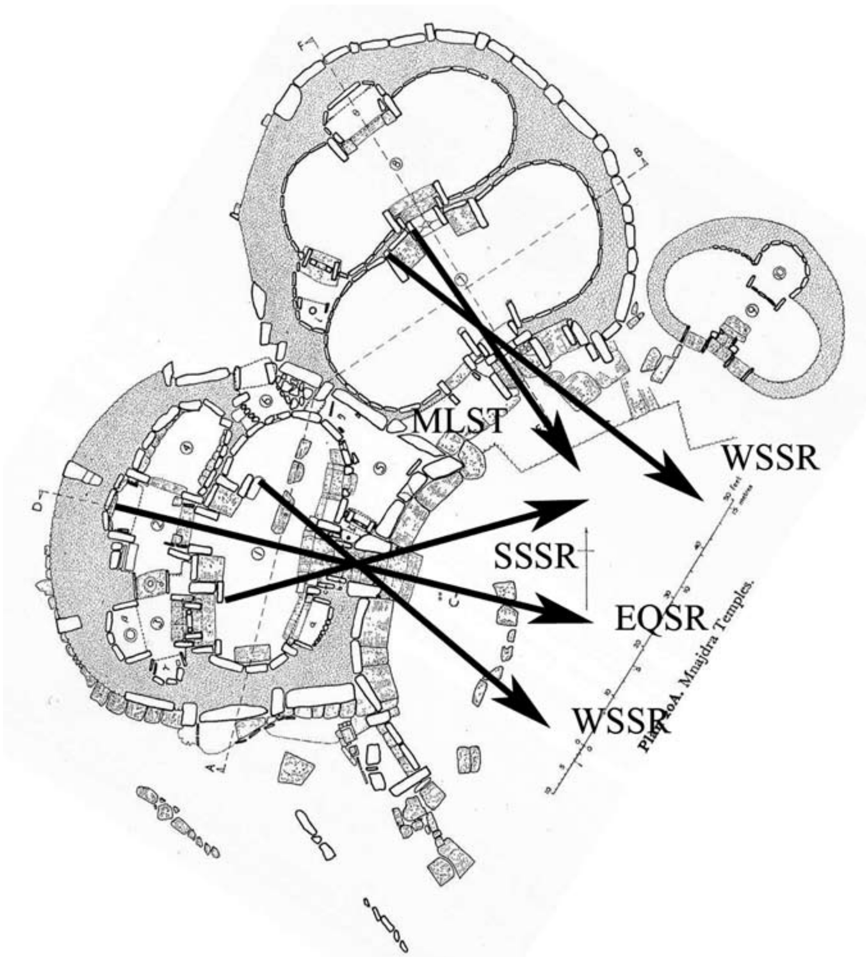

Figure 5: Final stage in the hypothetical construction of the Mnajdra temple complex.

Conclusion

This paper has suggested that the careful consideration of archaeoastronomical features embedded in individual rooms and sections of the Mnajdra complex can support and further the hypotheses of archaeologists regarding the building sequence of the three temples. Fieldwork has indicated that the key orientations and celestial alignments that are visible in the final, and present, form of the temples can already be identified in their earlier counterparts, as suggested by the archaeology. This can then be taken further and archaeoastronomy can be used to fill in the gaps by making suggestions.

Based on this the following redefined constructional chronology has been proposed:

1) The small trefoil temple might be the first to be constructed in early Ggantija period (3,600 – 3,000 BC). This is rooted in typological and archaeological considerations and, unfortunately, archaeoastronomy can add little.
2) The middle temple could have been built in two distinct stages, one in the middle and the other in the late Tarxien period (3,000 – 2,500 BC). Based on archaeoastronomical considerations its construction could have started with the back apses and later expanded by adding a new room to the temple.
3) The complex lower south temple may have been constructed in four rudimentary stages:
    - 3.1) Room 3 dates from the early Ggantija period and could be contemporary or even older than the small trefoil temple. It contains several characteristics of a temple in its own right, including the solstitial and equinoctial illumination displayed by the final version of the South temple.
    - 3.2) Rooms 2 and 4 could then have been added in the middle Ggantija period. Room 2 again replicates the same archaeoastronomical signature now in its final form (that is with the central axis oriented towards the east).
    - 3.3) Extending the temple with front apses (room 1) seems to be the third building stage and may have been completed sometime in late Ggantija or early Tarxien periods.
    - 3.4) The fourth and final building stage may have been when room 5 was built as a foundation support for the middle temple. To maintain architectural uniformity the entrance was then prolonged and its present concave façade established. In doing this, fifteen hundred years of off and on building was concluded, already well into the Tarxien period.

It is questionable whether astronomical alignments and orientations towards celestial bodies can provide reliable dating evidence. Nevertheless, archaeoastronomy might provide data that supplements the archaeological evidence and thus be an aid in the formulation and testing of hypotheses.

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Placement and Orientations of Cairns around the Middle Neolithic Giant's Churches

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Abstract
Stone cairns are common around the Middle Neolithic Giant's Churches of Ostrobothnia. A popular hypothesis is that they were used for burial or as sacrificial cairns. In this study, the placement and orientations of the cairns were compared to the placement of the Giant's Churches and their axis and gate orientations. The orientations measured for the cairns, as well as their preferred placement facing the eastern and southern horizon resemble the results obtained for the Giant's Churches in previous studies. This supports the suggested dating of the cairns to the same period as the Giant's Churches, although the cairns may have been constructed somewhat later than the Giant's Churches. It was observed that large Giant's Churches have cairns around them more often and in greater numbers, which may point to their status as important, perhaps ritual sites.

KEYWORDS: Giant's Churches, cairns, astronomical orientations, Neolithic Finland

POVZETEK
V Ostrobothniji (Finska) okoli srednjeneolitskih struktur, znanih kot Velikanove cerkve, pogosto najdemo kamnite groblje. Popularna hipoteza pravi, da so služile za pokope ali kot žrtvene gomile. V pričujoči študiji primerjamo položaj in orientacijo grobelj s položajem Velikanovih cerkva ter njihovimi osmi in usmeritvami vhodov. Izmerjene orientacije grobelj in dejstvo, da so običajno obrnjene proti vzhodnemu in južnemu horizontu, sovpadajo z rezultati prej opravljenih raziskav na Velikanovih cerkvah. Na podlagi tega predlagamo, da groblje datirajo iz istega obdobja kot Velikanove cerkve, čeprav so bile groblje lahko zgrajene tudi nekoliko kasneje. Opazili smo, da so groblje pogostejše in številčnejše okoli večjih Velikanovih cerkva, kar kaže, da gre za pomembna, morda obredna mesta.

KLJUČNE BESEDE: Velikanove cerkve, groblje, astronomske usmeritve, neolitska Finska

Introduction

The Giant's Churches (*jätinkirkko*, pl. *jätinkirkot*, in Finnish), hereinafter the GCs, are Middle Neolithic (ca. 3000-2000 BC) large, mostly rectangular stone enclosures only encountered in Ostrobothnia, Finland. They range in size from about 15 m to over 70 m (the longer axis), and their walls, 0.5—2 m high, were built of stones sized from about 10 cm to 1 m. Many GCs have 'gates', which are openings in their walls. There is often more than one gate and they are symmetrically placed, usually in the middle of a wall.

The original function of the GCs is unknown, although some of the smaller ones are probably remains of pithouses. A popular suggestion is that the largest GCs may have been some kind of ritual enclosures, as they are too large to have been covered by a single roof structure (for other hypotheses, see, e.g., Ridderstad & Okkonen 2009).

The axis and gate orientations of 50 GCs had been measured prior to this study (Ridderstad & Okkonen 2009; Ridderstad 2011). Those studies revealed that most of the axes and gates of the GCs are oriented towards important annual solar and lunar events like the winter and summer solstices, the solar mid-quarter days, the minor lunar standstill, and the spring full moon event (also called the megalithic equinox, see da Silva 2004).

Majority of the GCs have stone cairns inside or around them (Ridderstad 2011). A cairn may be incorporated in the wall of a Giant's Church, or it may be located inside the enclosure or outside of it. The cairns placed around the enclosures may be immediately outside the gate openings of the Giant's Churches or at some distance. The number of cairns around a GC varies from a single cairn to several dozens.

Most of the cairns on the GC sites or on other sites located on the Neolithic shoreline level in Ostrobothnia are round; a few oval and rectangular cairns are known. No long cairns are known from the GC sites or the corresponding Middle Neolithic shoreline level. However, on a slightly lower shoreline levels the long cairns become frequent – it seems that the building of long cairns started when the construction of GCs had stopped after ca. 2000 BC (Okkonen 2003: 120).

The size of a cairn is typically 2 to 10 m across. There is often a depression in the middle of a cairn, resulting in a characteristic doughnut-shape of those cairns. In a few cases there is a standing stone in the middle of a cairn. Finds from the cairns are rare, consisting mostly of stone tools, remains of coal and bone fragments (Forss 1993). The finds, as well as the shoreline displacement method, date the cairns most likely to the Neolithic (Forss 1991; Okkonen 2003). However, although there are cairns in clear spatial connection with the Middle Neolithic GCs, it is not known whether the cairns were built simultaneously with the enclosures.

A popular suggestion is that the cairns were related to ritual activities, either for burials or for sacrifices of some kind (Forss 1993; Okkonen 1998). This hypothesis is supported mainly by the fact that in the Bronze and Iron Ages cairns were used for burial.

During the first phase of our GC project in 2008-2009, some orientations from the centres of the GCs towards prominent cairns ('sacristies') were experimentally measured to reveal possible need for further study. The results of these measurements, as well as the fact that in many cases cairns are placed symmetrically around the GCs, indicated that the orientations towards the cairns or possibly their mutual orientations could be meaningful.

The present sample includes not only some previously uninvestigated, large GCs but also structures classified as large housepits, i.e., the remains of pithouses, many of which present the same features as the largest GCs: cairns, standing stones, multiples wall openings etc. At present, there is no feature known other than the size of the structure to tell whether a GC would have been used for ritual or domestic purposes. The cairn orientations and placement could therefore bring some light into solving the difficult question of the original purpose of the structures termed as GCs.

In this paper, the placement and orientations of the cairns around the GCs, as well as the mutual orientations of the cairns relative to one another are presented, and the results are compared to the axis and gate orientations of the GCs measured in previous studies (Ridderstad & Okkonen 2009; Ridderstad 2011). The results are then used to evaluate the ritual hypothesis for the cairns and the GC sites.

Measurements

First, it was investigated how many of the GCs have cairns inside or outside of them, and how the cairns are placed. Then, two types of orientations were measured: a) the orientations towards the cairns from the centre of the GC, and b) the mutual orientations of cairns that are placed in tight triangular formations or in pairs in prominent positions relative to the GC (see Figure 1).

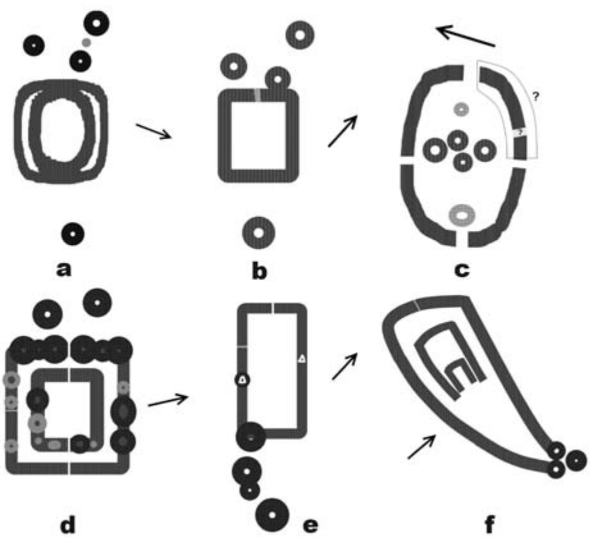

Figure 1: Schematic representations of the GCs of a) Keskimmäisenkangas, b) Kejsmolandsbacken, c) Hiidenlinna, d) Svedjebacken, e) Hembacken, and f) Kåtabacken. The long axes of Keskimmäisenkangas and Kejsmolandsbacken are ca. 25 m, others are 50 – 70 m long.

It turned out that in some cases the vegetation (trees, bushes, grass, moss, lichen) in and around a GC was so thick that a shallow cairn outside the structure could not be reliably observed from the centre of the GC. In those cases, only the general compass direction (N, S, E, W, NE, SE, SW, or NW) of the cairn was recorded. With the mutual orientations of the cairns in formations, the case was easier as all cairns were placed only a few meters from each other, and precise measurements could be carried out on all sites where triangular formations and distinctive pairs of cairns are presently known to exist.

The measurements of orientations were made with a magnetic compass, relative to the solar position. In principle, a measurement made relative to the solar position removes the need to separately correct for the magnetic declination; however, the magnetic declination-corrected values were also calculated for comparison. Moreover, a line of sight was measured in both, opposite directions to further eliminate possible local magnetic anomalies, although no large anomalies seemed to be present on the locations of this study, as revealed by the comparison between the magnetic declination-corrected and solar position-corrected values. The maximum error of the magnetic compass used was estimated to be 1 degree, resulting in the total maximum error of 2 degrees for a single measurement (when both the orientation itself and the position of the sun were measured). It was concluded on site that due to the ground cover and the present state of preservation of the structures, the greatest limiting factors for the accuracy of the measurements were the uncertainties in the original positions of the centres of the GCs – an error of 0.5 m in the position of the centre of a GC would result in an uncertainty of almost 2 degrees in the measured orientation of a cairn 15 m away. That this last source of error considered affects the orientation measurements of most Neolithic structures preserved to date must be kept in mind.

Measuring the horizon heights for the GC sites is hampered by the fact that the post-glacial rebound of the bedrock has moved the sites from their original positions near the shoreline to their present locations deep in the forest. Therefore, the original horizons could not be measured on-site, but had to be estimated using detailed maps obtained from the National Land Survey of Finland (Kansalaisen Karttapaikka 2012). The maps allow the height of the fixed horizon, i.e., hills etc. to be calculated. Unfortunately, even estimating the height of the Neolithic tree line is almost impossible, not only because of the human interference but also because the land uplift constantly moved the structures towards more sheltered locations: it is not known exactly when most GCs were constructed and, thus, whether they were built on small islands still far away from the coastline or on larger ones in the later archipelago phase.

Because of the large uncertainties in the horizon heights calculated from maps alone, an attempt was made to reduce the error in the calculated orientations by adding 0.5 degrees to all horizon heights seen in Table 1. In the East, where the line of sight would inevitably meet the tree line at some point, the chosen 0.5 deg height corresponds to a tree line 15 m high at the distance of about 1.7 km. On the other hand, should the tree line have been further away than 1.7 km in the East (as it often would have been in the open sea phase), the chosen 0.5 deg height would approximately correspond to the size of the full solar or lunar disk above the horizon and thus would not greatly contribute to the total error in detecting a possible solar or lunar orientation even when the true horizon height would have been close to zero. In the West, where the horizon was the sea horizon with occasional small, shallow islands (growing larger with time), the 0.5 deg height again corresponds to the size of the full solar or lunar diameter. This kind of horizon model has, of course, the effect of moving all declinations towards larger values.

Results and discussion

Of the 86 GCs investigated, 62 % had cairns in or around them. About half (53 %) of the GCs were over 25 m long; 76 % of these had cairns. 51 % of the smallest (less than 20 m long) GCs or housepits had cairns. Thus, the largest GCs have cairns more often than the smaller GCs or housepits.

Besides single cairns, there were small, tightly placed groups with less than about six cairns, and large, loosely placed cairn groups with more than eight cairns. To avoid bias resulting from the destruction of cairns in cairn groups, single cairns and cairn groups were given the same emphasis, i.e., each was considered one calculable unit. The total number of single cairns or cairn groups thus observed was 74. Of these, 12 were symmetrically placed tight groups, i.e., clear formations (see the examples in Figure 1). Triangular formations were observed in Keskimmäisenkangas of Oulu, Kåtabacken of Kruunupyy, and Kejsmolandsbacken of Pedersöre. One triangularly placed group of four cairns was observed in Hiidenlinna of Himanka. Prominent pairs of large cairns were observed in Pikku Liekokangas of Raahe, Kirkkoharju of Kokkola, and Svedjebacken of Pedersöre (Figure 1d). In three GCs (Pikku Liekokangas, Hembacken of Pedersöre (Figure 1e), and Tallbackharju N of Pedersöre), cairns were placed in an arc-shaped formation on the eastern, southeastern, or southern side of the GC, respectively. In Tallbackharju N, the cairns in fact formed the southernmost 'wall' of the GC with clear gateways, sided by large 'portal stones', between them. A largely destroyed cairn formation, which had probably been either of the triangular or the arc-like type, was observed in Pahikaisharju; presently, only one of its cairns was clearly distinguishable.

Based on their placement in or around the GCs, all the single cairns or cairn groups belong to one of the six different classes shown in Figure 2. To avoid bias formed by the extensive number of cairns the largest cairn groups, a single cairn and a cairn group were each again considered as forming one countable unit. With very large cairn groups, where one cairn could belong to class C and others further away to D, the group could have a multiple classification. The second case of multiple classification occurred, when a cairn in an inner double wall of a GC got two classifications: A and B. Third, in the few cases where cairns formed part of the wall structure with openings in between (e.g., Tallbackharju N), they were considered to be both B and B2, and the cairns right outside of these openings were then taken to be both C and C2. The six different classes of placement were then found to occur at the frequencies shown in Table 1.

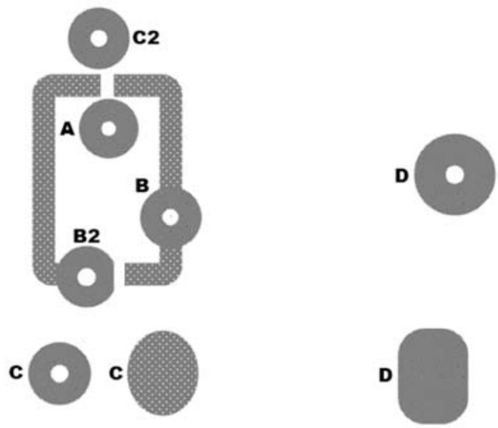

Figure 2: Different types of cairn placements in and around the GCs. A: inside the GC; B: in the wall; B2: in the wall, next to a gate; C: outside the walls; C2: outside a gate; D: outside the walls, more than 30 m away from the GC.

Table 1: Frequencies of the different types of cairn placements shown in Figure 2.

A	6
B	15
B2	10
C	36
C2	8
D	13

Most of the GCs examined to date are situated on the eastern or southern sides of the moraine drumlins or rocky formations they have been built on. In the present sample, 79% of the GCs are located on the eastern or southern edges of the ridges (see also Ridderstad 2011). In Figure 2 it can be seen that the positions of cairns or cairn groups around the GCs are also concentrated on the eastern sides of the enclosures, with the NE direction dominating.

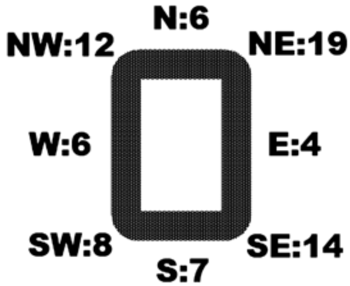

Figure 3: Frequencies of the different orientations towards cairns around GCs as seen from the centres of the enclosures.

In Table 2, the measured azimuthal orientations and the corresponding horizon heights (measured from the maps and without the additional 0.5 deg of the tree line model) are presented. In the table, the values for the orientations towards the cairn from the centre of a GC are shown in the third and fourth columns (labelled A). The values for the mutual orientations of the cairns in formations are shown in the fifth and sixth columns (B) – for the mutual orientations, the two opposite directions obtained for each cairn pair have been taken into account. In Figures 4 and 6, the corresponding declination distributions are shown. In Figures 5 and 7, the declination distributions calculated using the additional horizon height of 0.5 deg are presented.

Table 2: Orientations of the cairns. Columns A: orientations towards the cairns from the centres of GCs. Columns B: mutual orientations of cairns in formations.

Name of GC	Latitude	Azimuth A	Horizon A	Azimuth B	Horizon B
Mäntyselkä	65.26	310	0		
Rajakangas	65.23	59	0.1		
Keskimmäisenkangas	65.16	228	0	11/191	0.1/0
		243	0	97/277	0.1/0
		252	0	139/319	0.1/0
		49	0.3		
Linnakangas Tyrnävä	64.71	68	0.4		
Kotakangas	64.71	152	0.2		
Käyräkangas 1	64.71	46	0		
		197	0.4		
Käyräkangas 2	64.71	57	0.4		
Pikku Liekokangas 1	64.64	274	0	176/356	0.4/0
		239	0		
		132	0.7		
		112	0.5		
Kehämaa	64.62	68	0.7		
		104	0.7		
Kettukangas Raahe	64.58	204	0		
Pirttihaudankangas	64.54	102	0.6		
Hiidenlinna	63.98			13/193	0/0
				52/232	0/0
				115/295	0.3/0
				146/326	0.1/0
				171/351	0/0
Kirkkoharju	63.80			108/288	0.4/0
Pikku Hautakangas	63.78	103	0.3		
Kåtabacken	63.68			19/199	0.1/0.1
				91/271	0.4/0
				145/325	0.2/0
Hembacken	63.57	149	0.5		
		152	0.5		
		155	0.5		
Tallbackharju N	63.54	58	0.1		
		148	1		
		172	1		
		213	0.6		
		250	1.1		
Svedjebacken	63.51	270	0	0/180	0/0.1
		280	0	30/210	0/0
		295	0		
		308	0		
		27	0		
Kejsmolandsbacken	63.43	145	0.1	4/184	0/0
		302	0	29/209	0/0.3
		332	0	61/241	0.1/0
		347	0		
Bäckeshällorna	63.27	119	0.6		
Höjsalträsk	63.11	32	0		

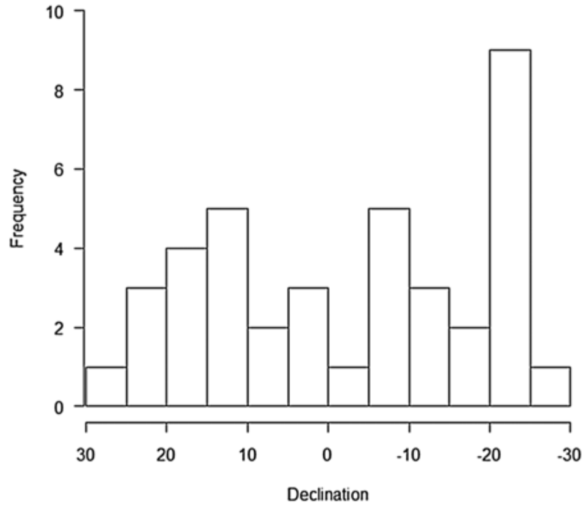

Figure 4: Orientations towards the cairns from the centres of the GCs with the horizon values estimated from maps.

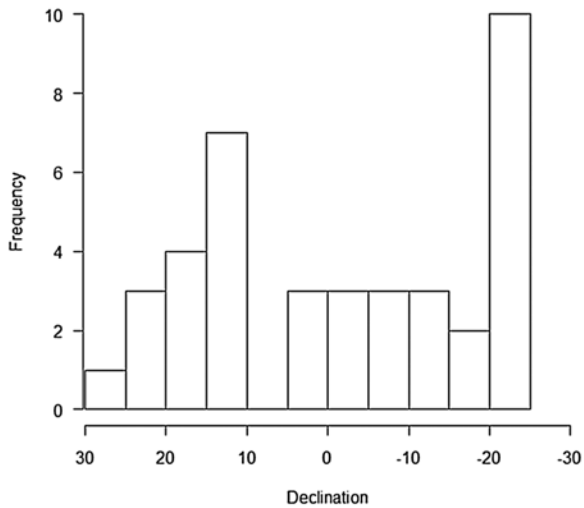

Figure 5: Orientations towards the cairns from the centres of the GCs with the horizon model used.

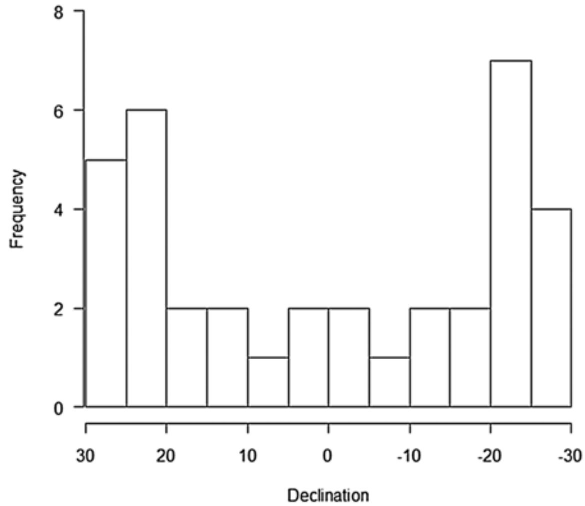

Figure 6: Mutual orientations of cairns in formations with the horizon values estimated from maps.

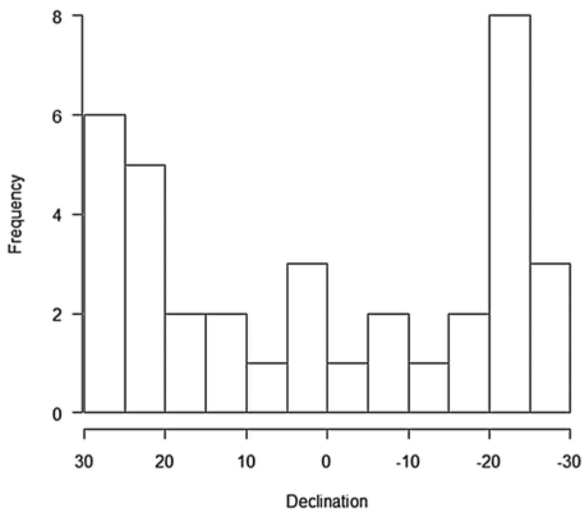

Figure 7: Mutual orientations of cairns in formations with the horizon model used.

The orientations towards the cairns from the centres of the GCs show a prominent peak close to the declination -24, the solar position on the winter solstice at the time the GCs were built (see Figures 4 and 5). The winter solstice orientation occurs in the axis orientations of the GCs, especially for the largest GCs (Ridderstad & Okkonen 2009; Ridderstad 2011). Therefore, the result probably reflects the fact that many cairns are located roughly along the long axes of the GCs.

There is also a peak around the declination 13. The GC axis and gate orientations do not show a peak at this position (Ridderstad 2011). The event possibly related to this peak is yet unknown – the orientation corresponds to the sunrises of late spring (around the Summer Nights, the ancient Fennoscandian start days of the summer time) and early autumn, but the target could also be a lunar event, e.g., a full moon rise in late autumn or early spring.

The mutual orientations of the cairns also seem to show the winter solstice peak (Figures 6 and 7). However, the sample size is small and the distribution still resembles the declination distribution corresponding to azimuths evenly placed along the horizon at the latitudes of Ostrobothnia. However, from the values given in Table 2 it can be seen that all three cairn pairs have mutual orientations close to the N-S or E-W lines. Also one of the cairn pairs in each of the triangular formations is positioned closely along these lines.

It can thus be concluded that the general placements and orientations of the cairns relative to the centres of the GCs are important, while the mutual orientations of the cairns in triangular formations are probably random. The triangular shape of the cairn formations may have resulted from adding a third (and a fourth, and a fifth, and so on) cairn next to a pair of cairns oriented along the cardinal directions. On the other hand, the symmetricity of the triangular formations, as well as that of the arc-shaped cairn rows, may be significant in itself and point to some ritual function for the cairns.

A prominent feature in most cairns is the central pit. The pits in the cairns are usually considered to have resulted from later diggings. However, some of the pits are very regular in form and there are no scatter stones around those cairns. It is thus possible that the pit in a middle of a cairn could have resulted from the collapse of the structure once a buried body and a possible wooden coffin would have decomposed without a trace in the local acidic soil. Considering the Neolithic burial practices elsewhere in Europe, it is also possible that the pit itself was used to place the body until all but bones would have decomposed, or that human bones or ritual offerings of food were placed in the pits. None of the above burial practices would have preserved any visible remains to date. Even pottery would be hard to find without a thorough excavation, since the fragments of the pots would have fallen between the stones and would likely have been broken into smaller and smaller pieces during the frost heaving movements of the stones. Burnt bone and coal would have preserved – indeed, layers of coal have been found inside and under some cairns (Forss 1993).

There is evidence that some Neolithic or Bronze Age cairns were constructed above the ground level of a previous Neolithic settlement (Forss 1993). If the cairns were ritual structures, used for burials or sacrifices, then the construction of cairns – as well as the large stone enclosures – could have been related to the ritualization of a former settlement site (Ridderstad 2011). The cairns would thus be of somewhat later date than their surrounding Neolithic settlements and the GCs – the age difference could be one day or hundreds of years. A single cairn next to a housepit could have enclosed the remains of the former inhabitants of the pithouse. The fact that the largest GCs have cairns around them more often than the smallest ones could indicate their status as important ritual sites: an extended group of cairns around a large GC could be a burial ground constructed on a site that once used to harbour many dwellings. People's perceptions of and their beliefs concerning the decayed remains of former dwellings could have caused the former settlement sites to become associated with the dead. Building the cairns would thus have marked the start of the site as a ritual place, a permanent feature in the landscape and a place of remembrance.

It can be concluded that the orientations measured for the cairns, as well as their preferred placements facing mainly the eastern and southern horizon, support their dating to the Middle Neolithic, i.e., to the same period as the GCs. However, only future excavations can settle the question of the original function of the large stone enclosures known as Giant's Churches and the possible ritual significance of the cairns surrounding them.

Acknowledgements

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The Astronomically Oriented Megalith of Monte Arcivocalotto

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Abstract
The Monte Arcivocalotto site, located on an insulated 579 m high hill dominating the western part of the Belice River Valley, was known for the presence of ceramic fragments dated from Eneolithic to the Bronze Age, when the related settlement was probably one of the most important hegemonic sites of the area. Near to the top of the hill, an imposing megalith is visible from many kilometres of distance. It is made of a single sandstone slab, triangular in shape, with a large circular hole piercing its centre. It is known to local people as *'U Campanaro* (The Bell Tower) and it was considered as a magical place until lately. Measurements performed in 2010 and 2011 have shown that the megalith is oriented toward the sunrise of the winter solstice, when, due to the shape of the local geographical horizon dominated by the mountain of Rocca Busambra (1613 m), the Sun rises exactly on the centre of the hole, a phenomenon observable from a very great distance. We analyze here the intentionality of this orientation, reaching the conclusion that the Monte Arcivocalotto megalith is purposely astronomically oriented for cultic and calendar reasons.

POVZETEK
Najdišče Monte Arcivocalotto se nahaja na osamelcu višine 579 m, ki dominira nad zahodnim delom doline reke Belice. Poznano je po ostankih keramike, ki izvirajo iz obdobij od eneolitika do bronaste dobe, ko je bil tu verjetno eden izmed najpomembnejših hegemonističnih sedežev tega področja. Blizu vrha se nahaja impozanten megalit, ki je viden z razdalje več kilometrov. Narejen je iz enotnega trikotnega bloka peščenjaka, z veliko okroglo odprtino v sredini. Domačini megalitu pravijo *'U Campanaro* (Zvonik), do nedavnega je kraj veljal za magičnega. Meritve v letih 2010 in 2011 so pokazale, da je megalit usmerjen proti Sončevemu vzhodu ob zimskem solsticiju, ko – zaradi oblike lokalnega horizonta, na katerem dominira gora Rocca Busambra (1613 m) – Sonce vzhaja točno v središču odprtine, kar je vidno z zelo velike razdalje. V članku smo analizirali namernost te usmerjenosti in prišli do spoznanja, da je megalit v Monte Arcivocalotto namenoma usmerjen astronomsko in sicer zaradi kultnih in koledarskih potreb.

Introduction

Astronomically oriented megaliths, often built by modifying natural rocks on the slopes of high mountains, are relatively common in Cilento and Basilicata (see, e.g., Polcaro & Polcaro 2009; Curti et al. 2009). These megaliths have common characteristics with other astronomically oriented structures found in Calabria and Apulia. They show alignments to the meridian and to the winter solstice sunset, probably because of calendric and ritual purposes. Although only a few reliable datings are available, in many cases it is possible to hypothesize that the use of these monuments started in the Early Bronze Age. Until two years ago, astronomically oriented megaliths were unknown in Sicily. The discovery of the astronomically oriented megalith of Monte Arcivocalotto is thus extremely interesting.

The context

The site is in the area of the Monti Sicani, the northern territory of the central - western Sicily still, for the most part, preserved in its natural aspects. The Jato River, which runs through much of the territory in direction North - West / South - East, joining the Belice River in its northernmost right arm, connects the interior with the southern coast of the Island. For the particular position and the morphological characteristics, the area had to be, since ancient times, an important link node for trade. The area, inhabited at least since the Neolithic epoch, strongly developed in the Eneolithic and in the Bronze Age.

Probably the numerous Bronze Age sites, scattered on the sandstone ridges of the Jato Valley, may have formed homogeneous portions of a political - economic – cultural area, in synergy with each other, as it appears from an initial survey of the territory having the extreme points in the Balletto - Raitano - Arcivocalotto - Pietralunga sites (Scuderi et al. 2011).

Of particular importance is the site at the foot of Pizzo Pietralunga: this is a single, isolated rock, ~150 m high, standing over the Belice River plain. It came up from the ground millions of years ago because of unusual tectonic interactions between the faults crossing in this unstable area, but its impressive shape, dominating the plain, made it a sacred place at least since the Eneolithic to the Bronze Age. Actually, many luxury goods, as well as a fragment of 'Bell-Beaker' culture ceramics (extremely rare in the area) were found there, suggesting the presence of a cultic area and of votive offering.

Figure 1: The Pizzo Pietralunga rock (right); the orthophoto, taken by a kite, shows the area of the archaeological findings (right).

The Monte Arcivocalotto site is located in a prominent position, on an isolated hill (Monte Arcivocalotto) at about 500 m above sea level. The hill is situated halfway along the mountains of Rocca Busambra and Monte Jato, ~2.5 km from Pizzo Pietralunga. The place was known because pottery fragments dating from the Eneolithic to the Bronze Age were found in the neighbourhood. During Bronze Age, it belonged to the settlement complex of Pietralunga and would seem to have been the hegemonic centre of the area. The site was reused during the Roman, Byzantine and medieval epochs.

The Monte Arcivocalotto megalith

On the slope of Monte Arcivocalotto, an imposing megalith, known to local people as *'U Campanaro* (i.e. 'The bell tower'), is sited near to the top and is clearly visible from a great distance (see Fig. 2).

Figure 2: The Campanaru megalith (SW sight), seen from the Jato Valley bottom, at ~1 km distance.

It is a large sandstone slab, shaped as a scalene triangle of ~4 m in length, ~3 m in height. Its section is roughly triangular, with a thickness of ~1.5 m at ground level. The western side is nearly vertical, while the eastern side is inclined at ~75° respect to the horizontal plane. In its centre, a nearly perfectly circular, clearly artificial, hole of ~2 m diameter is pierced (see Fig. 3).

Figure 3: The Campanaru megalith, NW sight.

The thickness inside the hole was converted into a concave seat, with a small overhang perhaps for devotional deposition, with small cupmarks; a small step follows the north-western side of the monolith. On it, a concentric square petroglyph is carved (see Fig. 4).

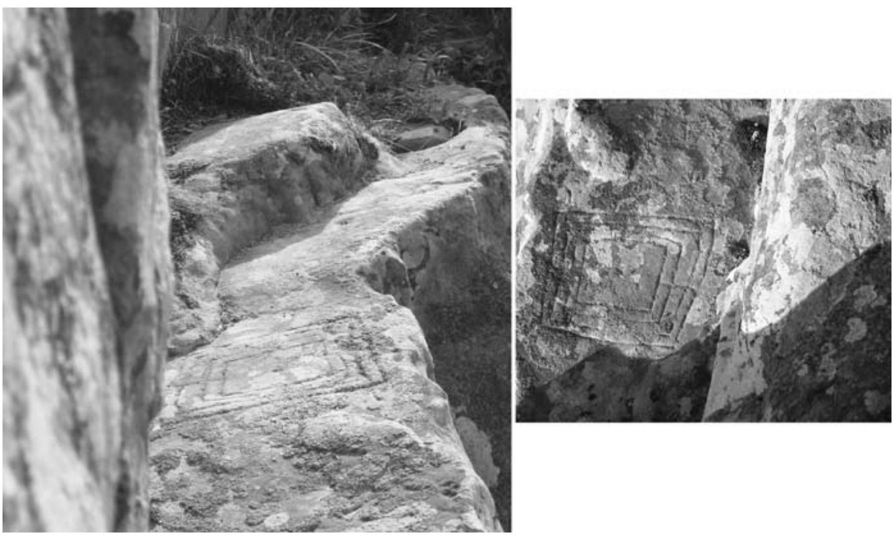

Figure 4: The step on the NW side of the megalith (left) and detail of the petroglyph (right).

Oral testimonies indicate the presence – up to a few decades ago – of a fence, made by small triangular blocks planted in the ground, which delimited in a semicircle. This fence has been removed by farmers to increase the area under cultivation. However, in the west side there is still a single rock with the characteristic triangular shape, belonging to the destroyed semicircle of stones stuck in the ground.

The astronomical orientation of the Monte Arcivocalotto megalith and its intentionality

Measurements made with a precision bearing compass on June 23rd 2011, corrected for the local magnetic declination using accurate GPS coordinates and compared with IGM (Italian Military Geography Institute) cartography and geo-referenced satellite images, show that the axis of the central hole has 133°±1° azimuth and 15°±1° elevation with respect to the horizontal surface. This axis is clearly indicated by a reverse V-shaped notch on the hole's upper perimeter, making it easily recognizable even from a great distance.

Because of this orientation, the Sun rises over the geographical horizon at the centre of the hole exactly at the winter solstice (see Fig. 5).

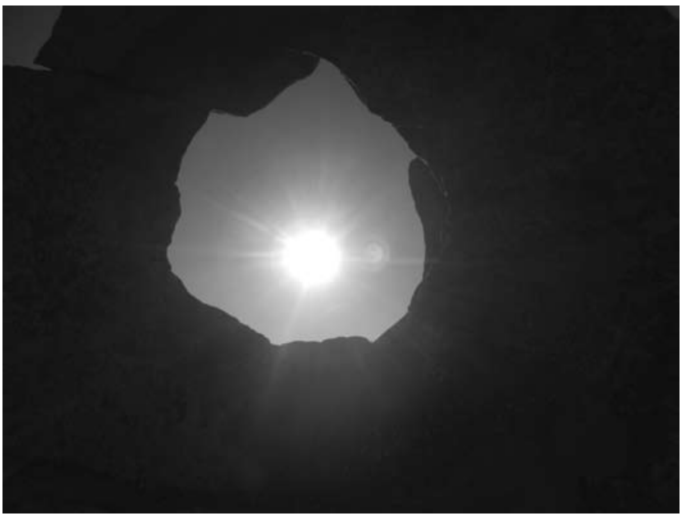

Figure 5: 2010 winter solstice sunrise at the Monte Arcivocalotto megalith (photographed by A. Scuderi).

The megalith thus presents a manifestly astronomical orientation. The problem is to determine if this orientation is intentional.

Following Schaefer (2006), in order to claim an astronomical orientation, three conditions must be satisfied: the orientation must be statistically significant (at least 3 σ, better 4 σ), archaeological evidence of its intentionality must be present and ethnological evidence of the symbolic value connected to the claimed astronomical orientation must be found.

Again following Schaefer (2006), the probability of finding a single intentional solar alignment in a monument is 1/22 over the null hypothesis (random orientation), corresponding in Gaussian statistics to 2.08 σ. However, in the case of the Monte Arcivocalotto megalith, we have to consider that the phenomenon happens because the rising Sun, when its azimuth is the same as that of the megalith hole, has also the height on the astronomical horizon equal to the one of the geographical horizon, obstructed by ~15° by the mountain of Rocca Busambra (1613 m). We can compute that the probability of this event is 1/45 (Curti et al. 2009), corresponding, in Gaussian statistics, to ~2.5 σ. The conditional probability of these two events is 3.25 σ and is thus slightly higher than the accepted threshold.

Archaeological evidences of intentionality are numerous: the hole is manifestly artificial and the megalith shows clear evidence of workmanship in order to point the hole axis to a precise direction. Furthermore, the petroglyph of concentric squares carved on the step at the foot of the megalith on its NW side is exactly aligned with the hole axis: it is thus oriented to the winter solstice sunrise. On this day, the first rays of the rising Sun light the external sides of the larger square graved in the rock because of two small notches pierced in the lower part of the megalith hole. In this way, the petroglyph allows somebody near to it to recognize with high precision that the rays of the rising Sun actually come from the direction of the winter solstice sunrise: it can thus be considered a 'fine measurement tool' to determine the exact day of the winter solstice.

Concerning the ethnographic evidence, it is surely difficult to imagine proofs of this kind related to such an ancient artefact as *'U Campanaro*. However, as stated by Jacques Le Goff (1977), 'The sacred is tenacious: a sacred place, once consecrated, retains its aura through the changes in society, culture, religion'. Actual testimonies from modern folklore show that the megalith was considered, until recent times, a sacred and magical place, as evidenced by the legend that justifies its popular name: imagining it as the bell tower of a destroyed church, playing alone on special days, which gives it a mystical and possibly calendric role.

We can thus state that the *'U Campanaru* satisfies all the internationally accepted criteria to claim that it is an intentional astronomically oriented structure, although the statistical evidence of this alignment is only slightly higher than the accepted threshold.

The relationship between *'U Campanaru* and Pizzo Pietralunga

However, a further point must be considered concerning the statistical significance of the astronomical alignment of the megalith: at winter solstice, exactly at the same time when the rising Sun illuminate the hole of the megalith, it can be seen to shine back to Pizzo Pietralunga, if observed from the right position. Of course, this is a natural fact and cannot thus have any statistical significance. However, from the same position, the Sun's reflection is seen through the megalith hole, in the river down in the valley (see Fig. 6): this is not a natural circumstance, since it depends upon the position of the megalith and upon the azimuth and elevation of its axis that, as we have seen, are surely artificial.

Figure 6: The reflection of the Campanaru on the Belice river (right), the shining of the sunrise at winter solstice through its central hole at winter solstice (centre), and back of the Pizzo Pietralunga rock (left), photographed from the same position (photograph by A. Scuderi).

Furthermore, in 2012, a group of four manmade holes, on the SE side of Pizzo Pietralunga, were noticed. They are clearly made to host poles, sustaining an unknown structure, maybe a panel of some perishable material. These holes are oriented in such a way that, at winter solstice sunrise, the sunlight directly illuminates their bottoms. This means that, on this date, at the sunrise and only at that time, the shadow of the structure supported by the poles was projected onto the surface of the rock exactly on the rectangle defined by the holes, giving a visible signal of the date.

Lastly, in the same year, a carved stone was found near the Monte Arcivocalotto megalith (see Fig. 7).

Figure 7: The carved stone found near the Monte Arcivocalotto megalith; the symbols identifed by Prof. Holbl are marked.

Many symbols are represented on it. Following is the interpretation of Gunther Holbl (Universitatsprofessor - Institute of Egyptology, University of Vienna) who visited the site and later sent us this mail: ‘On the rock I see on the left the phallus, on the right two Tanit signs – and a standing winged god with a big hat ... Above, as we have already observed together, there is a snake, which covers the divine representations. ... The said phallus is clearly Pizzo Pietralunga. By the way, this artifact is a *unicum* in Sicily and the Mediterranean basin.’

Apart from Holbl’s interpretation of the other symbols, this rock clearly shows that the megalith and Pizzo Pietralunga are connected, since the shape of the phallic symbol exactly repeats the one of Pizzo Pietralunga. The conditional probability of coincidence of the aforementioned fact with respect to the null hypothesis thus becomes negligible.

Winter or summer solstice?

Once it is proven that *’U Campanaro* actually has an intentional solstitial orientation, we have to decide if it is oriented to the summer solstice sunset or to the winter solstice sunrise.

That the direction of orientation is toward the dawn of the winter solstice can be inferred from the fact that at the sunset of the summer solstice, given the vertical tilt of the megalith and the NW geographical skyline, the Sun is actually seen to set in the hole, but not centrally and only by those in the immediate vicinity of the megalith.

By contrast, at the dawn of the winter solstice the Sun is perfectly centered and also clearly visible from many miles away. It is therefore much more easily observed by many people at once.

Conclusions

In conclusion, the megalith therefore presents a clearly intentional astronomical alignment.

Surely, its function is the same as the one of astronomically oriented megaliths of continental Southern Italy, previously discovered. The chronology of the site is also in accordance with the most probable one for these ‘stone calendars’. Even the astronomical event that is indicated (i.e. the winter solstice) is the same. However, the technology used is markedly different, as is the time at which the phenomenon is detected (sunrise instead of sunset). This suggests that the rituals associated with this megalith were substantially different from the ones performed in continental Southern Italy in the same epoch.

This would indicate that the megalith or astronomical calendar of Monte Arcivocalotto is the product of a culture with the same economic and organizational level of contemporaneous cultures in Cilento, Basilicata and Apulia (and maybe in Calabria), with similar practical needs and symbolic representations, but distinct from those concerning customs and cults.

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Deconstructing the Neolithic Myth: The Implications of Continuity for European Late Prehistory

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Abstract

The Neolithic has traditionally been characterized by the arrival of Near Eastern farmers to Europe, replacing the indigenous foragers. This view postulates a cultural, genetic and linguistic discontinuity that allows the Neolithic archaeological record to be analyzed and interpreted outside of its diachronic context. However, there is now a wealth of information supporting continuity since the preceding Palaeolithic and Mesolithic periods, revealing a slow and gradual adoption of Neolithic elements by local indigenous populations. This is especially true for Atlantic Europe, the very same area that becomes populated with megaliths during the subsequent Neolithic and Early Bronze ages. The totality of this evidence forms a new interpretative paradigm, the 'Continuity Paradigm', which doesn't allow for loose interpretations or the 'blank slate approach'. Instead it calls for an evaluation of the local Mesolithic as a preliminary to understanding the Neolithic: to see the world through Mesolithic eyes in order to understand the transformations that took place during the Neolithic. The importance of cosmology and ideology is thus brought to the forefront of archaeological interpretation. This paper showcases the evidence for continuity in Atlantic Europe, reviews its implications for the interpretation of Neolithic archaeological remains and highlights certain readings and approaches that impact the study of the archaeoastronomies of the period.

KEYWORDS: Palaeolithic Continuity / Refugia Theory, Mesolithic, Neolithic transition, genetics, Continuity Paradigm

POVZETEK

Evropski neolitik je tradicionalno opredeljen s prihodom bližnjevzhodnih poljedelcev, ki naj bi izpodrinili domače nabiralce. Takšna opredelitev predpostavlja kulturno, genetsko in lingvistično diskontinuiteto, ki omogoča analizo in interpretacijo neolitskega arheološkega zapisa zunaj diahronega konteksta. Vendar pa imamo zdaj obilico podatkov, ki podpirajo kontinuiteto s predhodnima obdobjema paleolitika in mezolitika in razkrivajo, da je lokalno domorodno prebivalstvo počasi in postopoma prevzemalo neolitske elemente. To še posebej velja za Atlantsko Evropo, območje, na katerem je bilo v kasnejšem neolitiku in zgodnji bronasti dobi postavljenih največ megalitov. Vsi ti dokazi tvorijo novo interpretativno paradigmo, t. i. 'paradigmo kontinuitete', v kateri ni prostora za ohlapne interpretacije ali 'princip praznega lista', temveč terja ovrednotenje lokalnega mezolitika kot predpogoj za razumevanje neolitika: torej je treba pogledati svet skozi oči mezolitika, če naj bi razumeli spremembe, do katerih je prišlo v neolitiku. Pomen kozmologije in ideologije zato v arheoloških interpretacijah prihaja v ospredje. V članku so podani dokazi za kontinuiteto v Atlantski Evropi, predstavljene so njihove implikacije za interpretacijo neolitskih arheoloških ostankov in osvetljeni nekateri pristopi, pomembni za arheoastronomska preučevanja tistega obdobja.

KLJUČNE BESEDE: teorija paleolitske kontinuitete/refugijev, mezolitik, neolitski prehod, genetika, paradigma kontinuitete

Introduction

The Neolithic is usually interpreted with recourse to a 'blank slate approach', that is, cosmological and archaeoastronomical interpretations of the archaeological record typically disregard diachrony and tend to rely on loose ethnographic or cross-cultural analogies. Behind this approach lies the assumption of discontinuity between the Mesolithic and Neolithic periods and therefore that pre-Neolithic material cannot be used to infer Neolithic ideology or to test different analogical models.

This assumption, often taken unconsciously and uncritically, is based on one of two traditional narratives for the Neolithic: either that of population replacement or that of acculturation. Both narratives posit discontinuities ranging from the purely populational, and hence genetic, to discontinuities operating at the cosmological, ideological, linguistic and even cognitive levels. However, recent studies discredit these narratives. The latest results from population genetics refute theories based on a scenario of Neolithic invasion, while both archaeology and ethnographical analogy disfavour cosmological and ideological discontinuities. In fact, a narrative of continuity and transformation across the Mesolithic to Neolithic transition is now replacing the traditional narrative, especially in the case of Western Europe.

This paper reviews and consolidates the evidence for what is known as the 'Palaeolithic Continuity / Refugia Theory', and explores the implications of 'continuity and transformation' for the interpretation of the Neolithic record. As will be shown, these implications impact the way archaeologists and archaeoastronomers alike interpret their data and formulate their theories on European Late Prehistory.

Traditional Neolithic Narratives

The Neolithic has traditionally been characterized by an influx of Near Eastern peoples into Europe, bringing with them the 'arts of civilization' (Renfrew 1999). Such narratives of discontinuity, so prevalent among Victorian scholars, are now referred to by the term *Ex Oriente Lux*, or 'light from the East' (Renfrew 1999: 38-9). In these narratives, two opposing groups were posited: the indigenous, and allegedly barbarian, Europeans and the civilizing Near Easterners that replaced them. Narratives, such as the one brought forward by Vere Gordon Childe (1973), were both based on, and used to explain, similarities between Western European megalithic sites and Eastern monuments (Renfrew 1999: 42-4). This methodological circularity was only broken in the fifties with the rise of absolute dating techniques, namely radiocarbon, which showed that, in general, the Western megaliths were older than their Greek and Egyptian counterparts (Renfrew 1999: 53-75).

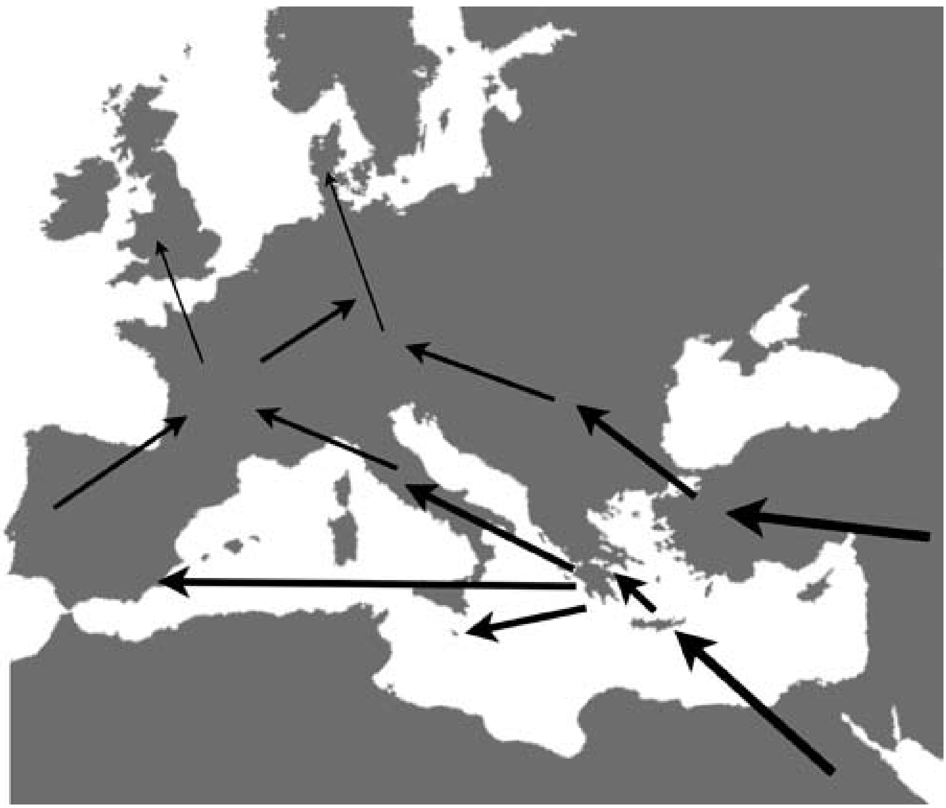

Figure 1: Map of Europe indicating, with arrows, the directions of diffusion of prehistoric cultures out of Egypt and Mesopotamia according to Gordon Childe.

Nevertheless, this overarching theme of migration was never fully discarded. It would find its place in a 1980's rescripting that seemed to find support from results in the field of genetics. Ammerman and Cavalli-Sforza (1984) identified a geographic trend in the modern genetic make-up of Europeans that they interpreted as representing migration – a demic diffusion or wave-of-advance – from the Near East into the Atlantic façade. A very similar East to West dispersion pattern was also observed in the Neolithic radiocarbon record (figure 2) and the authors proposed that this similarity was not due to chance but that both were signatures of the same Neolithic demic diffusion. This migration was portrayed as peaceful and quite feasible, since, according to the demic diffusion model, it required a single movement of about 20 km in a random direction each generation.

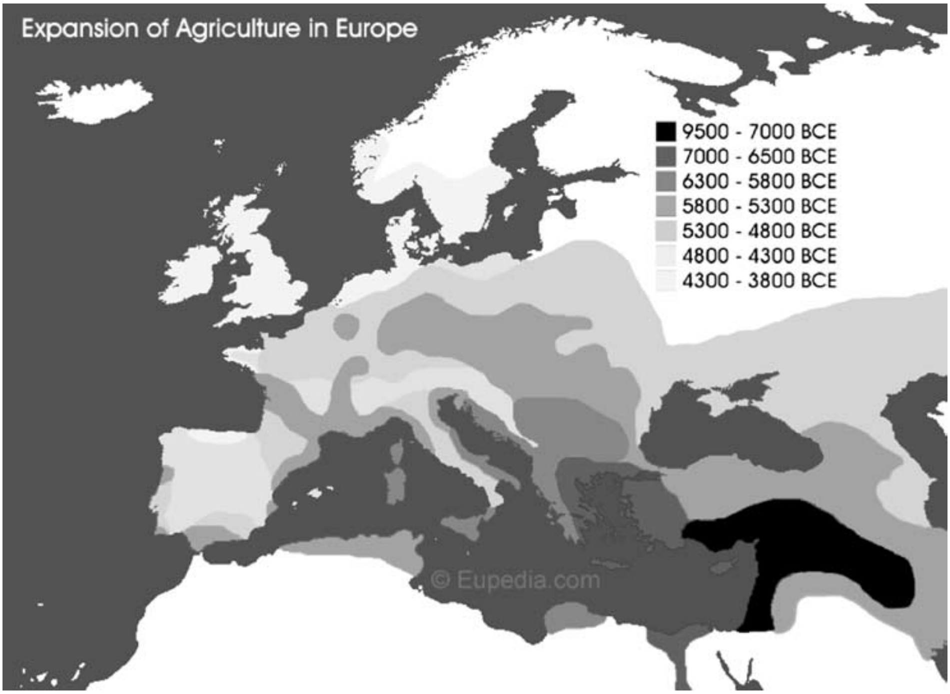

Figure 2: Synthetic map of the expansion of agriculture in Europe. The different shadings indicate different dates for the first local evidence of agriculture. The darker the shading the older the evidence. Ammerman and Cavalli-Sforza found a similar geographic pattern in the genetic makeup of Europeans and equated it with the putative expansion of these Neolithic farmers (Source: Eupedia.com).

This idea was further popularised by Colin Renfrew who took their model of genetic and technological diffusion a step further by applying it to explain the spread of Indo-European (IE) languages (Renfrew 1987). He proposed that the Near Eastern farmers were speaking a form of Proto Indo-European which subsequently branched out and developed into the languages comprising the Indo-European family today. In order to account for the different IE languages Renfrew posited 'cultural and linguistic transformations' against a background wave-of-advance movement. His hypothesis, however, did not find support among Indo-European linguists (Mallory, Blench & Spriggs 1997: 93-121; Mallory, Jones-Bley & Huld 1993) nor, as will be shown below, among many prehistorians.

With the rise of post-processualism and interpretative archaeologies, in the 1980's, archaeologists became interested in the immaterial beliefs and practices of past peoples (Renfrew & Bahn 2008: 44). Neolithic narratives shifted from placing emphasis on technology and subsistence strategies to focusing on the ideologies and ritual practices of Neolithic peoples. Notable examples include those of Ian Hodder and, more recently, David Lewis-Williams & David Pearce.

Hodder explored the European Neolithic from its inception in the Near East to its incarnation along the Atlantic coast (Hodder 1990). In the former, Hodder sees a dialectic between the concepts of 'domus', the house, domestication and sedentarity, on the one hand, and 'agrios', foraging, hunting and warring, on the other (Hodder 1990: 44, 85). As his analysis approaches Western Europe the emphasis on domestication, the 'domus', is replaced by liminality, the 'foris', i.e. the boundaries and entrances of structures (Hodder 1990: 130-8). In the case of Lewis-Williams and Pearce, they saw the Neolithic of both East and West as different ways of handling the same 'neurological resources', that there was a common cognitive background (Lewis-Williams & Pearce 2009). However, both approaches fail to ask whether the structures identified were already present in the preceding Mesolithic and Palaeolithic records, and thus could not be characteristic of the Neolithic. Neither did the authors ask themselves whether the identified structures truly drove the Neolithic, as opposed to merely being modern projections (Silva 2012: 51-7).

In sum, as this brief survey of traditional Neolithic narratives indicates, historical, processual and post-processual narratives completely disregard the indigenous Mesolithic Europeans, based on an unproven assumption of discontinuity.

The Evidence from Population Genetics

At this point we will turn our attention to the impact of recent findings in the field of archaeogenetics and population genetics on the narrative of discontinuity. Since its inception in the 1980s, the field of archaeogenetics has matured considerably. Much more powerful statistical analyses coupled with a superior understanding of the lineages, or haplogroups, that constitute the human genome and hence provide a glimpse into humanity's past, provide a far more solid basis for interpreting the populational genetics data.

The gradients that resulted from the analyses of Ammerman and Cavalli-Sforza are now seen as 'chimeras' (Pereira et al. 2005: 20). Given the remarkable advances that have taken place in the field over the past decades, modern archaeogeneticists can focus on particular DNA types and lineages, such as particular haplogroups of mitochondrial DNA. The latter, transmitted from mother to child, do not suffer recombination and their mutation rate is stable and well known, allowing for any identified signatures to be dated using what geneticists call a 'molecular clock' (Soares et al. 2009). The analysis of several mitochondrial haplogroups have provided consistent results: about 80% of European lineages can be traced back to a small region between Cantabria, Spain, and Aquitaine, France, and to a period about 20-25 thousand years ago (Richards 1996; Richards 2003; Soares et al. 2010). This geographical zone is called 'the Franco-Cantabrian refuge': it was a refuge for modern humans during the peak of the last glacial period, as we'll discuss next. In summary, these analyses reveal that most of the maternal lineages of modern Europeans date back to the Upper Palaeolithic, severely undermining the genetic influence of any post-glacial demic diffusions or population replacements that might have occurred.

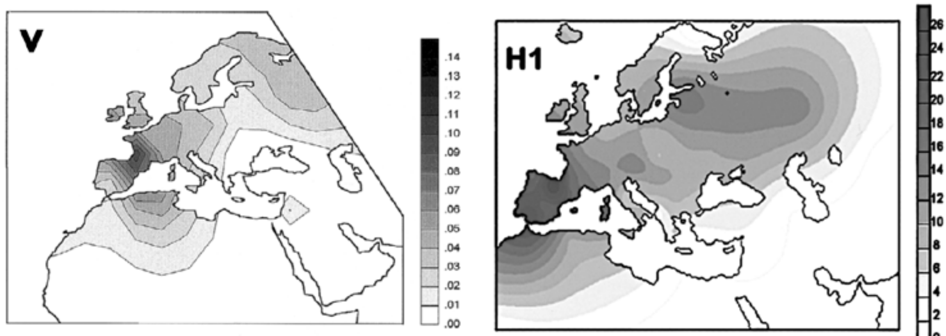

Figure 3: Spatial frequency distributions of haplogroups V (left) and H1 (right). The darker the shade the higher the frequency. Adapted from Torroni (2001: fig.4) and Achilli et al. (2004: fig. 3) respectively.

Other lineages, however, still display patterns similar to those emphasized by Ammerman and Cavalli-Sforza which have, consequently, been considered Neolithic in origin (Richards 1996: 196). However, even this is now changing based on results from more recent and wider studies. In a paper published in 2012, Maria Pala, Martin Richards and several other colleagues demonstrated how the mitochondrial lineages J and T, which comprise most of the remaining 20 % of mitochondrial lineages and which previously were thought to have spread primarily from the Near East into Europe with a Neolithic population, in fact reflect dispersals that occurred during the Late Glacial period (Pala et al. 2012). These results suggest an Arabian glacial refuge, as a counterpart to the Franco-Cantabrian refuge, a hypothesis that should now be put to the test by archaeologists.

Palaeolithic Continuity / Refugia Theory

As concerns Western Europe, archaeology validates the narrative stemming out of archaeogenetics. From around 25 to 20 thousand years ago, at the Last Glacial Maximum, most of northern Europe was covered by ice. Humans seem to have retreated into refuges in the warmer southern territories. When Clive Gamble and his collaborators in the S2AGES project analysed the archaeological record of the Late Glacial in Western Europe, they identified a refuge roughly encompassing the same areas identified by the geneticists (areas A and C in figure 4) (Gamble et al. 2005). According to the archaeologists it was from this refuge that Western Europe was repopulated nineteen thousand years ago (the Late Glacial period), in several stages or phases.

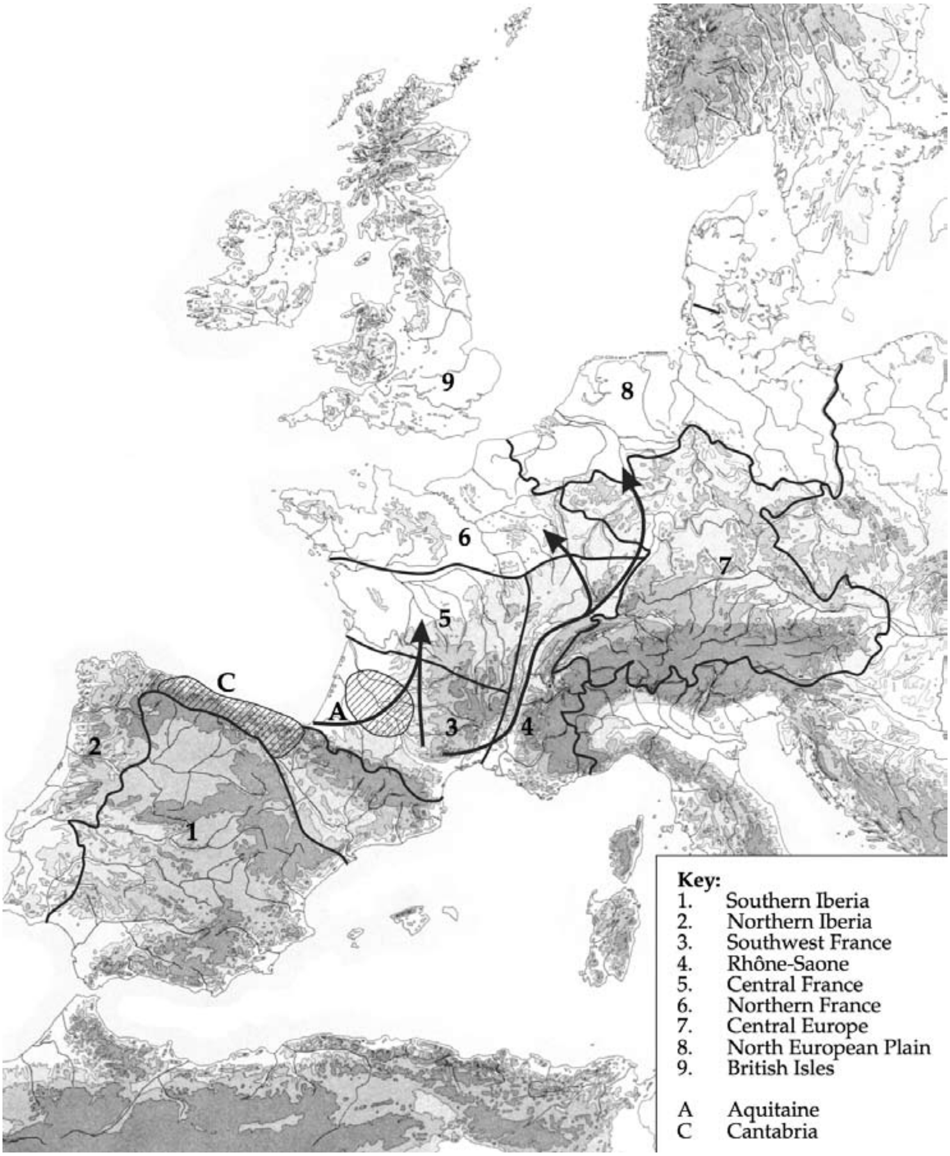

Figure 4: Map of Western Europe showing the location of the Franco-Cantabrian refuge (areas A and C) and probable expansion routes (arrows). Adapted from Gamble (2005: fig. 1).

As far as Atlantic Europe goes, we see that the narratives derived from two completely different datasets and methodologies - Archaeology and Genetics - are in agreement. The narrative that results from this interdisciplinary interface has been called the 'Palaeolithic Continuity / Refugia Theory', or PCRT for short (Frank 2008). Its implications for late prehistoric archaeology and linguistics are profound, but until now they have not been fully appreciated by most researchers. Briefly stated, PCRT constitutes a new interpretative paradigm for the post-glacial prehistory of Europe, one that emphasizes continuity and, therefore, doesn't allow for loose interpretations or the imposition of 'a blank slate' approach. Instead, it calls for an evaluation of the Mesolithic as a preliminary step for understanding and interpreting the Neolithic. In order to understand the transformations that took place during the Neolithic, one has to start by attempting to see the world through Mesolithic eyes. In this manner, cosmology and ideology are also brought to the forefront of archaeological interpretation.

The Mesolithic to Neolithic Transition

Some archaeologists, too, have been shedding their 'agriculturalist thinking' and, in reinterpreting the records of the Mesolithic to Neolithic transition, now understand it to have been essentially a slow and gradual indigenous process of transformation, especially in Atlantic Europe.

Graeme Barker has surveyed the adoption of farming in all continents and highlights Zvelebil and Rowley-Conwy's three-stage availability model as an apt description of the process by which many foraging communities in Europe first encountered, and eventually adopted, farming and other Neolithic elements (Barker 2009: 380). This model consists of a phase of first contact between foragers and farmers, the availability phase, followed by a substitution phase in which the foragers adopt Neolithic traits and which can be a slow or a very fast process. Lastly, there is the consolidation phase, defined by an irreversible commitment to mixed farming (Zvelebil & Rowley-Conwy 1984). Barker equates these three phases to the Late Mesolithic, Early Neolithic and Middle/Late Neolithic respectively (Barker 2009: 380). Evidence for this is quite strong along the Atlantic façade where the forager-farmer boundary was static for over a millennium, thus yielding a very long availability phase. Elsewhere in Central Europe, Barker contends, a pioneer colonization model might still apply, although he also remarks on the increasing evidence for Mesolithic to Neolithic Continuity even there (Barker 2009: 361; Jochim 2000).

Our understanding of the process of Neolithization, and the interpretation of material remains has also evolved. In the archaeological record, the Neolithic transition is marked, by the appearance of Neolithic material culture: pottery, polished stone tools and domesticates among others. But farming, as it is usually conceived, was not adopted until considerably later. Figure 5, based on a paper published by Chris Stevens and Dorian Fuller, results from the analysis of both the archaeological and paleobotanical records of Great Britain (Stevens & Fuller 2012). The authors found that, after an initial, but somewhat limited adoption of agro-pastoral techniques at the onset of the Neolithic there was a sharp decline soon after, with mixed farming only being widely adopted later, during the Bronze Age. Although their analysis focuses on Britain there is a growing body of evidence for such a 'boom and bust' scenario elsewhere in Europe (Shennan 2012).

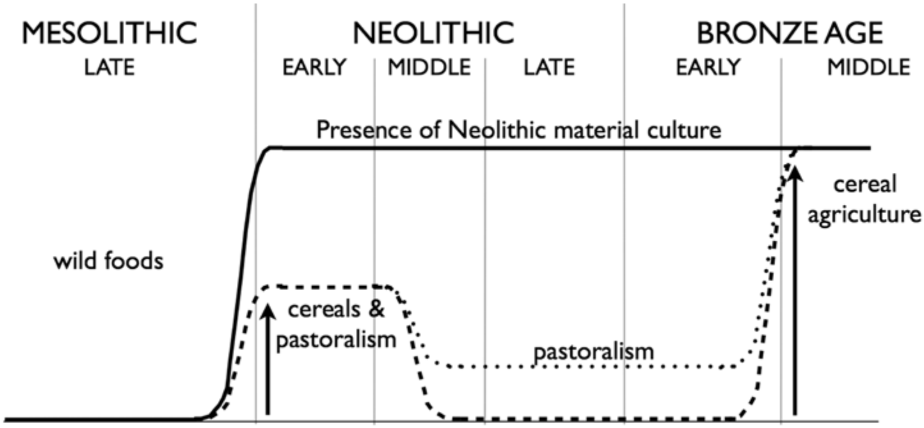

Figure 5: The 'Multiple Transference' model for farming in late British prehistory. Based on Stevens & Dorian (2012: fig. 6).

Neolithic Western Europeans should then be regarded as horticulturalists at most, with only a small percentage of their subsistence being catered for by products of farming and pastoralism, and not as full-fledged farmers. Moreover, Neolithic Western Europeans were far more nomadic than their direct Mesolithic ancestors who, by the Late Mesolithic, already had developed sedentary or semi-sedentary lifestyles (Whittle 1996: 357).

This brings us to a very important point to keep in mind when studying transitions in the archaeological record: a technological shift does not necessarily equate with a populational, economic, ideological or cosmological shift. If it did, archaeologists of the future would think that the USA successfully replaced the entire West based on how quickly iPhones dispersed.

Cosmological Transitions: Transformational Processes

We have already seen how the results of archaeogenetics, the discipline that can probe into populational dynamics of the past, indicate that no significant population replacement occurred in the past twenty thousand years. The fact that Neolithic archaeology clearly demonstrates that a technological shift did occur shows that the diffusion of technology was not linked to population diffusion. On the other hand, acculturation narratives, which are to some archaeologists the alternative to demic diffusion, assume that technological and ideological shifts are correlated. Thomas, as an example, believes that Late Mesolithic Britons decided to cut with past traditions, and swiftly adopted Neolithic traits and the agro-pastoral lifestyle (Thomas 2003). However, no convincing explanation for this has been forthcoming. Thomas' approach is limited in that he focuses on Britain, which has a relatively poor record of the Late Mesolithic, making it difficult to gauge continuity.

Chris Tilley, on the other hand, has surveyed the wealth of Scandinavian material related to the Neolithic transition (Tilley 1996). The Late Mesolithic record in southern Scandinavia is very rich, thus providing a welcome counter-point to the British case. Tilley observed a trend of ‘continuity and change’ from the Mesolithic well into the Neolithic period (Tilley 1996: 108). As an example, once pottery was introduced to the Mesolithic Scandinavian communities, it quickly became the primary canvas for their art work. However, the artistic motifs engraved or painted onto the ceramic vessels are the same as those found in the bone and wooden tools that preceded pottery as an art medium (Tilley 1996: 44). Further, in the early Neolithic, pottery along with domesticated species is primarily encountered in ceremonial contexts, exactly like the art-covered bone and wooden instruments were in the preceding periods. Tilley suggests that the Neolithic elements were being *structured* into pre-existing social and material structures (Tilley 1996: 108-9). Only later, in the Mid to Late Neolithic did these elements acquire new meanings and begin to appear in domestic contexts.

Anthropologists, too, have reappraised the ethnographic and historical records of colonized peoples, and suggest that rather than the uni-directional process of acculturation that was once believed to have occurred, ‘transformational ethnic processes’ acted upon both the indigenous and the new, exotic elements, creating syncretic cosmologies with elements from both the colonised and colonizer’s world-views (Viegas 2012). Although these processes are always at work, they are intensified by the introduction of foreign elements, whether they be material or ideological, and benefit from long exposure times or significant ’pause and retreat’ colonising events (Viegas 2012: 538). These allow communities to structure the foreign elements, adapting them into a syncretic world-view. The thousand year period during which the forager-farmer boundary did not advance along the Atlantic façade would have provided ample opportunity for the foragers to slowly, but steadily, integrate Neolithic elements into both their material and ideological worlds, in a way not unlike that described by Zvelebil & Rowley-Conwy in their availability model mentioned earlier.

Megalithism as a Transformational Process

This method of interpretation of transitions which we call ‘the transformational approach’ (Silva 2012: 58), can also be applied, albeit tentatively, to some general notions of megalithism, and used to discuss its broader implications for archaeoastronomical theory.

Megalithism can now be seen in a new light. Glimpses of ‘continuity and change’, the very ingredients of the transformational approach, can already be seen in broad strokes. The megaliths of Western Europe were only new in that they were made of a new construction material – stone, as opposed to earthen and wooden structures that preceded them. Moreover, as archaeologists turn their gaze to the Mesolithic record, other, often unsuspected, forms of monumentality are also being considered, such as the massive accumulations of shells typically called ‘shell middens’ (Cummings 2001; Tilley 1996: 15-7, 109; Warren 2007: 312-6).

Similarities between Neolithic monuments and Mesolithic shell middens range from their sizes and shapes, to their geographical distribution, at both the local (close to rivers and/or coasts) and continental levels (both are found along the Atlantic façade). Moreover both are often, but not always, associated with evidence of feasting and with contemporary human burials (Gutiérrez-Zugasti et al. 2011). More research is needed but it is also interesting to note at this stage that, in Scandinavia alone, the largest Mesolithic shell middens were found precisely in the same region where the largest megalithic passage graves and barrows were constructed.

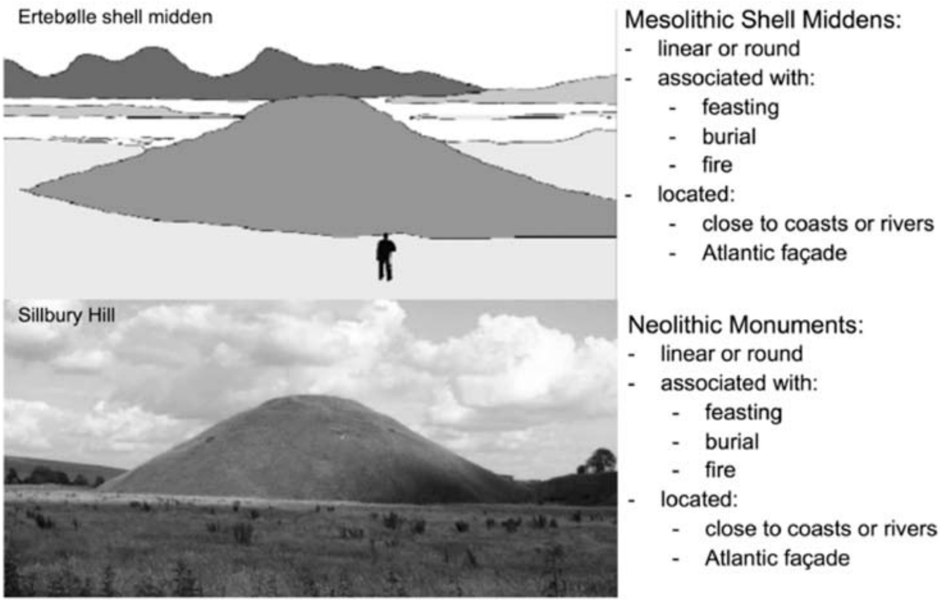

Figure 6: Comparative table of key general similarities between Mesolithic and Neolithic monuments.

Tilley, moreover, observed a progression from the wooden mortuary structures found in Mesolithic cemeteries to the Middle Neolithic long barrows in Scandinavia, with elements of both continuity and change in architectural form (Tilley 1996: 75-79).

Conclusions and Implications for Archaeoastronomy

Although in this paper we have not brought to the fore any specific archaeoastronomical results, the impact of PCRT and the transformational approach on the interpretation and theorisation of post-glacial archaeoastronomy, especially megalithic, should be clear.

Firstly, radical changes in material culture do not necessarily signal population replacement or invasion, nor do they signal ideological, cosmological or cognitive shifts. Artefacts can be traded across vast distances, across cultural boundaries and structured into pre-existing world-views. Secondly, continuity highlights diachronic studies of the archaeological record as well as localised approaches. Studying archaeological remains across time, starting with the Late Mesolithic, wherever possible, allows: i) for the possibility of discontinuity to be tested, ii) for instances of continuity and change across the Neolithic transition to be observed, and iii) for the Neolithic changes, at the local level, to be analysed and interpreted and in the process to be compared and contrasted with those of neighbouring groups.

Once this approach is taken, megalithism is best understood as an innovation on monumentality and not as a result, or the cause, of a sharp ideological or cognitive shift. In the same way, the cosmological and archaeoastronomical elements identified in the megaliths and other monumental structures of Western Europe should not be immediately seen as 'new' or as a significant bump in Neolithic people's understanding of the cosmos, but simply as the first crystallizations of this knowledge to have survived in copious quantities to our days. Most pre-monumental and perennial forms of crystallizing knowledge and beliefs are lost to us, but absence of evidence is not always evidence of absence.

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Monuments as Myth or Myths of Monuments?

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Abstract
Myth as irrational thought can be found in the continued downplaying within archaeoastronomy of the significance of the moon in prehistoric cosmologies in favour of the sun. Myth as science can be found in the invariant syntax of the origin stories of traditional societies in which the moon, especially when dark, plays a prominent role (Levi-Strauss 1969). Gow (2001) has shown that transformations of invariant myth motifs are designed to re-establish their syntactical integrity from socio-political assaults and are a record of that history. Palaeolithic Continuity and Refugia Theory (Alinei 1998; Zvelebil & Zvelebil 1990; Frank 2008) suggests long run continuity in cultural tropes between our hunter ancestors and Neolithic monument builders. If all three models are valid, then there should exist a substrate in proto Indo-European (*IE) myths that can be discerned in the design and ritual attributes of the ancient monuments in the *IE region. This paper demonstrates that myth-as-science elaborates the archaeoastronomy of the West Kennet Avenue and provides a modern test for the myths we mobilise which interfere with our science.

KEYWORDS: Structuralism, Palaeolithic Continuity-Refugia Theory, solarism, lunar-solar, dark moon

POVZETEK
Mit kot iracionalno misel najdemo v arheoastronomiji v stalnem pripisovanju manjšega pomena, ki naj bi ga imela v prazgodovinskih kozmologijah luna v primerjavi s soncem. Mit kot znanost pa najdemo v nespremenljivi sintaksi izvornih zgodb tradicionalnih družb, v katerih ima luna, posebej temna, pomembno vlogo (Levi-Strauss 1969). Gow (2001) je pokazal, da imajo transformacije nespremenljivih mitskih motivov namen ponovno vzpostaviti njihovo sintaktično integriteto, v obrambo pred družbenopolitičnimi napadi, in so zapis te zgodovine. Teorija paleolitske kontinuitete in refugijev (Alinei 1998; Zvelebil & Zvelebil 1990; Frank 2008) zagovarja dolgoročno kontinuiteto v kulturnih izrazih med našimi lovskimi predniki ter neolitskimi postavljalci spomenikov. Če vsi trije modeli držijo, mora v protoindoevropskih (*IE) mitih obstajati substrat, viden v strukturi in ritualnih simbolih starodavnih spomenikov *IE regije. Ta članek kaže, da mit-kot-znanost izpopolnjuje arheoastronomijo Avenije West Kennet in predstavlja sredstvo za preverjanje mitov, ki jih proizvajamo, a so v navzkrižju z našo znanostjo.

KLJUČNE BESEDE: strukturalizem, paleolitska teorija kontinuitete/refugijev, solarizem, luna, sonce, temna luna

Forty years after Alexander Thom rediscovered lunar standstills, a leading member of SEAC could write of most archaeoastronomy publications that '[t]he Sun is the object of first interest, and the Moon behaves like a pale imitation of the Sun.' (Lebeuf 2007: 155). Nevertheless amongst SEAC scholars Da Silva (2010) has rejected solarist theories of Mediterranean tombs, Ruggles (1999), McCluskey (1998) and North (1996) have all rejected calendrical and eclipse prediction theories for Neolithic and EBA European monuments, and Sims (2006, 2007, 2009) has shown that dark moon not full moon is the ritual focus of the solstice marker during lunar standstills. Therefore in spite of these and other scientific tests undermining the primacy of the sun in original cosmologies arguably a tendency exists within archaeoastronomy to remain locked within a myth of solarism.

This modern use of myth-as-irrationalism is in contradistinction to myth-as-science within traditional societies. Levi-Strauss (1969) demonstrated through the structuralist analysis of over eight hundred Amerindian myths that they could all be linked by an invariant syntax – a system of rules which links binary categories in relations of equivalence and opposition. It is a remarkable discovery of scholarship that when the human mind is given licence to break all common sense rules of material being, instead of a wild chaos of stories all the world's myth and magical tales display a crystalline invariant order of rules. While the grammar remains the same in all the world's myths the political coding of these categories is infinitely variable. Gow (2001) has shown that transformations of myth motifs are designed to re-establish their syntactical integrity from the socio-political assaults of historical events, and that these transformations are a record of that history. Thus while all myths destroy time to transport us back to our origins, they can only do this by continually updating themselves. Since each myth is but a fragment of an invariant meta-myth, there is no one true myth, but each is an aspect of a 'transformational template'. Levi-Strauss favoured a cognitive explanation for the invariant syntax of myth, claiming that this reflected the very structure of the brain. As such myths are the science of the 'savage mind'. He also suggested a second model that predicted that the order within myth derived from the first social order that broke with animality. If such, myths are the science of 'savage society' and the scripts for ritual (Levi-Strauss 1981; Knight 1991: 79-87).

Our scientific understanding of prehistory is being re-shaped by an anthropological model which challenges the view that culture began with and by an agricultural revolution. Palaeolithic continuity-refugia theory suggests long run continuity in cultural tropes between our Palaeolithic hunter ancestors, who were fully human and cultural, and their descendant Neolithic monument builders (Alinei 1998; Frank 2008; Zvelebil & Zvelebil 1990). If myths are the 'science of savage society', and if Palaeolithic Continuity-Refugia theory is correct, then there should exist a substrate in proto Indo-European (*IE) myths that can be discerned in the design and ritual attributes of the ancient monuments in the *IE region. Contrarily if the Neolithic agricultural revolution theory (Renfrew 2001) is correct, there should be no overlap between the two. We can test both models by using the archaeoastronomy, archaeology and anthropology of Neolithic monuments to test for any deep pattern in *IE mythology. Any Indo-European origin myth, according to structuralism, should be amenable to this test. We will begin with a selection from the Greco-Roman origin myth:

> In the beginning the goddess Eurynome emerged naked from chaos, and separated the sea from the sky. She danced upon the waves travelling south and created in her wake the north wind. From this vortex came the serpent, Ophion or Boreas, with which she mated. They lived first upon Mount Olympus, but when the serpent bragged that he had created the cosmos, she banished him to the underworld. ...Her son was born as the star of life which heralded the coming of the Moon. He grew rapidly during the year, destroyed the serpent and won the love of his mother the goddess. Her love led to his destruction, and from his ashes a new serpent was born. This laid a red egg at the spring equinox, and when she ate this egg her son was re-born. ...As goddess of the four winds, of which the North wind was the most important, her name was Cardea, and as her herald her son was Hermes. As one of the few gods who could travel to and from the underworld unharmed, his path was marked by a stone pillar. ...With his 'golden staff' of hazel, around which twined two snakes, 'he charms (to sleep) the eyes of men, those he wishes to, and wakes others from sleep'.... Hermes conducted the first cattle theft (from Apollo) and invented astronomy, music, mathematics – all the arts and sciences.... Cardea is the White Goddess of the hawthorn.... In becoming the mistress of the Janus, the god of oak doors, she was rewarded by him with the protection of the hinges of doors to prevent witches' night time attacks on sleeping children to suck the blood out of them. With hawthorn and other magical substances 'Her power is to open what is shut, to shut what is open'. ...As ruler of the four winds she lives in Arianrhod's Castle, with frost and as the ruler of the celestial hinge at the back of the North Wind around which the millstone of the universe revolves...During the month of May, when she blooms, marriage is dissolved for orgiastic rites. Purification rituals are conducted in preparation for the 'killing of the oak-king at midsummer and his transformation into the Corona Borealis, which was then just dipping over the Northern horizon....' (Graves 1960: 27-30; Graves 1961: 173-5, 387-8)

These myth fragments can be broken down into translated and measurable indicators, as shown in Table 1 below. The archaeology of the Avebury monument complex provides us with some high fidelity data to make such a test. In the 1930's Keiller and Piggot (Smith 1965) excavated and reconstructed the northern section of the West Kennet Avenue which once held, with one exception, 37 pairs of parallel stone pillars. Those stones that had been removed or destroyed in modern times were marked by concrete markers set in the stone holes, and those that had been toppled and/or buried were re-set in their original holes.

Table 1: Greco-Roman origin myth motifs re-stated as indicators.

1.	place of ritual re-enactment;	20.	pathway marked by stone;
2.	moon in its wandering aspect;	21.	Hazel as herald;
3.	women's power;	22.	double dragon;
4.	north as origin point;	23.	death and resurrection;
5.	From and out of north wind comes the dragon;	24.	Hazel god cattle theft from sun god.
6.	species ambiguous sex;	25.	Hazel source of all invention and knowledge;
7.	above world residence;	26.	Hawthorn;
8.	male usurpation of goddess's power;	27.	Oak as Janus door;
9.	underworld dragon;	28	Hawthorn and Oak in illicit sex;
10.	above world son;	29.	Hawthorn as hinge;
11.	skyscape 'herald' to the moon;	30.	children's blood at risk;
12.	lunar-solar timescale to ritual round;	31.	hinge point of alternation;
13.	'human' killed dragon; incestuous sex;	32.	corona borealis;
14.	death of son;	33.	winter;
15.	son's ashes;	34.	pole star;
16.	resurrected dragon from ashes;	35.	month of May;
17.	spring equinox lunar eclipse at standstill;	36.	May as anti-marriage;
18.	resurrected full moon restores heterosexual humans;	37.	May-time seclusion;
		38.	summer solstice sacrifice of Oak;
19.	cardinality;	39.	Oak ashes ascend to the north.

The 2.4 kilometre West Kennet Avenue once linked the Avebury stone circle with the oak West Kennet Palisades and the Sanctuary wood and stone circle with about 100 stone pairs (Fig. 1). When standing alongside each of the Avenue stones with an eye height of a Neolithic man of 1.65 metres and looking to opposite and adjacent stones, many of the foresight stones have been arranged for their tops to coincide exactly with the changing background horizon. Also Gillings and Pollard (2004) have noted that while the original land surface *within* the Avenue has numerous half buried stones which would have impeded processions and lacks compression signs indicating use, the land surface just *outside and running parallel* to the Avenue was clear of obstructing stones and heavily compressed. These three properties support the hypothesis that some horizon events were built into the structure of the Avenue when observing a changing vista of stone combinations while processing *outside* the Avenue stone pillars.

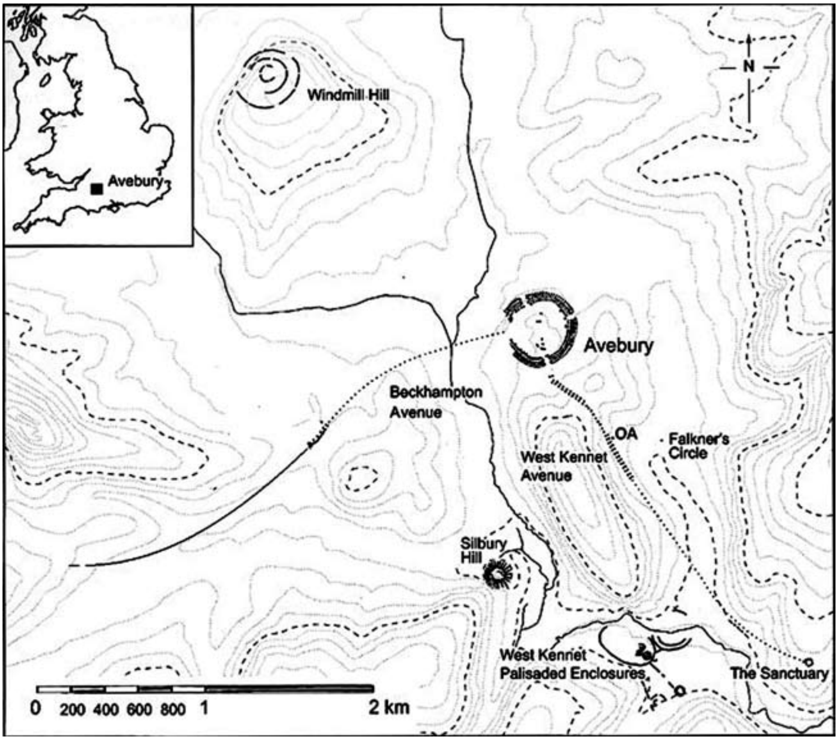

Figure 1: The Neolithic/EBA Avebury monument complex showing the 'Occupation Area' (OA) within the West Kennet Avenue.

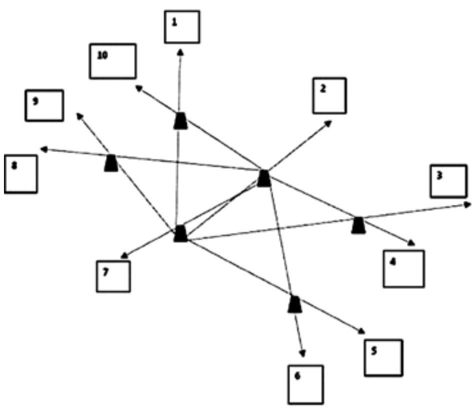

Figure 2: Ten possible alignments across adjacent stones from a central pair of stones.

With opposite stones on average 14.7 metres apart and diagonal stones 27.5 metres apart, and an average stone mid-width of 1.7 metres (Sims, Field Notes), the angles subtended by viewing either side of each pair are respectively 5.5° and 11°. These are large values for those schooled in the Thom paradigm, but high fidelity alignments are not necessary for a builder who wishes to create the illusion that the moon or sun descends into or rises out of the top of an Avenue stone. If we adopt this religionist (North 1996) or ethnographic (Ruggles 1999) approach we can use a range of 5° at the top of each stone to identify any alignments out of the ten possible logical combinations of adjacent stones (see Fig. 2). As can be seen in Table 2 there are 167 alignments over 37 pairs of stones or their markers, of which 90 are aligned on lunar (32 major and 58 minor) standstills, 36 on solstices (19 summer settings and 3 summer risings; 10 winter risings and 5 winter settings) and the remaining 35 upon cardinals (17 north, 10 south, 8 west and 5 east).

In spite of the large range accepted for each alignment, such a high number of alignments for just 37 pairs cannot be explained by random accident. From $n(Ø/360)^{n-1}$ (Ruggles 1999: 95), as an avenue of 37 single pairs the probability of such a chance occurrence is 1 in 5.217E -107, or as an avenue of ten 'straight' sections of 1 in 6.77425E -29, both *extremely* improbable events.

From this brief introduction to the Avebury monument complex we have accounted for eight of the thirty-eight indicators identified in the Greco-Roman origin myth. Avebury is a place of *ritual re-enactment* (Table 1, Indicator 1, *passim*) with a *pathway marked by stone* (20), which maps the *moon in its wandering aspect* (2) and locks ritual to *winter* (33), a *lunar-solar timescale* (12), *north* (34) and the *cardinal* directions (19). And since the west-east cardinal directions are bracketed with the southern major standstill (Table 2, columns 3 & 8 for stone pairs 7-16), the crossover equinox full moon is always *eclipsed* during a lunar standstill (17. Da Silva 2010; Sims 2006; 2007).

Present archaeological interpretations of West Kennet Avenue are confounded by the paradox that at one point, 30b within the so-called 'Occupation Area', no stone was ever placed by the builders (Smith 1965: 212). Yet it was here that the excavators found the greatest mass of deposited material culture found anywhere in the Avebury monument complex. In previous publications I have demonstrated that a key property of the Avebury monuments simulated for participants a journey through the underworld culminating in a winter solstice dark moon ritual at the Avebury Circle (Sims 2009). Since the West Kennet Avenue leaves or arrives at the Avebury Circle at stone pair 1, then position 30b is 29.5 intervals, or the 29.5 days of the average synodic cycle of the moon, south of the Circle and could therefore represent another dark moon signifier along the Avenue (Sims 2012a). It is in this region of the Avenue that running alongside the 'left' and 'right' sides of the Avenue when moving north to the Avebury circle are ten natural holes and 2 artificial pits, with the greatest concentration around position 30b (Fig. 3). The monument builders deposited within these holes and pits different types of wood ash, a broken stone axe, sarsen and exotic stones and animal and human remains. Zig-zagging between the stones on the stripped chalk surface they placed a massive concentration of flint tools (Smith 1965: 206-223). Therefore around the Avenue position at which no stone was ever placed there lies an '*underworld*' (partially 9) of material culture consistent with the

Table 2: Alignments of West Kennet Avenue stone pairs 1-37 with adjacent and opposite stones. Note: For any pair of stones with adjacent pairs on either side, the ten possible combinations of pairings from the central pair to all six stones are shown in Figure 2. These combinations are numbered clockwise 1-10 as azimuths from North starting at the northern diagonal and are the column headings in this Figure. The row headings identify the number of the stone pair positions 1-37. The azimuth bearings for zero horizon altitude at this latitude of 51° 25′ for lunar standstills, the sun's solstices and cardinal alignments (not to be confused with equinoxes) are: North 0°/360°; Northern Major standstill moonrise (NMajR) 40.5°; Summer Solstice sunrise (SSR) 48°; Northern Minor standstill moonrise (NMinR) 59°; East 90°; Southern Minor standstill moonrise (SMinR) 121°; Winter Solstice sunrise (WSR) 129°; Southern Major standstill moonrise (SMajR) 141.5°; South 180°; Southern Major standstill moonset (SMajS) 218.5°; Winter Solstice sunset (WSS) 231°; Southern Minor standstill moonset (SMinS) 239°; West 270°; Northern Minor standstill moonset (NMinS) 301°; Summer Solstice sunset (SSS) 312°; Northern Major Standstill moonset (NMajS) 320.5°.

Comb:	1	2	3	4	5	6	7	8	9	10
Pair										
1								NMajS		
2			SMinR					NMinS		
3				SMajR		South	SMinS			NMajS
4		NMinR	South				WEST			NMajS
5			SMajR			South		North		
6	North						WSS	NMajS		
7		SSR		WSR	WSR		SMajS	West	NMinS	NMinS
8			East	SMinR	SMinR				SSS	SSS
9			East	SMinR	SMinR		SMajS	West	NMinS	SSS
10				WSR	SMinR		WSS		SSS	SSS
11			East		WSR		WSS		SSS	SSS
12			East	SMinR	SMinR		SMajS	West	SSS	SSS
13				WSR	SMajR		SMajS	West	NMinS	NMinS
14		NMajR		WSR	WSR		SMajS	West	SSS	NMinS
15		NMajR	East				WSS	West	NMinS	NMinS
16		NMajR				South	WSS	West		
17	North	NMinR	SMinR	SMajR	SMajR	South			SSS	
18	North	NMinR	SMinR			South			NMajS	NMajS
19	North	SSR						NMinS		
20	North	SSR	SMinR			South	SMinS	NMinS	NMajS	
21	North	NMinR	WSR	SMajR		South		NMinS	NMajS	
22	North	NMinR	SMinR			South		SSS	NMajS	
23	North	NMinR	SMinR			South		SSS		
24	North	NMinR	SMinR					NMajS		
25		NMinR	SMinR					SSS		
26		NMinR	SMinR					SSS		
27		NMinR	SMinR					NMajS		
28	North	NMinR	SMinR					NMajS		
29	North	NMinR	WSR					SSS		
30	North	NMinR		SMinR				NMinS		
31			WSR					SSS		
32		NMinR						NMajS		
33	North	NMinR	SMinR					NMinS		
34	North	NMinR	SMinR					NMinS		
35					SMajR			NMinS		
36	North	NMinR	SMajR	SMajR				SSS		
37	North	NMinR	SMinR	SMajR	SMajR			SSS		

hypothesis that position 30b signifies a dark moon position in a lunar-scheduled Avenue. This hypothesis is strengthened, if not confirmed, by noting that across the large stone pairs 15 and 16 at the top of a local ridge, and only here, there is a *reverse* pairing of the northern major standstill moonrise and winter solstice sunset, generating a winter solstice rise of *full moon* (partially 18). Yet when the area around the base of these two pairs of Avenue stones was excavated by Keiller and Piggot no material culture was found around these stones. Since along the entire length of this Avenue section, excluding pairs 15 & 16, major and minor, southern and northern standstill alignments are bracketed *in the same direction* with winter and summer solstice alignments (Table 2 all columns except 1 and 6), in the combination of winter solstice with southern standstills and summer solstice with northern standstills there is always a dark moon (Sims 2007). Therefore the monument builders emphasised dark moon position 30b with votive deposits while for full moon positions 15 & 16 they did not. From positions 30a and b only lunar alignments were made, and either side of pair 30 the adjacent pair of stone positions have reverse diagonal solstice alignments that cut across each position of pair 30 (Table 2, rows 29-31). In addition the location of 30b in the Occupation Area is at the one point in the Avenue when the horizon altitude across the tops of all five adjacent stones and on to background horizon is an equal 1.5° (Sims, Field Notes). Dark moon at 30b is therefore '*hinged*' (31, partially 29) either side by '*Janus*' (partially 27) solstice alignments that point to both exits and entrances of the solar year.

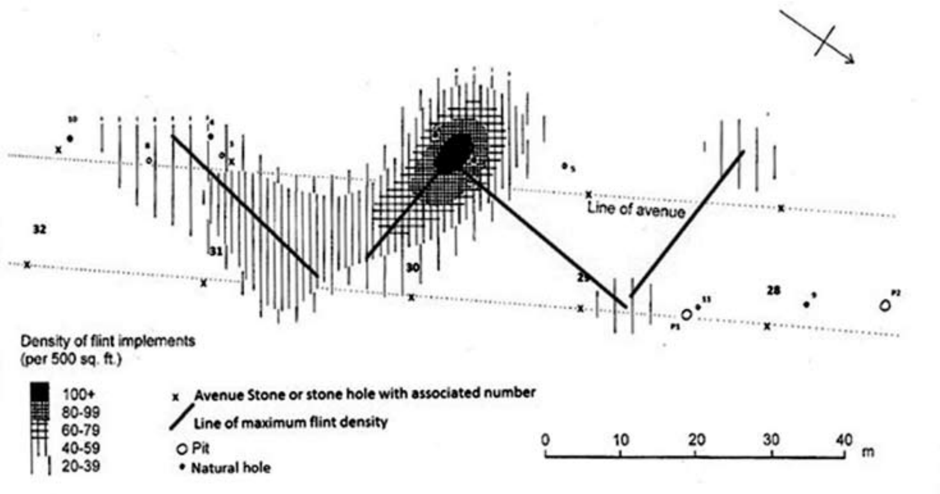

Figure 3: The Occupation Area within the West Kennet Avenue.

We have found only partial expressions of four indicators for the Greco-Roman myth motifs. The dark moon position of 30b was the site for an underworld deposition of a concentrated mass of material artefacts yet this could not justify the interpretation of a 'dragon' for indicator 9. While we could justify the finding of a full moon for indicator

18 at this stage we cannot bracket it with the restoration of heterosexual relations. There is evidence that position 30b has the attributes of an Avenue *hinge* but not Hawthorn as in indicator 29 and evidence for Janus solstice alignments but not Oak as in indicator 27. Nevertheless partial connections are connections. And as we continue to move through the findings we can test for further linkages that may justify a more complete representation of these and other indicators. At the end of this process we can assess how complete or not has been our interpretation.

It may be thought that the construct of a 'dragon', which has no empirical referent but is central to this Greco-Roman origin myth, is culminating proof of the pre-logical 'primitive' mind of traditional societies. This view betrays a lack of familiarity with the ethnographic imagination. In a refutation of the view that the lack of abstract words in many languages of traditional societies confirms the primitivism of hunter-gatherer thought, Levi-Strauss showed how abstraction is behind the traditional symbolic practice of amalgamating dissimilar things to create a new emergent level of meaning (Levi-Strauss 1963). The Stadel cave Aurignacian lion-headed figurine, for example, brings together the properties of a cave lion with those of a human (Duckeck 2011). Similarly a dragon combines a snake with wings and thus unites the lowest with the highest, which may inhabit a watery underworld or the heavens above, it can breathe fire yet have a wet-slimy scaly skin, is hydra-headed with all-seeing eyes and cannot be killed by normal means. Dragons have been known to shape-shift into a maiden or a crone. From all the world's therianthropes the culturally universal dragon unifies the greatest number of contradictions as the most powerful of beasts that can travel unharmed between worlds beneath and above this world (Knight 1991: 480-513). Viewed as a social abstraction it connotes a powerful coalition that can metamorphose through all social states.

What evidence do we have for a dragon as part of the West Kennet Avenue? Some archaeoastronomers may need to be reminded that the rhythm of lunar standstills is called the 'draconic' cycle, and for just this part of the Avenue the majority of alignments, 54%, are on major (32) *and* minor lunar standstills (58). A further 10% of alignments are on North, and during the third millennium BCE the pole star was Thuban, which in Arabic means serpent or in its Bayer designation - Alpha Draconis. Even today, when observing the constellation Draco by naked eye, it will be noticed what an advantage it is to look for this large shape at dark rather than full moon. And since lunar standstills always generate dark moon at the solstices, the grouping of standstills, solstices and north alignments along the Avenue all combine to be consistent with this interpretation at Avebury. The main archaeological model for the Occupation Area part of the West Kennet Avenue is that it is an ancestral midden, and that the Avenue itself is a commemorative structure of those ancestors (Pollard 2005). As can be seen in Fig. 3 and Tables 2 & 3 this model fails to specify the structure, components and properties of the material culture found by the excavators. Instead of a random pattern that we would expect of a midden over one thousand flint artefacts were deposited in an alternating cardinal arrangement, all focussed and concentrated around position 30b. Therefore around the dark moon position of 30b one of the oldest cultural motifs known, a zigzag, as is the serpentine shape of the Draco constellation, is constituted from flint tools. The excavators, in a somewhat embarrassed admission, contradicted their own label for the Occupation Area by pointing out the arrangement and type of this and all other material could not be interpreted as occupation debris. Instead and arguably, we now have three indicators consistent with the properties of a *dragon*, and this can account for the indicators 4, 5, 7 and partially 16 and 22 in Table 1. It is also the case that with this evidence we can now claim full evidence for indicator 9 and remove it from our list of partially explained indicators.

Figure 3 shows how the rows of natural holes and artificial pits switch from one side of the Avenue to the other between hole 5 and pit 1 in the move from position 30b to 29a. It should be noticed that the two pits supplement the east side of the Avenue which has the least number of natural holes, and that they have been placed in exactly the same arrangement to holes 11 and 9 as holes 10, 8, 4 and 3 are to each other on the west side of the Occupation area. The addition of these two pits brings the total number of holes and pits to twelve, and this is a common motif in those patriarchal cosmologies which have an interest in disguising the thirteen full or dark moons that occur in every year. Table 3 shows the objects deposited within the holes and pits organised in their sequence in the Occupation Area. Common to all holes and pits were deposits of flint tools and flakes and pieces of sarsen stone. But at hole 10 was deposited the butt end of a Group VII axe, at hole 3 an axe fragment, and at hole 1 the cutting edge of a Group VII axe. Therefore approaching the Avebury circle alongside the west row of the West Kennet Avenue the equivalent of a whole axe-head is distributed between the holes that terminate with the *cutting edge* around position 30b. Now crossing the Avenue to the right hand side, the row of holes and pits re-commences, but now with the 'grave' of an adult man by stone 29a, then in pit 1 the skulls and vertebrae of ox and pig and antler of red and roe deer, followed by an ox tooth in hole 9 and the long bones of ox and pig and red deer brow tine in pit 2. Further along the Avenue at stone 25b were two adolescent boys and another man, at 22b and 18b each an adult man. One of the adolescent boys had sarsen boulders crushing his head and the other had 'part of a humerus had been forced through the jaw and well into the base of the skull' (Smith, 1965:210), while the adult male at 18b had ante-mortem cuts on his femurs (Smith, 1965:230). The fragmented instrument of *death* (partial 14) and dismemberment was distributed in the western row and precedes, in this direction, the deposition of a *sacrificed man* (partial 14) and animal remains in the eastern row. The point of transformation again hinges around position 30b – the area where the greatest density of cutting flint was concentrated. Therefore symbols, instruments and products of *children's blood* (30), human sacrifice and dismemberment *hinge* (30) around position 30b.

Table 3: Contents of holes and pits in the Occupation Area of the West Kennet Avenue. Note: data from Smith 1965: 213-216.

Hole/ Pit	Flint	Sarsen	Stone	Bone	Antler
10	Flakes 32; cores 2/Arrowhead (D); scraper; Flakes 14.	2 small pieces	Butt end of polished axe – Group VII.	-	-
8	-	-	-	-	-
4	2 arrowheads (C1 & D); scrapers 3; flakes 89; cores 4; nodules 20 – 6.5lb.	1 grain-rubber fragment (burnt); 11 pieces – 54.5 lb.	-	-	-
3	Scrapers 3; retouched flakes 2; flakes 58; nodules 9 – 2.5lb.	1 large piece – 26.5 lb; 16 small pieces – 6lb.	-	Calcined fragments	-
2	Scrapers 2; flakes 64; nodules 27 – 9lb	10 pieces – 6 lb.	-	-	-
1	Scrapers 2; Discoid; Serrated flake; Flakes 91/, Nodules 21 @ 4.5 lb	4 pieces – 7.75 lb.	ting edge of polished axe - Group VII.	-	-
7	Flakes 2; nodules 21.	2 pieces – 1.25 lb.	-	-	-
5	-	Small chips at 0.3ft.	-	-	-
P1	Arrowhead (C2); Scrapers 3; Burin; Pounder; Flakes 340; Cores 4.	5 pieces - 3.5 lb.	-	Tip of pin; Ox – fragments of skull, mandible, vertebra, ribs, long bones; Pig – teeth (worn), fragments of mandible, vertebra, ribs.	Red deer – fragment from slain animal; Roe deer - fragment from slain animal.
11	Arrowhead (C1); scraper; pounder; flakes 74; spallls 37; cores 2.	6 pieces – 2.5 lb.	-	-	-
9	rowheads 2 (C2 & D); retouched flake; serrated flake; flakes 85; cores 3; nodules 26.	2 small pieces	-	Ox tooth; calcined fragments	-
P2	head (E/F); Serrated flake; Retouched flake; Flakes 109; Spalls 129; Core 1.	Large piece – 26.5 lb.	-	Ox – parts of tibia, scapula, vertebra, 3 phalanges, 1 tooth, other small fragments; Pig – humerus.	Red deer – brow tine.

So far we have used the archaeology and archaeoastronomy of the West Kennet Avenue to test whether its structure is isomorphic with the Greco-Roman origin myth. The anthropology of the North West European monument builders adds another crucial dimension – they were cattle herders who hunted and occasionally planted (Thomas 1999; Whittle 1996; Zvelebil & Zvelebil 1990). In the shift from hunter-gathering pastoralist bride price replaces hunter bride service. From women's point of view this is a qualitative reversal in their fortunes, since purchasing brides with cattle rather than a performing a lifetime of hunting services breaks them adrift of their blood relations and locks them into their affinal kin group. Women become wed-locked. This is invariably associated with a simultaneous shift in the male monopolisation of ritual. Feuding over cattle through marital and raiding disputes is endemic in such societies (Evans-Pritchard 1940, Maison des Sciences de l'Homme 1979). This is the standard model in anthropology, and we can see it supported at West Kennet Avenue in the archaeology of ox skulls, male blood sacrifice rituals, left versus right symbolism, the displacement of lunar rituals onto lunar-solar cycles and the automatism of reverse solstice alignments to guarantee the turning of the year. *Women's power* (3) is displaced by *male usurpation* (8) in their monopoly of *death and resurrection* rituals (23) and feuding over *cattle theft* (partial 24).

We are left with the mythic drama of Cardea, Hermes and Janus, each bracketed respectively with Hawthorn, Hazel and Oak. In Fig. 1 it can be seen that the West Kennet Avenue links the mainly stone Avebury Circle with the oak and stone Sanctuary circle and the mainly oak West Kennet Palisade Enclosures - an enormous oak palisade enclosure as big as Avebury stone circle. The connection between them along the outside of the Avenue is specified by handedness when passing the full moon stone pairs 15 and 16. It can be seen in Table 2 that when travelling south from pair 16 looking forwards and sideways but not backwards, risings (Table 2 columns 2 & 3) not settings (Table 2 columns 6 & 7) prescribe walking along the right hand side only of the Avenue. A deposit of oak ash is made in hole 8 at the southern end of the Occupation Area in the direction of the Sanctuary and West Kennet Palisades (Table 4), and since the 'burials' are placed on the north-east side of the Avenue stones (Smith 1965), the separation from corpses and association with risings is suggestive of resurrection. Contrarily when travelling north past full moon stones 15 & 16 the emphasis is on settings (Table 2 columns 7 & 8) rather than risings (Table 2 columns 1 & 2), and with an open aspect to the corpses both are suggestive of death. In both cases processions along the outside of the Avenue are prescribed to be on the right hand side once having passed the full moon stone markers. Thus according to the direction we are travelling along the Avenue oak ash may be signifying *death* (23) when travelling north and *resurrection* (23) when travelling south. This property allows us to fully interpret the earlier partial treatment of indicators 16 and 38.

In each of the holes and pits a complex arrangement of deposits included a central core of charcoal, for which the excavators have provided the proportions of the types of wood. We have already encountered oak ash and sarsen stone in these holes, and this may cause no surprise since the main monuments utilise both materials in their construction. However, Hazel and Hawthorn, not Oak, dominate the hole and pit charcoal contents (Table 4). When walking north along the western row of holes the median percentage of

Hazel is 59.5% and for Hawthorn 34.5%, while the eastern row has medians of 62% Hawthorn and 28% Hazel – nearly an exact reversal of combinations. These differences in combinations by stone row cannot be explained by chance alone. Using the Wilcoxon-Mann-Whitney U test for non-parametric data, two-tailed tests for both Hazel and Hawthorn allow us to reject the null hypothesis (Hazel: $U=24$, $p=0.012$; Hawthorn: $U=23.5$, $p=0.012$). These results are not altered if we include the values for Elm, Blackthorn or Oak.

The Greco-Roman myth associates Hermes with Hazel as a herald and Cardea with Hawthorn as a hinge into the anti-marriage preparation for the summer solstice death of Janus as oak. The ecology of European native trees fits the chronology of these motifs. Hazel catkins, with a tiny red flower, blossom in January/February, long before it leafs, while its nuts ripen from late August to October. Hazel catkins flower while frost is still prevalent and are therefore pollinated by wind rather than by insects, and is the first arboreal resurrection from winter. Coming with and at the time of the cold north wind of winter the flowering of Hazel *heralds* (21) resurrection and, in so far as the north wind has already been linked to the coming of the dragon, Hazel is also imbued with a connection to the dragon as a *double dragon* (22). This new evidence completes what was an earlier partial explanation for indicator 22. In the connection of Hazel's re-birth from the North wind as dragon also suggests it is the product of *species ambiguous sex* (6). Hawthorn's musky hermaphrodite blossoms of five white petals and numerous small red stamens appear, along with its leaves, in May, while its deep red haws stay on the tree long after its leaves have dropped in early winter. The bio-chronometry of Hawthorn therefore *hinges* (29, 31) around the two solstices by opening and closing both the summer and winter halves of the year. This cancels the earlier partial treatment of indicator 19. During the summer solstice, Oak leafs and flowers in late spring in May/June. Pivoted around the June leafing and flowering of the oak, late winter Hazel blossoms alternate with spring May's Hawthorn, while Hazel's late summer's cob nuts alternates with early winter's Hawthorn's deep red haws**.** Rather than a linear or mirror image sequence the timings of the Hazel's and Hawthorn's flowerings and fruits leap frog each other in a diacritical combination around the pivot of the oak of summer solstice. This is the same association in bio-chronometry as we find in deposited ash proportions and fits precisely the Greco-Roman myth motifs of alternating death and resurrection between the three myth components. We now have not just an identity relation in components between the myth and the monument, but the second and third order relations of their association and interaction is matched for these three items.

Returning to our earlier evidence of the handedness of prescribed processions outside the Avenue, we can now see that while the archaeoastronomy requires walking on the right hand side when travelling south away from the full moon positions 15 and 16, by the time we pass position 30b Hazel comes to dominate the holes. Contrarily when travelling north towards the full moon positions and as we pass position 30b Hawthorn comes to dominate. Since we have already found that travelling south is to resurrection and travelling north is to death, then by association it is consistent to associate Hawthorn's dominance with an entry into death, which is exactly what the myth prescribes with *summer solstice sacrifice of Oak* (27, 38, 39). No other two native British Trees

(Thompson 1998, Rackham 1976) can provide the same combination of bio-chronometry with a strong emphasis of white/red alternation. The arboreal mythic symbolism is not arbitrary but consistent with the seasonal alternation in the properties of Hazel, Hawthorn and Oak, and rests upon the ecology of the ancient British flora. Therefore the evidence of Hazel, Hawthorn and Oak and their arrangement, association and interaction accounts for the indicators 15, 21, 24, 26, 28, 35, 38 and 39.

Table 4: Ash contents by type in Holes and Pits in the Occupation Area of the West Kennet Avenue. Note: data from Smith 1965: 213-216.

Holes & Pits	Corylus	Crataegus	Ulmus	Prunus	Quercus
Row B	(Hazel)	(Hawthorn)	(Elm)	(Blackthorn)	(Oak)
10	65	35			
8	50?				50?
4	59	34		7	
3	100				
2	50	50			
1	52	38		10	
7	60	40			
5	100				
Row A					
Pit 1	28	62		10	
11	25	68	7		
9	No data	No data			
Pit 2	39	50		11	

In an earlier publication I showed that the shapes of the West Kennet Avenue stones were sequenced according to their lunar scheduling, and that while at full moon they polarised into heterosexual pillar (male) and lozenge (female), the closer they came to dark moon they merged into combined properties of both pillar and lozenge suggestive of gender ambiguity. This property is consistent with matrilineal sororal seclusion strategies, in which classificatory brothers and sisters temporarily suspend their marital ties and heterosexual identities and merge themselves into blood rather than affinal relations (Sims 2012b). For a monument building culture confiscating and subverting an earlier lunar cosmology into a lunar-solar religion (Sims 2006), then it is consistent for this waxing and waning of stone shapes along the Avenue to be superimposed upon a seasonal system of time reckoning. Thus *May time seclusion* (37) and *May time anti-marriage* (36) is a transposition onto a seasonal time scale what would have previously been conducted during each waxing moon phase of the month while *full moon restores heterosexual identities* (18).

Gender ambiguity is, in ritual mode, accompanied by *species ambiguity*, which are displayed along the West Kennet Avenue with human 'graves' accompanied by ox, pig, sheep and goat remains (6). Hazel ash in the Occupation Area holes and pits connects Hazel with the *world above* (10). Gender and species ambiguity combined connotes the *illicit sex* of ritual seclusion which we find from Australasian corroborees to Pharonic Egypt, and this is consistent with Hawthorn, Hazel and Oak ash bracketed together in the Occupation area (28) of non-heterosexual stones. *Children's blood* (30) was spilt in the 'burials' of two adolescent boys at stone 25b and the *Corona Borealis* (32) may be signified in the many alignments on north found along the Avenue. The stealing of cattle into the underworld in Pits 1 & 2 follows on from Hazel's dominance along the western role of holes when moving north into the dark moon death of the winter sun at the Avebury Circle (24).

By the overlay of all six of these methodologies and the redundancy of repeating myth motifs characteristic of all myths and fairy tales, what for some indicators was at first a partial interpretation gradually accretes into a near-full interpretation for all 39 indicators. The argument is amenable to further test, as shown by Levi-Strauss in his four volumes of *Mythologiques,* by moving on to further fragments of *IE myth and actively seek to refute it by looking for exceptions. Nevertheless we have found not just a listing of the myth indicators at the WKA, but also for an important minority their association, interaction and sequence in the myth is the same as at the West Kennet Avenue. In particular, we have saturated the *herald* and *hinge* attributes of Hazel and Hawthorn around the dark moon position 30b by combining all six methodologies. Surprisingly we have also been able to provide an arguably convincing explanation of the Greco-Roman dragon motif by combining data from archaeoastronomy and archaeology. Taken together this all offers a near complete congruence between the Greco-Roman origin myth considered as a substrate and the components and arrangement of the Avebury monument complex. The probability of two independent systems of thought generating 39 identical components by chance alone is vanishingly small. This raises our ability to interpret both.

Beginning this exercise with the Greco-Roman origin myth would serve little purpose if it were not one fragment of a more ancient meta-myth from which the Avebury monument builders drew their own myths. All scholars in Indo-European poetics confirm that this is the case for all local versions of Indo-European origin myths (Doniger 1999, Lincoln 1991, Watkins 1995). This can be seen, for example, in the evidence of equivalents to Greco-Roman myth gods and goddesses elsewhere in the *IE region. Hermes has equivalents of Fionn (Ireland), Mercury (Rome) Thoth (Egypt), and Panus (Tamil). This does not mean that we would expect to find Hermes and Cardea amongst the Avebury monuments. Rather, it is to expect that the culture of the monument builders shared a cultural substrate with *IE cultures which encourage a common symbolic loading to Hazel, Hawthorn, Oak and dragons which subsequently diverge through the same transformational template. Both structuralism and Palaeolithic continuity-refugia theory predict that *IE origin myths themselves derive from some more ancient substrate of myth. Lincoln (1991) has shown that the names of IE gods and goddesses are not reducible to root *IE names from which they all genetically derive. However, the *IE words for Hawthorn, Hazel, Oak and dragon do derive from common *IE roots. The *IE term for Hawthorn is *h$_2$ed(h) deriving from Old Irish and Hittite terms which also have ritual and magical connotations. Coming from the north western and west central branch of Indo-European the *IE term for Hazel is *kós(V)los deriving from Old Irish, Latin, north eastern Europe and Lithuania terms. While the *IE word for oak is not recoverable, the root word for tree overlaps with that for oak in Celtic and Greek, and has religious connotations. And the Indo-European word for dragon is *dr$_o\hat{k}$ which derives from a Celtic and Greek root to 'see', 'as the dragon fixes its opponent with its baleful gaze'. The world serpent in *IE myth is associated with the resistance of pent up water and cattle in a cleft (Mallory & Adams 2007: 156, 159-60 and 148). Therefore while the gods named as Janus, Cardea and Hermes do not apply to the Avebury monuments builders, the same tree symbolism from which these Greco-Roman gods draw their magical power are appropriated by them for the conduct of their origin and initiation rituals at the Avebury monuments. If the agricultural revolution theory were correct this would not be the case. But as we have found evidence for all 39 indicators from these myth fragments of the Greco-Roman origin myth, this is consistent with the predictions of structuralism and Palaeolithic continuity-refugia theory that *IE language and culture derive from a common European root, and assists an interpretation of these monument building cultures of prehistory. These findings make claims for what the monuments meant to their builders. They are achieved by integrating the methods of six disciplines: linguistics, *IE poetics, ecology, archaeology, archaeoastronomy and anthropology. No one of these disciplines can or have achieved this structural level of interpretation, and it is only in their combination that this higher level of emergent meaning can be reconstructed. The gains from using such a multi-disciplinary method are large.

Since myths are scripts for rituals on this basis we can now make more precise claims for the rituals conducted at Avebury, and by implication elsewhere, during the late Neolithic. Seen as a continuation and confiscation of Palaeolithic lunar-scheduled matrilineal seclusion rituals the Avebury monument complex is an estrangement of what had once been a naturalistic alternation of a ritual and ludic-suffused culture. Where once there had been masquerade performance of blood relatives scrambling gender and species to motivate heterosexual partners, now boy's and men's blood sacrifice testified commitment to collective monument enterprises to domesticate the dragon of matrilineal clan power and cement emerging patriarchal alliances. Under the tutelage of specialists regional coalitions claimed their control of the 'axis mundi' against other regional groups of cattle owners.

We can now see that archaeoastronomy's present downplaying of the moon in ancient cosmologies in preference for the sun, in defiance of the evidence, is repeating the confiscation of lunar symbolism into a solar religion found in the Neolithic monument cultures. It appears that today's myths which are our context for scholarly work are still working through the same 'transformational template' as those of the monument builders of prehistory.

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Europe in Historical Times

Plato's Cosmic X: Heavenly Gates at the Celestial Crossroads

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Abstract
Heavenly gates existed in 'pagan' times long before Christians appropriated them for their purposes. Literary evidence links Macrobius back to Cicero, and then to Plato, whose *Republic* gives the earliest account of celestial portals in the Western tradition. Macrobius reveals that these gates stand at the intersections of the Milky Way and the Zodiac, which is composed of the constellations along the path of the Planets. Astronomical photographic evidence proves that Manilius' claim in *Astronomica* is correct – the intersection in the sky is indeed visible, at certain times of the year. Numismatic evidence corroborates that the celestial crossroads played a crucial role in the cosmology and soteriology of the Hellenistic world – appearing on Roman coins over centuries, from the Republic to the end of the Empire. Connecting these various strands of research together, we can conclude that the heavenly gates found in Plato's *Republic* correspond to Plato's cosmic X in *Timaeus*, a symbol of the pagan belief in a heavenly afterlife over hundreds of years.

KEYWORDS: Plato, *Timaeus*, *Republic*, Macrobius, Manilius

POVZETEK
Pojem nebeških vrat je znan že iz 'poganskih' časov, veliko preden so si ga kristjani prisvojili za svoj namen. Pisni podatki povezujejo Macrobiusa s Cicerom in naprej s Platonom, čigar *Republika* podaja najzgodnejši opis nebeških vrat v zahodni tradiciji. Macrobius razkriva, da ta vrata stoje na sečišču Rimske ceste in zodiaka, ki ga sestavljajo ozvezdja vzdolž planetarnih poti. Astronomski fotografski viri dokazujejo, da je Maniliusova trditev v delu *Astronomica* pravilna – v določenih delih leta je presečišče na nebu zares vidno. Numizmatični viri potrjujejo velik pomen nebeškega križišča v kozmologiji in soteriologiji v helenističnem svetu; ti motivi se na rimskih kovancih pojavljajo več stoletij, od časa republike do konca imperija. Če povežemo različne smeri te raziskave, lahko zaključimo, da nebeška vrata v Platonovi *Republiki* ustrezajo kozmičnemu X v njegovem *Timaeusu*, simbolu poganskega verovanja v več sto let trajajoče nebeško posmrtno življenje.

KLJUČNE BESEDE: Platon, *Timaeus*, *Republika*, Macrobius, Manilius

'This is not the way things were supposed to go,' thought Cato.

Didn't Rome's greatest general, Pompey, agree to champion the cause of the Republic? Didn't a large army assemble under Pompey's command in Greece to face the looming threat of dictatorship?

Yet the upstart Julius Caesar had triumphed over Pompey, hunting him all the way to Egypt, where Cleopatra lay in wait like a spider. The defenders of the Republic managed to regroup, but Caesar would pursue them relentlessly across North Africa.

Upon receiving news that Caesar had defeated the last troops that stood in his way, Cato put his affairs in order, retired to his chambers to read Plato's discourse on the immortality of the soul in *Phaedo,* and then, like a true Roman, he took his own life.

Plato's writings – with the immortality of the soul – were the Bible of the Greco-Roman world over centuries, laying out a cosmology and soteriology that promised a blessed afterlife to virtuous souls.

Plato's Heavenly Gates

At some point, we've all heard jokes that go something like this: 'Three men die and they arrive at the heavenly gates guarded by Saint Peter, who asks each man a probing question…'

Now, where did the heavenly gates originate?

It might come as a surprise to some that the celestial portals already appear in Plato's *Republic*, written around 350 BC. At the end of that tome, in the story of the fallen warrior Er, Plato describes heavenly gates through which the souls of the just ascend to the celestial abode.

> There were two openings in the earth, and above them two others in the heavens, and between them judges sat. These, having rendered their judgment, ordered the just to go upwards into the heavens through the door on the right…– Plato, *Republic* (from Cooper 1997: 1218)

Plato also influenced the great Roman statesman Cicero who, like Cato, would lose his life for defending the Republic. Over the course of his literary career, Cicero would translate Plato's *Timaeus* and emulate his other important works (*Laws, Republic*). The 'Dream of Scipio' at the end of Cicero's *On the Republic* is in fact a reworking for a Roman audience of the 'Myth of Er' at the end of Plato's *Republic*.

Cicero's protagonist meets his adoptive father and grandfather in the Milky Way, the abode of virtuous souls. Then Scipio hears the Music of the Spheres, the harmony generated by the movement of the Planets along the ecliptic, the path that traces out the Zodiac.

These two intersecting paths would be of utmost importance, as they point to a specific location in the heavens, a location evoked by an unplaced fragment from Cicero's *On the Republic*.

> 'If it is right for any man to climb to the tracts of the heavenly ones, then the great gate of heaven lies open for me alone… It is so indeed, Africanus, that same door lay open also to Hercules.' – Lactantius, *Divine Institutes* (from Bowen & Garnsey 2003: 101)

The 'tracts of the heavenly ones' is of course the course of the planetary gods in their celestial chariots, the ecliptic that runs through the constellations of the Zodiac. Somewhere along this path, somewhere along the Zodiac, lies 'the great gate of heaven' that is invoked by Cicero, who was following his hero, Plato, who had already given us the celestial portals.

The heavenly gates could be reached by heroic strivings, such as the Labors of Hercules that were often shoehorned into a dozen, to echo the twelve astrological signs through which the heavenly Wanderers traveled. Where along the planetary path of the heroes and the gods can we find the gates of heaven?

Macrobius' Heavenly Gates at the Intersections

Four centuries after the demise of the Republic, the Roman writer Macrobius employed Cicero's 'Dream of Scipio' as a framework for his understanding of Platonist cosmology, and to reveal that the Gates of Heaven stand at the intersections in the firmament.

> The Milky Way girdles the zodiac, its great circle meeting it obliquely… Souls are believed to pass through these portals when going from the sky to the earth and returning from the earth to the sky… – Macrobius, *Commentary on the Dream of Scipio* (from Stahl 1990: 133)

Macrobius links us back in time directly to Cicero, where we find the Milky Way and hear the music of the planetary spheres. These elements can already be found in Plato's 'Myth of Er,' where celestial gates lead to a 'pillar of light' – the Milky Way – and the harmony of the planetary Sirens points to the movement of the Planets along the ecliptic that traces out the Zodiac.

From Macrobius to Cicero to Plato – the path of Platonist cosmology can be traced back cleanly across seven centuries. The two intersecting structures in the sky are the Milky Way and the path of the Planets along the Zodiac, and Macrobius squarely places the celestial portals at these intersections.

Plato's Heavenly Intersections

The celestial intersections can be found in Plato's *Timaeus*, where the Creator fashions a long strip of cosmic material that he splits in half lengthwise. He places these at an angle to each other, like an X, and then he bends the extremities in a curve until they meet each other on the opposite side of a sphere – giving two intersecting circles on the celestial sphere, one the circle of the Same, the other the circle of the Different.

> Next, he sliced this entire compound in two along its length, joined the two halves together center to center like an X, and bent them back in a circle, attaching each half to itself end to end and to the ends of the other half at the point opposite to the one where they had been joined together. He then included them in that motion which revolves in the same place without variation, and began to make one the outer, and the other the inner circle. And he decreed that the outer movement should be the movement of the Same, while the inner one should be that of the Different. – Plato, *Timaeus* (from Zeyl 2000: 21)

In order to gives us a clue, Plato reveals that one of these circles is the path of the Wanderers, the Planets that travel along the ecliptic.

> When the god had finished making a body for each of them, he placed them into the orbits traced by the period of the Different – seven bodies in seven orbits. – Plato, *Timaeus* (from Zeyl 2000: 25)

In Plato's own words, we clearly find celestial portals through which virtuous souls ascend to the divine abode (*Republic*) and two circles that intersect in the heavens (*Timaeus*), one of them being the course of the Planets.

Visible Intersections in the Heavens

The crossroads in the sky can be found in Manilius' *Astronomica* from the time of Augustus, where the author, a great admirer of Plato, claims that this phenomenon is visible in the night sky.

> To these [previous circles] you must add two circles which lie athwart and trace lines that cross each other. One contains the shining signs through which the Sun plies his reins, followed by the wandering Moon in her chariot, and wherein the five planets that struggle against the opposite movement of the sky perform the dances of their orbits…
> Nor does it elude the sight of the eye, as if it were a circle to be comprehended by the mind alone, even as the previous circles are perceived by the mind: nay, throughout its mighty circuit it shines like a baldric studded with stars and gives brilliance to heaven with its broad outline standing out in sharp relief.
> The other circle [the Milky Way] is placed crosswise to it…
> – Manilius, *Astronomica* (from Goold 1977: 57-59)

The only time the path of the planets 'gives brilliance to heaven with its broad outline,' as Manilius claims, is when the zodiacal light, a broad swath of interplanetary dust, envelops the Wanderers, a rare sight best seen in the fall and in the spring.

And when the zodiacal light intersects the Milky Way (Fig. 1), we witness the cosmic X that Plato describes in *Timaeus*, the intersection that Macrobius calls the celestial gates, the heavenly portals that Plato describes in the Myth of Er at the end of *Republic*.

Figure 1: The zodiacal light rises from the horizon, envelops planets along the ecliptic, and intersects the Milky Way, revealing the celestial crossroads – Plato's X – the location of the Gates of Heaven (Photo: Matt BenDaniel).

Celestial Intersection on Roman Coins

The celestial intersection, Plato's X, could be seen on Imperial coins over hundreds of years, where it proclaimed Rome's control of the Gates of Heaven (Fig. 2). The cosmic crossroads would appear on coins of the emperors Domitian, Antoninus Pius, Marcus Aurelius, Lucius Verus, Macrinus, Licinius, Constantine, Constantine's sons, etc.

Figure 2: Plato's X on Roman coins. Left: Denarius of Antoninus Pius, with Italia enthroned on celestial sphere with intersecting lines (RIC III, 98C). Middle: Coin of Constantine, with Jupiter presenting the cosmic orb with intersecting lines and dotted with stars (RIC VI, Cyzicus 80). Right: Coin of Constantine's son, Constans, where he grasps the heavenly globe with stars and intersecting lines (RIC VIII, Rome 158).

We should not think that the X in the sky was a latecomer to Roman cosmology because it could already be found on coins of the Republic. A denarius struck by Manlius (c.107 BC) shows in the center the Sun god in his quadriga, on the right the crescent Moon, and on the left the X in the sky, the intersection that indicates the heavenly gates (Fig. 3).

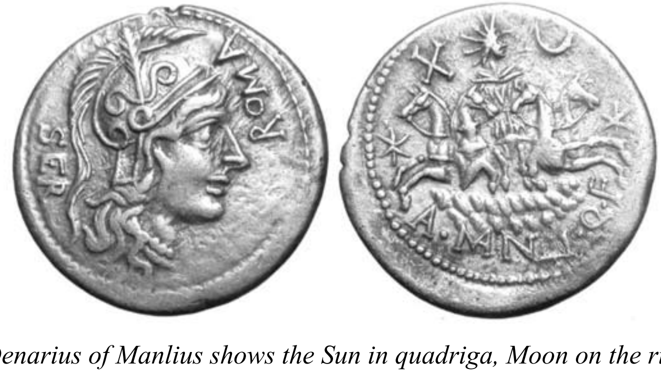

Figure 3: Denarius of Manlius shows the Sun in quadriga, Moon on the right, and the celestial X on the left.

Wonderfully depicted on the coin of Manlius, we see the path of the Wanderers – the Sun and the Moon – as well as the celestial X – Plato's cosmic X – the intersection in the sky that stood for the Gates of Heaven.

Conclusion

Although most Christians today do not know that heaven already existed in the pagan mind, a mechanism for reaching the celestial abode was in place long before the Christian era. Hundreds of years before the Christian cult made its appearance, Plato described heavenly gates through which virtuous souls entered a blissful afterlife.

Erased from our cultural memory for more than a thousand years, the pagan Gates of Heaven at the celestial intersections offered a blissful afterlife in the Milky Way to those who followed the ways of the planetary gods and goddesses.

Unfortunately with the expansion of light pollution, fewer and fewer will ever see the Milky Way and even fewer will ever witness the Zodiacal Light, the two visible circles in the night sky that revealed Plato's cosmic X, the crossroads that once indicated the Gates of Heaven.

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Djordje Nikolić' *Yugoslavs in Astronomy*

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Abstract
The serendipitous re-discovery of an old paper and appendix entitled *Les Yougoslaves en Astronomie (XV-XX siècles)*, by Djordje M. Nikolić (Warszawa 1938-1939), gives the opportunity for a concise review of the advances in Astronomy due to south-Slav scientists in the past centuries. The importance of the works by these scientists is apparent especially in the case of those belonging to the 'school of Dubrovnik' – whose most famous, but not unique, representative is Rudjer Bošković. It is worth to point out their marked experimental-practical inclination as well as the international context in which they were used to work, with intense and lifelong collaborations all over Europe. The humanistic and cosmopolitan character of their inspiration is repeatedly underlined by Nikolić himself, and strengthens the conclusion that scientific research can only fully flourish under the conditions of free transfer of knowledge and multi-national cooperation.

KEYWORDS: astronomy, history, Yugoslavia, Dubrovnik/Ragusa: Republic

POVZETEK
Ponovna naključna najdba starega članka z naslovom *Les Yougoslaves en Astronomie (XV-XX siècles)* avtorja Djordjeja M. Nikolića (Varšava 1938-1939) je lahko izhodišče za zgoščeno ovrednotenje prispevka južnoslovanskih znanstvenikov k razvoju astronomije v zadnjih nekaj stoletjih. Pomen del teh znanstvenikov je bil znaten predvsem v času t.i. 'dubrovniške šole', katere najbolj poznani, a nikakor edini predstavnik je bil Rudjer Bošković. Poudariti je treba njihovo opazno nagnjenost k eksperimentiranju, pa tudi mednarodni kontekst, v katerem so intenzivno delovali in bili v stalnih stikih s celo Evropo. Nikolić je na več mestih poudaril humanistično in kozmopolitsko naravo njihovega dela, na osnovi česar je mogoče zaključiti, da lahko raziskovalno delo cveti le ob prostem pretoku znanja in mednarodnem sodelovanju.

KLJUČNE BESEDE: astronomija, zgodovina, Jugoslavija, Dubrovnik/Ragusa: Republika

Introduction

It was by chance that an appendix to the *Bulletin of the polish group affiliated to the Committee of the International Academy of History of Science*, dated 1939 (Nikolitch 1939), was discovered in a stack of old scientific publications collected at Bologna University by Prof. Ettore Bortolotti, which were being catalogued by one of us. We subsequently searched for and requested the main paper (Nikolitch 1938c) from the National University Library in Strasbourg, where the only available copy is preserved.

The paper and appendix entitled *Les Yougoslaves en Astronomie (XV-XX siècles)* and written by the Serbian science historian Djordje M. Nikolić, led us to reflect upon its content and may be of general interest. In these papers, Nikolić divides the history of Yugoslav Astronomy into three periods which we may identify with the customary philosophic-historical concepts of *Humanism*, *Enlightenment* and *Positivism*. In the following, we highlight the personalities and themes which characterized each period, add some notes about the several scientists from Dubrovnik and comment on the overall characters of south-Slav Astronomy.[1]

Djordje M. Nikolić (1908-1971) completed his degree and PhD in Astronomy in France where he was a member of the Resistance during WWII. He was detained in a concentration camp in Germany from 1943 to 1945. Afterwards (1947-1966) he worked at the Geography Institute of the Yugoslav National Army. Before the war, he had been the first president (1934-1936) of the Belgrade Amateurs Astronomers Club 'Rudjer Bošković' and the founder of its magazine *Saturn*. He was not only the author of several popular papers on the work of Bošković (e.g. Nikolitch 1938b), Astrogeodesy, Mathematics etc., but also the translator of Einstein's *Relativity: the Special and General Theory* in 1935 into Serbocroatian.[2]

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[1] Since the information on individuals given by Nikolić is sometimes incomplete or uncertain, we performed checks and additions. In particular, we use here the 'true' names of the scientists, giving priority to the historically most recurrent or proper 'ethnic' way of writing instead of Nikolić' French option (e.g. De Dominis instead of Gospodnétitch).

[2] Cp. http://www.adrb.org/index.php?lang=en&page=presidency. Strasbourg librarians also sent us a third paper in French language written by the same author, entitled Roger Bochkovitch (i.e. Rudjer Bošković: Nikolitch 1938a). The paper has an Annex which is the integral text of a Conference that the author had held on the occasion of the 150th anniversary of Bošković' death. Interestingly, Nikolić opened his talk by stressing that his due, to speak about Bošković as a Yugoslav, was 'a little bit difficult, given the present circumstances' (Nikolitch 1938a: 185). It was in fact the eve of WWII with the subsequent disgregation of the Kingdom of Yugoslavia by German and Italian occupiers and their local collaborators. Nikolić clearly endorsed the same pro-Yugoslav viewpoint of the biggest intellectuals of pre-WWII Yugoslavia, e.g. 'the writer Ivo Andrić and the sculptor Ivan Mestrović [who] eschewed both supranational Yugoslavism and separatist nationalism in order to create a "synthetic" Yugoslav culture that could "join the existing tribal cultures into a new and dynamic culture suitable for the new state"' (Clark 2003, quoting Andrew Wachtel's contribution in Djokić 2003).
Let us make an important remark at this point. When using the term Yugoslav one may intend it in the 'ethnic' and literal meaning of south-Slav - thus including all Serbs, Croats, Slovenes, Slav Muslims, Montenegrins and Macedonians; however, it can be also used in the even broader sense of 'anybody who was born or lived in the nationally-mixed area of the late Yugoslav State', be it the Kingdom or the Socialist Federation - thus including also not-Slav individuals in the ethnic sense. The latter meaning actually prevailed in the XX century. When accepting this meaning, then people which were not Yugoslavs in the ethnic sense but lived in a south-Slav context - e.g. Hungarians from Vojvodina or Italians from Dalmatia - can be also considered.

The first period (Humanism)

Interestingly, many astronomers of the post-Middle Age epoch and up to the end of the XVII century originated from Dalmatia – i.e. the Adriatic coast and islands (several of them from the Republic of Dubrovnik/Ragusa: we will deal with these separately below). Scientists in this epoch used to communicate in Latin language, which was the international language of science and intellectuals at the time.

The first to be mentioned are the priests ***Martina*** (1450s) and ***Janus Pannonius*** (Ivan Česmički, alias Joannes Quinqueecclesiensis, 1434-1472). Both worked at the service of the Hungarian Kingdom and the Roman Church.

Andrej Perlah (German: Perlacher, Latin: Perlachius, 1490-1551) was born into a family of Slovene peasants but reached the position of professor, to become later rector at the University of Vienna and court astrologer to Archduke Ferdinand of Habsburg. Nikolić remembers Perlah for his almanacs and ephemerides.

Franciscus Patricius (Frane Petrić, 1529-1597), a well-known philosopher, is mentioned by Nikolić in his accompanying paper (Nikolitch 1939: 125). Although being born in the Dalmatian island of Cres he moved to Italy and actually maintained quite poor relationships with the south-Slav culture. Based on a section of the book *Nova de universis philosophia* (1553), entitled *Pancosmias*, that outline some fundamental ideas of the Universal Gravitation, Nikolić speaks of Patricius as a forerunner of Newton and '*an ardent partizan of the ideas of Copernicus*' (Nikolitch 1939: 127).

Marcus Antonius De Dominis, alias Marko Gospodnetić or Domnianić (1566-1624), was born in the isle of Rab/Arbe and became later archbishop of Split/Spalato. He also spent a large part of his life in Italy (esp. Padua, Venice), but also in England. He investigated the spectrum of light and the appearance of rainbows. His work is mentioned in detail by Nikolić, who quotes two entire chapters from the rare book *De radiis visus et lucis*, dealing with the refractor telescope and the formation of rainbows:

> Gospodnetić wrote in 1591 a manuscript, which was published in Venice in 1611, entitled *De iride*, where there is the very first description of the astronomical lenses (refractor) telescope, which is identical to the lenses-refractor telescope discovered by Galileo 20 years later. (Nikolitch 1938c: 118).

De Dominis' achievements in this field were recognized and reported by Newton and Goethe themselves. Moreover, he correctly understood the tides as a moon-induced phenomenon. Galileo did not, and sarcastically commented (as cited in Pecker 2001):

> Lately, a certain prelate [*De Dominis*] has published a little tract wherein he says that the Moon, wandering through the sky, attracts and draws up toward itself a heap of water which goes along following it...

De Dominis died in Castel Sant'Angelo prison in Rome following a conviction by the Inquisition because of theological 'errors' contained in his book *De Republica ecclesiastica*. His corpse and all his manuscripts were burnt on the Campo dei Fiori in Rome (Newland 1859).

Basic Astronomy must have been also cultivated in the Yugoslav hinterland, including Bosnia and Serbia, although Nikolić does not mention this. These regions belonged to the Ottoman Empire at least since the XV century, and basic astronomy was linked to the religious rituals of Islam. We know that the first Astronomical posts were assigned in Belgrade in 1741 to the *muvekit*s, religious officials who were responsible for the exact time for prayer and determined the direction of Mecca (Milisavljević et al. 2011).

The second period (Enlightenment)

South-Slav scientists used in this period mainly Latin or German as a scientific language, but in some cases of Russian or French. The most famous astronomer of this epoch is Rudjer Bošković from Dubrovnik; others are:

Ivan Paskvić (1754-1829), born in Senj, moved first to Zagreb and then to Hungary where he teached and worked mainly in the fields of Mathematics and Astrometry. He worked at the Observatory of Buda (Hungary, although Nikolić uses the German name of the town *Offen*), as did both ***Daniel Kmet*** (1783-1825), a Slovene, whose astronomical publications in Latin language have survived to our epoch, and ***Jan Horvat*** alias János Horváth (1732-1799), actually a Hungarian from the border town of Koseg. One of Paskvić' disciples was ***Mirko Danijel Bogdanić*** (1760-1802) from Virovitica, a Croatian town at the border with Hungary. He spent most of his life in Vienna and Budapest, but also lived in France, Germany, Italy and Vojvodina. His work includes Cartography and Geodesy.

Jurij Vega (Georg von Vega, 1754-1802), of Slovenian origin, was in Ljubljana as a student but then moved to Vienna; as an army officer he was sent to Belgrade to combat the Turks and to Paris to combat the revolutionaries. Although his knowledge extended over several different fields, especially Mechanics and Mathematics, his contribution to Astronomy can be recognized in a book on Newtonian General Gravitation, edited in 1800 in German language.

As a last protagonist of this epoch, Nikolić finally mentions a linguist – ***Žiga Popovič*** – and an extraordinary intellectual – ***Zaharije Stefanović Orfelin***. While the first is said to have created the German word for *observatory* (*Sternwarte*), the second popularized Astronomy through his *Perpetual* (Eternal) *Calendar*. Orfelin (1726 – 1785), a prominent Serb literary man born in Vukovar, deserves perhaps a few more words than Nikolić used:

> Among his most important works is *Slavenoserbski magazine* printed in Venice in 1768. This is the first South Slavic magazine. Although it was printed just one volume, its importance is great. In the preface he presents the idea of civil enlightenment, and also speaks that science, literature and philosophy should leave the narrow circle of educated people and should become available to everyone. In 1768 Zechariah Orfelin introduced into the Serbian literary a language which was a mixture of Church and peoples language, having many Russian words. In this way he practically **founded Slavoserbian language**. (...) Orfelin's *Perpetual Calendar* has been printed in Vienna in 1783. The book has 366 pages and 9 astronomical drawings at the end of the book. Its content is mainly on natural sciences and astronomical phenomena and contains as well description of historical events (...) ***Perpetual calendar* is the first book on astronomy written in Slavonic language**, how Orfelin says *'to the benefit of the people slovenoserbskim'*. (Pejović & Mijajlović 2010).

It was in the same years indeed that some Astronomy was taught at the first Serbian schools in Slavonia as part of the first school program in 'slavonic' language (Milisavljević et al. 2011).

The third period (Positivism)

Like Orfelin, also ***Toma Mikločić*** published an *Eternal Calendar* (Zagreb 1819). With this author we have entered the latter period in the description of Nikolić', which covers scientists who worked in XIX century and up to the dawn of the XX century. Most of them were born under the Austro-Hungarian Empire and used German as their customary scientific language.

A few names of scientists (***Benko, Carić, Gelčić***) are listed by Nikolić who were mainly experts in nautical sciences; not by chance, all of them were from the Adriatic coast. Afterwards, he mentions three scientists of Slovenian origin:

Jožef Stefan (1835-1893) is for sure the biggest Yugoslav scientist of the XIX century. He is best known for his achievements in Thermodynamics (the well-known *Stefan Law* of black body radiation), but the very same achievements paved the way for the whole new science: Astrophysics. Born in the small village of Sveti Peter near Žrelec, Slovenia,

> like Bošković and Getaldić, Stefan always remains connected to his homeland, through several collaborations with slovene magazines where he publishes his poems and stories. (Nikolitch 1938c: 148)

Matej Vodušek (1839-1931) wrote several Astronomy textbooks in German language, and, in particular, was '*the first to edit a book* [Grundzuge der theoretischen Astronomie, 1890] *on theoretical Astronomy in Yugoslavia*' (Nikolitch 1938c: 150), while ***Viljem Ogrinc*** (1845-1883) was a writer and popularizer of Astronomy into Slovenian language.

Spiridon 'Spira' Gopčević, (alias ***Leo Brenner***, 1855-1928) was a Montenegrin from Trieste. Both an astronomer and a historian, he was also a patriot; he was imprisoned in 1893 due to some articles against the Austro-Hungarian government. Immediately after his release he moved to Chile, where he '*worked in private astronomy*' (Nikolitch 1938c: 146). But in 1893 he returned to Dalmatia, to found the Manora Observatory on the island of Mali Lošinj. The observatory was '*named for his wife, a wealthy Austrian noblewoman. At this observatory, Spiridon used the 17.5 cm refractor telescope to make observations of Mars, the rings of Saturn, and other planets. However he would eventually close the observatory in 1909 due to financial problems.* (...) *A new observatory was built on Mali Lošinj in 1993, and was named* Leo Brenner' (http://en.wikipedia.org/wiki/Spiridon_Gopčević).

> At Manora Observatory he had a 17.5 cm Rasmussen refractor telescope at disposal, furnished with objectives Reimfelder and Hertel, and also a Negus chronometer and an excellent micrometer, apart from a huge library. It is worth mentioning that the library and instruments owned by Gopčević are now [1938] in possession of Mr **Nika Miličević**, astronomer in Brać, an island where he holds a private observatory. (Nikolitch 1938c: 147-148).

Nikolić further mentions other cases of small observatories and instruments existing at the end of XIX century in Slovenia (owned by ***Andrej Krajtz***) and Croatia (owned by ***Ivan Stozira***, an Astronomy writer himself. Nikolitch 1938c: 150). Spira travelled again to South America at the beginning of the XX century, for instance to Arequipi (Peru) in 1903 where he carried on important observations of planets at the local observatory. In the same years he was the founder and editor of the popular scientific journal *Astronomische Rundschau*. His personality must be remembered as a typical world-open, polyglott, eager to travel and learn.

Oton Kučera (1857-1931), a Croat, '*was in relation with Gopčević for the installation of an observatory in Zagreb*' (Nikolitch 1938c: 150) - more precisely, he was co-founder of the town's observatory at Popov Toranj (Priest's Tower) which '*disposed of a 16.5 cm* Reinfeld *refractor telescope, subsequently furnished with a position micrometer and small meridian made by the* Mailhat *firm*' (Nikolitch 1938c: 151). However, Kučera's main activity was popularizing Astronomy in Serbocroatian language, as he wrote for example *Naše nebo* (*Our sky*) and a plethora of magazine articles. Evidence of cooperation between Serbian and Croatian astronomers at the dawn of the XX century is contained in the early publications of the Astronomical Observatory of Belgrade *Godišnjak našeg neba* and *Nautical Almanac*, including several articles by Croatian scientists (Milisavljević et al. 2011).

Serbian astronomers are subsequently mentioned by Nikolić, most of them affiliated to the 'Društvo srpske slovenosti' (Society of Serbian Letters) in Belgrade. They are: ***Gavrilo Popović*** (1821-1867); ***Konstantin Dragačević***; ***Milan Andonović*** (1849-1926), author of an important *Kosmografija* which was the first Astronomy textbook in Serbia (just like Kučera's *Naše Nebo* was the first in Croatia: both were published in 1888. Milisavljević et al. 2011); ***Radovan Miletić*** (born 1844); and, most importantly, ***Milan Nedeljković*** (1857-1950), a former student at the Sorbonne University in Paris and the founder of the first State Observatory in Serbia in 1891:

> This first observatory was small and developed very hardly. It disposed of a meridian, an altazimuth and a refractor telescope. (...) The State did not want to invest bigger sums of money for 'stars'. This situation forced Nedeljković to deal more with metereology. (Nikolitch 1938c: 151-152).

Nevertheless he wrote some interesting astronomical books, including a *Project for a Calendar Reform* (1900, in French).

In fact, it was precisely at the eve of the XX century that the question of a calendar reform was posed in Serbia like in the other christian-orthodox countries where the Julian calendar had remained in use for centuries after the Gregorian reform. The Gregorian calendar would be adopted for civilian purposes in Serbia in 1918 and Yugoslavia in 1919 (the Orthodox Church still uses the old calendar). Other yugoslav scientists which were involved in this discussion are ***Mirković***, ***Mihailović***, ***Savić***, ***Maksim Tripković*** and ***Milutin Milanković*** (Nikolitch 1938c: 152). The latter two wrote important essays on this issue, respectively in 1900 and 1924 - but Milanković (1879-1958) gaine world fame after linking Earth climate changes to the variations of the Earth orbital parameters.

Nikolić ends his main essay with a few remarks on the contemporary situation of Astronomy at the eve of WWII. The accompanying paper finishes instead with a longer and detailed section on meteorite findings in Yugoslavia and a complete list of the meteorite collection which was held by the Museum of Serbia, in Belgrade, until WWI. It is worth remembering that the first work on meteorites in the world was written in Russian language by another Yugoslav scientist, ***Atanasije Stojković*** (1773-1832), who worked in Kharkov, Russia, but was not mentioned by Nikolić.[3]

A 'School of Dubrovnik'?

Several scientists mentioned by Nikolić were born and/or worked in the here presented first period in the then Republic of Dubrovnik.

Giovanni Gazoli or Gazzoli alias Ivan Gazolić (1460s) is referred to as a mathematician and the builder of an armillar sphere ('*Ptolomeus sphere*') in a letter that was addressed to him in 1466 by Pannonius. This letter is fully reproduced in both the original Latin (from: Appendini 1802: 40) and a French translation in Nikolić' accompanying paper (Nikolitch 1939: 123-124).

> The bare fact that an instrument existed in Dubrovnik in the XV century is outstanding and enough as a proof that Astronomy was very developed there already in 1460. (Nikolitch 1939: 125)

Furthermore, only sparse information can be found on Gazoli (Appendini 1802: 40-41, 207-208; Nikolić 1938d) and all his work is lost.

The development and use of scientific instruments in Dubrovnik is also apparent in the case of ***Marino Ghetaldi*** alias Marin Getaldić (1568-1626). This scientist, who originated from a noble family of ancient south-Italian origin and studied in Italy and Germany, was said to perform 'magic' experiments with sunlight reflected by parabolic mirrors in the Betina Špilja cave near Dubrovnik, therefore being renowned as a sorcerer who was able to set fire to fishermen's boats at a distance.

This is indeed the time when a famed '*Dubrovački durbin*' was said to exist, i.e. a reflector telescope in Dubrovnik, especially after the testimonies by contemporaries like T.L. Burattini and A. Gisgoni. The Italian physician Gisgoni had practiced his profession in Dubrovnik for almost ten years when he met Burattini in Warsaw in 1670 (almost half a century after the death of Ghetaldi). Gisgoni told Burattini about an earthquake which had recently struck the Dalmatian town, perhaps destroying '*that admirable instrument, that the tradition ascribed to Archimedes, and which made it possible to see the boats at 25 or even 30 miles away, just as clearly as if they had been within the haven!*' (Lebeuf 1990). However, such an 'admirable instrument' – similar to a Cassegrain telescope and installed '*on a tower*' - could not really date back to the time of Archimedes, since its existence had never been reported by scientists before, not even by '*Marino Ghettaldo*' who was among

[3] For more personalities of Yugoslav astronomers which were not mentioned by Nikolić, cp. for example the recent contributions by Pejović & Mijajlović (2010), Milisavljević et al. (2011).

others the author of a *Promotus Archimedis* (Rome 1603). However, it may be that Ghetaldi, the likely builder of this 'admirable' artifact, simply had not found the occasion to write about his outstanding achievement during his lifetime. This comes as no surprise if one considers the following significant quote from Ghetaldi reported by Nikolić: 'Is enim ego sum qui malim scire quam nosci, discere quam docere', that is: '*I belong to those who prefer to know, instead of being famous, and to learn, instead of teaching*' (from the Preface to *Promotus Archimedis*). As a matter of fact, a parabolic 66 cm mirror attributed to Ghetaldi is currently kept at the National Maritime Museum in Greenwich, UK.[4] In Nikolić' words (1938c: 135), 'Getaldić had built the first parabolic mirror, a full century before Newton, and it is likely that he had used it as a mean to observe with the naked eye the real image of a boat by projection.'

It is known that Ghetaldi wrote several works dealing with Optics and was able to apply full algebraic methods to geometrical and optical problems for the first time. He had intense correspondence with all main scientists of his epoch, including Galileo, Clausius and Viète. Strictly speaking, he was rather a mathematician and physicist than an astronomer: his name is linked to Astronomy only for his activity as a telescope builder.

More *Dubrovnicians* are mentioned by Nikolić. ***Nicola Sagri*** alias Nikola Sagroević (died 1573) was above all involved in studies on sea currents and tides; ***Nicola Nale*** alias Nikola Nalješković (1510 ca. - 1587) was rather a poet and cultivated person than an astronomer, nevertheless he participated in serious discussions on the calendar reform. ***Stefano Gradi*** alias Stjepan Gradić (1613-1683) dealt with Mathematics, Astronomy and Physics, but Navigation was at the top of his interests. After settling in Amsterdam, he wrote several works which are mentioned by Nikolić, who presents the full text (Nikolitch 1939: 129-130) of two letters which cardinal Barbarigo addressed to Gradi in 1660-1661, asking for advice on the interpretation of the Copernican theory and the odd appearance of Saturn. Nikolić also mentions a 'Ragusan' ***Vinko Pučnić*** alias Pozzo, and 'Ivan Odierne' that is Giovanni Battista Hodierna (1597-1660). In the latter case, the place of birth appears to have been mistaken after Appendini 1802 (pp.48-49): Odierna was clearly born in the Sicilian town of Ragusa, not in the Dalmatian Dubrovnik, given that he spent all of his life in Sicily.

With ***Rudjer Josip Bošković*** (Dubrovnik 18 May 1711 – Milan 13 February 1787) we cover the second of Nikolić' periods. Nikolić gave an especially interesting contribution in the controversy about Bošković' *nationality* by stressing the special *Ragusan* and *Yugoslav* identity of the great scientist. However, Bošković biography and achievements are already well known especially after the recent celebrations which took place in 2011, for the 300th anniversary of his birth; therefore we are not going to write further about him here.

Several important personalities had already emerged in Dubrovnik in a time span of barely two centuries and an even more relevant personality would be added to the count, that is Rudjer Bošković, although he actually lived in the following (XVIII) century. Given such a large number it could be appropriate to speak of a specific Astronomy

[4] Cp. http://collections.rmg.co.uk/collections/objects/10955.html. The testimonies by Burattini and Gisgoni are mentioned in Nikolitch 1938c, p.135. In his Doctorat, Arnold Lebeuf (1990) explains that these testimonies were originally reported by M. Libri and critically analyzed by Martin 1871. We thank Arnold Lebeuf for providing us with his text.

'school'. This would then be called the 'school of Dubrovnik' - or 'The Ragusan school', from the old Latin name of the Dalmatian town. As a figurative symbol of 'the Ragusan school' we could use the beautiful image of the astronomical clock tower, dating back to 1444, which - located at the bottom of the *Stradun* (main avenue) - still dominates the view of Dubrovnik's old town center.

Alternatively, we could also include individuals such as Patricius and De Dominis who lived in different locations at the Dalmatian coast, and then speak of an even more extended 'Dalmatian' tradition in Astronomy. At the core of this tradition are scientists (De Dominis and Ghetaldi) who were among the *very first* telescope builders! Dalmatian Astronomy indeed showed a marked experimental-practical inclination, with interests and abilities closely related to Navigation, i.e. the main activity in the coastal context.

Dalmatian scientists were used to write their scientific essays in Latin, the customary international language for scientific correspondence at the time. They normally also had close relations with the Catholic Church that was the most powerful scientific institution at the time, and some of them also belonged to the clergy, like the great majority of cultivated people and intellectuals at that times. This did not avoid, however, conflicts and problems with the religious authorities, even leading to the involvement of the Inquisition. The 'Dalmatian' tradition is placed in the period of Humanism and Enlightenment, whose *esprit* had a clear influence on these intellectuals, including De Dominis and Bošković as the greatest examples.

Conclusions

The modern concept of *nation*, based on language, culture, religion, customs, etc., was developed only in the 19th century. Not by chance, the idea of a common south-Slav (*Yugoslav*) identity was born at the same time. Still, the attribution of a definite 'nationality' to individuals who lived in the previous centuries often remains arbitrary; it is indeterminable above all when they lived in ethnically mixed regions and frequented various cultures, peoples and languages.

The humanistic and cosmopolitan character of all the scientists we mentioned here is repeatedly and correctly underlined by Nikolić. As far as their 'humanism' is concerned, Nikolić stresses that 'the Balkans possessed (…) great humanism seven centuries before the French Revolution' (Nikolitch 1938c: 116), making reference (Nikolitch 1938a: 187) to Emperor Dušan and his advanced *Code of Laws* (1349).

Western-Balkan scientists gave their own contribution to the study of phenomena such as: the nature of rainbows and the understanding of the Earth's atmosphere; theory and use of telescopes, either based on lenses ('*cannocchiale*') or on parabolic mirrors; light, radiation and temperature - up to the formulation of Stefan's Law; Geography and Cartography; computation of time and the calendar reform. Most of them used Astronomy as a test field for advanced physical theories in the domains of Optics, Geodesy, Mathematics and Geometry. Thermodynamics, Hydrodynamics, Oceanography, Earth Sciences (Milanković), and Planetology (Bošković, Gopčević) were developed by them to the highest level.

Many of these south-Slav scientists were not only astronomers but intellectuals in a broader sense. Starting with Enlightenment, they often contributed to the establishment of a defined south-Slav identity in the domains of language, literature, and politics by striving for independence and freedom. Finally, the activity of communicating and popularizing the astronomical knowledge was common for many of them.

Their attitude was progressive and world-open during Renaissance, Enlightenment and beyond, which is to be expected in a territory like the western Balkans where many different cultures coexist and people of all origins pass through. All these scientists had an international stature. Speaking in modern terms: we can say that they were great *Yugoslavs* and best examples of *Europeans* at the same time.

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Further useful resources

Edizione Nazionale delle opere e della corrispondenza di Ruggiero Giuseppe Boscovich: http://www.edizionenazionaleboscovich.it/

Hrvatski Biografski Leksikon: http://hbl.lzmk.hr/

Slovenski Biografski Leksikon: http://nl.ijs.si/fedora/get/sbl:sbl/VIEW/

Virtual library of the Mathematical Faculty of the University of Belgrade: http://elib.matf.bg.ac.rs:8080/virlib (contains a collection of Yugoslav astronomical books printed in the XVIII and XIX century)

Mesoamerica

Ethnography in Support of Archaeoastronomy: The Meaning of Tojolab'al Maya Mountain Alignments

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Abstract
Ethnographic material provides substance for interpreting Ancient Maya archaeoastronomical phenomena. Acquisition of such knowledge requires formation of hypotheses based on participation, observation, and documentation; querying for explication, and repeated testing through cross-verification. The present paper presents an example, documentation for which derived from a 40-plus-year association with a single Tojolab'al Maya community, Ingeniero González de León, Chiapas, México, and periodic study in additional Tojolab'al communities. In González de León, alignments between pairs of the four mountains that surround the village express continued dependence upon a tellurian-celestial cosmology, most directly the association of one kind of double-headed serpent with the Milky Way and that of another kind of double-headed serpent with the Ecliptic. Both serpents are associated with mountains and mountain alignments, and the first is believed to reside in a cave of one of the four mountains. The crossing of these two serpents in the night sky creates a representation of the Axis Mundi. The four mountains involved in the alignments are all strongly associated with water. The community actively engages these cosmic forces in important festivals in order to insure health within the present-day community, as attested by the reproductivity of the human, animal, and vegetative spheres.

KEYWORDS: ethnography, archaeoastronomy, pre-historic meanings, mountain alignments, Tojolab'al Maya

POVZETEK
Osnova za interpretacijo arheoastronomskih pojavov pri starih Majih so etnografski viri. Potrebni koraki za pridobivanje takih spoznanj so oblikovanje hipotez na osnovi opazovanj, neposredne udeležbe in dokumentacije, iskanje možnih razlag ter večkratno preverjanje z navzkrižno verifikacijo. V članku predstavljamo tak primer, ki temelji na več kot 40-letnem sodelovanju s tojolab'alsko majevsko skupnostjo Ingeniero González de León (Chiapas, Mehika) in na občasnih študijah v drugih tojolab'alskih skupnostih. V vasi González de León smeri, ki ju tvorita po dva para okoliških hribov, izražata stalno odvisnost od zemeljsko-nebesne kozmologije, najbolj direktno prek povezave ene vrste dvoglave kače z

Rimsko cesto ter druge vrste dvoglave kače z ekliptiko. Obe kači sta povezani z vrhovi in povezujočimi linijami, prva od kač pa naj bi živela v eni od tamkajšnjih jam. Prehod obeh kač preko nočnega neba razodeva sliko osi sveta. Vsi štirje hribi so močno povezani z vodo. Skupnost te kozmične sile aktivno uporablja ob pomembnih praznikih, da bi si zagotovila zdravje, ki se odraža v reproduktivnosti človeka, živine in poljščin.

KLJUČNE BESEDE: etnografija, arheoastronomija, prazgodovinski pomeni, smeri proti hribom, Maji Tojolab'al

> Mountain tops are the meeting ground between the two worlds, the Earth and the Sky, and it is here that humans perform ceremonies to assure the annual renewal of nature and the order and continuity of their society.
>
> Evon Z. Vogt (Nov. 16, 2000)

Introduction

Ethnographic details and exegeses reveal patterns in modern Tojolab'al thinking that enlarge our understanding of Ancient Maya beliefs about the cosmos. In the Tojolab'al-Maya-speaking village of Ingeniero Gónzalez de León, Chiapas, México (Figures 1 & 2), four sacred mountains surrounding the community condense the relation of underworld to earth and to sky. These mountains also are involved in the management of water from sky, underground, and earthly sources: the rain and mist; underground rivers, springs, and sinkholes, and surface seeps, streams, rivers, lakes, and reservoirs.

Figure 1: Map showing Tojolab'al region.

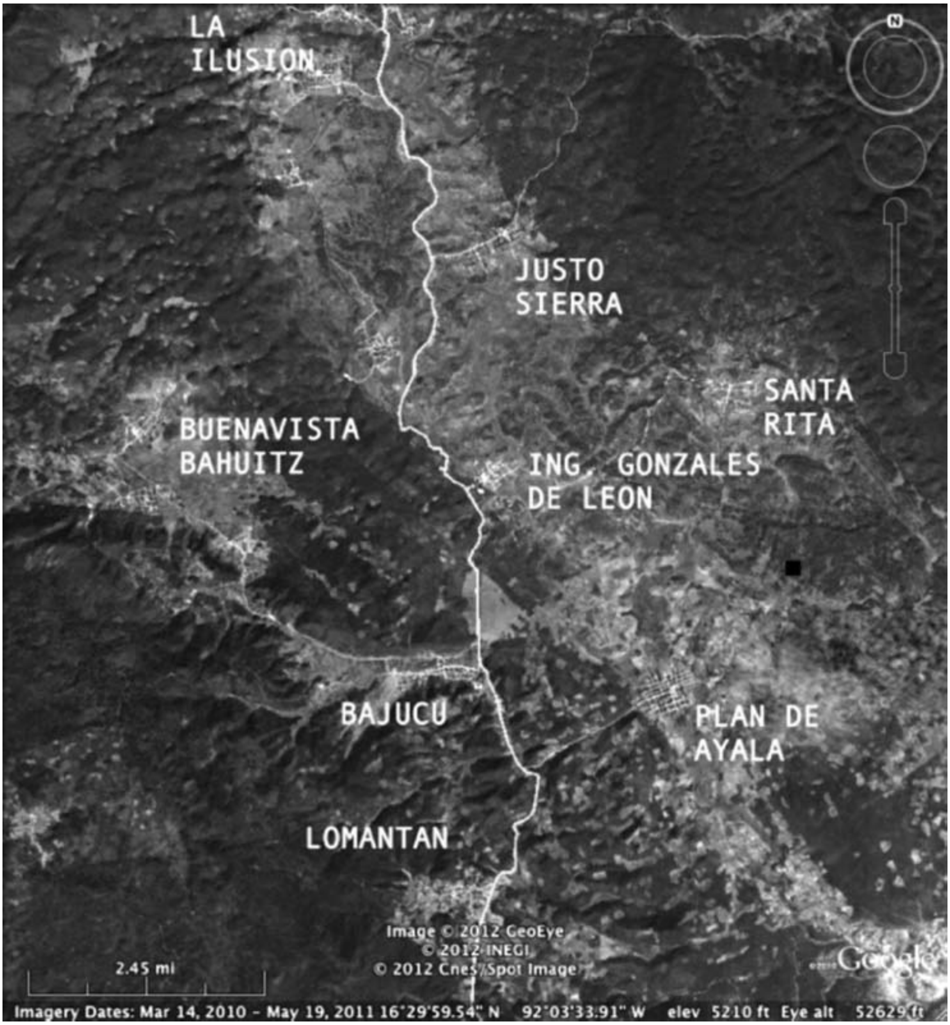

Figure 2: Village of Ing. Gónzalez de León and its near neighbors along the road from Comitán to Altamirano.

Mountain Alignments, Mountain Caves, and Cosmic Actors

The four mountains that dominate the landscape of Ingeniero Gónzalez de León are spoken of as marking cardinal directions. They participate in important alignments that mediate underworld, surface world, and sky relations. Some host cosmic actors. The most important of these alignments are between pairs of male and female mountains. Figure 3 identifies some of the natural and constructed features in the village landscape and shows alignments between mountains. The four sacred mountains are, to the North, *Represa* ('Reservoir' after a now nearly dry reservoir at its base); *Witz K'in Ip* ('Powerful Festival Mountain') in the East; in the South, *Toro Chan* ('Bull Serpent'), also called *Toro Ton* ('Bull Rock', after a large rock formation inside the cave that resembles the head of a horned bull and which is identified as the head of the cave serpent), and finally, in the West, *K'i'ix Sero* 'Spine Mountain' (after either its summit shape or a spiny plant). *K'i'ix Sero* is also called *Cham Trini* 'Died Trinidad' (after an event when a man named Trinidad (nickname, 'Trini') died at the foot of the mountain). *K'i'ix Sero* and *Represa* are female mountains, and *Toro Chan* and *Witz K'in Ip* are male.

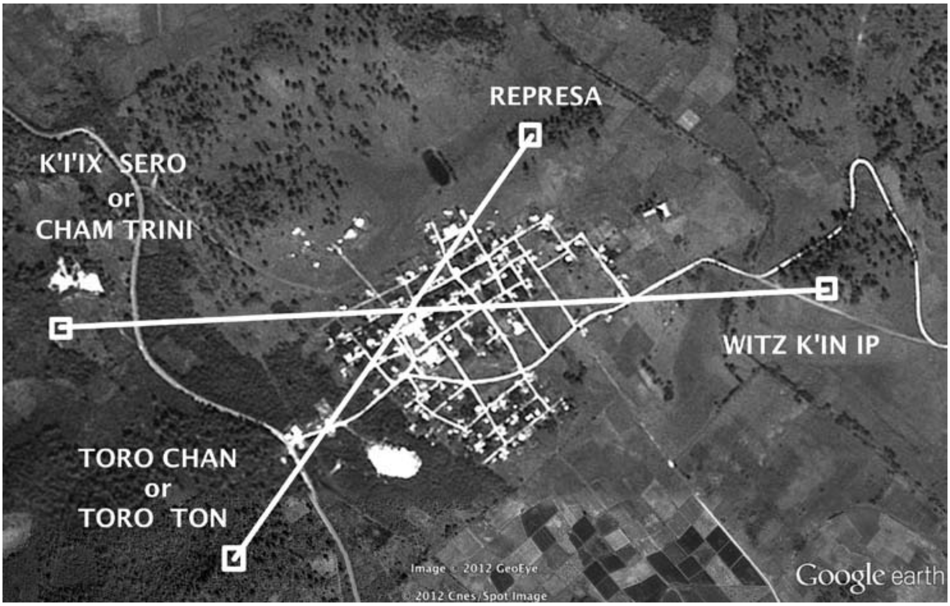

Figure 3: Natural and constructed features of the landscape of Ing. Gónzalez de León, including the 4 sacred mountains surrounding the village (labeled). Connecting lines indicate the alignment of Toro Chan mountain with Represa mountain at 34 degrees, one of the extremes of the Milky Way, & the alignment of K'i'ix Sero mountain with Witz K'in Ip mountain at 87 degrees, the ecliptic. These 2 cosmic serpents, the Milky Way snake and the ecliptic snake, cross near the church at the center of the village to form the world tree.

Milky Way and Ecliptic

An alignment between Toro Ton/Toro Chan, mountain and Represa mountain (Figure 3) associates both with the cave-dwelling serpent, which is itself associated with the Milky Way. The alignment between the peaks of these two is 34 degrees, one of the extremes of the Milky Way. Second, the peaks of the other two mountains, K'i'ix Sero and Witz K'in Ip, align along 87 degrees, which identifies the Ecliptic, the double-headed snake of representations of the sky in Maya iconography. These alignments between the two mountain pairs intersect at or near the site of the community church. That location is also recognized by some as the umbilicus (*muxuk*), or center point of the community, or even the world. When the Milky Way serpent exits the Toro Ton/Toro Chan mountain cave and travels toward the Represa mountain, it intersects the Ecliptic in the sky; the intersection of Milky Way and Ecliptic creates the Axis Mundi, the World Tree (Friedel et al. 1993: 53ff). (Alignments were measured on Google Earth images, where peaks could be identified; precise locations of the mouths of caves in the mountains are unknown.)

Older and some younger residents of González de León recognize that two of their four mountains point out the Milky Way, and that when the Milky Way crosses the Ecliptic, it is crossing a feature that is identifiable by the alignment of the other two local mountains, K'i'ix Sero and Witz K'in Ip, so the intersection of the two alignments form the Axis Mundi, the World Tree. The point of the earthly intersection of the two alignments also identifies the Zenith-Nadir dimension (the fifth 'cardinal direction,' with the four, North, South, East, and West). The Zenith-Nadir is the dimension through which the Sky, the Earth, and the Underworld communicate, and commonly considered points of passage for it are caves and the centers of communities, such as the Toro Chan cave and the church location in Gónzalez de León.

Two Kinds of Double-headed Snakes

In both Ing. Gónzalez de León and in the neighboring community of Buenavista Bahuitz, residents associate both the Milky Way and the Ecliptic with a 'double-headed' snake, but only the Ecliptic snake has the familiar form of a head at both ends of its body. The double-headed snake of the Milky Way (the Toro Chan snake) is said to have only one head that holds in its open mouth another head. Such a holding of one head within the other is also seen in some representations of the Ecliptic Serpent, as on the Tikal pot that shows the Maize God (as the trunk, with leafy arms) at the time of Creation holding the ecliptic snake in his arms, from which the Stingray Paddler emerges from one mouth and the Jaguar Paddler from the other (Friedel et al. 1993: 79).

This head-within-head representation in the iconography of the Ancient Maya has parallels in traditional stories told by Tojolab'als. One such story (from Manuel Aguilar Gómez, in field notes of N.L. Furbee, 1971) tells about recruitment of a curer/shaman, who once he has accepted the powerful role, swallows a snake. That snake will remain with him as a companion. Occasionally, the snake can be seen as it emerges a bit from the curer's mouth when the man sleeps and his mouth opens, thus identifying him as a curer.

Cosmic Actors on the Ground

Readily recognized are the sky and underworld cosmic actors; less well understood is the role of these and other figures in the local landscape of Tojolab'als. In fact, Tojolab'al persons daily interact with these important cosmic figures—the Toro Chan serpent in his cave, for example, which they avoid passing when it is dark because the Earth Lord, Sombrerón, also lives there. Sombrerón controls animal reproduction and is involved in the human witchcraft of selling souls. Residents pass by the K'i'ix Sero carefully to avoid the Pajk'intaj-Llorona there who can confuse or kill travelers. An alternative name for the mountain is Cham Trini 'Trini Died', which commemorates the death of one such victim.

Once, driving from Comitán to San Cristobal de Las Casas with a young Tojolab'al woman, I came around a tight turn on the part of the highway that mounts the escarpment outside of Teopisca. Around the bend, we came upon a young man whose motorcycle had slipped out beneath him on a steep blind curve. I was afraid I would hit him, he a young hippie sort with long hair who was just picking himself off the pavement. My companion exclaimed, 'Oh, how horrible! A Pajk'intaj! Be careful!' And I drove on around him; only a few miles on did I begin to feel guilty indeed not to have stopped to help the motorcyclist. But. the Pajk'intaj was a threat for my companion, and I drove on. I have since held guilty hope that the cyclist escaped without being hit by traffic.

Likewise, the Toro Chan, a local version of the Milky Way Serpent, dwells among residents of Ing. González de León. And the numerous *chawuk*, human and divine, also exist in a reality not of my own comprehension. In short, the landscape of Ing. González de León, much like any Tojolab'al community, is peopled with cosmic actors, some of whom had a role in the Creation of the world and its peopling by us, the present creation, and some of whom are of more recent origin. But they are all real, living beings from a different level of the cosmos and not of ourselves. They are nonetheless entities with whom one can interact daily.

Water and the Axis Mundi

The World Tree or Axis Mundi presents a series of visual metaphors. These express the critical acts and actors in the inception and maintenance of the present creation of Mayan persons. Among them are the maize plant, the ceiba tree, and the crocodile, which are expressed in representations of the Trunk of the World Tree. All speak primarily to reproduction and the nurturing of life. The maize plant provides the food that gave force to the flesh of this creation of humans (Recinos et al. 1950; Ruz and Schuman in Ruz 1981: 15-17) and continues to sustain them. Today, Tojolab'als speak of themselves as the People of Maize and as having flesh composed of maize. They do so in an uncontrived manner, just as an ordinary mestizo Mexican might speak of himself or herself with pride as a vigorous hybrid of European and indigenous stock, or those from the United States might claim to be genetic grand mixtures from the national 'melting pot'. In the World Tree, when the maize plant assumes the central position as the tree trunk, its leafy fronds spread out to hold aloft the double-headed sky serpent, the Ecliptic, the one with a head at each end, making the crossbar of the tree.

On the other hand, the ceiba tree is often said to be where souls rest (according to Schele as the white flowers of the tree (Schele in Friedel et al. 1993: 396)) before being reborn. The ceiba tree trunk has a form that mimics the swelling of a pregnancy, and it has points or protrusions along the trunk that look like breasts. Myths speak of these as feeding others.

The swellings or points along the trunk appear in the Tojolab'al ceramics as a point-motif in the sacred context of the whitewashed flower vases and incense burners. They are seen also in Tojolab'al embroidery, especially on the shirts and blouses, designs for which are unique to each village (Figure 4). These points are called *sni'* 'its point', which term also refers to 'one's nose.' The *ni'* root appears also in the word for 'flower', 'son-in-law', 'mother-in-law', and a host of other nouns.

Figure 4: The point (sni') motif features prominently in Tojolab'al embroidery, here shown on cuffs from 2 men's shirts, one from the Tojolab'al community of Yashá (right) & the other from the community of Saltillo (left).

Although Aguilar Gómez told the snake story about a curer, ingestion of a supernatural snake is likely a part of the power associated with human <u>*rayos*</u> (or <u>*chawuk*</u>) as well. 'Rayos' or 'chawuk' can refer to lightning, thunder, the deities of these, and the humans who share their powers, serve them, and manipulate them. As Bayles points out, "*Rayos* ('lightning') are human beings who can transform into lightning, and are considered very powerful guardians of a community" (Bayles 2001: 182). They fight threats from the sky. A chawuk as a lightning strike may be 'hot' (also called 'red,' or 'dry'), in which case where it falls it will burn the plants and earth and thereafter the soil so scorched will not be productive. On the other hand, some chawuk are 'fresh' (literally the color 'pale green/blue'), and where these bolts strike future new growth will be lush.

Each of the four mountains has a function pertaining to water and cosmology. As mentioned, within village boundaries are expressions of cosmic grand-actors: The two double-headed snakes, the <u>Milky Way Serpent</u> forms the World Tree when it crosses the <u>Ecliptic Serpent</u>. Both the cave and the mountain in which the Milky Way Serpent resides is named Toro Chan (Bull Serpent).

As the connection of sky, earth, and underworld, the World Tree offers the path of communication between deities and both living humans and dead ones, between sky world, earth world, and underworld. It stands as the link among them all. The Axis Mundi is the route by which deity forces convey both benefit and castigation. The Axis Mundi passes through points on the surface of the earth that are the *muxuk*—the centers of socially defined Mayan worlds. These places are most often a central place in the community, a mountain peak, or a cave. A body of water can also serve as a muxuk, which makes clear the primary nature of mountain and cave to the life-producing water at the surface. Some mountains are water containers; below them run rivers and streams. Many hold pools or reservoirs. Their sides seep, and their forests draw mist and condense it to rain. The caves are important avenues to some of these underground reserves, and all of them house fog and mist that under changing weather conditions pour from their mouths, condense, and precipitate to the ground as rain, or sometimes create cascading falls of 'mist' that drop into the valleys. Among the essential fluids that constitute all living things, e.g. blood and sap, water is the fundament, and it drives the reproduction of all life.

Conclusions

In this paper I have argued points pertaining to both method and substance. The methodological issue is an appeal for seeking conversion of information from a variety of sources (as a means of testing and for verification) and according to more than one framework. Whether called cultural astronomy or archaeoastronomy or some other name, the intellectual enterprise of seeking knowledge of how people in the past interpreted the physical expression of the cosmos does not present an agreed-upon scientific model, much less theory, that can be applied in the absence of coherence to findings from other disciplines. It is not cultural or social anthropology, nor is it astronomy, nor is it archaeology. It is too nascent to have a coherent theory of itself. It *can*, however, offer a replicable set of methods drawn from each of these disciplines, and likely from others, to enlighten the student.

Cultural understandings of ancient cosmologies can be discerned using several respectable models for cultural and ethnohistorical study. Observations from astronomy may likewise be used to supply and test hypotheses about the use of natural and constructed landscapes and other features for making sense of an ancient world. And the methods and theories of archaeology can also enlighten the investigator about cosmological features. All of these can be used to supply hypotheses. None of them, however, is sufficient unto itself at this point. For that reason, the most satisfactory result is likely to be found when several approaches address the same question (for example, the meaning of mountain or cave alignments to a particular ancient people) and give convergent answers. There are some universals to be relied upon, but many seeming universals may not hold; for example, in the case of the cave, it seems obvious that it is a portal to an underworld, especially when the underworld is one such as the Mayans', where it is rich in cosmic actors and associations with earthly activities—animal husbandry, reincarnations and replacement of human, animal, and vegetative populations, threats to individuals through witchcraft, and so on. But at the other end of Mexico with the Tarahumara and in many other places, we find caves used for domestic residences, caves that have little role in a grand cosmology that might be related to the stars and constellations.

Rituals and ordinary practice do conserve aspects of ancient cosmologies, refitting them to changing cosmologies but sometimes leaving intact sufficient information to permit reconstruction from within a coherent system. Sometimes even the pathways of change may be recovered, as in Eva Hunt's brilliant analysis of a mid-20th century Zinacantec Tzotzil poem, 'The Hummingbird' (Hunt 1977). Her analysis presents an application of many of the precepts of the linguistic Method of Internal Reconstruction to a literary form and reaches deep into prehistory for explication of the metaphors and referents. In that way, one may approach earlier systems in search of how they have been repeatedly altered to find how meanings have shifted. These will have been flexible enough to accommodate innovation, but sufficiently conservative to express both new and old ideas within persistent frameworks, thus supporting the value of present-day ethnography and ethnohistory as interpretive resources for study of prehistory.

In terms of substance, I have argued for specific interpretive distinctions among representations of the trunks of the World Tree as a maize plant, a ceiba tree trunk, and a crocodile: The maize plant refers to the Creation of our present world, the ceiba tree trunk refers to the nurturing of our human, animal, and vegetative reproduction, and the crocodile refers to watery and celestial forces that control and protect us. The world tree holds all three perspectives, as well as others. I specifically distinguish two kinds of snakes, both double-headed, in that both may hold another deity-human within itself and be represented as giving birth to it, or in the contemporary folk story, transfer its significance to a supernatural snake figure swallowed by a curer as confirmation of his taking on the curer's role.

Finally, I opened with a quotation from one of the last papers presented by Evon Z. Vogt, a man who spent most of his career thinking about Highland Mayans and their connections to their environments and to their past cosmologies. He was particularly concerned with the symbolic importance of mountains within Mayan cosmology. In the concluding sentence quoted above, he identified the connection between sky and earth as being the mountain top and asserted that it was the most critical landscape feature; that summit is the place where humans hold rituals to petition deities for the fruitful reproduction of the world and its social order.

This paper has argued for an extension of that assertion to include the cave as a parallel muxuk, but one dedicated to communication between this earth and the underworld. Such a cave is often in a mountainside, and so in a sense, mountains in the whole may be considered the primary umbilical connections, not just their summits, and not just their cave mouths. However, given the role of central places as muxuk in settlements, I believe information is inadequate to make such a strong claim. Instead, I think the cave might be thought of only as a path to communicate with the underworld. Certainly there are reasons to think so given the evidence from Ing. González de León: Souls can be sold to the Earth Lord Sombrerón at the cave mouth in Toro Chan/Toro Ton; one can also petition the same Sombrerón for good fortune in animal husbandry at that cave entrance; and at another edge of the community, one can encounter the Llorona-Pak'intaj figure, who lives on K'i'ix Sero and threatens the person passing by. That passerby may lose his way and be inconvenienced, or he may be taken by the Pak'intaj and die. We must bear in mind the fact that an alternative name for the K'i'ix Sero mountain is Cham Trini ('Trini Died').

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The Length of the Year in Maya Calendar and Astronomy

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Abstract

From ancient Mesoamerica we know two different calendar counts: the 260-day *tzolk'in* cycle and the 365-day solar year. Like all other Mesoamerican 365-day calendars, the Maya solar year, known as the *haab'*, consisted of 18 months of 20 days each plus a 5-day period possibly representing the adjustment of the vigesimal system to the 365-day year. Though most scholars consider the Maya did not employ a leap-year correction to avoid any slip out of the seasonal cycle, some of them suggested they were able to compute the length of the tropical year in their astronomical calculations. Careful analysis of Teeple's *Maya Astronomy* shows that without any strong supporting evidence he speculated on the idea of precise computations of a tropical year made in Copán. The paper revises arguments in light of present understanding of the Mayan writing.

KEYWORDS: Maya astronomy, tropical year, 365-day year, Metonic cycle

POVZETEK

Stara Mezoamerika pozna dva tipa koledarskih štetij: 260-dnevni cikel *tzolk'in* in 365-dnevno Sončevo leto. Tako kot pri ostalih mezoameriških 365-dnevnih koledarjih je bilo tudi pri Majih Sončevo leto, imenovano *haab'*, sestavljeno iz 18 mesecev po 20 dni in dodatnih 5 dni, ki morda predstavljajo prilagoditev dvajsetiškega sistema na 365-dnevno leto. Čeprav večina znanstvenikov meni, da Maji niso uporabljali korekcij prestopnega leta, da bi tako ohranjali skladnost z letnimi časi, pa so nekateri mnenja, da so bili s pomočjo astronomskih dognanj sposobni izračunati dolžino tropskega leta. Podrobna analiza Teeplove knjige *Astronomija Majev* (v izvirniku: *Maya Astronomy*) kaže, da je, sicer brez trdnih dokazov, domneval, da so v Copánu natančno izračunali dolžino tropskega leta. Članek obravnava njegove in druge argumente v luči sedanjega razumevanja majevske pisave.

KLJUČNE BESEDE: astronomija Majev, tropsko leto, 365-dnevno leto, Metonski ciklus

Introduction

One of the most characteristic traits of the Mesoamerican culture area has been the widespread use of two different 'calendars': the 260-day *tzolk'in* that formed a structure for diverse ritual and divinatory activities and the 365-day *haab'* that operated in daily life. *Tzolk'in* based on a permutation of 13 numbers with 20 day names. The 365-day cycle consisted of 18 periods of 20 days each, with 5 extra days added at its end.

The Mesoamerican counting system was vigesimal. The passage of time was counted from the arbitrary or mythological base point fixed on the month of August of 3114 BC and recorded in form of a positional notation, called the Long Count. The Long Count brought together the number of days elapsed from the zero-date in form of powers of 20 units. This system was modified in the third position which denoted the unit of 360 days instead of that of 400 days and consisted in the reckoning of 18 periods of 20 days each. So, in the Classic Maya Long Count 'quasi-vigesimal' system we had the basic periods of 1 20, 360, 7200, and 144 000 days, respectively termed as *k'in*, *winik*, *haab'*, *winakhaab',* and *pik* (see Table 1). At the time of the Conquest words were still known for *k'in*, *winal*, *tuun*, and *k'atun* (all terms derived from the Yukatekan Maya).

Table 1: Names for basic calendar periods. The term 'b'ak'tun' ('four hundred precious stones' or 400 x 360 days) was invented by modern epigraphers and is not placed in the table. For further details consult Kettunen and Helmke (2011: 47-49).

Intervals	Classic Period	Meaning	Colonial Yukatekan	Meaning
1 day	K'in	Day, sun	K'in	Day, sun, feast-day
20 days	Winal	Twenty	Uinal	Twenty
360 days	Haab'	Time of rainfalls, year of 360 days	Tuun	Precious stone (360 days)
7,200 days	Winikhaab'	20 years (of 360 days)	K'atun	The binding/wrapping of precious stones, 7200 days
144,000 days	Pik	Four hundred		

Long (1924:575-580) first observed that in Colonial Yucatan the 360-day cycle had been designated by two different Mayan terms – *haab'* and *tuun*. The *haab'* in the Long Count consists of 360 days, but referring to the solar year it has 365 days. These two cycles should not be confused with each other (see Table 2).

Table 2: Differences between the periods of haab' and tuun.

Classic Period (AD 200 – AD 1000)	Length	Function
haab'	365 days	solar vague (wandering) year
haab'	360 days	the Long Count time unit
Colonial Period (ca. 1542 – 1821)		
tuun	360 days	the Short Count time unit, K'atunic Wheel

The Maya 365-day *haab'* is the nearest whole number of days to the tropical year (365.2422 days). Their uncorrected 365-day year continuously drifted in relation to the tropical year at a rate of less than one day in four years. There is no evidence that the ancient Maya added or subtracted days from their 365-day *haab'* year before the adoption of the Julian calendar in the 16th century AD. In spite of this, scholars have long suggested that the Maya developed some type of tropical year calculations, or at least were aware of the accumulated difference between their *haab'* and the tropical year (see discussion in Bricker and Bricker 2011). Studies of the Maya astronomy led Teeple (1931: 70-85) to propose his 'theory of determinants' to demonstrate that in the 7th century AD Maya priest-astronomers calculated the length of the tropical year to 365.2420 days (consult Table 3). This statement had a profound impact both within the scientific community and the wider audience. Teeple suggested that the ancient Maya developed an extraordinary high level of astronomical knowledge, yet their *haab'* appeared to systematically drift in relation to the tropical year. This lack of consistency forced scholars to believe in a certain type of corrections of the length of the tropical year or 'rules of thumb', but because they were unable to find any convincing pre-Hispanic evidence, they started to use the information given by Spanish chroniclers. However, these data were often used quite arbitrarily to fit preconceived ideas or simply reflected the wishful thinking of their authors (Prem 2008).

The progress in deciphering the Maya hieroglyphic texts contradicts many of the earlier conjectures concerning Maya astronomy and calendar-making (Coe 1994: 126-127; Stuart 2011). The year that celebrates the end of the 13th *b'ak'tun* is a good occasion to revise the means by which the Maya were able to determine the length of the tropical year and the methods and premises used by modern scholars to reconstruct them.

Table 3: Teeple's Maya year compared. Teeple established that the Maya determined the length of the tropical year between 9.15.0.0.0 and 9.18.0.0.0 [AD 731 – 791] at Copán. Data after Teeple 1931: 74.

Feature	Length (days)
Present tropical year	365.2422
Tropical year at AD 600	365.2423
Julian (calendar) year	365.25
Gregorian (calendar) year	365.2425
Maya year	365.2420

The length of the solar tropical year

There is no fixed value of the length of the tropical year. It both depends on the choice of the point of the year from which measurements are taken and on the precession. Following Hipparchus the tropical year was defined as the time interval between two successive passages of the Sun through the vernal equinox, but now it is equivalent to the time interval needed for the mean longitude of the Sun to increase by 360° (Meuss and Savoie 1992: 40). The present definition allows for the calculation of the length of the tropical year from any other arbitrarily chosen point (equinoxes, solstices, zenith passages, etc.), and there is no reason to assume that all cultural groups should have shared the idea of computing the tropical year from the spring equinox.

Due to the precession of the Earth's axis, the spring equinox slowly regresses along the ecliptic; hence, the Sun does not make a complete circuit when describing its annual path along the ecliptic. Tropical longitudes are measured from the vernal equinox and this point is steadily moving. Furthermore, the equinoctial and solstitial points depend on the position they take with respect to the perihelion of the Earth's orbit. All this affects the calculation: for example, the time interval between two successive spring equinoxes (365.242374 days) is today longer than the average length of the solar tropical year (365.24219 days). Thus, the length of the seasonal year evidently depends on the starting point adopted for the 'year' (Meeus and Savoie 1992: 42). The determination of the length of the tropical year is further complicated by its constant change (see Table 4). To conclude, the length of the tropical year can be measured from any arbitrary solar events.

Table 4: The length of the tropical year for selected years. The values for the length are computed from the VSOP 87 theory-based formula given by Meeus and Savoie (1992: 42).

Year	Length
500 BC	365.2423389
AD 1	365.2423103
AD 500	365.2422809
AD 700	365.2422689
AD 800	365.2422629
AD 1000	365.2422508
AD 1500	365.2422203
AD 2000	365.2421896

The *haab'* – its meaning and length

Though the 365-day cycle is believed to be younger than the 260-day count, the evidence clearly shows that it has been deeply rooted in Mesoamerican history.

The term *haab'* registered among the Yukatekan-speaking Maya, appears to be derived from the word *ha'*, 'water', and a suffix *–ab'* also denoting 'water'. Therefore the word *haab'* can be translated as 'much water' and 'rainy season' (Brown 1987, Kettunen and Helmke 2011: 109-110; Lounsbury 1978: 765; Rice 2007: 64; Stuart 2011: 108). The arrival of the rainy season was probably considered as one of the major events in the daily life of horticultural and agricultural societies and following Nilsson (1920) it may be argued that the (arrival of the) rainy season could have easily been used as a timing device shared by the wider population. Over time, through expansion of reference the term 'rain' initially referring to the specific point in time - started to represent the unit of time called 'year' (Brown 1987: 365,370-372, 376-379). This counting of time was irregular and discontinuous (see also Elias 1992: 75-77; Hallpike 1979: 348-349; Lucas 2005:71-79) and unrelated to celestial phenomena.

Since most environmental events contain a strong seasonal aspect, they may often be tied to specific parts of the year. In Mesoamerica the most frequently recorded dates embodied in architectural alignments may best be explained by their link with various seasonal climatic-meteorological changes (the wet and dry season) and important moments of maize cultivation stages (Iwaniszewski 1991; Broda 1993; Šprajc 2001: 79-88). In other words, calendars based on the observations of the Sun's movement along the horizon had many pragmatic uses, related to agricultural and ritual activities in the annual cycles. They were not specifically introduced to establish the dates of astronomical events with a high level of accuracy.

In light of the above, it may be speculated that the Mesoamericans first counted years from one wet season to the next, later they used the solar astronomical phenomena such as the equinoxes, solstices or zenith passages for dating specific events, and finally incorporated the observations of seasonal changes into mathematical systems of time-reckoning such as has been their Long Count. With this last invention all practical engagements with the environment were abandoned and substituted for a more universal system.

The ancient Mesoamericans merged the cycles of 260 days and 365 days in a superior cycle known as the 'Calendar Round', or a 52-year cycle. Since 52 x 365 days match 73 x 260 days, it takes a total of 18,980 days for a given date to repeat (the least common multiple); it is based on arithmetical rules, not astronomical events and its structure does not permit the introduction of a 365.25 day long years (Thompson 1978: 121; Prem 2008: 92). The synchronization of the *tzolk'in* cycle with the *haab'* seems to be far more important for ancient calendar-keepers than their astronomical accuracy. This cycle was adopted in all Mesoamerica and constituted the basis for calendar forecasting. The Long Count 'zero-point' day coincided with the combination of the Calendar Round date of 4 *Ajaw* 8 *Kumk'u*.

Solstices, equinoxes, zenithal passages of the Sun and solar horizon calendars

Now, if – for consistency – the *haab'* were as was described in 16th century Yucatan, starting with the seating of *Pop* day on the 16th of July in 1553-1554, then it is easy to infer where the *haab'* was when 0 *Pop* fell near the winter solstice (in Julian calendar). Drawing on an earlier study by Graulich (1981) of the systematic seasonal drift of the Aztec solar year, Victoria R. Bricker (1982) found that the best match might be obtained when the first day of the *haab'* coincided with the winter solstice around 550 BC. Bricker first assumed that month names may be compared with particular seasonal features and supposed that the best association with the seasonal changes was achieved when the *haab'* started with the winter solstice. Then, assuming that the *haab'* wandered with absolute regularity, she extrapolated backwards to find that such a coincidence first occurred around AD 950-960 and moving a further 1,507 years backwards, she arrived at around 550 BC when 0 *pop* again fell on the winter solstice (Bricker 1982: 103). This method suggested that the *haab'* was first used by the Maya around 550 BC, during the Middle Preclassic period. In her paper Bricker utilized the well-known relationship between a 365-day and a 365.2422-day tropical year:

$$1{,}508 \times 365 = 1{,}507 \times 365.2422 = 550{,}420 \text{ days}$$

Aveni (2001: 245-250; Aveni, Down and Vining 2003: 162) and Šprajc (2010) have shown that most of the astronomical alignments embodied in the Late Preclassic and Early Classic monumental architecture focused on the horizon positions of the Sun at solstices. Though solstitial alignments may reflect the Mesoamerican concept of the four corners and bearers of the sky (Milbrath 1999, Šprajc 2010), the solstices can also be taken as the most elementary references for orientation in time.

However, observing the day-to-day movement of the Sun at or near the solstice is difficult: the Sun is essentially not moving, especially when it is observed within the Tropics (Aveni 1981). Since it is impossible to decide which of the subsequent positions of the Sun denotes the exact solstice day, the best way to exactly determine its position for that day is to observe the Sun before the solstice (Zeilik 1987: 26). Nevertheless, undisputed examples of anticipatory pre-solstice alignments in the Maya region have not been found so far.

Among the earliest orientations in Mesoamerica are the alignments towards the so-called quarter-days of the year or mid-points in time between two solstice extremes, indicating the dates of March 23 and September 21. There is no evidence that true equinoxes were known in Preclassic Maya Lowlands (Šprajc 2010). Hence, the quarter-day orientations may be taken as an indirect evidence for the fixing of the solstices. Modern Maya communities also lack the terms to refer to the equinox and seem not to be aware of the equinox positions of the Sun on the horizon (Vogt 1997: 111). Thus, the Maya year was most probably not based on the time interval between two equinoxes.

Now, during the Late Classic and Terminal Classic periods the old system of orienting to solstice points had been supplemented with a scheme based on a zenith-passage/

winal calendar. The study of Aveni et al. (2003) regarding the alignments of a greater number of Group E assemblages has shown that in many instances the targeted positions of the sunrise marked specific 20-day intervals (or their multiples) in relation to the zenith passage of the Sun. Zenith passages of the Sun are still important among the Maya (Vogt 1997: 111). Though 'zenith-observing tubes' have not been found within the Maya region yet, references made to the solar zenith passages have long been discussed by various scholars. So, it appears that Late Classic and Early Postclassic Maya priest-astronomers were interested in establishing architectural relationships between the dates of the zenith passages of the Sun and tropical year stations (Bricker and Bricker 2011: 685). Nevertheless, due to the quick solar displacement, zenith passages may only provide a very approximate length of the solar year, at least of 365 ± 1 day (Aveni 2009: 72-73).

Finally, the length of the solar year can also be computed from horizon calendars. The treatment of the observational data by Šprajc (2001: 294-313) offers important insights into understanding how they could have been corrected in the past. From observations of the sunrise over the Mount Tlaloc taken at the Tenayuca pyramid, Šprajc reconstructed the declinations of the Sun for a period of 4 years by the end of the 12th century. In this way he proved that the annual variations produced interval patterns of 365, 365, 365 and 366 days; the total of 1,461 days could have allowed the ancient skywatchers to discover shifts of their 365-day calendar. Solar calendar dates based on the observations of the rising or setting Sun from the same location and in association with the same natural or artificial marker may provide a means to arrive at the length of the solar year of 365.25 days. However, any attempt to compute the length of the solar year of a specific year would yield 365 days with an error of at least ± 1 day.

Last but not least, it is observed that the dates produced by horizon calendars are scattered throughout the year indicating they were important for local observations and specific calendar computations rather than emphasizing collectively shared astronomical phenomena. Hence, the reference points through which two successive passages of the Sun might have been observed can vary from site to site. There is no reason to assume that the establishment of the *haab'* was originally determined by a specific astronomical event. Also the implication seems to be misleading that the *haab'* was based purely on astronomy.

Teeple and Stela A from Copán

The Spanish conquest of Mesoamerica produced a profound break in the astronomical tradition of Mesoamerican elites since their knowledge of the sky was abruptly removed and replaced by the science of European origin. In his brilliant monograph *Maya Astronomy* Teeple (1931) demonstrated that, using the current astronomical knowledge, it was still possible to reconstruct the methods used by Maya skywatchers. Teeple identified the function of the Lunar Series and reconstructed the methods of lunar computations; he also discovered the ways in which the Maya calculated the length of the tropical year; and demonstrated how they utilized the Eclipse and Venus Tables in the Dresden Codex. In short, Teeple showed how the Maya skywatchers could have reached the high level of naked-eye observations of the night sky and how they predicted various astronomical events with great precision.

In his study of the tropical year in Copán Teeple utilized the dates placed on Stela A. The discovery of the interval of 6,940 days in Copán motivated Teeple to look for the record of the tropical year in Copán. He noticed that the second date on this monument (9.14.19.5.0) corresponded to the Metonic cycle counted forward from 9.14.0.0.0. Knowing that the Metonic cycle associates 235 synodic months with the cycle of 19 tropical years, he then proposed that the Maya skywatchers in Copán already knew how to calculate the length of the tropical year. Since the first date of the monument, 9.14.19.8.0 12 *Ajaw* 18 *Kumk'u* was placed 200 days before the period-ending date of 9.15.0.0.0 4 *Ajaw* 13 *Yax* (third date), Teeple deduced that this was exactly the difference in the regular backward shift of the *haa*b' year in relation to the length of the tropical year (365.2422 days) as observed from the zero-date on 13.0.0.0.0, 4 *Ajaw* 8 *Kumk'u*. The third date, 9.15.0.0.0, is 1,404,000 days after the zero-point and equal to 3,844 tropical years plus 9 days or to 3,846 *haab'* periods plus 210 days. It means that the *haab'* dates moved backward two full years (of 365 days each) to return to the same tropical date 4 *Ajaw* 8 *Kumk'u* (2 x 365 = 730 days) and at 9.15.0.0.0 they moved 201 days more (Teeple calculates 200 days). I suspect that Teeple arrived at this conclusion using the value of 365.2420 days which he presumably inferred from posterior computations: 1,404,000 days are equal to 3,844 Copán tropical years plus 9.75 days. If correct, this would explain why Teeple calculates only 200 days, the backward drift amounting to 930 (2 x 365 + 200) days.

According to Teeple Maya skywatchers constructed a system of 'determinants' by which they recorded the accumulated error between the *haab'* and the tropical year since the start of the Long Count 'zero-date'. The methods in which determinants were computed were never clearly defined, though Thompson (1978: 317-320) thought this was calculated on Calendar Round anniversaries of 4 *Ajaw* 8 *Kumk'u*. Recent epigraphic research proved that these supposed 'determinant' dates in fact recorded historical events. Today's scholars still believe that the Maya had an extremely precise knowledge of the length of the tropical year, despite the fact that a substantial part of Teeple's study concerning the calculation of the tropical year depends on his theory of determinants that has long been discarded and abandoned (Satterthwaite 1947: 135-142; Aveni 1980: 170-173; 2001: 164-166).

Teeple arrived at the value of the length of the tropical year by assuming the ancient Maya knew the Metonic cycle, but one might be inclined to question what the ancient Maya knew about this cycle. Sylvanus G. Morley (1920: 221-223) first noticed that the date occurs 260 days before the end of *k'atun* possibly indicating the start of activities related to the *k'atun*-ending ceremonies in the same way as the beginning of 5 *wayeb* days was used to start the rituals indicating the end of the *haab'*. Herbert J. Spinden (1924: 143) proposed that the Maya invented the rule of thumb 'one *k'atun* less a t*zolk'in* equals 19 tropical years'. Dividing 6940 days by 19 years gives the value of 365.2631579 days without the need of using the moon (Chambers 1965: 351; Berlin 1986: 53).

Today we know that this monument, erected in the reign of Waxaklaju'n U B'aah K'awiil (the 13th Copán ruler who reigned in AD 695-738), was commissioned to commemorate the period-ending on 9.15.0.0.0 4 *Ajaw* 13 *Yax* (AD 730). The text states that the monument was erected on 9.14.19.8.0 12 *Ajaw* 18 *Kumk'u* (the first date), mentions a ceremony to honor K‘ahk‘ U Ti‘ Chan Yopaat, the 11th Copán ruler, on 9.14.19.5.0 (second date), the period-ending event on 9.15.0.0.0 (third date) and the final dedication rite on 9.15.0.3.0 (fourth date, see Biro y Reents-Budet 2010: 65-86; Helen 1988). It should be remarked that Helen (1988) associated the 260-day interval with the positions of Venus. However, the celebration of the *k'atun* ending seems to be more important here. The second date placed on Stela A bears the Calendar Round date 12 *Ajaw* 18 *Kumk'u* and the *k'atun*-ending displays the day of 4 *Ajaw* revealing a striking similarity with the 'zero-date' 4 *Ajaw* 8 *K'umku*.

Given the evidence, it is probable that the Maya never discovered the Metonic cycle (Iwaniszewski 2012). The problem is to find a common multiple of the lunar and solar cycles: the *haab'*-based calendar does not follow the lunar cycle. Eclipse Tables of the Dresden Codex commensurate the lunar cycle and a 260-day *tzolk'in*. Since the Metonic cycle represents an astronomically defined cycle, it is not divisible by 260 days, and therefore less useful for the Maya who were interested in finding commensurations in relation to *tzolk'in*. Hence, Teeple's arguments based on his choice of the dates recorded on Stela A are much weakened.

Dates recorded on Maya monuments combined with alignments

Another further way to approach this problem is to combine architectural alignments with the dates placed on monuments.

The best known example is the alignment from Stela 12 to Stela 10 at Copán. In 1920 Morley (1920: 133-134) showed that the Sun sets on April 12 and September 1 as viewed from Stela 12 to Stela 10. He noticed that the event in April could have heralded the start of the rainy season when the agricultural slash-and-burn system required fields to be burnt to clear them for planting. The monuments were erected during the reign of K'ahk' Uti' Witz' K'awil, the 12th ruler of Copán. This ruler inaugurated at least seven monuments around the Period Ending 9.11.0.0.0 (AD 652) positioning them at important locations across the Copán valley and in Santa Rita. Mayanists have alternatively interpreted them as territorial, landscape, calendar or astronomical markers (Fash 1991: 101).

Aveni (1980: 240-245; 2001: 252-258) concluded that the dates derived from the alignment occurred in the middle of the period between the equinoxes and solar zenith passages establishing four intervals of nearly 20 days each: [22.03] vernal equinox + 21 days = 12.04 + 19 days = 1st zenith passage [1.05] and 2nd zenith passage [13.08] + 19 days = 1.09 + 21 days = autumnal equinox [22.09]. Simply calculations indicate that in AD 651 zenith passages occurred on May 1 and August 14, and while a year later on April 30 and August 13. In AD 652 the dates of equinoxes also drifted backwards (Meeus 1995: 117). Thus the stelae might have been positioned according to AD 651 observations and inaugurated in the year in which all alignments 'moved backwards' for 1 day. This example proves there has been no fixed consistency between the dates indicated by the alignments, the equinoxes and zenith passages. The length and accuracy of inferred *winal* periods is 20 ± 2 days.

In 1989 Carolyn Tate noticed that several Yaxchilan buildings were aligned upon the solstices and proposed that Maya rulers selected the summer solstice to celebrate rituals and solar year anniversaries. The rituals listed in the inscriptions record the dates that often fall on the month of *Yaxk'in* and occur some days before or after the summer solstice (Tate 1989: 420, table 32.2). However, the dates recorded between AD 722 and 768 are centered on the *haab'* date 19 *Yaxk'in* and do not match any summer solstice date (compare Tate 1992: 95 Table 4 and 1992: 239 with the commentary of Bricker and Bricker 2011: 686-689). This, combined with the lack of strict solstitial alignments (Iwaniszewski and Galindo 2006) at Yaxchilan substantially weakens earlier arguments by Tate. I concur with the argument put forward by Bricker and Bricker (2011: 689) that the Maya would have recorded the summer solstice with much greater precision. Perhaps, as is suggested by Bricker and Bricker (*ibid.*), the goal was to register the changes in time intervals between the end of *Yaxk'in* and the day of the summer solstice.

At Uaxactun, the well-known Group E astronomical alignments (Aveni and Hartung 1989) combine the spatial relationships between the radial steep-sided pyramid E-7 located on the west side of a large plaza with a long terraced platform E-16 and three small temples called E-1, E-2, and E-3 located on the eastern edge of the whole complex and with the positions of the rising Sun at the solstices and equinoxes. Though none of the sightlines functioned as a precise solstice or equinox observatory, they nevertheless approximated the alignment at least before the Classic Period (before AD 250). During the Early Classic period (AD 250 – 550) local rulers erected four stelae bearing the dates (8.16.0.0.0 and 9.3.0.0.0 on stelae 18, 19, and 20) that registered the smallest time interval at which a *k'atun* returns to about the same date in the tropical year period: 7 x 7,200 = 54,400 days = 137 tropical years plus 361.82 days (Spinden 1924: 275; Kelley 1989). Archaeologists who excavated Group E at Uaxactun (Ricketson and Ricketson 1937: 108) applied Spinden correlation to find almost exact coincidences between the dates recorded on monuments and the sightlines directed from E-7 towards E-2 (see Table 5). The implementation of the G-M-T correlation eliminates this. Hence, there is no correspondence between the dates placed on Uaxactun monuments and the Group E observational calendar.

Table 5: Dates and alignments at Uaxactun Group E.

Monument	Initial Series plus Calendar Round date	Spinden Correlation (JDN = 489,384)	G-M-T Correlation (JDN = 584,283)
Stelae 18 and 19	8.16.0.0.0 3 *Ajaw* 8 *Kank'in*	5.04.97	1.02.357
Stela 20	9.3.0.0.0 2 *Ajaw* 18 *Muwan*	3.04.235	28.01.495
Alignments			
From E-7 to the NW corner of E-2 (Ricketson 1928)		6.04./6.09	
From E-7 to the SW (?) corner of E-2 (Ricketson 1928)		3.03./10.10	

Discussion

On many occasions it has been confirmed that Maya monumental architecture incorporates alignments to solar positions on the horizon at certain dates (Aveni and Hartung 1986). According to Šprajc (2010), the structure of horizon calendars reconstructed from Maya archaeological sites, with its clustering around 13-day and 20-day intervals, may be interpreted as an observational equivalent to the 13-day and 20-day units of the *haab'*. This may create some confusion: the dates revealed by architectural alignments may be taken as being homologous to the calendar dates. But this is highly misleading, structural similarity observed between the horizon calendar and the *haab'* should not be confused with the identity of both calendars. The identification of certain dates inferred from horizon calendars with the days appropriate for various agricultural, political or religious activities is site-dependent and subject of considerable diversity. This makes them less useful in the study of the methods employed to compute the length of the tropical year.

It is necessary to emphasize that observational calendars using the horizon allow for *ad hoc* introduction of a leap day when the displacement of the rising or setting solar disk in relation to a specific marker is perceived. However, this does not affect the rest of the scheme. The 365-day *haab'* represents a fixed and predictable scheme designed for divination, rituals, and astronomical computations; so any insertion of leap days may easily affect its usefulness. In other words, a solar observational calendar represents a more flexible scheme, while the *haab'* itself constitutes an already fixed calendar. Thus, the start of the fixed *haab'* meant also the start of its drifting in relation to the tropical year.

Though they bear a structural similarity, they should be distinguished from each other. My statement is based on following arguments:

First, already Brown (1987: 379) suggested that the term *haab'* was probably unknown to most Classic Maya peoples since it might have been part of the secret knowledge of the elites (the earliest use of this term on Tikal Stela 31 is dated to AD 445). This would indicate that a technical term to denote 'calendar year' was created relatively late evolving from an earlier imprecise count of rainy seasons.

Second, the Zinacantecos described by Vogt (1997) still use a type of a horizon calendar to determine the days of ritual festivities, independently of printed calendars. The association of the position of the Sun on the horizon is first indicated with a particular marker; this spatial specific configuration is then transformed into a temporal referece point.

Third, observational calendars related to the positions of the Sun on the horizon or the projections of shadow-casts provide the length of the solar year of 365 ±1 days. I concur withth argument by Šprajc that after several years, the Sun returning to the same horizon marker will be seen as being displaced and that this observation may raise the possibility of computing the solar year of 365.25 days. This can be done only if the concept of indicative time is substituted with a fixed calendar consisting of regular divisions and continuous keeping of time. If the Maya really knew that the length of the year was 365.25 days, they would have easily found that their *haab'* advanced by one day in four years arriving at the well-known solution: 365 x 1,461 = 365.25 x 1460 = 533,265 days. However, this cycle does not commensurate with the *tzolk'in*.

Naturally, the length of the observational solar year should not be confounded with that of the Julian calendar which is based on a mathematical system.

Commensuration of calendric cycles with the tropical year

It is believed that the Maya were able to predict astronomical phenomena through the establishment of the long-term, calendrical, cyclical relationships between recurrent astronomical phenomena and calendar cycles (Justeson 1989: 83 Table 8.1 and 102 Table 8.6). These intervals were usually composed of *tzolk'in* or its multiples, planetary synodic periods and eclipse cycles. Less known are the commensurations of the 260-day *tzolk'in* with the length of the tropical year. Below I briefly discuss two such examples.

29 Calendar Rounds

Given the fact that one Calendar Round equals 52 x 365 = 73 x 260 = 18,980 days, it follows that

29 x 52 x 365 = 29 x 73 x 260 = 550,420 days and 1,507 x 365.2422 = 550,419.9954 days.

In other words,

1,508 x 365 = 2,117 x 260 days

This gives a value of 365.2422031 days for the length of the tropical year. Such commensurate relationships have widely been described (Bowditch 1906, Spinden 1924: 190; Carlson 1978: 208, Table 19.1; Kelley 1983: 182-183; Edmonson 1995: 146-147; Lounsbury 1978: 760; Siarkiewicz 1995: 96).

Evidence regarding this commensuration has usually been supported by the following facts:

1. The dates of birth of the Palenque Patron deities, known as the Palenque Triad. The births of these deities as recorded in the three temples of the Group of the Cross yield three following dates: 1.18.5.3.2, 1.18.5.3.6, and 1.18.5.4.0 corresponding to October-November of 2360 BC. This is 754 years after the 'zero-date'. Counted from the 'zero-date' in 3114 BC, the year of 2360 BC stays in middle of the cycle of 1508 *haab'* years. By 2360 BC the dates of the solstices and equinoxes moved already up to 182 ½ days (Bowditch 1906; 1910: 120; Thompson 1932: 402, 1936: 291; also Spinden 1924: 184; Lounsbury 1978: 807-808) in relation to the tropical year.
   The specific reasons for choosing the dates of birth are strictly related with the history of Palenque rulers. Lounsbury (1978: 804-808), Stuart (2005: 183-185) and Aldana (2007: 162-166) have shown that the dates of birth were manipulated to stay in the numerological relation with either other mythical dates, such as the birth and the accession of Ix Muwaan Mat, seating of GI, etc., or many historical events such as the birth and accession date of Palenque rulers. To treat the Long Count computations in pure astronomical terms is not only reductionist but also, incorrect.
2. The sum of the numerals contained in the fourth tier (block) of the Dres-

den Codex page 24. All numbers in question are multiples of 260 and contain 1.5.5.0 = 9,100 days = 35 x 260, 4.12.8.0 = 33,280 days = 128 x 260, 9.11.7.0 = 68,900 days = 265 x 260, and 1.5.14.4.0 = 185,120 = 712 x 260. Now, Siarkiewicz (2001) proposed the following way of counting: (185,120 + 68,900 days) x 2 + (33,280 + 9,100) = 550,420 days = 2117 x 260.

The *haab'* is under a quarter of a day shorter than the tropical year of 365.2422 days and exactly a quarter of a day shorter than the 365.25-day long year of the 'horizon calendar'. Thus, the *haab'* shifts in relation to the seasons at a different rate than in relation to a fixed horizon marker. The Maya did not use fractions, nor did they add or subtract days from the *haab'*; instead, they often utilized the 'computing year' of 364 days to find calendar dates (see below). Evidence derived from Maya codices indicates this shift was exactly one year in four days. This argument may warn us against the premature acceptation of the idea that the cycle of 29 Calendar Rounds implies the knowledge of the modern value of the tropical year.

42 tropical years = 59 *tzolk'in* cycles

42 x 365.2422 = 15,340.1724 days and 59 x 260 = 15,340 days

The discrepancy between 42 tropical years and 59 tzolk'in cycles amounts to 1-day difference after 252 tropical years (260 x 59 x 6 = 92,040 days, 252 x 365.2422 = 92,041.0344 days, Siarkiewicz 1995: 94-95) and provides the value for the tropical year of 365.2380952 days.

69 tropical years = 70 *tuun* cycles

69 x 365.2422 = 25,201.712 days and 70 x 360 = 25,200

The length of the tropical year is 365.21739 days (Spinden 1924: 144). The discrepancy of 1,712 days over 69 tropical years yields the length of the tropical year equal 365.21739 days (Spinden 1924: 144).

While the former commensuration was inferred by Siarkiewicz (1995) from non-Maya codices, the latter one has not been found in Maya records yet.

The *haab'* stations of *wayeb*, New Year and Half Year

The 'computing year' of 364 days (Lounsbury 1978: 773; Carlson 1981: 211) found in Maya inscriptions and codices enabled quick seasonal calendrical computations. The least common multiple of the computing year and the *tzolk'in* is 1,820 days: 5 x 364 = 7 x 260 = 1,820 days (Spinden 1924: 202-203), suggesting it was used to track the coincidence of the *tzolk'in.* The computing year tables found in the codices often account for the cycle of 20 x 91 or 1820 days in total. According to Bricker and Bricker (2011: 489-690), the popularity of this cycle may indicate a growing interest in the use of the *tzolk'in* to fix various seasonal phenomena, such as rain and planting cycles, and its commensuration with the seasons of the tropical year. Naturally, the discrepancy between the computing year and the tropical year, produced frequent changes of the base dates of 182-day tables (Bricker and Bricker 2011: 536). The identification of various records of the changing relationship between both cycles in codices does not mean there were systematically collected to attempt to determine rules of intercalations.

At Machaquila the *ho'tuun* period of 1,800 (5 x 360) days is associated with the records of 1,820 (5 x 364) days and 1,825 (5 x 365) days (Graham 1967; Just 2007:8; Lacadena 2011: 229-230). The Maya often erected stelae following *ho'tuun* anniversaries (5 x 360, 1,800 days), but the ninth-century Machaquila rulers decided to commission the monuments on recurrent *tzolk'in* or *haab'* dates, corresponding either to the same *tzolk'in* day 1 *Ajaw* (if a 1,820-day cycle is used) or the *haab'* day 13 *Kumk'u* (if a 1,825-day cycle is used) (see Table 6). Thus, the cycles of 364 and 365 days run parallel to the celebrations of *ho'tuun* endings.

Table 6: 1 Ajaw and 13 Kumk'u dedicatory dates at Machaquila (data after Graham 1967: 97, Table 2, Just 2007:8; Lacadena 2011: 229-230).

Monument	Period Ending	Final (Dedicatory) Date
Stela 18	9.17.5.0.0 6 *Ajaw* 13 *K'ayab*	9.17.5.1.0 13 *Ajaw* 13 *Kumk'u*
Stela 2	9.18.10.0.0 10 *Ajaw* 8 *Sak*	9.18.10.7.5 12 *Chikchan* 13 *Kumk'u*
Stela 3	9.19.5.0.0 2 *Ajaw* 13 *Yaxk'in*	9.19.5.11.0 1 *Ajaw* 13 *Kumk'u*
Stela 4	9.19.10.0.0 8 *Ajaw* 8 *Xul*	9.19.10.12.0 1 *Ajaw* 8 *Kumk'u*
Stela 8	9.19.15.0.0 1 *Ajaw* 3 *Tzek*	9.19.15.13.0 1 *Ajaw* 3 *Kumk'u*
Stela 7	10.0.0.0.0 7 *Ajaw* 18 *Sip*	10.0.0.14.15 3 *Men* 13 *Kumk'u*
Stela 6	10.0.5.0.0 13 *Ajaw* 13 *Woh*	10.0.5.16.0 8 *Ajaw* 13 *Kumk'u*
Stela 5	10.0.10.0.0 6 *Ajaw* 8 *Pop*	10.0.10.17.5 13 *Chikchan* 13 *Kumk'u*

Conclusions

In the absence of detailed records, the Maya methods to determine the length of the tropical year may only be inferred indirectly. One method is to associate the calendar horizon observations with fixed dates of the *haab'*. The accuracy of sunrise/sunset sightings depends on the choice of reference points and on the selection of suitable horizon markers, the choice of the equinoxes is much better due to the very fast change in declination of the Sun, compared to the solstices. Another method is to study the drift of the Maya *haab'* in relation to the seasons, or, better, the sidereal year indicated by the rising dates of stars or constellations. Vail and Bricker (2004: 180, Table 7.3) illustrated this wandering motion using the dates from the Madrid Codex, created during the 2nd half of 15th century and relating *Kumk'u* days with the Gregorian calendar. However, the time span examined is too short to be able to deduce if the ancient Maya had ever been aware of the difference between the tropical year and that of the 365.25-day cycle.

It is difficult to assess if the *haab'* was determined and regulated on the sole basis of astronomical knowledge. While the inaccuracy of the *haab'* could easily have been corrected, the insertion of an additional day every four years would seriously affect the predictability and stability of the Calendar Round.

To conclude, none of the methods described here allows us to conclude that the ancient Maya computed the length of the tropical year with much greater accuracy than other known peoples.

Table 7: Diverse concepts of the solar year used in this paper.

Year	Length
Haab' or *tuun* 360	360 days
The length of the computational year	364 days
Haab'	365 days
Solar horizon calendar	365.25 days
Average length of the tropical year AD 700	365.2422689
Tropical year fixed on the winter solstice AD 1	365.24288 days
The length of the year derived from the number of 6940 days	365.26316 days
The length of the year derived from 59 *tzolk'in* rounds	365.23810 days
The length of the year derived from 70 *tuun* cycles	365.2173913 days

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Palenque: Astronomical-solar orientation of Pakal's tomb

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Abstract
We support the hypothesis that Lord Pakal's tomb in Palenque, Mexico, has an astronomical orientation, namely the orientation to the summer solstice sunset. We measured inside of the tomb using a large and precise magnetic compass and we corrected the measured magnetic azimuths to the astronomical azimuths. The accuracy of our result is better than ±2°.

KEYWORDS: archaeoastronomy, Pakal's tomb, astronomical orientation, summer solstice

POVZETEK
Z raziskavo smo podprli hipotezo, da ima grobnica kralja Pakala v Palenqueju (Mehika) astronomsko orientacijo, t.j. da je usmerjena proti Sončevemu zahodu ob poletnem solsticiju. Meritve smo izvajali znotraj grobnice, uporabljali smo velik in natančen magnetni kompas, izmerjene magnetne azimute pa smo korigirali v astronomske. Natančnost rezultatov je pod ±2°.

KLJUČNE BESEDE: arheoastronomija, Pakalova grobnica, astronomska usmerjenost, poletni solsticij

Introduction
The great king K'ihnich Janaab' Pakal ('Great Sun/Flower Shield') was an important ruler in Palenque (orig.: Lakamha, which translates as 'big water'). He ascended the throne when he was 12 years old and died at age 81, in AD 683 GMT (= 787 B&B: Klokočník et al. 2008). The Temple of the Inscriptions (Fig. 1) contains the funerary crypt in the basement of the pyramid. The large sarcophagus of Pakal inside the crypt lies below a cover (lid). Relief carving on the upper surface of the sarcophagus lid shows a youthful-appearing person falling into the Underworld (Xibalba) (e.g. Coe 1999: 137).

The role of astronomy in ancient Mesoamerica has been discussed by various authors (e.g. Aveni 1977; Aveni & Hartung 1986; Šprajc 2011). The orientation of the Temple of the Inscriptions is mentioned in Mendez et al. (2005) and Mendez (2013). Here we discuss the orientation of the crypt itself and the sarcophagus inside it with respect to astronomical North. We conclude that the crypt's orientation is not arbitrary, that it is intentional and expresses something. It would not be surprising that the motivation for the orientation would be based on astronomical hierophanies, on imaginations which we would now call 'divinatory'.

In older literature (Stingl 1971: 256) we found plans reproduced here as Figure 2, which may show the orientation of the crypt, but verification is necessary. The orientation of the temple and of the surrounding structures is shown in Figures 3 a and b. Later we will show also 'height profiles' from the temple in the direction to sunset at summer solstice based on a digital model of terrain (Figs. 7a, b, c).

We made relevant measurements inside the crypt (using a precise magnetic compass), and after computations (necessary reduction of the measured magnetic azimuths to the astronomical ones) we verified the astronomical, solar orientation of the crypt. Its orientation differs from the orientation of the whole pyramid (so there is a mistake in the middle-left image of the composite Figure 2). Some details and the results of our investigation are given in the following sections.

Figure 1: The Temple of the Inscriptions in 2010, photo © J. Klokočník. The top has geodetic latitude φ = 17°29'01" N and longitude λ = 92°02'49" W.

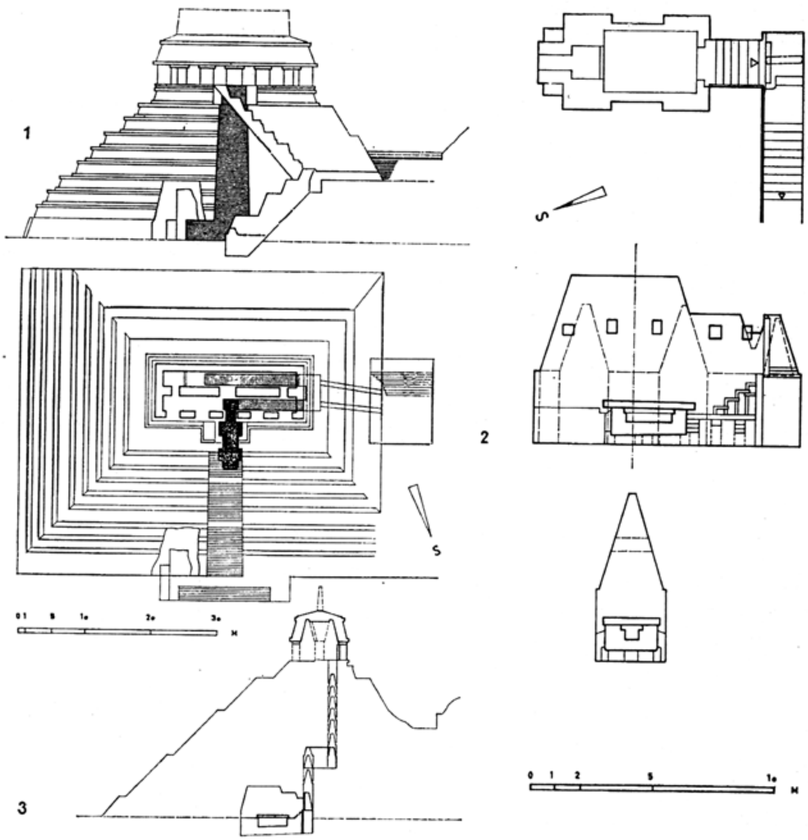

Figure 2: Temple of the Inscriptions in plans reproduced from Stingl (1971). The arrows S mean North (in Czech language Sever).

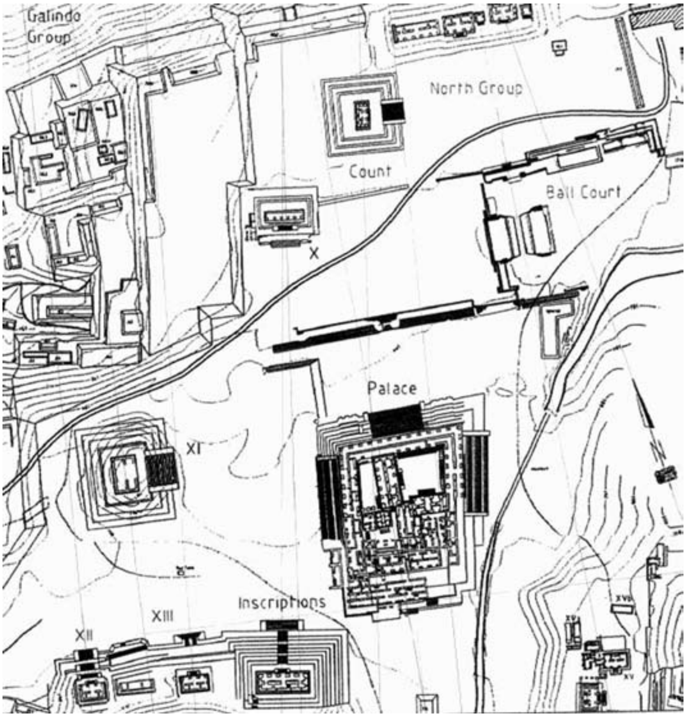

Figure 3a: The Temple, the Palace and surrounding structures on a precise map from the US mapping project (Joel Skidmore, personal comm. 2000, see also www.mesoweb.com/palenque/resources/maps, © 2000 E. Barnhart).

Figure 3b: Palenque: a 3D model (from French & Duffy 2010, published with permission by Kirk French). Compare with our profiles based on a digital terrain model in Fig. 7c below.

Astronomical-solar orientation of Pakal's tomb

Hypothesis

Lord Pakal may have wished to have his tomb oriented according to the Sun. The hypothesis is that the crypt with the sarcophagus is oriented according to sunrise or sunset on important days of the year, for example at summer or winter solstice or with respect to the days of the Sun's zenith passages, or perhaps with respect to the Sun's position on Pakal's birthday. Recalling Mendez (2013), 'though the Temple of Inscriptions is clearly associated to winter solstice, there is also a summer solstice hierophany that is incorporated as a defining element of its design…' We prefer the summer solstice orientation of the sarcophagus and there are practical reasons for it (see below).

Computation of astronomical azimuths

Figure 4a shows the astronomical azimuths *A* (measured from north to east) for sunrise/sunset at the solstices for the latitude of Palenque (φ = 17.5° N) for an ideal horizon. We see horizon, zenith, local meridian and the direction to the astronomical North pole *N*. We can read from this figure, for example, that the azimuth *A* of sunrise/sunset around June 22 should be 65°/295°. More illustrative is Figure 4b, where the observer is looking on this situation from the local zenith. (The values in figures and the following text are rounded to one degree because this precision is sufficient for our goal, but the values were computed more precisely).

We derived the angle of astronomical azimuth *A* by means of spherical trigonometry:

$$\cos A = \frac{\sin\delta - \cos z \sin\varphi}{\sin z \cos\varphi}, \qquad (1)$$

where δ is the declination of the Sun (we take δ =23.5° for the summer and δ = -23.5° for the winter solstices), φ is latitude of the place and z is zenith distance, z = 90° - h, where h is height above the ideal horizon. For ~ AD 700, the declination of the Sun δ was a bit higher than now (by about 0.2 deg) – there are quasiperiodic changes with time, between roughly 22.5° and 24.2° (see Vondrák et al. 2011: Fig. 4). For the latitude of Palenque, for sunrise on winter solstice we calculate A = 114.5° or for sunset at summer solstice 294.5° (for z = 90°).

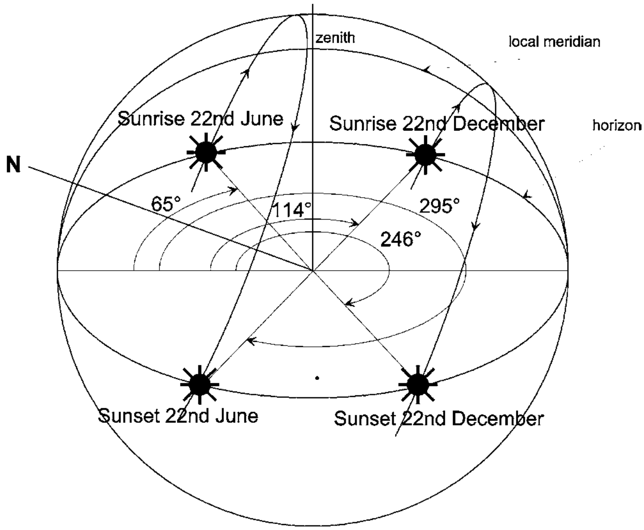

Figure 4a: Approximate astronomical azimuths of sunsets and sunrises at summer and winter solstices, on a sphere and for an ideal horizon.

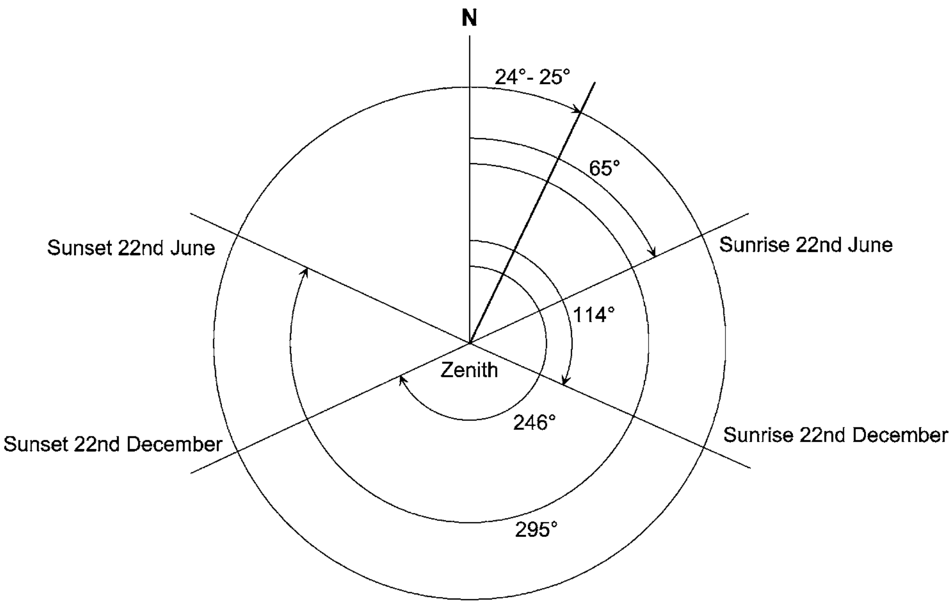

Figure 4b: Approximate astronomical azimuths of sunsets and sunrises at summer and winter solstices, as seen from the zenith on an ideal horizon.

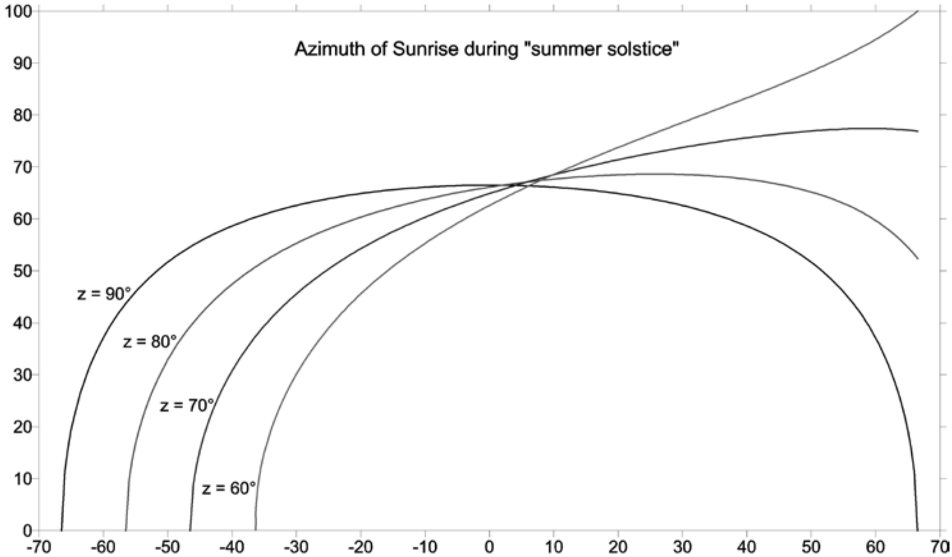

Figure 4c: Astronomical azimuths of sunrise (y-axis) at summer solstice for various latitudes (x-axis, negative to South) and several zenith distances z (in degrees).

In the mountains, we often do not see sunrise/sunset at the theoretical zero horizon, $z = 90°$, but at some elevation angle (non-zero height or at zenith distance < 90°) dictated by the local topography. We can compute the differences to the azimuths of such actual sunrises/sunsets due to various elevations. We applied formula (1) for different z and φ and show the result in Figure 4c. Note that, for example, for $\varphi = 17.5°$ N (Palenque, Chiapas), the azimuth of sunrise behind a mountain which yields the elevation angle 30° is shifted by approximately 7° south of due east.

In order to obtain horizon elevations required in formula (1), we need a DTM (digital terrain model), now available nearly globally from satellite data. Its precision is estimated to be ~15 meters. For a model of local topography we used *ASTER GDEM, Earth Remote Sensing Data Analysis Center,* (2009), available at: http://www.gdem.aster.ersdac.or.jp. The result is in Figure 7.

Legitimate simplifications

Our goal was to determine the astronomical azimuth with a precision of ±2°, which is enough to decide on the type of orientation of the tomb. This means that the measuring tools can be simple and can be transported anywhere without any administrative troubles. The reading of the compass (Fig. 5) has precision of 1° and depends on the particular object; to reach a formal precision of 1° we needed to repeat measurements at irregular walls several times. The ordinary mean value was then computed from all measurements.

The correction to the astronomical azimuth was the most serious contributor to the inaccuracy of the final result with the error limit of approximately ±1.5° (see more details below). We needed a handheld GPS for this purpose.

Refraction is taken for an ideal horizon (36 arc minutes), which may yield an error in the azimuth of about 0.1°. The daily changes of the declination of the Sun near solstices are very small. Also, the declination of the Sun is slightly changing with time on a historical scale (Vondrák et al. 2011) and, as mentioned above, for Pakal's period (ca. AD 700), the difference from today is ~0.2°.

The latitude of Palenque rounded to 17.5° (instead of precise value given at Fig. 1) leads to the error in A only on the 5th digit, thus completely negligible for our purpose. The total error in the derived astronomical azimuth (the square root of the quadratic sum of all contributors mentioned above) should thus be <±2°.

Method of measurements to prove the hypothesis

Any magnetic compass measures the azimuths related to the magnetic pole which is, however, not identical with the pole of rotation of the Earth that defines the astronomical azimuths. So we have to correct all magnetic azimuths to the astronomical ones. The correction (magnetic declination) can be derived by comparing compass measurements with those based on GPS positions (the astronomical azimuths). The same baseline is measured with both instruments and the directional correction is derived from the difference between the measured and computed azimuths. By GPS we get coordinates of the end points of a baseline, from which it is easy to compute the astronomical azimuth. The usual handheld GPS is enough for this purpose. It had precision ±10 m in 2003 and has precision 3–5 m now. The baselines should be as long as possible; to keep the relevant directional error below 1.5°, the baseline should be (taking the precision of the GPS coordinates 3–5 m) longer than about 120–200 m. To keep the directional error <1°, and assuming pessimistically the error of the handheld GPS ±5 m, we would need a baseline longer than 300 meters.

Another way to calculate the correction can be via a model from the NGDC (National Geophysical Data Center) of NOAA Satellite and Information Service (www.ngdc.noaa.gov), where for a given latitude and longitude (and time) estimated values of magnetic declination are available. The relevant model values from the NGDC were known before our trips to Mexico for various localities and were consulted in conjunction with our on-site measurements. For Palenque we found that, for years 2010 and 2003, 2.5° and 3.0°, respectively, must be added to the magnetic azimuths to get the astronomical ones. The model cannot, however, absorb possible local magnetic anomalies which can reach up to a few degrees.

Figure 5: Measurements with precise ('mining') magnetic compass equipped with a special fitting (kindly provided by Ass. Prof. Radim Blažek, Faculty of Geodesy, TU Prague, Czech Rep.; photo © D. Lampířová, 2010).

Measurements in Palenque

We had a handheld GPS receiver (Garmin) and a magnetic compass (Fig. 5). In 2003 we got permission to measure inside the crypt, but no so in 2010. So we had to use only the measurements from 2003. The GPS data (outside the crypt) were collected in 2003 and 2010 without any problem. Two baselines were deployed (between the Temple of the Cross and the plaza between structures XIII and XI, about 170 m long, and between the North Group and the Temple of the Inscriptions). Unfortunately, due to the local terrain, the baselines were not long enough, so we had to rely more than we would wish on the NGDC model mentioned above. Nevertheless, the correction deduced from our measurements was +2.4° – and it agrees very well with the correction from the model, i. e. +2.5°.

We made measurement repeatedly several times inside the crypt, and along the three sides of the sarcophagus, but there was a problem: at the entrance to the crypt, there was a steel lintel which disrupted compass measurements to a distance ~1 meter, so on that side of the tomb measurements with the compass were impossible.

Results and their interpretation

The magnetic azimuths of the longer walls of the sarcophagus are 21° ± 1°. Adding the magnetic declination of 3°, the astronomical azimuths are 24° ± 2° east of north. As seen in Figures 4 a and b, there is a good agreement between the perpendicular to this direction and either the setting Sun at the summer solstice or the rising Sun at the winter solstice.

The staircase to the Temple of the Inscriptions has an astronomical azimuth 20° ± 2°. As we said in the introduction, Figure 2 is incorrect in that the long axis of the crypt is declined more from north to east than is shown in this figure.

Our measurements support the hypothesis about astronomical, namely solar orientation of the crypt. The direction of the long axis of the crypt is 24° east of north (with an error estimate ± 2°). The long axis of the crypt is perpendicular to the direction of sunset at the summer solstice or sunrise at the winter solstice. We cannot decide only by 'astronomy' (due to the inherent symmetry of these alignments) which of these two the Maya actually employed. But we know the topography at the place. From this evidence, we prefer a sunset alignment during summer solstice. But we will verify this by using height profiles derived from the DTM for this locality (Figs. 7a, b, c).

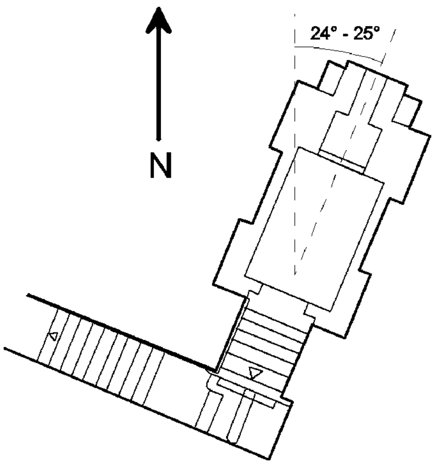

Figure 6: Solar orientation of the crypt and the sarcophagus in the Temple of the Inscriptions according to our hypothesis and compass measurements. The long axis of the crypt (see also Fig. 2), aligned 24° east of the astronomical north, is approximately perpendicular to the direction of sunset at the summer solstice or sunrise at the winter solstice.

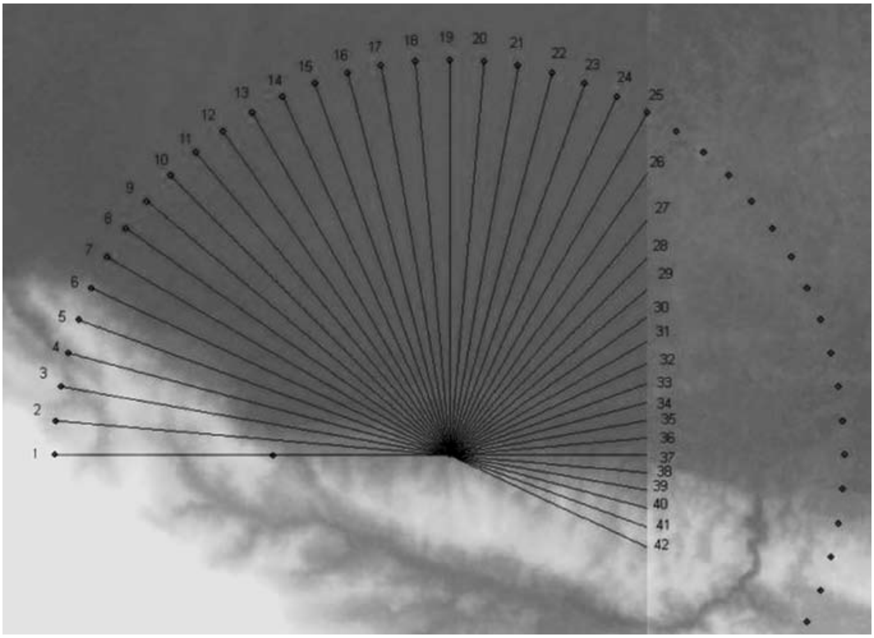

Figure 7a: Profiles from the DTM, viewing from the front steps of the Temple of the Inscriptions; profile 1 to west, profile 19 to north, etc.

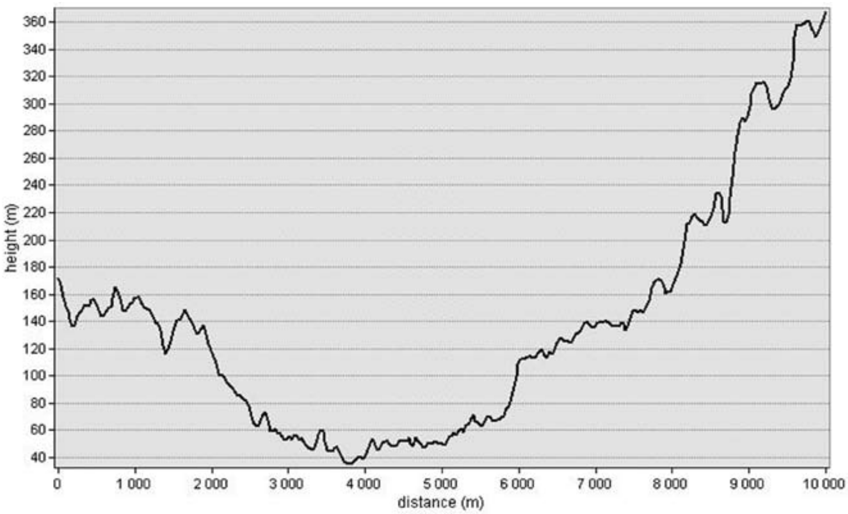

Figure 7b: height profile 5, with distances given on x-axis, and heights above sea level on y-axis (meters).

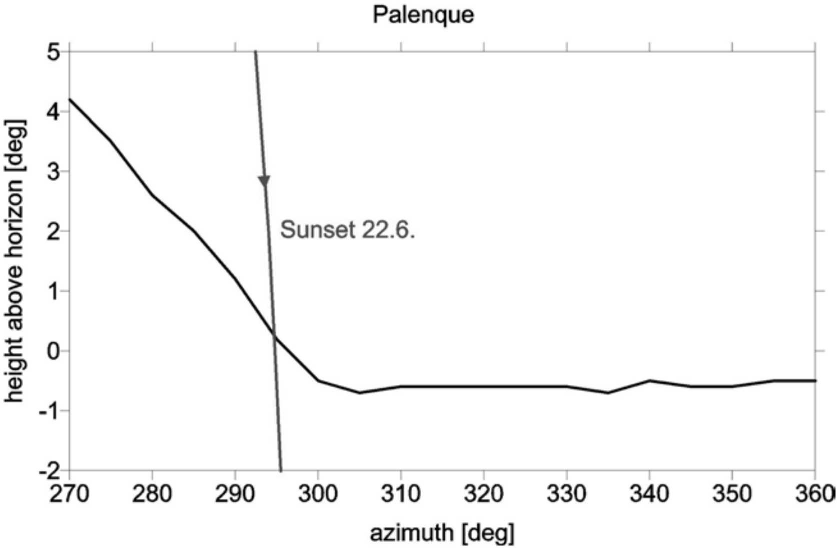

Figure 7c: Azimuth corrections due to the actual horizon for various astronomical azimuths in W and NW direction, based on the DTM (viewing from the front steps of the Temple of the Inscriptions).

The DTM model was downloaded for this area. The profiles from the DTM (valid for an observer at the front steps of the Temple of the Inscriptions) were plotted (Figs. 7 a and b) and the correction of A due to the actual horizon was derived (Fig. 7c) for the summer solstice. The correction is roughly zero.

Note that the azimuths of sunrises or sunsets at the days of zenith passages of the Sun over Palenque (11 May and 5 August) are 71°/288° ($z = 90°$). Since our measurements have a precision of 2°, it is very improbable that the orientation refers to these events. The Moon, planets or bright stars at certain moments cannot be excluded as alternate targets, but they are much less likely than the solstitial Sun.

Concluding remarks

We support the hypothesis that Pakal's tomb in the Maya city of Palenque has astronomical-solar orientation. We measured inside the tomb with a precise magnetic compass and corrected magnetic readings to the astronomical azimuths. The long axis of the crypt is directed 24-25° east of astronomical north. This axis is perpendicular to the direction of sunset at the summer solstice or sunrise at the winter solstice. The result has accuracy better than ±2°. Astronomy itself cannot distinguish between the directions to sunset/sunrise at summer/winter solstices, but the local topography and the profiles from the DTM clearly prefer the summer solstice sunset.

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Equinoxes in Mesoamerican Architectural Alignments: Prehispanic Reality or Modern Myth?

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Abstract
While the equinoctial Sun is commonly believed to have been an important target of Mesoamerican architectural orientations, the results of systematic archaeoastronomical research accomplished during recent decades do not sustain this opinion. Analyzing particular alignments that have been claimed to refer to the equinoxes, we show that such a relationship exists in very few cases, for which reason their intentionality remains questionable; instead of the true astronomical equinoxes, the quarter-days of the year were much more likely referents of several allegedly equinoctial alignments.

KEYWORDS: Mesoamerica, architecture, astronomical alignments, equinoxes

POVZETEK
Čeprav se na splošno domneva, da je Sonce ob enakonočju predstavljalo pomembno tarčo pri usmeritvi stavb v Mezoameriki, pa rezultati sistematičnih arheoastonomskih raziskav iz zadnjih desetletij tega mnenja ne podpirajo. Z analizo posameznih usmeritev, ki naj bi se nanašale na enakonočja, smo pokazali, da takšna zveza obstaja v zelo redkih primerih, zato je njihova načrtnost vprašljiva; nekatere domnevno enakonočne usmeritve se tako bolj verjetno nanašajo na dneve četrtin leta.

KLJUČNE BESEDE: Mezoamerika, arhitektura, astronomske usmeritve, enakonočja

Introduction
Every year on the March equinox, numerous archaeological sites surviving as a material testimony of ancient Mesoamerican civilizations are flooded by increasingly large numbers of visitors. Particularly crowded are some of the largest and most famous sites, such as Teotihuacan, Chichén Itzá and El Tajín in Mexico. While multiple groups of modern

pilgrims dressed in white (and pertaining to different versions of esoteric movements whose ambitions are to revitalize ancient wisdom) expect to receive supernatural energy and spiritual enlightenment, many other people simply want to share the experience and see whether anything happens.

This modern tradition has little to do with prehispanic astronomical concepts, and it is surprising that even in scholarly literature, particularly in general archaeological works not focused specifically on astronomical matters, the importance of equinoxes in prehispanic times continues to be highlighted in ways that are entirely inconsistent with the results of serious archaeoastronomical research carried out during recent decades. The equinoxes are often mentioned in tandem with the solstices, apparently because, for many Western-minded modern people sharing superficial but evidently ethnocentric astronomical notions, they represent the only significant moments of the tropical year. Nobody seems to care that, while the solstices are marked by easily perceivable extremes of the Sun's annual path along the horizon, the equinoxes are not directly observable and can only be determined with relatively sophisticated methods (cf. Ruggles 1999: 148f, 150f). While the search for equinoctial and solstitial orientations was a general trend in early archaeoastronomical work, largely based on preconceived ideas (Ruggles 2007: 314ff), it is still rather common in Mesoamerican studies. The purpose of this paper is to call attention to specific cases and to evaluate the viability of arguments about the existence of equinoctial alignments. In order to do that, however, we must first summarize the current knowledge on the astronomical significance of Mesoamerican architectural orientations.

Orientation patterns in Mesoamerica

The results of systematic research accomplished so far indicate that the orientations of civic and ceremonial buildings in Mesoamerica largely refer to sunrises and sunsets on certain dates. For central Mexico and the Maya Lowlands it has also been shown that the dates recorded by orientations tend to be separated by multiples of 13 and 20 days. It has thus been argued that the architectural alignments allowed the use of observational calendars composed of calendrically significant intervals, and that these observational schemes – considering the distribution of the most frequently recorded dates in the tropical year – served to facilitate an efficient scheduling of agricultural activities and the corresponding rituals (Aveni & Hartung 1986; Aveni, Dowd & Vining 2003; Šprajc 2001; Šprajc & Sánchez 2012; Šprajc, Sánchez & Oštir 2011).

In view of the prevalent clockwise skew from cardinal directions, observed in Mesoamerican architectural orientations since the very beginning of serious archaeoastronomical research (Marquina & Ruiz 1932; Macgowan 1945; Fuson 1969), it has long been clear that the purpose of recording equinoctial sunrises or sunsets could not have been a dominant underlying motive. The available data clearly show that, among the dates most frequently targeted by orientations, the solstices appear rather prominently, but not so the equinoxes. Ponce de León (1982: 60, note 33; 1991: 422ff) and Tichy (1991: 29ff, 56ff) noticed that the orientations close to the east-west direction tended to mark the dates falling two days after and before the spring and autumn equinoxes, respectively, rather than the true equinoxes. This orientational trend, confirmed by systematic research in central Mexico (Šprajc 2001: 75ff), is particularly evident in the data sample recently collected in the Maya Lowlands. In the curvigrams of east and west declinations – which present relative frequency distributions, considering errors assigned to individual declination values on the basis of uncertainties in azimuths – a group of near-equinoctial values can be observed among both east and west declinations, but in neither case are they centered on 0° but rather on approximately -1° (east) and 1° (west) (Figure 1). Unlike the other most frequently recorded pairs of dates, those corresponding to the east declinations around -1° (March 19 and September 25) do not delimit calendrically significant intervals. It is more likely that these orientations were functional only to the west, since the corresponding dates are the so-called quarter-days, March 23 and September 21 (± 1 day), which fall two days after and before the spring and fall equinoxes, respectively; these dates, together with the solstices, divide the year into four equal periods of approximately 91 (= 7 × 13) days each.[1]

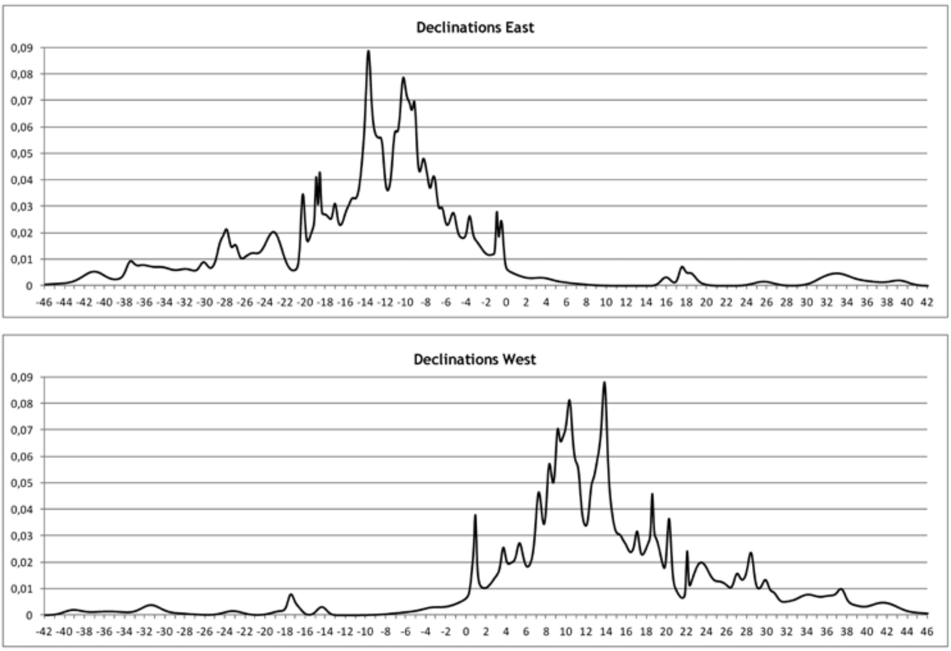

Figure 1: Relative frequency distribution of declinations corresponding to architectural orientations in the Maya Lowlands.

[1] The results of the research in central Mexico also indicate that many important buildings were located on spots that allowed prominent mountain peaks on the horizon to be used as natural markers of sunsets and sunrises on relevant dates, including quarter-days of the year (Šprajc 2001). Particularly interesting examples are Teotihuacan and Cuicuilco, which are, paradoxically, two of the sites most invaded by modern equinoctial pilgrims. While at the astronomical equinoxes no phenomena can be observed that might corroborate the visitors' preconceptions, both sites offer a visual spectacle on the quarter-days: observing on top of the Sun Pyramid at Teotihuacan, the Sun rises over Cerro Colorado, the most prominent mountain on the eastern horizon, while for an observer on the round pyramid at Cuicuilco, the rising Sun aligns with Cerro Papayo, a notable feature on the eastern horizon of the Valley of Mexico (Šprajc 2001: 170ff, 208ff).

In sum, the systematic studies accomplished so far, based on large samples of alignment data, provide no compelling evidence indicating that the true astronomical equinoxes were targeted by Mesoamerican architectural orientations. In fact, the persistent popularity of the idea about the existence of equinoctial orientations has been nurtured by relatively few specific cases, which have received disproportionate attention, probably because of the aforementioned ethnocentric prejudices. In the following case-by-case discussion we will analyze particular alignments that have been claimed to refer to the equinoxes, in order to assess the likelihood of their intentionality.

Claimed equinoctial alignments in Mesoamerica

Uaxactún

One of the best known cases, first discussed by Ricketson (1928a; 1928b) and thereafter referred to on innumerable occasions as a solstitial and equinoctial observatory, is Group E of Uaxactún, Petén, Guatemala. Its main components are Temples E-I, E-II and E-III, erected on an elongated platform flanking a plaza on its east side, and Structure E-VII-sub, a pyramid on the west side of the plaza. Having measured various alignments that may have been observationally functional (the differences among them being due to different possible observation points), Aveni and Hartung (1989) established that the best fit to a functioning solar observatory corresponds to the observation point being situated at the upper end of the eastern stairway of the first construction stage of Structure E-VII-sub, because from this point the rising Sun at the solstices would have appeared just left and right of Temples E-I and E-III, respectively, while at the equinoxes it would have aligned with the upper mid-point of the terraces built upon the eastern platform to support Temple E-II (and rising above natural horizon to the angular height of 3.5°). When Temple E-II was erected, however, it blocked the view to the rising equinoctial Sun along the alignment, rendering it non-functional. The authors, therefore, conclude that Group E 'should be regarded as a functioning (though not precise) *solstice* observatory only and not as an equinoctial one' (Aveni & Hartung 1989: 445).

Significantly, the azimuth given by Aveni and Hartung (1989: Table 35.1) for the sightline connecting the centers of Structure E-VII-sub and Temple E-II is 90°54' (closely agreeing with the value S89°03'E formerly determined by Ricketson, 1928a: 437). The widespread occurrence of orientations skewed about 1° clockwise from cardinal directions, both in the Maya area and in central Mexico (Šprajc 2001; Šprajc and Sánchez 2012), suggests they had an astronomical basis; while they cannot be related with the equinoctial Sun, the corresponding declinations calculated for the western horizon are neatly centered on the value reached by the Sun on the quarter-days of the year (cf. Figure 1). Given the relative heights of Structure E-VII-sub and the temples on the eastern platform, and in view of the evidence indicating that the final eastern platform was built before the final version of Structure E-VII (Aveni & Hartung 1989: 459, note 10), an observer standing at the doorway of Temple E-II may well have been able to see the natural horizon above Structure E-VII-sub and the quarter-day sunsets along its axis.[2] When

[2] According to our calculations based on cartography, the horizon altitude in that direction is slightly above 2.5°.

this view was obstructed by the later and higher stages of Structure E-VII, the alignment would have become non-functional; but it is possible that the observation point was actually on top of Structure E-VII, whose substructure also exhibits a slight clockwise skew from cardinal directions (Aveni & Hartung 1989: 458, note 1).[3]

We do not pretend to solve the question concerning possible observational practices associated with either Group E of Uaxactún or other similar compounds very common in the Maya Lowlands. However, the foregoing discussion allows the conclusion that even Group E of Uaxactún – which appeared to be the only assemblage of this type incorporating a true equinoctial and observationally functional sightline (all others have notably different orientations: Aveni, Dowd & Vining 2003) – fails to provide convincing evidence of the existence of such an alignment.

Dzibilchaltún

The Temple of the Seven Dolls or Structure 1-sub at Dzibilchaltún, Yucatán, Mexico (Andrews and Andrews 1980: 82ff), is one of the increasingly popular focuses of modern equinoctial pilgrimages. A common belief, never substantiated by a sound argument, is that the passage shaped by four east-west aligned doorways of this building was intentionally oriented to the rising Sun at the equinoxes. The widely publicized photographs showing the solar disk nicely framed by the doorways (Figure 2) contribute to the popularity of the event. Nobody seems to care that the axial orientation of the temple, skewed about 1° clockwise from cardinal directions (Figure 3), does not correspond to the equinoctial position of the Sun on the horizon and that virtually the same picture can be taken from different points and during several consecutive days, but only after the Sun has reached a substantial altitude above the horizon. Since the causeway leading westward from the temple (Sacbé 1) is skewed 1°40' north of due west,[4] and because its central axis extended eastward passes a few meters north of the center of the temple (cf. Stuart et al. 1979; Andrews & Andrews 1980: 14, Fig. 2), the appropriate points for observing the phenomenon are located along a line running considerably south of – but not exactly parallel to – the central axis of the causeway. The line also runs several meters south of Stela 3, which would appear to be a convenient marker of the observation spot, because it stands on a platform in the middle of Sacbé 1, some 130 m west of the temple (Figure 4).

[3] To discuss the alleged solstitial alignments incorporated in Group E of Uaxactún is beyond the scope of this paper, but we see no contradiction in the possibility that they were functional in the eastern direction, as proposed by Ricketson (1928a; 1928b) and Aveni and Hartung (1989), whereas the target of the quarter-day alignment was the setting Sun. While the height of later stages of Structure E-VII resulted in the presumed solstitial alignments becoming non-functional, the quarter-day direction, if embedded in the orientation of Structure E-VII, may have continued in use.

[4] This value, obtained in 2010 by our own field measurements along the southern edge of Sacbé 1, can be easily verified on Google Earth images (http://www.google.com/earth/index.html). The azimuth of 93°30' given for the causeway by Coggins and Drucker (1988: 18) is misleading; it corresponds approximately to the line from Structure 66 to Structure 1-sub, but the two buildings are not located at the extremes of a single causeway, as the authors imply. While Sacbé 1 leads eastward from the core area of Dzibilchaltún to Structure 1-sub, Sacbé 2 runs westward from the central part of the site, terminating at Structure 66, but the two causeways are neither coaxial nor exactly parallel to each other (cf. Andrews & Andrews 1980: 14, Fig. 2; Stuart et al. 1979).

Figure 2: Rising Sun viewed through the doorways of the Temple of the Seven Dolls at Dzibilchaltún, Yucatán, Mexico, around an equinox.

Figure 3: Google Earth image of the group of the Temple of the Seven Dolls at Dzibilchaltún; note that the architectural compound, including the temple itself (on the right), is skewed slightly clockwise from cardinal directions.

Figure 4: View to the west through the doorway of the Temple of the Seven Dolls at Dzibilchaltún, with Structure 7, Stela 3 and Sacbé 1 in the background.

About 40 m west of Structure 1-sub there are three pairs of buildings aligned in a north-south direction. The central doorway of Structure 7, the eastern one of the central pair of buildings, lies on the line of points suitable for observing the equinox Sun through the doorways of Structure 1-sub, and might represent an archaeologically preserved marker. From that vantage point, the azimuth of the vertical axis of symmetry of the opening shaped by the four east-west aligned doorways of Structure 1-sub is 93°31', and the angular altitude of the lower edge of the opening (front threshold) is about 7°15' (our measurements). Since the resulting declination is -0°41', the equinoctial Sun aligns with the opening somewhat above its lower edge. However, observing this way, it would have been difficult to pinpoint the equinox date: due to the relatively short distance to Structure 1-sub and the consequent apparent size of the passage shaped by its doorways, the decision about which is the relevant altitude of the Sun with respect to the doorways would have been quite subjective, and the determination of the date corresponding to the alignment would have depended on both the exact point of observation and the observer's height (Figure 2). It is hard to imagine why the builders would have designed an observational device with such poor precision.

It is noteworthy that, as in the case of Uaxactún discussed above, the orientation of the Temple of the Seven Dolls is skewed about 1° north of west (Figure 3), pertaining to the alignment group for which the sunsets on quarter-days of the year represent a much more likely target. These dates could have been determined not only by direct observation of the setting Sun along the axis of symmetry of the four doorways (cf. Figure 4), but also by observing light-and-shadow effects produced by pairs of windows and smaller openings in the eastern and western walls of the temple (Šprajc 1995).

Coggins and Drucker (1988), defining the group of Structure 1-sub as an observatory assemblage, argued that one of its functions was to determine the equinoxes. Choosing Stela 3 and Structure 66 – the latter is situated at the west end of Sacbé 2, about 2.2 km away – as the most likely observation points, they do not find any prominent architectural feature of Structure 1-sub that would match the equinoctial position of the Sun; but they contend that its windows and doorways, through which the Sun was visible several days after/before the equinox, served as anticipatory or predictive markers (Coggins & Drucker 1988: 24, Table 1, Fig. 11). The doorways are said to have marked sunrises on March 16, which in A.D. 692 was the katun ending 9.13.0.0.0 8 Ahau 8 Uo. In the absence of explicit Long Count dates associated with this architectural group, the authors claim that the cited date, to which they attribute special importance on the basis of indirect evidence, is encoded in the iconography of Structure 1-sub. Aside from depending on their interpretation of iconographic elements, their argument is flawed by erroneous dates they associate with the alignments.[5] In sum, the complex observational scenario presented

[5] For example, Coggins and Drucker (1988: 24, Tab. 1, Fig. 11) assert that, observing either from Structure 66 or from Stela 3, the Sun could have been sighted through the central doorways of Structure 1-sub on March 16. Instead, since for an observer standing at Stela 3 the azimuth, altitude and declination of the central doorways are 93°50', ca. 1°54' and ca. -3°00', respectively (our measurements), this alignment would have marked the Sun's position on March 13 ± 1 day. We did not take readings from Structure 66; however, since it lies along the same alignment, but at a distance of about 2 km to the west (cf. Stuart et al. 1979), the angular height of Structure 1-sub viewed from that point (0.5° at most) would have shifted the corresponding date to March 11 or 12.

by Coggins and Drucker – in spite of their emphasis on the equinoctial character of the 'observatory' – contains no unequivocal evidence indicating the importance of the equinoxes, let alone the existence of equinoctial alignments.

Observing from Structure 41, located just south of the western terminus of Sacbé 1, the rising Sun at the equinoxes appears on top of Structure 1-sub, located some 630 m away (azimuth: 90°24', altitude: 1°05', declination: -0°08'). The alignment could have been functional in the eastern direction only if Structure 41 had been built before Structure 1-sub was covered by the later building (cf. Andrews & Andrews 1980: 82ff). Since the chronological relation between the two structures is not known, the issue remains unsolved. It should also be noted that, while the axes of both structures approximately agree with the line connecting them (which might be an indicator of intentionality) the alignment may well be coincidental, particularly because Structure 41 is a relatively minor and unsophisticated building (Maldonado 2002: 480).

Copán

In his study of the Sepulturas group at Copán, Honduras, Hohmann (1995: 104ff, Fig. 195) suggests that Structures 9N-81 and 9N-83, oriented exactly east-west, compose an equinoctial alignment, but does not provide the corresponding horizon altitudes. According to our calculations based on cartography, the eastern and western horizon contours along the east-west axis of the architectural group rise to more than 6° and 2°, respectively. The alignment, therefore, corresponds to neither sunrises nor sunsets at the equinoxes, but may have been intended to record sunsets on the quarter-days of the year.

Tikal

According to our measurements, the westward azimuth of the visual line connecting the centers of the entrances to the upper sanctuaries of Temples I and III at Tikal, Petén, Guatemala, is 269°54', equal to that given by Aveni and Hartung (1988: 9, 12, Table 2). Although the alignment reproduces the true east-west direction almost perfectly, it cannot relate to the equinoxes, as suggested by Aveni and Hartung (*ibid.*) and Malmström (1981: 253f, Fig. 22.1; 1997: 169ff, Figs. 48, 50). This is because the equinoctial sunrises or sunsets along this line could only have been observed on the natural horizon (with an altitude of about 0°). In fact, due to their heights, both temples mutually obstruct the view of the natural horizon. As rightly noted by Hartung (1980: 148), there was evidently no opening in the back wall of either building; hence the equinoctial observations were not possible once the construction was completed. If we nonetheless assume that both temples composed an observationally functional alignment, the heights of their roof combs must be taken into account. Observing in front of the upper sanctuary of Temple I westward, the angular altitude of the roof comb of Temple III is 3°36'; the declination corresponding to this altitude and the azimuth of 269°54' is 0°55'. Inversely, observing from the entrance to the sanctuary of Temple III, the roof comb of Temple I, rising to 2°36' of altitude, marks the declination of 0°47'. Remarkably, the two declinations are very similar, but do not correspond to the positions of the Sun at the equinoxes but rather on the quarter-days of the year, March 23 and September 21 (Figure 5; Šprajc, Richter & Sánchez 2012). Considering that these dates are frequently recorded by orientations, they may well have motivated the relative placement of the two temples; to support this possibility, however, independent evidence and/or comparable spatial patterns at other sites would be needed.

Figure 5: Tikal, Petén, Guatemala; rising Sun above the roof comb of Temple I, observed from Temple III on September 21, 2011 (photo: Dieter Richter).

Chichén Itzá

The most famous prehispanic building believed to reflect the importance of the equinox Sun is undoubtedly El Castillo of Chichén Itzá, Yucatán, Mexico. Year after year thousands of visitors gather at the spring equinox to observe the light-and-shadow effect produced before sunset on the northern balustrade of the pyramid, giving impression of the descent of a rattlesnake with illuminated dorsal triangles (Rivard 1969; Arochi 1976; Carlson 1999). The ophidian heads decorating the base of the northern stairway make this visual effect even more persuasive. Rivard (1969: 52), who was the first to describe the phenomenon in some detail, characterizing it as a 'hierophany', observed:

> None of the other three stairways bears any decoration nor are large serpent heads to be found at its base. One might have expected such heads at the bottom of the southern stairway since the phenomenon is visible one hour after sunrise on the eastern side also. Their absence (if they were originally absent) would seem to indicate that the hierophany was of supreme significance only at the end of the day and not at its beginning.

These circumstances, as well as the fact that, around the winter solstice, a comparable effect can be observed on the northern stairway of a similar pyramid at Mayapán, also known as El Castillo (Arochi 1991; Aveni, Milbrath & Peraza 2004), seem to suggest the intentionality of both phenomena. It should be underscored, however, that the play of illuminated triangles at Mayapán is visible during about a month before and after the December solstice and, likewise, the Chichén phenomenon does not change much during a few days before and after the equinox (Aveni et al. 2004: 130f). Moreover, the most attractive illumination of the balustrade occurs about one hour before the sunset. For these reasons it is impossible to ascertain – even assuming the intentionality of the light-and-shadow effect – which was the date targeted by the builders; and it would have certainly been impossible for them to determine whatever date by observing this phenomenon only. If the play of light and shadow at El Castillo of Chichén Itzá is the result of a conscious architectural design, it could only have had a symbolic function (as already suggested by Aveni, 2001: 295, 298ff); in view of the lack of equinoctial alignments elsewhere, however, it seems more likely that the quarter-days of the year were targeted. If, indeed, the four stairways had 91 steps each, as noted by Landa (Tozzer 1941: 178), we may recall that the solstices and the quarter-days, rather than the equinoxes, divide the year into four equal parts of approximately 91 days each. Even if there were serpent heads at the foot of each stairway (as also stated by Landa (*ibid.*), but never confirmed archaeologically) a special importance of the northern direction is indicated not only by the north-facing main entrance of the upper sanctuary but also by the layout of the substructure, whose single stairway descends from the upper temple northwards (Carlson 1999: 140f). If the significance of the northern stairway reflects the builders' desire to witness the serpent's descent near sunset, as suggested by Rivard (see above), this would agree with the above-mentioned results of the analyses of large samples of alignment data, showing that the quarter-days were recorded on the western horizon.

According to Ponce de León (1991: 430f), the equinoctial Sun reaches the altitude equivalent to the inclination of the western stairway of El Castillo precisely when its azimuth coincides with that of the stairway; in other words, at the equinoxes the rays of the ascending Sun pass 'grazing' along the stairway in the moment when they align with its axis. Interestingly, the author discusses several Mesoamerican temples where the 'grazing Sun' phenomenon may have been observed, but in other cases the azimuths and inclinations of stairways correspond to solar declinations on the quarter-days of the year. El Castillo de Chichén Itzá, therefore, leads him to infer that it was only during the Postclassic that the knowledge of the true equinox may have been acquired (Ponce de León 1991: 431, note 17). While this is an interesting hypothesis, additional evidence is needed to support it. It should also be recalled that the 'grazing Sun' effect is not easy to observe and would have hardly allowed accurate determination of the intended date. It could have had, however, a symbolic significance, and the cases analyzed by Ponce de León certainly call for further systematic research, which should shed light on the validity of the 'grazing Sun' hypothesis.

For the Caracol tower at Chichén Itzá, Aveni, Gibbs and Hartung (1975: 982f) provided support to the former proposal by Ricketson (1928a; 1928b), observing that a diagonal line from inner right to outer left jambs of window 1, opening to the west, corresponds to the sunset on the equinoxes. While a photograph supports their finding (Aveni et al. 1975: Fig. 9), they are careful enough to mention both the possibility that some of the blocks composing the window have shifted from their original positions and the difficulties involved in observing the event (which could be seen only from the floor level, due to the oddly inclined and apparently misplaced block of the inner right jamb); for these reasons, the 'solar equinox alignment in window 1 remains problematical' (*ibid.*: 985). The fact that no other similar devices have been found further weakens the intentionality of the equinoctial alignment, and even of other astronomical sightlines presumably incorporated in the Caracol (cf. Schaefer 2006: 42ff).[6]

Templo Mayor of Tenochtitlan

Fray Toribio de Benavente o Motolinía (1971: 51), a Spanish friar who arrived to Mexico soon after the Conquest, writes that the Aztec feast of Tlacaxipehualiztli 'fell when the sun was in the middle of Uchilobos, which was the equinox'. This comment, referring to the main temple in the Aztec capital of Tenochtitlan, as well as the map of the city attributed to Cortés, where the face of the Sun is shown between the twin sanctuaries of the temple (Aveni 2001: Fig. 84), suggest that the building currently known as *Templo Mayor* was aligned to sunrise or sunset on a certain date. In the attempt to reconcile Motolinía's statement and the image on the map of Cortés with the orientation of the temple, which is skewed notably south of east, Aveni and Gibbs (1976: 513ff) and Aveni, Calnek and Hartung (1988) proposed that the observations were made at the equinoxes from a spot at the ground level west of the temple; due to the building's height, the rising Sun appeared in the notch between the two upper sanctuaries only after it had moved considerably south of the east-west line. Since they did not observe any notable change in the temple's orientation throughout its various construction stages, Aveni et al. (1988: 297), after discussing different possibilities to overcome the problem, concluded that this conformity 'may be taken to imply either that the differences of linear height between observer and sun disk were always kept constant in the engineering problem, or that the desire to preserve the equinox orientation, once established, simply was abandoned.'

The difficulty of the first option, apparently reflected in the authors' remark that 'a number of pieces of the orientation puzzle still do not fit perfectly' (*ibid.*), is in that the angular height of the notch with respect to observer could have hardly been kept constant: as the temple grew in height, the observation point would have had to be moved either farther away or to a higher level above natural ground. While this scenario finds no support in archaeological evidence, the alternative option – implying that the alignment was preserved in the late buildings but lost its function – contradicts Motolinía's comment, which obviously refers to the latest construction stage of the temple used at the time of the Spanish Conquest. The problem, however, has another solution, which is in perfect accord with both Motolinía and archaeological evidence.

Aveni and Gibbs (1976) and Aveni, Calnek and Hartung (1988) assumed that the orientation of the early and best preserved Phase II of the Templo Mayor was maintained

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[6] Inspecting the windows of the Caracol tower in 2010, we noticed that the inner right blocks of window 1 are now missing.

in subsequent construction stages. This assumption was supported by the north-south alignment azimuths, which remained virtually the same throughout the temple's construction history. Precise measurements in the Templo Mayor precinct revealed, however, that the east-west running walls of Phase III adopted a different orientation, which was maintained in all the following phases up to the Conquest, and incorporated also into many adjacent structures. One of the two sunset dates corresponding to the east-west axis of the temple's late construction stages, including the last one, is April 4, which in the sixteenth-century Julian calendar corresponded to March 25. In 1519, this was the last day of the month of Tlacaxipehualiztli, according to the correlation of the Mexica and Julian calendars established by Caso (1967: 58, Table IV) and supported by different kinds of evidence (Prem 1991). Various sources, including Motolinía (1971:45), indicate that the main feast of every month was celebrated on its last day (Caso 1967: 39, 51; Prem 1991: 395). On the other hand, March 25, the Feast of the Annunciation was, in medieval Europe, commonly identified with the vernal equinox (McCluskey 1993: 110f, 114; Newton 1972: 22ff).[7] We can thus conclude that Motolinía's (1971: 51) statement quoted above did not refer to the astronomical equinox (the date of which would have hardly been known to a non-astronomer at that time). Rather, he only noted the correlation between the day of the Mexica festival – which in the last years before the Conquest coincided with the sunset along the axis of the Templo Mayor – and the date of the Christian (Julian) calendar that corresponded to the traditional day of the spring equinox (for the whole argument see: Šprajc 2000; 2001: 383ff).

Both the text in Motolinía and the drawing of the Templo Mayor in the map of Tenochtitlan attributed to Cortés, where the Sun disk is shown between the twin sanctuaries, have frequently been interpreted as references to the observation of *sunrises*, but the sources are far from explicit. The fact that Marquina (1960: 113), paraphrasing Motolinía, mentions the Sun 'in front of Huichilobos' shows clearly that the text is ambiguous and may well refer to *sunsets* along the building's axis. The very fact that the temple faces west suggests a special importance of that direction.

Finally, let us recall that, whereas the hypothesis forwarded by Aveni and Gibbs (1976) and Aveni, Calnek and Hartung (1988) implies an alignment to a celestial target well above the horizon, the astronomically and calendrically significant patterns of dates recorded by Mesoamerican architectural orientations are consistent with horizon-based observations. Indeed, orientations similar to that of the late stages of the Templo Mayor of Tenochtitlan (5°36' south of east) seem to have been common in the neighboring area of Texcoco (Šprajc 2001: 322, 324f, 330). The agreement between the text in Motolinía and one of the two sunset dates corresponding to the archaeologically attested orientation of the late phases of the Templo Mayor is thus hardly coincidental and offers probably the most convincing support to the conclusion that this structure, as so many others, was intentionally oriented to the Sun's positions on the horizon, although not at the equinoxes.

[7] Even if the canonical date of the ecclesiastical equinox established in A.D. 325 by the Council of Nicaea was March 21, the Roman tradition associating the equinox with March 25 also survived (Newton 1972: 22ff).

Alta Vista

In their analysis of astronomical aspects of Alta Vista, Zacatecas, Mexico, located almost exactly on the Tropic of Cancer, Aveni, Hartung and Kelley (1982a; 1982b) affirm that a passage called Laberinto and aligned to the Cerro Picacho on the eastern horizon marks sunrises at the equinoxes with impressive precision. They support their statement with both alignment data and photographs. Among the alignments detected in Mesoamerican archaeological sites and claimed to refer to the equinoxes, this is one of the very few that are both exact and clearly marked by material remains preserved *in situ*.

Aposento de Moctezuma

According to Galindo (2003: 64ff), the platform constituting the so-called Aposento de Moctezuma, on the eastern slope of Cerro de Chapultepec within Mexico City, is oriented to Mount Tláloc, which marks the equinoctial position of the Sun on the eastern horizon. The orientation of this structure, in view of the author's description, cannot be determined with precision, making it difficult to reliably establish its possible astronomical referent and to assess its intentionality.

Teotihuacan

Aveni and Hartung (1982: 28f; Hartung & Aveni 1991: 34f) mention that the alignment involving the Pyramid of the Sun and two petroglyph complexes located to the west (labeled TEO 11 and TEO 16) marks the equinoctial sunsets with considerable accuracy. The problem concerning the intentionality of this alignment is that the two groups of rock carvings are of different types and that, due to the large number of petroglyphs in the area of Teotihuacan, one can trace numerous lines connecting them. That two of these designs align with both the Pyramid of the Sun and the equinoctial sunsets certainly calls attention, but one wonders how (un)likely it is, in statistical terms, for this arrangement to have been produced by chance (cf. Ruggles & Saunders 1984).

Cempoala

As pointed out by Galindo (1996) and confirmed by our measurements, the orientation of the Postclassic Templo de las Caritas at Cempoala, Veracruz, Mexico, corresponds quite accurately to sunrises at the equinoxes. The intentionality of this correspondence remains questionable, however, because the same orientation agrees also with sunsets on the quarter-days of the year. Significantly, the orientation of the much larger Templo Mayor of the same site also corresponds to quarter-day sunsets, but cannot be related to sunrises at the equinoxes (Sánchez & Šprajc 2012).

Other cases

A number of other equinoctial alignments have been claimed to exist in Mesoamerican architecture and urban patterns. Aside from being impossible, it would be pointless to discuss all these proposals, because they involve methodological incoherencies that prevent their verification. Some authors present deficient or imprecise data, leaving the possibility that other astronomical referents – if any – may have been involved; others construct alignments connecting different architectural elements of a single building, different buildings at a site, or different architectural groups or sites in an area, without employing any consistent methodology in alignment selection and analysis. Several of these problems are often combined, and the resulting astronomical hypotheses thus remain entirely speculative. Two cases should illustrate the point.

In the distribution of archaeological sites in the Holmul region in Belize, Tomasic (2009) identifies solstitial and equinoctial alignments, but recognizes that errors of up to 2° are involved. Since only three alignments are discussed, such low precision data do not allow their possible astronomical referents to be determined with any confidence. Furthermore, two architectural groups, claimed to mark equinoctial and summer solstice sunrise directions from Holmul, were found as a result of survey transects that were made in these directions precisely because of their preconceived astronomical significance. This procedure, obviously, raises methodological objections, because one wonders how many other sites or building complexes would have been found had the surveyors followed other directions; considering high settlement density in the Maya Lowlands, this is by no means a pedant question. Clearly, only objectively collected data on site distribution and typology in an area may serve as a reliable basis for assessing possible astronomical potentials of intervening alignments. Alternatively, if unique cases are dealt with, some other indications of underlying intent should be sought; in the absence of independent contextual evidence, a building clearly oriented to another one, for instance, may at least hint at a deliberate spatial relation between the two.

To cite one more example, Méndez et al. (2005) found an equinoctial alignment in the Temple of the Sun at Palenque, Chiapas, Mexico. In fact, this is only one of a number of astronomical alignments they identified, both in the complex architectural composition of this building and in its relation to the surrounding architecture and topography. However, their alignment selection criteria are neither made explicit nor respected in practice: instead of analyzing all possible corner-to-corner, pillar-to-pillar or other sightlines along comparable features, they choose those that match the astronomical targets they believe to have been significant: the solstices, equinoxes, zenith and nadir passages of the Sun, and lunar standstills. While it is certainly possible that some of these alignments were achieved on purpose, the authors' procedure seems to be biased by their own prejudices: none of their celestial events figures prominently among the targets of axial orientations in Mesoamerica, including the Maya area (Aveni & Hartung 1986; Aveni, Dowd & Vining 2003; Šprajc 2001; Šprajc & Sánchez 2012; Sánchez & Šprajc 2012). It is fair to add that a comprehensive analysis of all possible alignments in the Temple of the Sun would be, indeed, a formidable task, and not a particularly productive one if no other comparable buildings were also included.

Summary

The cases discussed above represent a very mixed bag, but we hope we have been able to show that, in spite of the popularity of equinoctial pilgrimages to Mesoamerican archaeological sites, and although even many serious researchers still believe that the Sun at the equinoxes had an important role in the precepts dictating architectural design and urban planning, the evidence in favor of this opinion is, at best, scanty.

In Group E at Uaxactún, the Temple of the Seven Dolls at Dzibilchaltún, El Caracol of Chichén Itzá and the Templo Mayor of Tenochtitlan, the alignments that could have been related to the equinoxes are not unequivocally attested in archaeological record, but are rather constructed on the basis of certain assumptions. In the case of the Sepulturas group at Copán, the equinoctial hypothesis is ruled out by the effect of horizon altitudes. Temples I and III of Tikal compose an alignment whose intentionality has no visible support, because neither of the two buildings is oriented to the other; if we nonetheless assume an astronomically-based rationale of their spatial relationship, the resulting observationally functional alignments could only have served to record solar positions on quarter-days of the year. The Aposento de Moctezuma does not allow its orientation to be established with sufficient precision. The line connecting the Sun Pyramid of Teotihuacan and two petroglyph areas agrees with equinoctial sunsets, but the intentionality of this correspondence is, in view the circumstances discussed above, open to question. A similar caution applies to the line connecting Structure 41 and the Temple of the Seven Dolls at Dzibilchaltún. The famous light-and-shadow effect at El Castillo of Chichén Itzá could not have served as a precise marker of any date; if it only had a symbolic significance, the commemorated dates may have been either the true equinoxes or some other nearby dates, including quarter-days. Finally, many allegedly equinoctial alignments, which involve certain buildings on a site, architectural features within a building, or sites in an area, have been selected arbitrarily and considered significant only because they fit the preconceptions about the importance that the equinoxes should have had. Consequently, the alignments embedded in the Laberinto passage at Alta Vista and in the Templo de las Caritas at Cempoala seem to be the only equinoctial directions clearly indicated in the preserved architectural remains. Having only two cases, however, we cannot ascertain whether they, indeed, reflect the purpose of recording the equinoxes.

The doubt cast on most, if not all, of the claimed equinoctial alignments discussed above is based particularly on the known distribution patterns of architectural orientations in Mesoamerica. The buildings clearly exhibit their axial orientations; the fact that the corresponding horizon declinations evidently cluster around certain values indicates that the important civic and ceremonial structures were, in most cases, deliberately oriented to celestial events on the horizon. Since most of the east-west axes lie within the angle of solar movement along the horizon, it is also highly likely that they refer to the Sun's positions on certain dates. One of the most evident declination groups is centered on approximately 1°, probably referring to the quarter-days, but truly equinoctial orientations are virtually absent. It is for this reason that, for several of the cases discussed above, we have suggested the quarter-day Sun as a more likely target.

While it would be imprudent – despite the foregoing arguments – to dismiss outright the possibility that some alignments were intended to record the true equinoxes, it does seem significant that the scarcity of equinoctial dates, in contrast to relatively frequent references to the solstices, has also been observed in Maya inscriptional records (Nikolai Grube, personal com., 2011). In agreement with this fact is the ethnographic information given by Vogt (1997: 111) for the Tzotzil Maya of Zinacantan, Chiapas, Mexico: while they are acutely aware of the solstitial positions of the Sun, and even have names for the solstices in their own language, there are no words in Tzotzil to describe the equinox, nor do the modern Zinacantecos seem to be aware of the equinox positions of the Sun on the horizon. If the equinoxes, indeed, appear in Maya codices, as has been argued (cf. Bricker & Bricker 1988; Bricker & Vail 1997), we should recall that they are all from the Postclassic period; this might suggest that the concept of the equinox came to be understood only in later times.

These cautions notwithstanding, we can conclude that the popularity of ideas about the importance of equinoxes in prehispanic Mesoamerica is, with respect to the real significance they may have had, tremendously disproportionate. If the goal of modern pilgrimages to archaeological sites is to recover the ancient wisdom on ancestrally important dates, the equinoxes are definitely the least suitable for these purposes. To judge by the alignment data, we can be reasonably certain about which were the most special days in one or another civic and ceremonial center. Equinoctial invasions should thus be replaced by visits more evenly distributed through the year; such rescheduling may not guarantee a more effective transmittal of ancestral values and spiritual energy, but would certainly have beneficial effects for the conservation of Mesoamerican archaeological heritage.

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Possible Mesoamerican Naked-Eye Observation of Sunspots – III: Evidence from the Hauberg Stela

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Abstract

Many cultures of antiquity have made naked-eye observations of large sunspot displays. The Chinese, Japanese, Koreans, and Greeks, have all made such observations. Pictorial evidence on dated Mesoamerican monuments suggests that similar observations may have been made in the New World as well. In this regard, the object known as the Hauberg Stela is of particular interest. It depicts a spotted Sun God as Kinich Ahau (or possibly the Maize God) in profile with a sunspot on his cheek. The stela itself dates to 199 AD (or possibly 197 AD) and is the oldest known dated stela, belonging to the Late Preclassic period. The presence of spotted Sun God imagery on a dated – or dateable – artifacts may give important clues about solar activity in pre-telescopic era times.

KEYWORDS: Sunspots, Maya, Hauberg Stela

POVZETEK

Več starodavnih kultur, npr. Kitajci, Japonci, Korejci in Grki, je večje Sončeve pege opazovalo s prostim očesom. Slikovni dokazi na datiranih mezoameriških spomenikih nakazujejo, da so to počeli tudi prebivalci Novega sveta. V tem pogledu je posebno pomembna t. i. Haubergova stela. Na njej je v profilu prikazan pegasti bog Sonca kot Kinich Ahau (ali morda bog koruze), s Sončevo pego na licih. Stela je iz poznega predklasičnega obdobja: z datumom, ki ustreza letu 199 (ali morda 197) n. št., je to najstarejša poznana datirana stela. Prisotnost pegastega boga Sonca na artefaktih, ki jih je mogoče datirati, nam lahko razkrije pomembne podatke o Sončevi aktivnosti v obdobjih pred izumom teleskopa.

KLJUČNE BESEDE: Sončeve pege, Maji, Haubergova stela

Background – The Hauberg Stela

There are many artifacts in Mesoamerica that show a spotted Sun God, usually with three spots on the cheek (Milbrath 1990: 87-88). And, some of these artifacts are dated, or at least datable. Cheek spots have been variously interpreted as an artistic motif possibly representing death spots or jaguar spots. Neither of these ideas has proven completely acceptable because the Sun is associated with growth and the jaguar is a night animal. Another possibility exists, namely that the Maya simply observed large naked eye sunspots as part of their tradition of astronomical observations. A sunspot record, independent of ancient Asian observations, would be an invaluable aid to solar astronomy. In this regard, the Hauberg Stela is of particular interest because it is the oldest dated stela. The exact date of the stela has proven difficult to establish. This report will begin with the first date analysis by Linda Schele (1985) and will conclude with the analysis of Schele, Mathews, and Lounsbury (1990).

The Hauberg stela is a problematic object for several reasons. First, it has been removed from its context. Stylistically, it appears to have originated in the Kohunlich' area of Yucatan Mexico (near the border with Belize) because of the similarity of some of its glyphs to those seen on a masked façade found in that city state. It is currently owned by John Hauberg, hence the name. Second, the stela is in poor condition, with several of its most critical glyphs damaged so that they are either unreadable or ambiguously readable. Third, the stela is of great antiquity. In fact, it is the oldest known dated stela. Style indicates a creation date of 100-200 AD (Schele 1985). Consequently, the glyphs were still evolving and had not yet reached the classic style and ordering that scholars are most familiar with. This last fact makes reading difficult. But, it also makes the stela an extremely valuable tool for tracking the development of writing in the new world. In particular the Hauberg stela may form a vital link between Sun God imagery of the Preclassic period (2000 BC to 250 AD) and the Classic and Postclassic periods (250 AD to 1697 AD). The initial goal of this series of papers is *to correlate the occurrence of well understood and dated spotted Sun God imagery in Classic and Postclassic times with naked eye sunspot observations from Asia, supported by tree ring data, isotope data, and medieval Islamic Nilometer measurements when available.* Once this correlation is established, it will be possible to use Preclassic Mayan imagery (preferably dated) to gauge solar activity during a time period when there is little or no naked eye observational data from Asia. However, Preclassic imagery may look different from the imagery of later periods, and Preclassic dating schemes may differ as well. In this regard, the Hauberg stela is of primary importance because it forms a link between what is understood and what is unknown.

The stela itself is a more or less rectangular parallelepiped with a single vertical column of glyphs on the left, two rows of glyphs on the bottom, and the remainder of the front face of the stela occupied by a standing figure of a ruler nick named 'Bone Rabbit' and his curious accoutrements. The stela is believed to record a bloodletting initiation ritual of leadership that took place 52 days before taking office (Schele 1985). Glyph A1, in the upper left-hand corner, is an introductory glyph for a date that is recorded in the next 5 glyphs. The last of these (A6) is of primary importance for this report. It shows an *Ahau* box with *Plumeria rubra* petals below, and indicates the day *Ahau*. In the box is a portrait in profile. Who is this figure? Two observations may help answer this question. First, the Maya had a propensity for punning, and their language lends itself very easily to this practice. The Sun God *kinich Ahau* (Sun faced lord) is an appropriate name for a day, much as we would use the name 'Sunday'. So, *Ahau* may refer to both the Sun God and to one of the 20 Mayan day signs. Therefore, it would not be unreasonable to suspect that the portrait in the *Ahau* box is the Sun God *Kinich Ahau*. This hypothesis needs to be tested. Schele (1985) refers to this figure as the portrait of a 'young male'. However, the image is foreshortened so that the Mayan artist could fit his text into the allowable height of the stela. Suppose the image is stretched in the vertical direction to make the *Ahau* box square, as it should be. Figure 1 shows the result of this trivial bit of image processing. Now, the head of the 'young male' is more clearly seen. First, he has a mouth volute, a kind of downward extension at the corner of his mouth. Second, he has two 'buckteeth' (egg tooth) protruding from the front of the upper part of his mouth. Third, he has what looks like a kind of band (possibly a sky band) over the top of his head in the ear-to-ear direction. And, most importantly for this paper, as pointed out in a personal communication to Schele in 1982 by Lounsbury et al. (Schele 1985), there is a single 'sunspot' on his face. All of these features, except the sky band, if that is what it is, are characteristics of the Sun God *Kinich Ahau*. It is important to note that in this early stela, the 'Roman nose' of the Sun God is missing. Furthermore, when spots are present on the Sun God in later periods, there are usually three spots arranged so as to form a small equilateral triangle on the cheek. Here, in this Late Preclassic period, we only have one spot. These changes give some clue as to what might be expected when interpreting the iconography of other objects from the Preclassic period. In the next section, the thorny problem of the date on the Hauberg Stela will be addressed.

Figure 1: The Sun God Kinich Ahau in position A6 on the Hauberg Stela. The image has been stretched in the vertical direction so as to make the Ahau box square. The coefficient (3 'rings' to the left of the glyph) indicates the number 3, as in the Mayan date 8.8.0.7.0 3 Ahau 13 Xul (or equivalently October 10, 199 AD).

Historical Naked Eye Sunspot Observations

There are four possible readings of the date in glyphs A1 to A6, owing to ambiguity caused by difficulties in recognition and the unfamiliar presentation of information in this early stela. Two of these possibilities, both pertaining to the year 344 AD, can be eliminated on the basis of style (Schele, 1985). The other two possibilities are more subtle. They correspond to Gregorian dates of October 10, 199 AD and September 16, 135 AD. Schele (1985) thinks the former date more likely. This author agrees with that assessment because there was an outstanding naked eye sunspot display recorded by Hou-han-shu, chih in China during March or April of 187 AD and again in the February to March time frame of 188 AD (Clark & Stephenson 1978). As was demonstrated in the first publication of this series (Zito, 2010), and will be demonstrated many more times in subsequent papers, such multiple naked eye sunspot events were considered portents of political change. And, there appearance during Bone Rabbits life would not have been overlooked by him and his priesthood in hindsight. Such astronomical events would have been recorded on monumental stelas.

With regard to the other date of 135 AD, it should be noted that no naked eye sunspots were observed after the outbreak of March 17, 20 AD or before that of 187 AD. If the spotted Sun God in Mayan iconography is indeed associated with the physical condition of the Sun, it would imply that the October 10, 199 AD date for the Hauberg Stela is the correct date. This is a good example of how spotted Sun God iconography can be used to place artifacts in their proper time context if, as just stated, the association of the spotted Sun God with sunspots is demonstrated.

Carbon-14 Measurements

Examination of the carbon-14 anomaly versus time, as measured from tree ring wood, indicates a drop in ^{14}C production (Zito, 2012) associated with increased shielding of the upper atmosphere from productive cosmic rays by a more dense ionosphere. Such an ionospheric change is caused by increased solar activity. Therefore, the 187 to 188 AD time period was probably a peak in the sunspot cycle.

Tree Ring Measurements

Tree ring (*Pinus longaeva*) measurements for the 180 AD to 200 AD time frame in the southwestern United States do show an expected decrease in ring width of about 50% in the year 189 AD from the abnormally high levels in 188 AD and returning to these levels about 192 AD. Tree ring measurements were taken at Methuselah Walk in California and Hill 10482 in Nevada (USA). Measurements at the first location involved 27 measurements per data point (year) and at the second location 2 measurements (NOAA 2009). This drop is probably traceable to solar activity induced climate change in the 187-188 AD time frame. However, the record is very noisy with additional droughts in 181 and 197 AD, both of which seem unconnected to any solar activity.

Oxygen-18 Measurements

Because the growth of trees is affected by fire, insects, gnawing animals, diseases, and unpredictable local climactic conditions, it would be helpful to have another source of climate information to supplement tree ring data that is inherently noisy. This is especially true for years prior to 622 AD, before Islamic Nilometer data existed. In this regard oxygen-18 data from Greenland ice sheet cores is particularly valuable. The climate of Greenland responds remarkably to changes in solar activity. The 'Medieval Warm' is an example of this. The time period from about 1100 to about 1250 AD was a time when the southern coast of Greenland was at least habitable, if not pleasant, and it was also a time of intense solar activity judging from Asian sunspot records. This was also the time of arrival of settlers from Iceland (Eric the Red) in 983 AD; the settlement (Qagssiarssuk) was later abandoned by the early 1400's when the climate turned much colder. The theory and practice of oxygen-18 measurements will be summarized next.

Water, of course, is composed of two atoms of hydrogen and one of oxygen. But, there are two naturally occurring non-radioactive isotopes of hydrogen; ordinary hydrogen (H) with an atomic mass of unity, and deuterium (D) which is twice as heavy and 6400 times less common. There is a third naturally occurring radioactive isotope of hydrogen as well, but it is so rare that it is of no importance to this discussion. Oxygen has three isotopes as well; ^{16}O (99.76%), ^{17}O (0.04%), and ^{18}O (0.20%), all stable (Lederer & Shirley 1978: 20, 22, 25). All these isotopic abundances come from hydrogen and oxygen extracted from sea water. In fact, there is an official standard water sample called 'Mean Standard Ocean Water', or SMOW. So, there are 9 different types of water; ordinary 'light water' $H_2{}^{16}O$, and 8 types of 'heavy water' ($H_2{}^{17}O$, $H_2{}^{18}O$, $HD^{16}O$, $HD^{17}O$, $HD^{18}O$, $D_2{}^{16}O$, $D_2{}^{17}O$, $D_2{}^{18}O$). Light water has the highest vapor pressure, because of its low molecular weight, and *evaporates* most easily from tropical oceans. So, clouds over the tropical oceans of the world are slightly enriched in light water and slightly depleted in heavy water. However, as this moist air moves north and south, it cools because of its altitude and its increasing latitude. Cooling results in rain and, if the latitude of the air mass is sufficiently high, snow. When precipitation occurs (rain or snow) it is the heavy water components of water vapor that *condense* out first. So, the precipitation that comes from vapor that was partially depleted in heavy water, is now enriched in heavy water. One might think that the two effects offset each other, and they do, but generally not exactly. Furthermore, the further north (or south) of the equator that the air mass moves, the cooler it gets, and the more times precipitation occurs. By the time a tropical air mass reaches Greenland in the north, or Antarctica in the south, the snow fall is significantly enriched in heavy water over light. The colder the Earth's climate gets, the greater the sub-arctic precipitation, and the greater the enrichment of heavy water. When the Earth's climate is warm, the enrichment is less. So, measuring the amount of heavy water enrichment in ice cores taken from Greenland and Antarctica can reveal a lot about the Earth's climate history. The deeper the ice sample, the older the water. Since Greenland (like Antarctica) is a continental land masses, the ice sheet is 1,390 m thick (at Camp Century), and this entire depth has been cored, representing a heavy water history of approximately 100,000 years. In practice, only the ^{18}O enrichment is measured since this is the most abundant (and, therefore, the easiest to measure) of the rare heavy isotopes. The enrichment, called the oxygen-18 anomaly, δ (expressed in parts per thousand, ‰) is, of course, measured relative to SMOW so that (Faure 1977: 325)

$$\delta^{18}O = \{ [(^{18}O / ^{16}O)_{sample} - (^{18}O / ^{16}O)_{SMOW}] / (^{18}O / ^{16}O)_{SMOW} \} \times 10^3 ‰ . \quad (1)$$

If enrichment in deuterium is measured (less common) instead of ^{18}O, then

$$\delta D = \{ [(D / H)_{sample} - (D / H)_{SMOW}] / (D / H)_{SMOW} \} \times 10^3 ‰ . \quad (2)$$

Figure 2 shows $\delta^{18}O$ for Camp Century in Greenland as a function of date and ice depth for the Common Era (Dansgaard et al. 1969). Assumptions have been made regarding the relationship between depth and date. In particular it was assumed that ice sheet thickness grows uniformly. However, recent global warming has disrupted this relationship a little. For example, the $\delta^{18}O$ peak at 1825 AD (off the scale in Figure 2) corresponding to the Dalton sunspot minimum, and global cooling, is displaced by 25 years from where it should be. That is to say, the peak is too close to the surface due to recent ice sheet melting. This 25 year error should be kept in mind when examining ^{18}O data. The $\delta^{18}O$ data in the time neighborhood of the year 200 AD is relatively flat, so there is little chance of error, and has a value of about -28.5‰. This high value of δ suggests a warm climate and an active Sun, in agreement with Asian naked eye observations, carbon-14 measurements, and tree ring measurements.

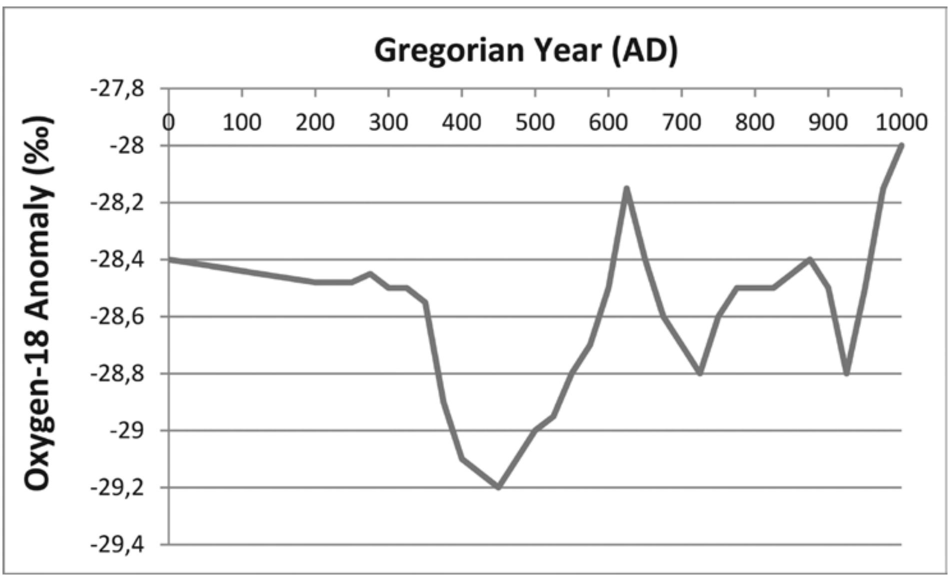

Figure 2: The Oxygen-18 anomaly relative to SMOW for the first millennium of the Common Era.

Summary

The commemorative Hauberg Stela tells the story of Bone Rabbit's coming to power and initiation in 199 AD. The stela would not have failed to record the solar events 11 years earlier as a 'sign' by the Sun God that an important change of power was imminent. This type of prognosticator seems to have been established by the time of the *'Entrada'* (Zito 2010) and, as will be shown in subsequent publications, the kings who were born, or ascended the throne, during times of the active Sun adopted the spotted Sun God as part of their emblematic accoutrements. The reliability of the Asian naked eye sunspot reports is probably high, since they are supported by physical data in the form of carbon-14 measurements, oxygen-18 measurements, and tree ring measurements. It is doubtful that the observer (Hou-han-shu, chih) was simply observing some transient atmospheric phenomena.

Although there has been some uncertainty about how to read the date on the Hauberg Stela, there seems little doubt that it would have to be *after*, and *within a lifetime* (perhaps 40 years in Preclassic Mesoamerica), of 188 AD. Of the original four possibilities, the only date that makes sense is the October 10, 199 AD date. In that case, the Hauberg's mysterious glyph A4 may indeed signal a 'Yucatec-style' date (requiring a 1 to be added to the coefficient 12 of the glyph in position A2) as suggested by Schele (1985)[1]. It is most unfortunate that half of the markings internal to glyph A4 have been obliterated by the ravages of time. Nevertheless, this Terminal Late Preclassic model date may aid in the decipherment of other Preclassic dates.

Finally, recognition of the Sun god is always problematic when a name is not attached to the icon, or at least written nearby. In this regard it should be noted that a re-dating of the Hauberg stela was made by Schele, Mathews and Lounsbury (1990). In this more recent decipherment glyph A6 is interpreted as the Maize God, and the equivalent Gregorian date is March 19, 197 AD. Certainly there is much to be said for this interpretation. The Maize God, personified by Hun Hunahpu, is the father of Hunahpu, one of the

[1] Deciphering an ancient language is, in principle, no different than breaking any code. Therefore, unambiguous decipherment is only guaranteed if the length of available glyph text (intercepted ciphertext) exceeds the 'unicity distance'; the minimum amount of information (ciphertext) required to uniquely determine the 'key', or rule of translation (Konheim 1981: 61-62). In that case, a meaningful probability distribution (frequency of occurrence) of Mayan glyphs can be constructed and compared, for example, to the frequency distribution for certain words or syllables in derivative modern Mayan languages to effect a decipherment (Coe 1999: 50). First, the most common glyphs can be matched to the most common syllables. Then, the next most frequent glyphs and syllables are matched, etc. However, when a new, unique, glyph is discovered (a fairly frequent event), there is no immediate way to determine its frequency of occurrence. In that case, mathematical decipherment (as opposed to epigraphic decipherment) is theoretically impossible, and solution must rely on side information provided by the often inspired insights and interpretations of epigraphers. In the case of the Hauberg Stela, the side information for the decipherment of A4 is provided by the spotted Sun God image. In summary, even though thousands of glyphs have been catalogued (e.g. Thompson 1976), the number of Mayan hieroglyphs is so large that the unicity distance has not yet been reached! This difficulty was anticipated by Berlin as early as 1963 on the basis of qualitative arguments (Berlin 1963). Had Landa not burned the Mayan library at Merida, this regrettable shortfall of information would probably not have occurred.

Hero Twins who eventually becomes the Sun (Miller and Taube 1993: 69). Therefore the Maize God and the Sun God are related by both divine lineage as well as agricultural necessity. So, it would not seem unreasonable for the Maize God to display a sunspot during an active phase of the Sun. As will be described in the seventh paper of this series, something similar occurs with the Venus God who is the 'brother' of the Sun and is closely related astronomically as well. Also, 197 AD is even closer to the date of the actual solar outbursts than the original date of 199 AD. Finally, the March 19, 197 date may explain the curious coefficient of 17 in glyph A5. On the negative side, the head in glyph A6 does not look very much like the Maize God. First of all, images of early Maize Gods (Fig. 2 of Schele et al.) all show an elaborate headdress with curling 'plums' that represent the golden tassel at the top of an ear of corn (Miller and Taube 1993: 109). This is a persistent signature device in Mayan art that is cleverly transformed into tresses of hair in later periods. The A6 headdress does not have any convincing plumes of this kind. But, perhaps they were omitted or abbreviated to a few strokes (see Figure 1) to save vertical space. Second, the 'vertical and scroll' markings on the cheek of early Maize Gods are probably not equivalent to the cheek spot in A6. Finally, the A6 headdress seems to have a kind of sky band skull strap not seen in Maze God representations. So, there are some problems associated with recognition. Nevertheless, the reinterpretation of the Hauberg date by Schele et al. (1990) needs to be taken into account.

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Possible Mesoamerican Naked-Eye Observation of Sunspots – IV: Evidence from Tikal Stela 31

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Abstract
Many cultures of antiquity have made naked-eye observations of large sunspot displays. The Chinese, Japanese, Koreans, and Greeks, have all made such observations. Pictorial evidence on dated Mesoamerican monuments suggests that similar observations may have been made in the New World as well. In this regard, the object known as Tikal Stela 31 is of particular interest. It depicts a spotted Sun God as the father of the Tikal king known as 'Curl Snout', who ascended the throne in 379 AD and died in 404 AD. Curiously, outstanding naked eye sunspot displays were seen four years before Curl Snout became king, and four years before his death. In retrospect, Mayan priests would have associated the sunspot displays with the change in political power, and recorded the phenomena on historical Stela 31.

KEYWORDS: Sunspots, Maya, Tikal, Stela 31

POVZETEK
Več starodavnih kultur, npr. Kitajci, Japonci, Korejci in Grki, je večje Sončeve pege opazovalo s prostim očesom. Upodobitve na datiranih mezoameriških spomenikih nakazujejo, da so to počeli tudi prebivalci Novega sveta. V tem pogledu je posebno pomembna Stela 31 iz Tikala. Na njej je pegasti bog Sonca prikazan kot oče tikalskega kralja, znanega kot 'Kodrasti rilec', ki je zasedel prestol leta 379 in umrl leta 404 n. št. Nenavadno je, da so zelo izrazite Sončeve pege s prostim očesom opazili štiri leta pred začetkom vladavine Kodrastega rilca in tudi štiri leta pred njegovo smrtjo. Verjetno so majevski svečeniki pojav Sončevih peg retrospektivno povezali s spremembo politične oblasti in to zabeležili na zgodovinsko Stelo 31.

KLJUČNE BESEDE: Sončeve pege, Maji, Tikal, Stela 31

Background – Stela 31
At the south entrance of Tikal's North Acropolis lies the structure known as 5D-33. This four sided pyramid is actually 3 pyramids, one covering the other in a complex way so that some part of each structure is still visible. The earliest structure is called 5D-33 3rd, and the latest 5D-33 1st. The excavations of 1959 and 1960 ultimately revealed the struc-

ture tourists see today. However, the real treasure of 5D-33 was what was discovered by tunneling under 5D-33 1st. Finds included the burial chamber of king Siyaj Chan K'awiil II (Burial 48) with a Mayan date on the chamber wall corresponding to March 18, 457 AD (Coe 1967: 46-49). This is not the only burial to be found in the North Acropolis. Under pyramid 34 another royal burial (burial 10) was found. This was king Yax Nuun Ayiin I, known by the grave goods that were found in his tomb (Martin & Grube 2000: 32-36). It seems that at least some pyramids were also used as funerary temples. Yax Nuun Ayiin I ascended the throne in 379 AD, and died in 404 AD. This is known from inscriptions on the object known as Stela 31 (Martin & Grube 2000: 32-36).

Of all the objects found while tunneling under 5D-33 1st, Stela 31 was perhaps the most remarkable. This beautifully carved limestone monolith was buried in a solidly filled room in 5D-33 2nd (Coe 1967: 46-49) just above burial 48. The stela had been ritually burned before burial in the 8th century and structure 5D-33 1st was built above it (Coe 1967: 46-49). It was as if the 'sacrifice' of the stela marked the end of one dynasty and the accession of a new dynasty, with a new building program, as the Postclassic period was soon to begin. Examination and decipherment of the stela over the past 50 years has yielded a wealth of information. First of all, Stela 31 is an historical monument that records royal lineage, and was originally placed at the base of 5D-33 2nd. The stela was dedicated in the year 445 AD (Martin & Grube 2000: 32-36) during the reign of Siyaj Chan K'awiil II as a kind of political advertisement or reminder. There are 3 figures on the stela (Martin & Grube 2000: 32-36). The figure on the broad front face of the stela is Siyaj Chan K'awiil II (also known by the short nicknames 'Sky Born' or 'Stormy Sky') in profile. His nickname can be found in his elaborate headdress just above his head (Martin & Grube 2000: 32-36). This 'autograph' consists of a glyphic block containing a sky band with turbulent curling clouds sprouting from the block (hence the nickname 'Stormy Sky'). Some iconographers interpret the turbulent curling clouds as the sky being split open to give birth to the new king (hence the nickname 'Sky Born'). However, this author thinks the first interpretation is the correct one. Near the very top of the headdress is an 'Ahau' ('Lord') Sun glyph block containing four small circles near its perimeter to mark the solar cardinal directions (east-sunrise, zenith-midday heat, west-sunset, and nadir-night Sun) (Stone & Zender 2011: 153). There is also one interior spot (Coe 1967: 46-49). Hanging from the Sun glyph is an area containing the three facial spots so characteristic of the spotted Sun God, with each spot marking a vertex of a small equilateral triangle. Finally, as the spotted area descends, it morphs into a curled nose (the emblem of Stormy Sky's father Yax Nuun Ayiin I, or 'Curl Snout') (Figure 1). The message here is that Curl Snout is descended from the Sun God. So, apparently, the lineage, moving down from the top of the headdress to the head of the central figure, is Sun God (up there in the sky) - Curl Snout - Stormy Sky (here on Earth). And the figures on each side of Stela 31, who are they? They are both Curl Snout, in military dress. Both of these two figures carry a spear thrower, and the figure on the right wears a well designed combat helmet that protects the jaw, cheeks, and temples in a style reminiscent of a Greek combat helmet circa 500 BC. These ideas are further reinforced by a pottery container found in a cached offering under the west stairway of Early Classic structure 5D-46 on Court 6 of the Central Acropolis, Tikal (Coe 1967: 69-70). The outer surface of this container shows an ‘Ahau’ box with the frontal portrait of the Sun God inside. The Sun God is spotted. Under the box is attached a *kin* sign so that the two glyphs together read *kinich Ahau* (or Sun faced Lord). And, under the *kin* sign is the usual Curl Snout emblem glyph. The story is as old as civilization itself. Kings need to justify their claim to the throne by identifying the Gods as their progenitors. Hatshepsut, the famous New Kingdom queen of Egypt, claimed to descend from the God Amen (Weeks 2005: 155). And, Julius Caesar claimed the Goddess Venus as an ancestor (Hanford 1982: 19). And, even until recent times the Divine Right of Kings can be traced to this tradition. However, in the case of Curl Snout, identification isn’t just with any Sun God – *it is with the spotted Sun God*. That is different and unique. The reason for this will be established in the next section.

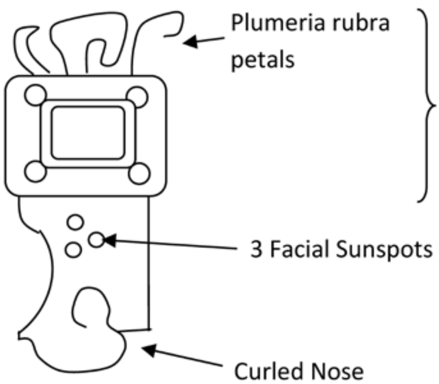

Figure 1: Stela 31 glyphs of Curl Snout as a descendant of the Sun.

Historical Naked Eye Sunspot Observations

Large sunspots are naked-eye objects which, during multiple spot displays, can cover as much as 1% of the solar disk (Murdin et al. 1979: 159-170). However, coverage in excess of only 0.05% of the central part of the solar disk allows naked-eye observation of sunspots (Bray & Loughhead 1964: 229). Many cultures in antiquity have observed naked eye sunspots. These include cultures in China, Japan, Korea, and Greece. According to Asian records (Clark & Stephenson 1978), there were many great naked eye sunspot displays during Curl Snout’s life. First, there was a series of six events that started in 369 AD and terminated in 375 AD, just 4 years before Curl Snout ascended the throne. The dates of these events are 7 November 369, 29 March 370, 28 January 373, 26 December 373, 6

April 374, and 10 January 375. During Curl Snout's life there were four other naked eye sunspot events (2 April 388, 17 July 389, 13 December 395, and finally 6 December 400 AD). The last event was four years before Curl Snout's death in 404 AD, and also foretold Stormy Sky's rise to power in 411 AD. All of these observations, from the beginning of the series in 369 to its termination in 400 AD were made by Chin-shu in China, and Sun worshipers like the Maya could hardly have missed them. After 400 AD there was not another Asian sunspot sighting for the next 99 years!

How would the Maya have reacted to such extraordinary astronomical events? There was a tradition already in place of astronomical divination. And, in hindsight, it would have seemed to the Mayan priest/ astronomers that the spotted Sun was a kind of 'presence' in Curl Snout's life. It presaged both his coming and departure by 4 years, and it shadowed him throughout his life. And when Curl Snout ceased to exist, so did the sunspots. It is no wonder that the spotted Sun glyph appears above his name sign! In addition, Stormy Sky himself could trace his own accession to power to the event of 400 AD, and he was certainly born before the sunspot events of 388, 389, and 395 AD, so why aren't there other spotted Sun God images on his body? Well, there are, cradled in Stormy Sky's left arm (at his elbow), and hanging from the front of his belt with a *kin* sign attached, are two spotted Sun God heads!

Carbon-14 Measurements

When the Sun is in an active phase, showing many sunspots, the stream of low energy protons that continually boils off the Sun and showers the Earth (solar wind) is relatively dense. These particles are trapped by the Earth's magnetic field and form a blanket around the Earth that shields it from high energy galactic cosmic rays. When the Sun is active, the blanket is thick and many cosmic rays are excluded. When the Sun is quiet, the blanket is thin and more cosmic rays (mostly high energy protons) are allowed into lower regions of the atmosphere where they can impact atomic nuclei and punch out a shower of lower energy neutrons. These neutrons can go on to interact with ^{14}N nuclei to produce ^{14}C according to the reaction

$$n + N^{14} \rightarrow C^{14} + p^{+} \ . \qquad (1)$$

Therefore, the amount of ^{14}C produced is modulated by the level of solar activity. The variations are on the order of 0 to 100 parts per thousand (ppt is denoted by the symbol ‰) above or below the average C^{14} level relative to the total amount of stable carbon C; where C = ^{13}C + ^{12}C. This radiocarbon anomaly (denoted by δ) is given by

$$\delta^{14}C = \{ [(^{14}C / C)_{sample} - (^{14}C / C)_{mean}] / (^{14}C / C)_{mean} \} \times 10^{3} \text{ ‰} . \qquad (2)$$

All isotopes of atmospheric carbon eventually ends up in the biosphere were they can be extracted from tree rings, thereby establishing a relationship between the Gregorian date and ancient ^{14}C levels (i.e. $^{14}C/C$). Of course, corrections must be made for the fact that ^{14}C is radioactive and undergoes decay with a half life of 5,000 years. Also, 'isotopic fractionation' occurs due to the chemical reactions in a living tree that may favor lighter isotopes of carbon over the heavy radioactive isotope. That is to say, biochemistry can upset the isotopic ratios. After reversing the effects of isotopic fractionation on δ, a corrected radiocarbon anomaly $\Delta^{14}C$ can be calculated.

Now, the reservoir of atmospheric C^{14} is large, and does not drop instantly as soon as solar activity increases. There is a delay on the order of 50 years. So, in a graph of Δ versus time, the maximum of solar activity will usually correspond to the trailing edge of a dip in Δ, not to the very bottom of the dip. Also, the large atmospheric reservoir of ^{14}C tends to average out small changes in solar activity so that only general trends can be discerned. Figure 2 shows a plot of the fractionation corrected radiocarbon anomaly versus time for the first millennium of the Common Era (Damon & Sonett 1991). Examine the value of Δ between the years 369 AD and 400 AD. The values all lie on the trailing edge of a significant dip. This is just what would be expected for an era of exceptional sunspot activity.

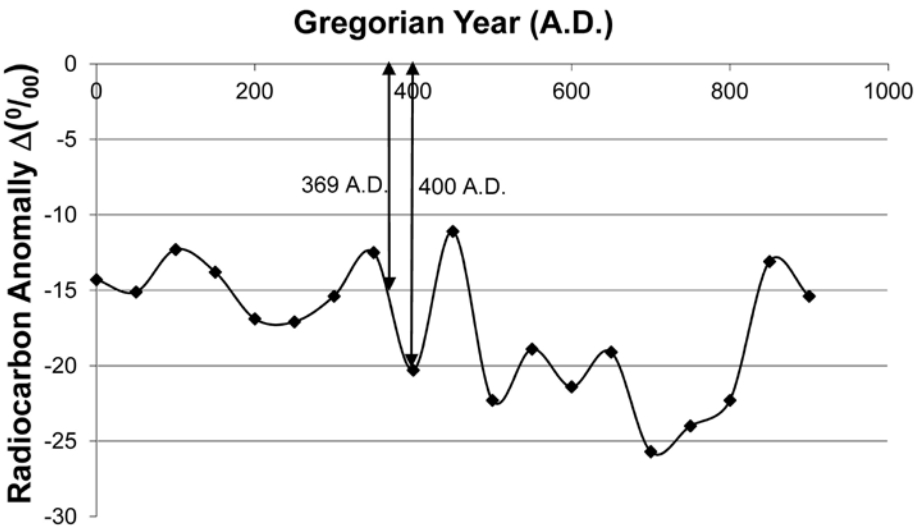

Figure 2: The atmospheric C^{14} history for the first millennium of the Common Era. The decline in C^{14} between the years 369 and 400 AD is associated with an active sun.

Tree Ring Measurements

The tree ring data of Figure 3 is a 30 year continuation of the tree ring data for *Pinus Longaeva* presented in the first paper of this series for the Tikal Ball Court Marker (Zito, 2010). High sunspot activity correlates with drought years in the southwestern part of the United States (narrow tree rings). However, the correlation is not perfect, and extra *El Niño* events can occur which can make the climate abnormally damp (wide tree rings). Such interference was not a problem for this 30 year set of data. Two sites were used to sample the American southwestern climate; Methuselah Walk in the White Mountains of California, and Hill 10842 in Nevada near the Utah border. All data from Methuselah Walk was collected by D.A. Graybill (NOAA 2009) and involved 23 to 26 samples per year for the 382-411 AD time period. All data at Hill 10842 was collected by V.C. Lamarche and C.W. Ferguson (NOAA 2009) and involved 5 samples/yr for the same time period. The comparison of dips in the tree ring growth pattern with naked eye sunspot activity is clear. There are 3 dips in the years 387, 392, and 400 AD. These correspond to the double sunspot event in years 388 and 389, and single events in the years 395 and 400 AD. The fact that the dip in 387 leads the sunspot observations by one year simply means that active solar conditions were well underway before the actual observations of naked eye sunspots were made. The same is true for the dip in 392 which leads the observations by 3 years. Comparison of Asian observations with tree ring data and C-14 measurements reinforces the idea that the observations made were true sunspots and not just atmospheric phenomena.

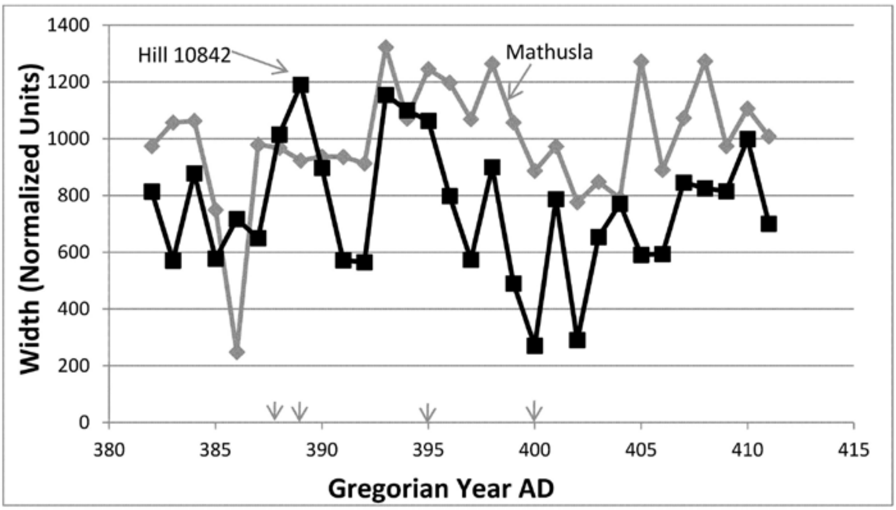

Figure 3: The arrows along the time axis mark the years of great sunspot displays. Tree ring data is for the annual June to August growth of Pinus Longaeva (Rocky Mountain Bristle Cone Pine). Tree ring widths are from the International Tree Ring Data Bank (NOAA, 2009). Widths are in 'normalized' units such that 1000 represents average growth. A 'width' less than 1000 indicates drought conditions, and above 1000 indicates wet conditions. Climate normally accounts for 63% of the growth variance (Fritts 1976: 379).

Summary and Conclusion

It is tempting to associate the sunspot event of 400 AD with the sunspot glyph on Stela 31. First of all, Stormy Sky would want to emphasize the fact that his father has passed on, and now *he* is king; the event of 400 AD presaging Curl Snout's death by 4 years (four Mayan vague years). But, another massive naked eye sunspot event in 375 AD presaged Curl Snout's coming to power in 379 AD. Again the prognostications (or 'omens') preceded events by 4 years. Moreover, the number 4 is particularly relevant to the Sun because the Sun marks the 4 cardinal directions. Indeed, the personification of the number four *is* the Sun God. So, perhaps the sunspot glyph pertains to both Curl Snout's rise to power and his death, or all the sunspot events from 375 to 400 AD. Or, possibly even from 369 to 400 AD, the duration of the entire series of solar events. It is impossible to tell, at present, which of these interpretations is correct. However, it is important to keep in mind that *the spotted Sun God may refer to a series rather than a single event*. A similar observation applies to the spotted Sun God on the *Tikal* Ball Court Marker (naked eye events in 369, 370, twice in 373, and 375 AD) (Zito, 2010), and to the Hauberg Stela (naked eye events in 187 and 188 AD) discussed in the previous paper of this series.

It is of considerable interest that Tikal Stela 1 (undated) also shows king Stormy Sky (accession 411 AD, death 456 AD), but now there is no mention of Stormy Sky's father, his lineage, or his birth, anywhere on the stela. Stormy Sky wears a 'sky band' belt and bracelets, perhaps a pun on his name. The emphasis of Stela 1 is *astronomy*, not *heredity*, with various Gods being eaten by the cosmic serpent (Coe, 1967: 94). God heads include a characteristic Sun God (*K'inich Ahau*) on the bottom of left edge (complete with an 'egg tooth', mouth volutes, and an Ahau glyph over his head) being devoured. The face does not have the leaf-crown on its forehead, so this is not the 'vision serpent' eating a king. This is like the serpent in frame 20 (M.66b2) of the Madrid Codex, where the face being eaten has a *kin* sign on his eye, a kin sign in his hand, and an eclipse glyph over his head (Vail & Aveni 2009: 181). In fact, there was a total eclipse of the Sun at about 1:40 PM local time over the Mayan city states on April 27, 450 AD (Anon., 2011). The eclipse lasted almost 7 minutes at the center of the path of totality, which was 248 km wide. Tikal was only 440 km north of this center line. With only a very slender crescent of the solar disk visible (~12%), it must have been an impressive sight, and it was the only total solar eclipse in the Mayan area during the 5th century! Most importantly, however, the Sun God that is being consumed on Stela 1 has no spots on his cheeks. That omission would make sense if Stela 1 was created circa 450 AD to record the eclipse because, according to Asian records, and verified by carbon -14 measurements, the 5th century was a time of the quiet Sun. In fact, between December 6, 400 and July 4, 499 AD, there was not a single sunspot report from Asia. And, the message of the stela? Perhaps it was something like, 'Stormy Sky can make the cosmic serpent disengorge the Sun. He is all-powerful. Obey him!' After all, Stormy Sky was getting old by 450 AD. He died 6 years later. In those days of violent politics, he may have needed this bit of superstitious intimidation to keep his enemies at bay. Stela 1 was probably erected shortly after Apr. 27 450 AD, but before Stormy Sky's death in 456 AD.

Finally, a few general comments need to be made. First, this paper and its companion (Sunspots III) do not, in themselves prove that the Maya really did observe sunspots. These two cases of matching sunspot iconography to astronomical events could have just been a coincidence. However, these two papers are part of a long series of seven papers, of which this paper is the fourth. Figure 4 gives an overview of the objects studied in the entire series. The rise and fall in sunspot iconography over the entire Early Classic period is matched by a rise and fall in Asian sunspot observations. Furthermore, there is always a small delay, about 2 to 5 years between the observation of solar events and its depiction in art, as one might expect. This is compelling evidence supporting the hypothesis of Mayan sunspot observation. It is the author's intention to cover each of the objects described in Figure 4 in detail as the series progresses.

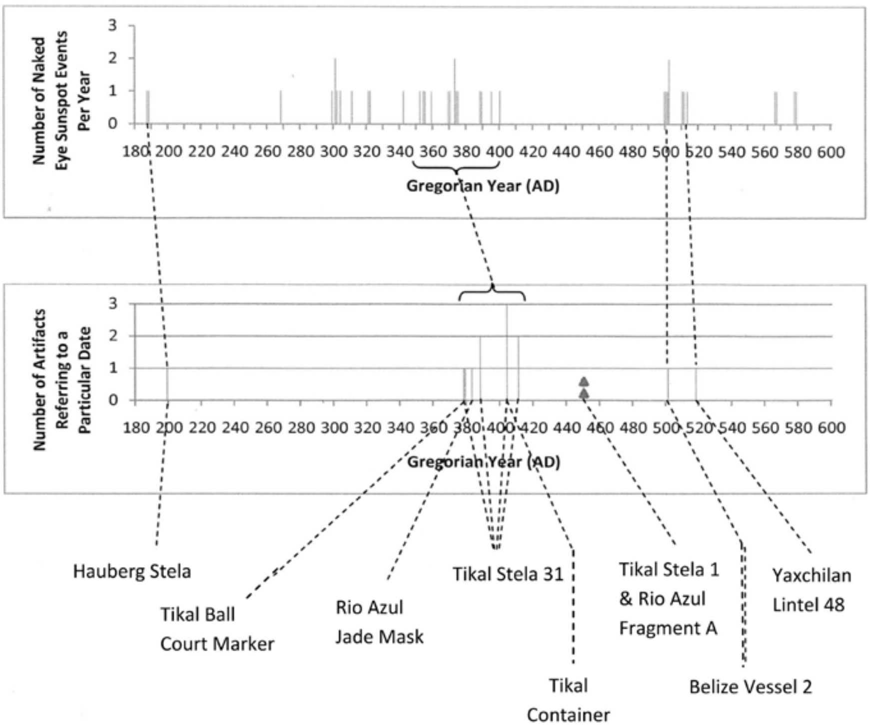

Figure 4: The correspondence between Asian sunspot observations (upper bar graph) and the occurrence of the spotted Sun God, or related deities, in Mayan Art (lower bar graph). The artifacts containing these images are indicated below the graphs. The double arrow head between the years 440 and 460 AD indicate a datable artifact containing Sun God imagery without spots during a time of the quiet Sun.

It is also important to note that spotted Gods, in general, are not uncommon in Mayan iconography. For example, the Venus God may occasionally be spotted. In fact one such spotted Venus God will be discussed in detail in 'Sunspots VII'. Venus, of course, is closely associated with the Sun, both astronomically at sunrise or sunset and in iconography as a member of the 'Palenque Triad'. As will be shown, like the Sun God, the spotted Venus God is also prevalent during the time of the active Sun!

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North and South America

Early Mounds in Peru that Resemble Mythical Animals Have Astronomical Orientations and Alignments

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Abstract

The archaeology team of the National Agrarian University of Peru has 'truthed', verified, images suggested from Google Earth Pro that are giant mounds of dirt and stone with curved walls containing stone-walled rectangular and circular structures (Benfer 2011a). They are found in lower and middle coastal valleys north of Lima, Peru. They date from Late Preceramic (3,600 BC to 1,900 BC) to Early Initial Period (1,700 BC to 900 BC). Their curved outline and, in all but two cases, three-dimensional surfaces – not platforms – distinguishes them from the symmetry and right angles characteristic of other Late Preceramic and Initial Period mounds. The curved mounds have astronomical associations and resemble in outline other ground figures previously identified as animals and birds found from the coast of Peru, the figures at Nazca being the best known. They differ in being more monumental than Nazca animal figures; the finds reported here more closely resemble the numerous giant, curved Adena Culture effigy mounds from North America. Since the Peruvian mounds have rectangular and square enclosures within them, they differ from other South or North American mounds, and represent a new settlement pattern, one of a built ritual space for astronomical alignments that marked key dates for seasonal ceremonies.

KEYWORDS: Coastal Peru valleys, Late Preceramic, Archaic, Initial Period, Formative, effigy mounds, archaeoastronomy, cultural astronomy

POVZETEK

Ekipa arheologov iz perujske Nacionalne agronomske univerze je preverila podobe, opažene v programu Google Earh Pro; šlo naj bi za ogromne groblje iz zemlje in kamenja z ukrivljenimi zidovi, znotraj katerih so pravokotne in krožne strukture (Benfer 2011a). Nahajajo se v nižjih in srednjih obalnih dolinah severno od Lime (Peru), datirane pa so v pozno predkeramično (3600 do 1900 pr. n. št.) in t. i. zgodnjo začetno dobo (1700 do 900 pr. n. št.). Zaradi njihovega zaobljenega oboda ter – razen v dveh primerih – tridimenzionalnih ploskev (ne pa platform) se razlikujejo od drugih gomil iz pozne predkeramične in začetne dobe, ki so simetrične in pravokotne. Zaobljene groblje imajo astronomsko ozadje, njihov tloris pa spominja na druge talne figure, najdene na perujski obali in prepoznane kot živali ali ptice; najbolj znane med njimi so tiste pri kraju Nazca. V primerjavi z le-temi so bolj monumentalne, zato bolj spominjajo na velikanske strukture, ki jih je oblikovala kultura Adena v Severni Ameriki. Ker perujske groblje vsebujejo pravokotne in kvadratne ograde, se razlikujejo od drugih v Severni in Južni Ameriki ter predstavljajo nov vzorec poselitve, nekakšen zgrajen ritualni prostor, v katerem so astronomske poravnave označevale ključne datume za obrede ob menjavi letnih časov.

KLJUČNE BESEDE: obalne doline Peruja, pozna predkeramična doba, arhaična doba, formativna doba, groblje v obliki podob, arheoastronomija, kulturna astronomija

Ground figures can be created so that they would appear in proper proportions if viewed from space, and mythical figures have been constructed in prehistoric times as geoglyphs, intaglios, and mounds.

In Europe, the famous Bronze Age intaglio of the White Horse of Uffington is well known (e.g. Miles 2003). Another important figure of an animal is a quadruped from Neolithic Russia (Grigoriev and Menshen 2012). A few giant intaglios of mythic characters are known from the United States (e.g. Jones and Klar 2007).

In the central part of North America, tens of thousands of three-dimensional, giant animal effigy mounds and other figures were constructed of earth and occasionally stone during the past millennium (Kavasch & Barrie 2004). They have been interpreted as part of the indigenous zodiac, since some have astronomical orientations and since there is supporting ethnographic evidence for that interpretation (Fletcher et al. 1996; Bernadini 2004). The oldest possible figure of an animal in the Americas is a mound from the Poverty Point site in Louisiana (Brecher & Haag 1980). This figure may date from 1,000 BC. The 'bird' looks down an 'avenue' with an approximate orientation of the equinox. Other 'avenues' of the site appear to define the solstices, although destruction of major portions of the site has made confirmation of earlier maps difficult (Ortmann 1997).

Geoglyphs are shallow figures, usually made with a single course of stone or the removal of surface stone to expose desert pavement; these are sometimes called intaglios. They present in the form of lines, rays, and zoomorphic and plant figures (e.g. Roselló et al. 1985; León Ascurra 1996; Pozorski et al. 1991; Aveni 2000). Larger representations of animal forms have been suggested.

The principle Inca settlement of Cuzco has been described as representing the head of a puma (13°31'42.13" S, 71°57'8.63" W) (Rowe 1967), and I note that the Urin-sector of the site of Machu Picchu also resembles a puma in outline (13°9'47.86" S, 72°32'44.21" W).

Pre-Inca coastal Andean figures associated with the sky are especially known from the highly graphic Moche (Régulo F. et al. 2001), Paracas (Gundrum 2000; Rocha Revilla 2011) and Nazca cultures (Silverman & Proulx 2008), all dating to a the centuries before and after the time of Christ. The origins of such animal figures have been speculated as earlier, perhaps as early as 1,200 BC (Urton 1982). I have presented evidence for an origin date of 2,200 BC in the site of Buena Vista where images of animals, such as foxes and llamas, are associated with constellations (Benfer & Adkins 2008; Benfer et al. 2011; Benfer 2012). These figures share critical diagnostic features with the 400 BC Moche figures such as a stained tail in the figure to the right in a pair of foxes. The Fox constellation continued to be seen through Inca times. Animals, projected into the sky as dark-cloud constellations (interstellar dust lanes), are still known to Andean peoples (Urton 1981; Sánchez & Benfer 2012), and their existence persists into the tropical lowlands (Itier 1997; Eechout 1998). Lacking surviving indigenous peoples, and with limited ethnohistory, knowledge of the association of animal figures with constellations for the Peruvian coast is most evident in the Nazca figures (Pitluga 2003) as well as murals from the Moche culture to the north. Moche figures can be related to the sky by the stars that surround them in murals (Franco et al. 2001).

In this paper, I emphasize astronomical alignments associated with giant mounds that have curvilinear outlines and complex internal structures. I will reserve detailed discussion of their possible interpretation as animal figures from the Andean zodiac for another venue but some similarities will be mentioned.

Large, curved, three-dimensional mounds of stone and earth like those of North America have not been previously described for Peru or anywhere else in the Americas. Although a few much smaller raised figures, clearly condor and fox, are known, for example, from Paracas, Peru (Rocha Revilla 2011), they have not been fully reported.

Our team has identified 16 giant mounds in Preceramic and Initial Period sites in coastal Peruvian valleys. They are generally three-dimensional figures characterized by curved perimeters. They are usually comprised largely of quarried rock, often with external stone walls. They have rectangular and sometimes sunken, subterranean circular stone structures within them. We have identified astronomical orientations or alignments with reference points for them, with the depth of the identification related in part to the length of fieldwork at any given mound.

I saw most of these mounds for the first time in Google Earth, and our team visited them to 'truth', to verify, their nature. About 30 % of suspect mounds were rejected on the ground suggesting strongly the inadvisability of depending on satellite images alone. Here I present those that on inspection were found to be Late Preceramic or Early Initial Period curved mounds.

Giant Mounds with Curved Perimeters

The prehistoric monumental architecture that will be discussed below can be divided into two groups. One group appears to be modeled from refashioned rocky outcrops, ridgelines, or erosional remnants. The second group was created as mounds generally of 1-3 m in thickness, usually built with quarried rock.

Fortaleza Valley

Google Earth Pro shows a figure that resembles an orca, or killer whale (10°40'4.32" S, 77°48'41.81" W) in the Fortaleza Valley (Fig. 1). It should be pointed out that representations of the mythical killer whale at Nazca as shown in the upper left inset in Figure 1, from Proulx (2010: 54, Fig. 5.44), do not demonstrate a large dorsal fin but in fact closely resemble the image shown in Figure 1. Proulx labeled the figure 'Naturalistic Mythical Killer Whale'. When we visited the Fortaleza site, we found a rock outcropping thickly covered by a preceramic midden with stone walls and other structures (see lower left inset in Fig. 1). It is located 500 m from a beach where orca used to hunt regularly before over-fishing reduced stocks (Yuri Hooker, personal communication). There should have been a Peruvian Air Force photo of the area from the 1940s, but it had been lost in the national archives, so we cannot know to what degree the houses set next to the stone outcropping affect the appearance of the figure. However, tracing the rock in the photograph still suggests an orca-like figure and its form contrasts with the adjacent rock outcropping, which has the more typical rounded lobes. The figure appears to be gazing to the south. We named the site Orca.

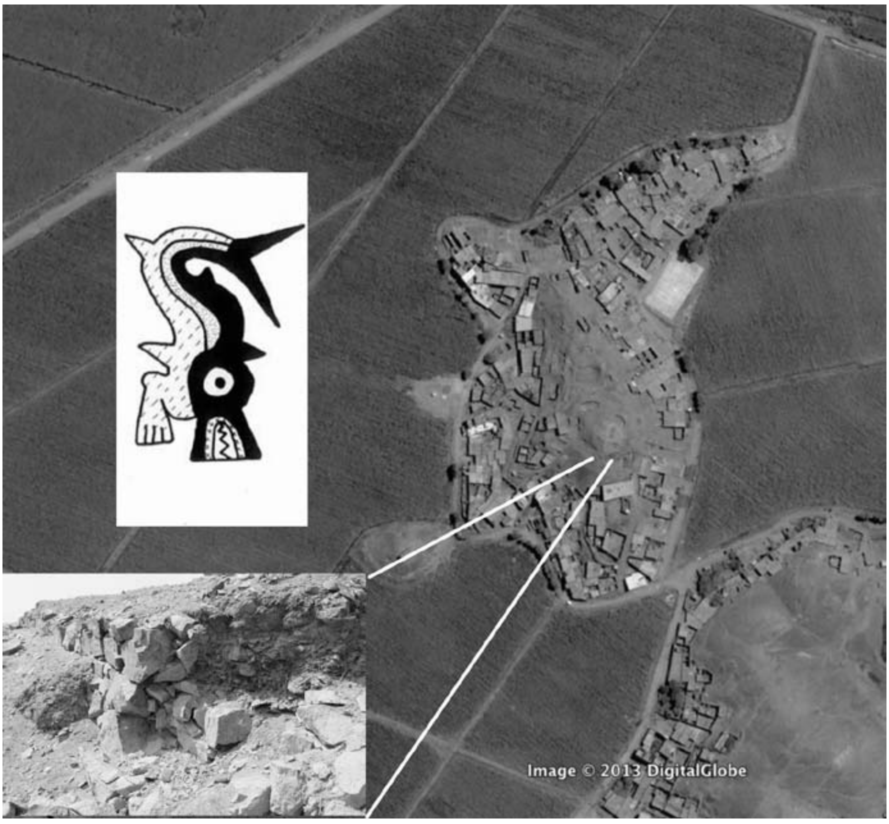


Figure 1: Orca from Patavilca Valley (Google Earth Pro image). Upper left inset is from Proulx (2010: Fig. 5.44); lower left inset shows preceramic wall covered by midden.

From Google Earth Pro, a small complex of rectangular structures (10°40'24.81" S, 77°47'59.44" W) can be identified 1.4 km away from the Orca site with an azimuth of 114º58' from the 'eye' of the figure. We also found a small U-shaped structure at a site (10º39'0.97" S, 77º51º7.53" W) with an azimuth 294º1' from the eye. However, time did permit visiting these possible solstice points. Any built reference points in the floodplain would have been removed for modern agriculture.

The Patavilca Valley

This larger valley lies directly to the south of the Fortaleza. Figure 2 shows a mound about 1,000 m in length, situated on a bluff, which bears a striking resemblance to the sperm whale (see lower right inset in Fig. 2) (10°41'0.58" S, 77°40'37.81" W). We named the figure Vinto Alto III for our archives, but I will refer to it as the Sperm Whale here. It lies 15 km to the east of the Orca site. The majority of the figure is on private property. With the assistance of the Ministry of Culture, our team was allowed to visit but not map that section. The 'fluke' was not on private property, although squatters had invaded one side after the image in Figure 2 had been taken. The squatter settlement shown towards the head in Figure 2 has been since removed. The map in the lower left overlay of Figure 2 shows a small platform pyramid on one side of the fluke; next to it, now covered with houses, lies the other side of the fluke. This other side demonstrates a three-dimensional character, more like part of an organism than a platform. We found *shicra* (simple net bags of rock for fill) eroding from the 'fluke'. Shicra bags in such quantity are restricted to Late Preceramic and Formative sites. At the other end of the figure are two features that would occupy the place of the 'eye' and 'fin'. They are Late Preceramic platform mounds (indicated in Fig. 2) with some stone walls still visible. The spiral path of the 'fin' has been made or remodeled for a road up to a modern water tank. *Shicra* was found in this area also. The main 'body' of the mound has a much later final occupation (see upper left inset in Fig. 2), judging from the ceramics seen in unfinished modern house foundations. This could be a later reoccupation. However, absent excavation, we do not know whether there exists an earlier occupation that would link the 'eye' to the 'fluke' through the 'body' of the hypothesized Sperm Whale.

An alignment can be suggested (Fig. 2) through the top of the two preceramic mounds on the Sperm Whale. Such an alignment points to a rectangular structure, on the northwest side and highest point on the early Late Preceramic mound, Vinto Alto I (10°41'20.29" S, 77°41'20.56" W). This alignment is 244º36' at -1º12'). The December solstice sunset at this altitude in 800 BC was at 245º31'. The nearly one degree divergence from the expected azimuth does not disqualify the two sites as being associated astronomically, given the lack of knowledge of the precise location of the supposed *ushnu* at Vinto Alto I. Western valley *ushnus*, defined on the basis of ethnography (Pino Matos 2005; Matos 2010) or archaeology (Benfer et al. 2011; Duncan et al. 2011) may differ from the definitions appropriate for later Inca high *ushnus* from Cuzco (e.g. Staller 2009: 284). In the coastal valleys, *ushnus* are defined as locations where offerings, often libations filtered through river pebbles (Pino Matos 2010), are made to the earth, *Pachamama*, and where observations of sky events were made to identify dates for ceremonies marking important seasonal shifts (Benfer 2012). Staller (personal communication, March 9, 2010) notes that the word *ushnu* has an underworld referent in Quechua dictionaries.

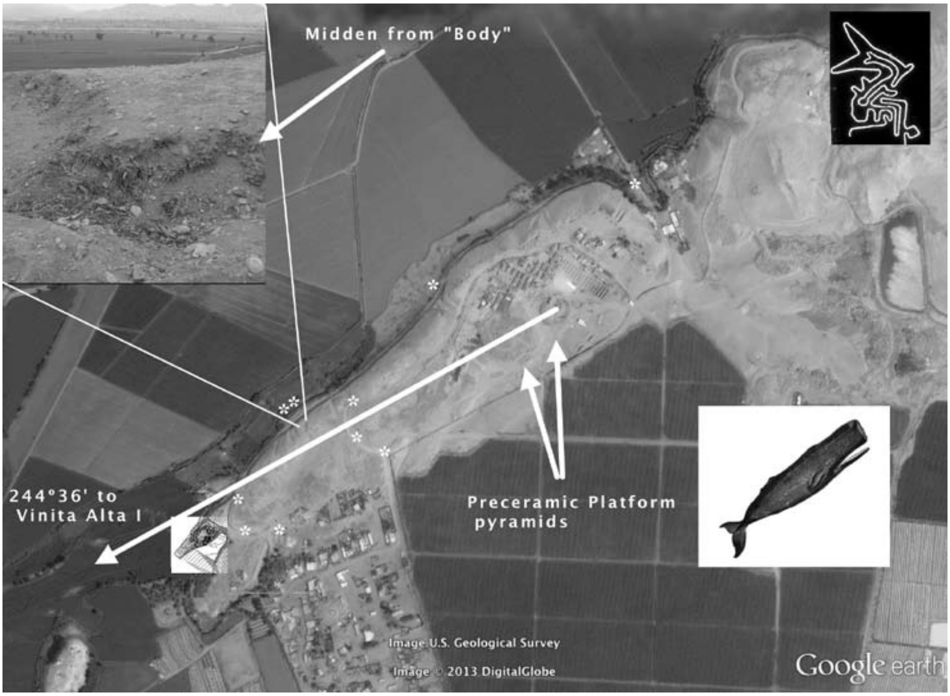


Figure 2: Large figure in Google Earth Pro image that resembles a sperm whale in outline (see lower right inset). The upper right inset is of a whale from Nazca furnished by Phyllis Pitluga; it and several other whale figures have approximately the same orientation as furnished by the two preceramic platform pyramids that points to the principal mound of another preceramic site (see text). The upper left inset shows midden that has been cut by modern activity; late ceramics and maize are found eroding from the cut.

Another astronomical correspondence arises from comparing the whale-like Patavilca Valley figure to whale figures at Nazca that are associated with rays directed out from them with similar azimuths of 240º46, 242º07' and 252º44' (Pitluga 2003, Fig. 2; azimuths from Table 1, which presents azimuths of rays by species). The whale-like mound in the Patavilca has an azimuth of 244º36º with another preceramic mound (see Fig. 2, which compares well with the average of those for the three Nazca whales of 245º12'). The shape of the face of the Patavilca mound, as well as the Nazca figure, suggest a sperm whale, since it is the only whale with such a broad, rectangular face.

That two possible whale figures are found close together but are the only such in my survey of these valleys argues for further investigation. Orcas and whale geoglyphs can be seen on the plains of Nazca.

The Chillón Valley

The site of El Paraíso (Fig. 3) (11°57'0.78" S, 77° 6'51.98" W) is comprised of a number of monumental building complexes of platform pyramids plus two very large curved mounds, which, with the central temple, form a 'U' (Lanning 1963; Engel 1966; Quilter et al. 1991). The two 'arms' are in fact mounds with curved perimeters. They contain stonewalled circular and rectangular structures. In outline, they resemble a bird and a mythical animal (see map inset in Fig. 3), which I have presented elsewhere (Benfer 2011a) as the Condor and 'Monstruo', a mythical animal known from other depictions (Bischof 1994).

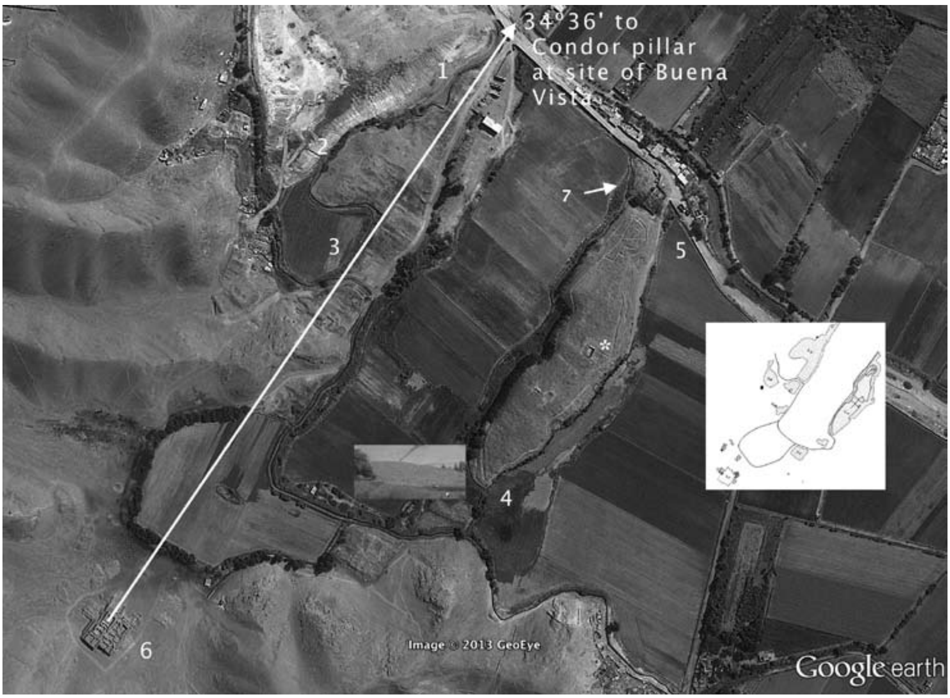


Figure 3: Site of El Paraíso. 1. Head of condor shaped mound. 2. Wing of mound. 3. Tail of mound. 4. Tail of 'Monstruo' mound. 5. Head of 'Monstruo' 6. Temple of El Paraíso. 7. 'Flame' or 'point' from snout (see Fig. 5).

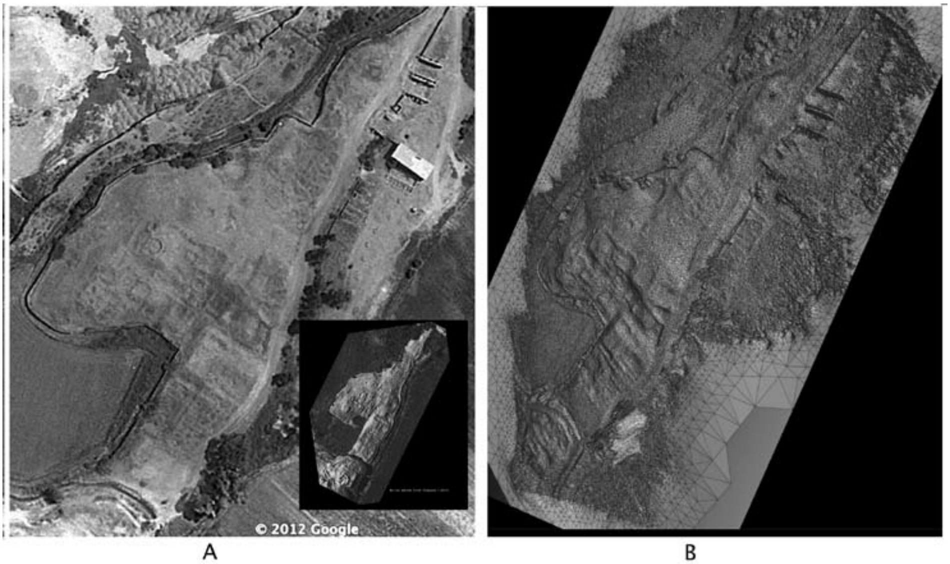


Figure 4: Condor images. A. Google Earth Pro image with Peruvian Air Force inset from 1946 showing the 'chin' later removed by expansion of a road. B. Wireframe image of same figure from kite photography by Nathan Craig.

The inset next to point 4 in Figure 3 of the 'Monstruo' is a surface-level photograph of the 'tail' showing its three-dimensional nature. Figure 4 shows the bird-like figure in three other kinds of imagery. The images in Figure 5 (A-C) show the El Paraíso 'Monstruo' mound compared to small bone carvings of the mythical 'Monstruo' from the same Late Preceramic Period. Note the 'teeth' at the head and the tucked-in 'belly'. One of three projections from the snout of the mound, the 'flame' motif (or 'point'), is marked as point 7 in Figure 3 and is indicated in Figure 5A. The 'flames' are evident in the two bone incisings depicted in Figures 5B and 5C. The other two 'flames' at the mound are presumed lost from the mound to the modern construction that can be seen in Figure 5A.

The three 'flames' motif is common at the time of the transition from Late Preceramic until Initial Period. See Suarez Ubillus (2010: Fig. 5) and Bischof (1944: Fig. 11) for other examples. I identify the mound, from its similarity to the incised bone figures, as a 'Monstruo', which is the name given to the incised mythical figures (Bischof 1994).

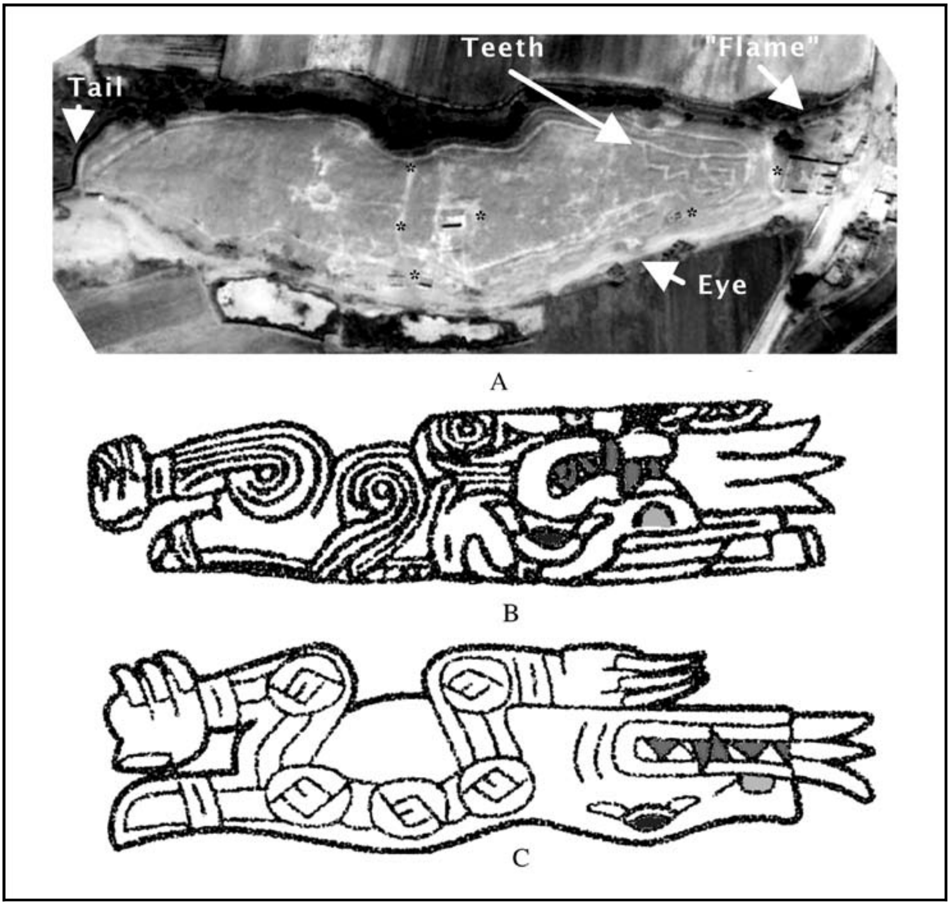


Figure 5: 'Monstruo'. A. Google Earth Pro image; asterisks indicate modern construction. B and C are two carved bone images from late Preceramic sites that depict the 'Monstruo'. I have shaded gray some anatomical details. See Bischof (1944) for further information about these images and Benfer (2011a) for details of their source.

Figures 4A and 4B show two images of the bird-like figure at the site of El Paraíso, the Condor. The wire mesh model, created by Nathan Craig by kite-photography (Fig. 4B), shows stone walls better than does the adjacent Google Earth Image (Fig. 5A). The inset in Figure 4A is an aerial photograph (Shippee 1932). Comparing it with the kite photo from 2011, one sees that the lower margin of the jaw of the bird was well defined in the past before a road past through it. At the Late Preceramic site of Pando, in the Supe Valley, another bird-like figure of similar size is also associated with a Late Preceramic site. It can be clearly seen in Google Earth Pro (10°50'38.50" S, 77°35'28.88" W), and although our team visited it, space does not permit its presentation here except to note that a mud-plaster beak remains in situ.

The ‘U’ shape of El Paraíso is a form of architecture that began in the Late Preceramic and continued to the Late Initial Period (Williams 1978-1979). The site of El Paraíso has always been noted as unusual in being asymmetric, with the temple not at the apex of the ‘U’. The investigation presented here may explain the asymmetry in the ‘U’. From the main temple of El Paraíso, I extended a line (see Fig. 3) in Google Earth from its offering chamber (Engel 1966) at 11°57’13.81” S, 77°7’6.18” W through the long axis of the body of the bird-like mound through the figure’s ‘eye’. The ‘eye’ is a midden of burned earth and charcoal. I did this looking for the first ridge with which it impacted in order to adjust the prehistoric azimuth for altitude. I determined the azimuth of this line to be 34º36’, which is the approximate azimuth of the extreme of the Milky Way. That azimuth is a common orientation for structures from various time periods, including walls at Pachacamac two valleys to the south (e.g. Piñansco 2007) and at other sites discussed below.

To our surprise, the line impacted another condor figure when the first ridge was encountered. The figure is at the site of Buena Vista. This creature is carved in one of two adjacent stone pillars (Fig. 6A and 6B). We had named the retouched one the Apuchin (11°43’49.72” S, 76°57’43.49” W), in Quechua, the master of the mountain peaks, because it gazes up the valley towards the peaks with its eye pecked into the stone (Fig. 6B) (Benfer & Adkins 2009). The discoverer, Lucio Laura, is a speaker of Quechua. Calculating the azimuth from coordinates obtained for the offering chamber of the Temple of El Paraíso and condor rock produced 34º24’, just 12’ different from the azimuth originally obtained from the line extended from the offering chamber through the Condor’s eye at the same site. The condor pillar and its untouched companion pillar (Fig. 6A) mark the end point of another astronomical alignment, that of an equinoctial line at Buena Vista. Figure 6C shows a map of the three temples excavated at Buena Vista, the main Late Preceramic occupation at the site (Benfer 2012).

The azimuth of the condor sculpture as seen from the entryway of Temple of the Fox at Buena Vista defines the rise of the equinoctial sun. This line from the entryway of the temple crosses another rock, which we named Condor in our notes, unaware of its precise location. It projects from the side of a ravine (Fig. 6E). Later measurement with a transit placed it, surprisingly, precisely in line from the entryway to the Temple of the Fox to the Condor pillar. The line impacts a cube-shaped black rock in transit (see Fig. 6D) (Benfer 2011b). Cube-shaped black rocks must have important meaning as they were found at three significant entryways at the site.

The altitude of the condor pillar was measured as 24º40’ from entryway of the Temple of the Fox. The azimuth of 83º24’ was obtained as the average of three transit readings to the black rock (S.D. 13.0’). Only the tip of the condor is visible to good eyes, so the black rock served perhaps its original purpose, to indicate the Condor rock behind it. Starry Night Pro calculated 84º41’ for the equinoctial sunrise for 24º40’ altitude for the black rock. The sun was observed rising about a half-degree to the right of the center of the rock two days before the equinox of 2009 (Fig. 6D). If the skies had been clear on the equinox, September 20, we would have seen the sun rise 49’ to the left of the position we observed, close to the black rock.

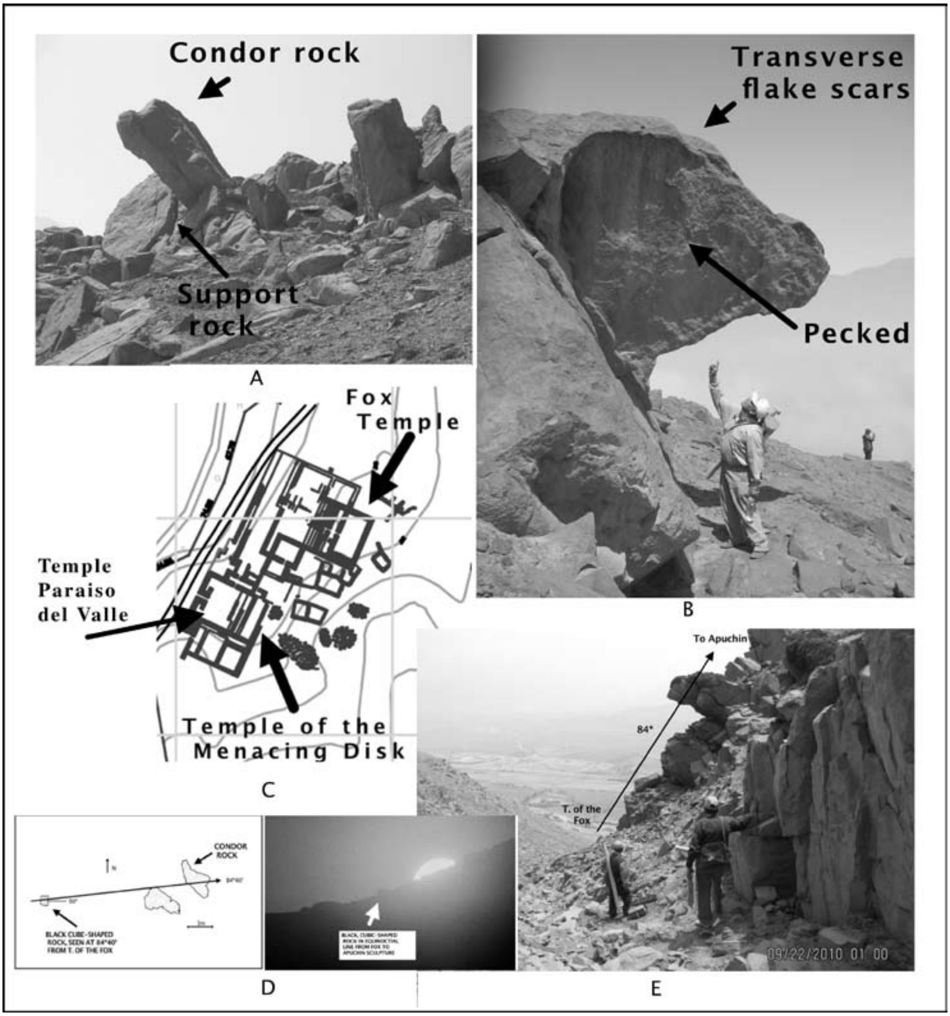


Figure 6: Condor rock of Buena Vista. A. Twin pillars. B. Profile, all of the perimeter of which has had transverse flakes removed and an 'eye' is pecked into the rock. The person pointing at the 'eye' is Lucio Laura, who discovered the sculpture. C. Map of the principal Late Preceramic architecture excavated at the site (Benfer 2012). D. Sunrise at a black rock that marks the location close to the condor rock as seen from the entryway of the Temple of the Fox, two days before the equinox 2009. E. Projecting rock that we had earlier identified as a condor rock; it lies precisely along the line from the entryway of the Temple of the Fox to the condor rock.

The Condor rock looks to the east with an azimuth of 33º, thus it is pointed towards the Milky Way extreme. Three other rocks at the site that participated in solstice alignments (Benfer et al. 2011) gaze towards the west with an average azimuth of 235º, also towards a Milky Way extreme. The long axes of Late Preceramic and Initial Period sites are oriented between 25º to 35º (Williams 1978-80: Fig. 3-5), as are those of Buena Vista and El Paraíso.

Association between the fox of the murals in the Temple of the Fox and the condor carved into the stone pillar is found in many Andean folk tales. For example, the mythical Andean Fox, incised in the entryway to the Temple of the Fox, would have informed the mythical condor, carved into the pillar, of the adequacy of offerings made in the offering chamber of the temple (Sanchéz & Benfer 2012). These offerings were directed to the *Apus*, mythical figures that inhabit the highest visible mountain peaks to which the Condor rock sculpture looks.

The Buena Vista and El Paraíso sites share many astronomical similarities. Their temple walls are oriented to precisely the same directions (Benfer and Adkins 2009). One temple at Buena Vista, the Temple of Paraíso del Valle (Fig. 6C), was named for its resemblance to the temple of El Paraíso. Given the extreme symmetry of Late Preceramic monumental construction, Paraíso del Valle almost certainly has four circular offering pits (although only three were excavated), situated around a central hearth. The temple at El Paraíso has four circular columns for offerings around a central hearth (Benfer & Adkins 2011). Two of the circular offering pits at each site describe the same June solstice sunrise azimuth of approximately 66º. The ones from Buena Vista point to another pair of stone pillars on a closer hill; we have not investigated that direction at El Paraíso, as it is heavily populated. At El Paraíso, a projecting rock near a mine of unknown age resembles a condor. Thus, the two sites, although 29 km apart, have similar dates and structural similarities with respect to astronomical orientations and alignments. Although we have located other large curved outline mounds in valleys immediately to the north of the Chillón, space limitations take us further north, next to the Supe Valley.

Supe Valley

The largest figure in the Supe Valley (10°54’48.30” S, 77°27’24.17” W) is at least 625 m in length (Figs. 7, 8A, and 9). It resembles an even longer Monstruo than that of El Paraíso (Fig. 3) with a head, belly and tail (Fig. 8A). The site has been recorded as Cerro Limoncillos II in our archives. We refer to it is Monstruo Grande here.

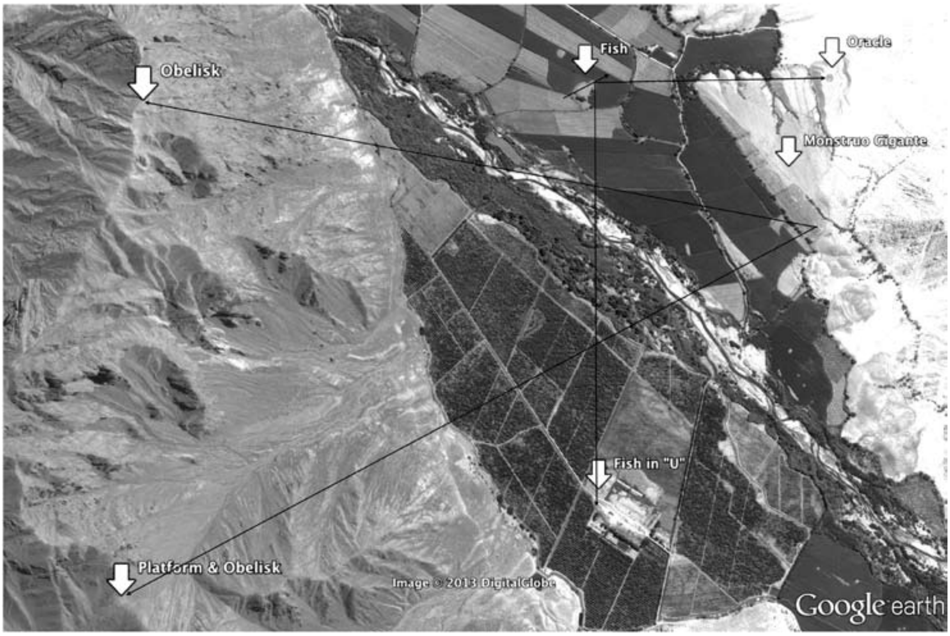


Figure 7: Google Earth Pro image of upper middle Supe Valley. The sites indicated are discussed in the text.

The Google Earth Pro image in Figures 7 and 8A was taken before most of this site had been removed for conversion to agricultural lands. We mapped what remained, which appears to have included the 'head' of the figure, although one cannot be certain the original figure did not extend further to the southeast due to evidence of heavy machine activity there. Irregularly aligned stonewalled structures in the remaining section of the site (overlay in Fig. 8A) are typical of Initial Period construction. The ceramics recovered from the surface of the Monstruo Grande also corresponds to this period. See Figure 4 for the Late Preceramic pattern of greater symmetry at a site with no ceramics.

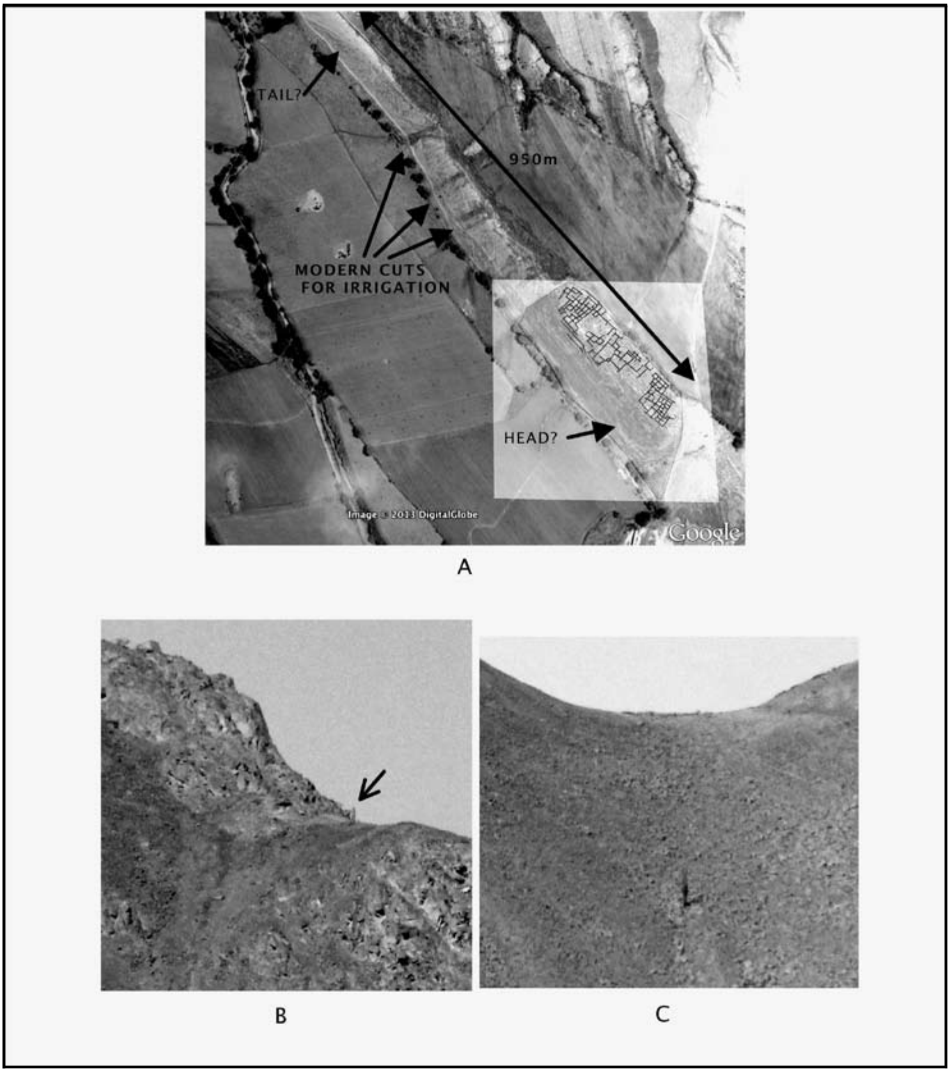


Figure 8: Sites from the upper middle Super Valley. A: 'Monstruo Grande'. B: A telephoto of one of the distant targets, an obelisk set into a niche, aligned as shown in B. C: Telephoto of a platform located in a mountain pass with an obelisk in line with the alignment shown in B.

Figure 9: A curved figure as one arm of a site in the form of an 'U'; it would appear to have represented a fish, or perhaps a whale. The 'eye' indicated is comprised of courses of stones, the collapse of the upper courses of which are visible in the inset.

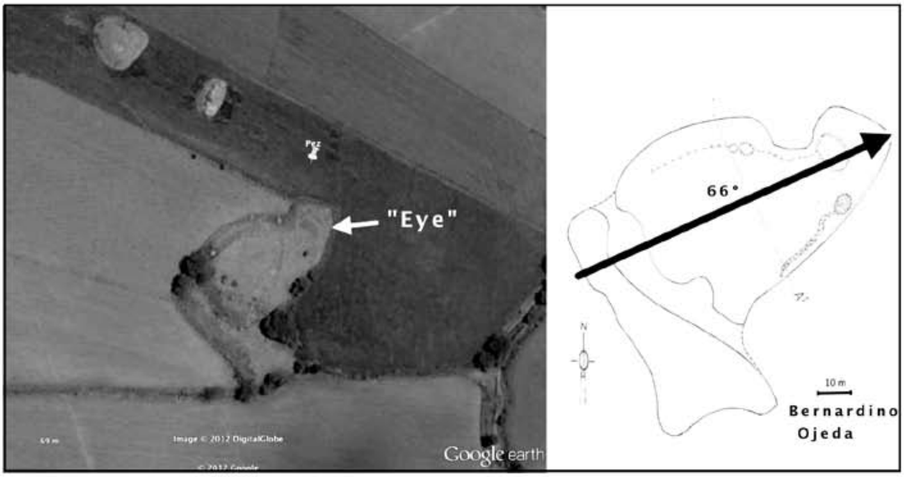
I set up a transit at the end of the available structures on the Monstruo Grande (see Fig. 8A), hopefully at the head (10°54'49.4" S, 77°27'23.2" W). My model requires that the '*ushnu*' or viewing point of figures that resemble animals, lacking an actual offering chamber or eye, should be found somewhere around the center of the head. I measured the altitude of the mountains two km to the east, and adjusted the expected azimuth for solstices and equinox for 800 BC, since that would be the earliest date possible for the late Initial Period ceramics and stone structures that we found there. I saw nothing human-made in the first view of the horizon for the equinox, but in the second field of view of one degree, a stone obelisk was visible (Fig. 8B). The azimuth for the obelisk was 277º8' at 10º20' altitude. Starry Night Pro predicted 277º26' sunset over the obelisk. The slight difference of 18' is presumably due to the 2 km sightline.

For the December solstice sunset search, the second view again revealed a structure, this one another stone obelisk centered on a more distant stone platform (Fig. 8C). The declination and refraction adjusted azimuth of the platform, which formed part of the skyline of a pass was 246º35' at 5º9' altitude. Starry Night Pro suggests that at 800 BC, the sun would have set over 246º52', a very close fit of observed to expected. Time did not permit visiting the two distant obelisk sites on top of the mountain. However, there was no question as to their nature as seen through high-powered binoculars or the Total Station lens by me or by my field supervisor. It is notable that a scan of the rest of the horizon defined by the mountain to the west produced no other candidate reference points, save the following.

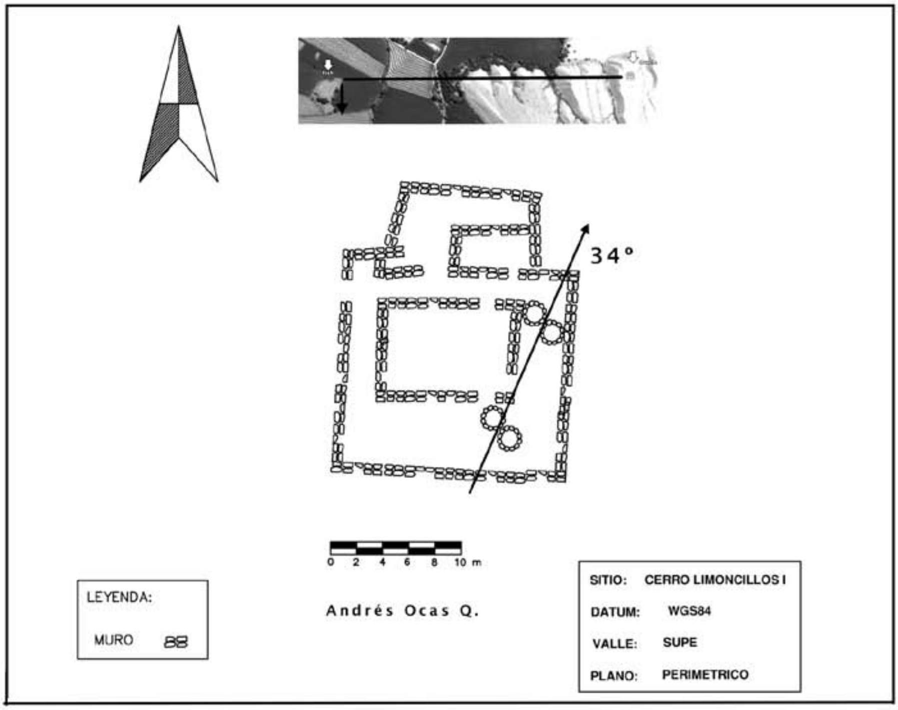
The June solstice sunset may have been marked by a niche (10°54'18.11" S, 77°28'32.21" W) possibly quarried in the side of the mountain (295º52' at -0.7º altitude), which is within one degree of the azimuth expected for the 800 BC June solstice sunset. Pedestrian survey would be necessary to confirm that reference point. Google Earth suggests additional structures to the west of the Monstruo Grande site, but time did not permit their investigation either.

I next present two mounds near to the Monstruo Grande. One resembles a fish or possibly the head of an animal (Figs. 7 and 10A) and the other, a fish or possibly a whale (Fig. 9). Our map in Figure 10A shows a figure that is looking towards the June solstice sunrise. The 'fish' has two more definite alignments. One is with a small platform mound we named the Oracle (registered as Cerro Limoncillos I) (Fig. 10B). We named it the Oracle because of the quantities of decorated ceramics found in a large midden in back of the extremely isolated site. The azimuth from the 'eye' of the 'fish' (10°54'34.85" S, 77°27'46.46" W) to the center of the Oracle (10°54'34.65" S, 77°27'21.85" W), with an altitude of 2.9º, is 89º54' (Fig. 10B, see inset), 88°46' is predicted for the equinox. If one uses the curved rooms on the north end of the Oracle (10°54'34.29" S, 77°27'21.73"), an azimuth of 89º12' is obtained, which would be a better match with the equinox. Perhaps that was the unpredicted *ushnu*. I note in passing that a line through two pairs of circular pits in the Oracle (Fig. 10B) defines the extreme of the Milky Way, as do the large curved mounds at El. Paraíso. The pairs of pits at the Oracle themselves each point to the other extreme.

Another cardinal direction is defined by a line from the same 'eye' of the fish-like creature in the north (Fig. 7) towards the 'eye' of the fish-like or whale-like figure in the south (Fig. 10A). The traditional name of the second site is La Emprenada (Figs. 7 and 9), but it is also referred to as Sitio en Forma de 'U'; like the mounds at El Paraíso, it forms one 'arm' of the 'U'. An 'eye' in the figure of La Emprenada was observed to have been constructed of courses of stone; their collapse is visible in the inset in Fig. 9. The road did not cut the 'tail' visible in the lower right as it would appear. Reconnaissance showed that the north-south road divided it from the 'body' while the southeast to north-west road traced a path around it. The azimuth between the two 'eyes' is 179º18', with very little vertical difference between the sites. A sketch map of La Emprenada is available (Williams and Marino 1979) and reproduced in a more available venue by Tantalaéan and Ysela Leyva (2011: 464, Fig. 5). The sketch map shows two platform pyramids that were formerly visible in the center of the figure are not now visible in the Google Earth image.



A



B

Figure 10: Sites with astronomical alignments in the Supe Valley. A: fish-like image shown in a Google Earth Pro image and our map. B: Oracle.

Cardinal direction orientations were not predicted. My working hypothesis was that these curved mounds would show orientations to the solstices, equinoxes, and the Milky Way. Thus, findings of cardinal directions are purely inductive. As can be seen from Fig. 10B, the Oracle is oriented within about four degrees of the cardinal directions, a deviation too large to appear to have been intended for those directions, but curious given its equinoctial orientation with the fish figure.

Summary

These monumental sites and others in the coastal valleys north of Lima, are curved in outline; most are made of dirt and stone. Unlike North American curved mounds, the South American ones have stone structures within or upon them. The mounds presented here range in length from 50 to 1,000 m, and several exceed in length the longest North American effigy mound, Great Serpent Mound (Glotzhober & Lepper 1994: 3). They represent substantial investment in labor.

The Peruvian mounds occur in the coastal valleys, a context in which ground depictions of plant and especially animal figures are known. The mounds and other ground drawings (e.g. Wilson 1998) would be viewed in their proper proportions only from overhead. Unlike geoglyphs, but like North American animal mounds, most of the ones reported here have a three-dimensional, body-like structure. The Peruvian mounds demonstrate solstice, equinoctial, constellation and probably cardinal direction alignments.

Temples and walls aligned with constellations have been reported from the coast (Piñasco Carrella 2007; Benfer et al. 2010). The orientation of the three Nazca whale geoglyphs, with rays that point to the same location in the Milky Way (Pitluga 2003), is similar to the orientation of the Patavilca sperm whale-like figure to the other mound (Fig. 2). This suggests the profitability of further comparison of those figures, as well as comparison with the astronomical ones presented in Moche murals (Franco et al. 2001) and in early decorated ceramics and textiles.

Since most of the mounds discussed here present an astronomical orientation, and many are part of an astronomical set of alignments, these figures may, like their North American counterparts and the animal figures with rays at Nazca, have been animal effigies of the South American zodiac. A useful critique of this hypothesis must explain the resemblance of the Peruvian mounds to the thousands of similar forms recognized as animal effigy mounds in North America. It must also provide an alternative explanation for the resemblance of these South American mounds to the more two-dimensional ground figures, such as those from Nazca. In addition, such a critique must explain away the iconographic resemblance of the figures presented here to representations common in the iconography of early coastal valley sites.

I have presented here a new category of very ancient monumental archaeology in South America, one of very large mounds with curved outlines that resemble animal figures, containing structures of stone and associated with astronomical events.

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A Possible Native Site of Alignment in Baja California, Mexico

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Abstract
West of Bahía de los Ángeles, Baja California, Mexico, there is a perimeter covered with rock crystals and closed into a row of stones. From this backsight, in a south-eastern direction, a row of hills on which the sun and moon rise when they reach their southernmost standstills (winter solstice and lunar southern standstills from the minor to the major lunistices) can be observed. Cairns are found on the tops of those hills so that the whole complex seems to constitute a perfect native ritual centre associated with observations of solar and lunar southern extremes. However, further inquiry indicates that scepticism should be maintained, and that Archaeoastronomy, such a new field of research, has perhaps already started to be the victim of its own success.

KEYWORDS: stone circle, standstills, rock crystals, touristic pollution

POVZETEK
Zahodno od kraja Bahía de los Ángeles, v državi Baja California, Mehika, se nahaja lok kamnitih kristalov, obdan z vrsto kamnov. S tega stojišča je v jugo-vzhodni smeri možno opazovati griče, nad katerimi vzhajata Sonca in Luna, kadar dosežeta najbolj južne točke (zimski solsticij ter male in velike lunarne ekstreme). Na vrhovih teh gričev so kamnite groblje, tako da celoten kompleks ustvarja vtis obrednega centra, povezanega z opazovanjem Sončevih in Luninih južnih ekstremov. Vendar podrobnejša raziskava kaže, da je treba ostati skeptičen in da arheoastronomija, sicer še mlada veda, morda že postaja žrtev lastnega uspeha.

KLJUČNE BESEDE: kamniti krog, solsticiji, lunarni ekstremi, kamniti kristali, turistično onesnaževanje

The small city of Bahia de los Angeles is situated in the state of Northern Baja California. Remnants of the site which are discussed here are situated to the north of the Playa de los Alacranes, on the Mar de Cortes (or Gulf of California), that is, 28° 54’ 35” North and 113° 23’ 09” West. At that location, a perimeter of about 50 meters in diameter may be found. It is not really a stone circle but rather a somewhat irregular area delimited by an alignment of stones. Figure 1 shows how the area appears.

Figure 1.

Although constructed with stones of modest size, the site seems very interesting, especially keeping in mind that similar such structures are well known in North America. The place is a desert with limited resources for humans so that the native population which lived there was probably very primitive, living on seafood and some hunting, *biznaga* cactuses, and little more. Drinking water is no closer than two days walk across a difficult mountainous terrain.

The stone perimeter is evidently an ancient man-made artefact. As is known in various primitive astronomical traditions and megalithic remnants, rock crystals are associated with astronomy and the sky in general. Specifically in Scottish stone circles described by Burl (Aubrey Burl, 'By the light of the cinerary moon, chambered tombs and the astronomy of death'. Astronomy and society in Britain during the period 4000–1500 B.C., Oxford, B.A.R. International, 1981.), in Scotland the stone perimeters contains a high concentration of quartz and rock crystals. Thus, the site of Bahia de los Angeles is even more interesting because of the very unusual layer of such pebbles and gravel found inside the circle. This may be seen in Figure 2.

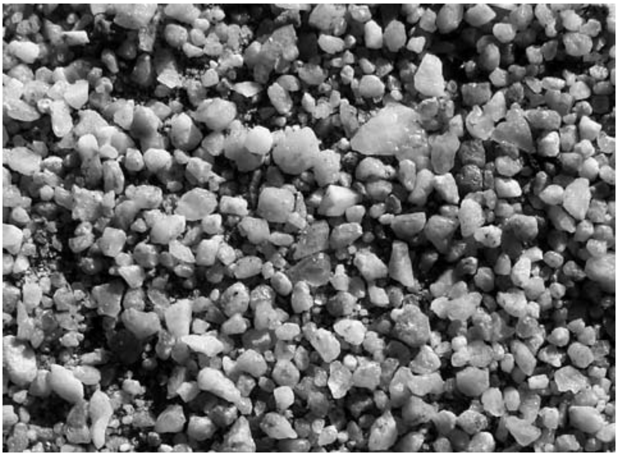

Figure 2.

Although I rarely enter the field of stone circles, I am familiar with the rich literature of my colleagues on the subject. When I came upon this site, I of course had to stop and think about it twice. Since I had no instruments of measurement with me, I calculated a rough East-West line relative to the position of the Sun to see if there were any significant features on the eastern and/or western horizons, more concretely at the locations of Sun and Moon extremes. To the southeast of the site, I noticed a well delimited but low mountain range with a series of rather steep hills. This seemed to be of possible interest for marking azimuths around the winter solstice. As it was near Christmas time, I returned the next day to observe the sunrise and take some photographs. Figure 3 shows what I saw.

Figure 3.

This looked very promising. There is a pathway which crosses the structure that is clear of stones. Could this have been a ritual meeting place for small groups of semi-nomads at the time of winter solstice? Everything seemed to lead to such a conclusion. As the sky was cloudy that day, it was difficult to determine the exact position of the sun at sunrise, but it seemed to rise just over a prominent sharp hill in the middle of the range. Most interestingly, due to the strong contrast of horizon on the eastern sky at morning dawn, I could see something peeping from the tops of the hills, something similar perhaps to nipples on a breast (Fig. 4). Could they define some ritual period around the winter solstice?

Figure 4.

As I had not expected to come across such a discovery, and was without any instruments of measure, I roughly traced the general orientation of the site by counting steps (one step represents a degree on the perimeter of a circle with a radius of 57 steps) and found that southernmost moon-rises would basically cover the area marked in Figure 5 between the two moon crescents.

Figure 5.

Both minor and major lunistices may also have been marked by prominent peaks. I went to the eastern range of hills where I climbed up to see how looked what seemed to be two horizon markers. Figures 6 and 7 show what I found.

Figure 6.

Figure 7.

I was in front of what seemed to be an apparently perfect and well-defined backsight. It was covered with rock crystals and quartz of clear ritual meaning. There was also an excellent foresight, a very well defined and well-situated mountain range to the southeast. It had sharp peaks on the horizon that appeared to cover the azimuths of southern moon standstills with a cairn marking the place of solstice sunrise. There were also other cairns which would need further measurements, but they appeared to be in the azimuths of southern moon standstills. I was enchanted with this site as I suppose anyone would be.

As seen in Figures 8 and 9, other cairns and man-made structures were visible on the top of neighbouring hills.

Figure 8.

All of these markers were situated more or less on a north-south line some two kilometres from the backsight. Of special interest was the fact that the hill in the direction of a major southern moon standstill was also marked by a cairn. The construction shown in Figure 10 was found on the top of the northernmost peak and perhaps corresponds to a minor moon standstill.

Figure 9.

Figure 10.

Could this be a minor lunistice marker? The cairns appear to have suffered little destruction and thus are probably not ancient. However, the area is very deserted, and the very rare human passing by would probably not climb such inhospitable mountains under a blazing sun just to destroy stone constructions which were of no concern in their daily life. In these regions, prehistory probably ended in the eighteenth or perhaps the nineteenth century. There is very little historical or ethnographic information concerning the local population.

Given the above, when I returned to the stone perimeter, I observed that the northernmost cairn and the moon crescent were not visible from where I stood. Instead, they were hidden by another hill just in front of them. When I moved two hundred meters south, the cairn appeared. Observation of the moon crescent structure was perhaps more difficult because its construction is low and is thus not visible from so far away.

While I climbed the next day, I inspected and measured the entire neighbourhood. Down the southernmost hill and near the southern beach I found the rare construction which may be seen in Figure 11.

Figure 11.

At this point I could not help but be amused. I wondered 'Could this be a dolmen? Could it be a Siberian altar for the burial of the bones of the bear, or a Japanese sacred gate?' It was, of course, so delicate and so near to the beach that had it been ancient, it would have been easily demolished in the last century, even with rare human presence.

From a distance, it looked as though it might be a New Age fantasy. Figure 11 shows that there was some sort of instrument lying on the ground. It appeared to be a piece of wood or broken rod ending with the remains of what had been a wooden ring. This appeared to be something like an observing instrument that someone may have used just to 'play at being primitive'. Well, it may be that pretending to be primitive is already primitive.

I later visited a very nice gentleman who is the administrator of the beach and found that it is an area where citizens of the United States come to fish. I asked him whether the cairns were ancient or more modern in their construction. He told me that two or three years earlier a group of 'gringos' had climbed up and built them all. I was of course disappointed. It had been all too beautiful, and it turned out to be false.

However, was it all fake? I also asked about the stone perimeter, and the same gentleman (who was about sixty years of age) told me that as a child, he came to the area to fish with his father. He said that the configuration of stones had always been there and then added that no one seemed to know who had made them or for what reason they were made.

Thus, the stone perimeter may indeed be ancient. It is covered with quartz and rock crystals, and both are clear signs of human ritual activity. Of course, further geological study is necessary to determine whether or not the quartz and crystal pebbles were brought there from different locations in the surrounding region. If so, they may have been brought as offerings to a sacred place. An alternative would be that the stone perimeter was built to enclose a natural sacred area where ground laden with quartz and crystal glows naturally in the moonlight.

As seen in Figure 12, another interesting structure which looks like a cross was also found inside the stone perimeter.

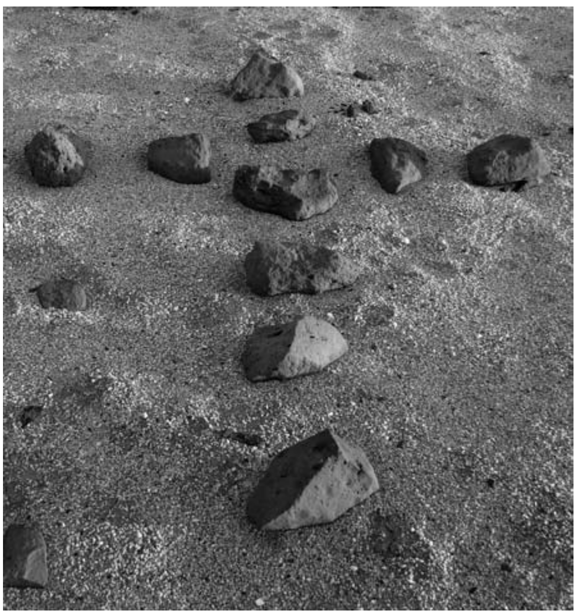

Figure 12.

How can this ‘cross’ be explained? It could perhaps be the grave of some Christian navigator after a shipwreck as the rocky beach is very near. It could also be a sign of early evangelisation of the region. That a priest or missionary would choose to teach religion and gather people together on a traditional religious ritual site would seem logical considering that this has been the usual practice of Christian religion. Such an interpretation would reflect the hypothesis that the location had been revered as a sacred place for a long time before the arrival of Christianity.

It is important to note that the range of hills is specific, well defined, and situated in an excellent direction to observe and mark the positions of the southern extremes of the sun and moon. Certainly the cairns are a modern addition, but even without the cairns, the horizon and its peaks could have been used for observations from the stone perimeter. In a country where human artefacts are so scarce, it is certainly a site worthy of further investigation.

I left a short preliminary written report and a series of photographs at the local centre for the protection of nature and landscape (CONANP, Bahia de Los Angeles, Northern Baja California) and made a request that the archaeologist in charge of the region be informed. It remains to be seen what may come from further investigation. Even if it is not an archaic astronomical site, something can be learned. It is that ‘half-baked scholarly tourism’ can be harmful and produce a lot of archaeological pollution.

Afterword

Figure 13 shows that the solstice sun really rises there. The public is usually very fond of such light effects.

Figure 13.

Astronomical Observations at Intimachay (Machu Picchu): A New Approach to an Old Problem

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Abstract

The imperial calendar, which facilitated the coordinating of administrative, economic, and religious-ceremonial functions, played an important role in managing the Tawantinsuyu or Inca Empire. A means of observing celestial bodies, primarily the Sun and Moon, was necessary for the practical operation of this empire. This article is dedicated to a special category of structures which may be called 'astronomical instruments'. These were intended for use by a narrow group of priests-astronomers, mentioned in some sources. An example is the case of Intimachay in Machu Picchu, which was indeed an astronomical observatory, as previous researchers have suggested, but one far more complex and precise than was previously believed.

KEYWORDS: Inca, astronomy, Intimachay, Machu Picchu

POVZETEK

Pri upravljanju inkovskega imperija (orig. Tawantinsuyu), je veliko vlogo igral imperialni koledar, ki je bil podlaga za koordinacijo administrativnih, ekonomskih in religiozno-obrednih opravil. Imperij je za svoje operativno delovanje potreboval tehnike opazovanja nebesnih teles, predvsem Sonca in Lune. V tem članku se posvečamo posebni kategoriji struktur, ki bi jih lahko imenovali 'astronomski inštrumenti'. Ti so bili namenjeni ozki skupini duhovnikov-astronomov, omenjenih v nekaterih virih. Primer je Intimachay na Machu Picchuju, ki je res bil astronomski observatorij, kot so to predlagale prejšnje raziskave, a precej bolj kompleksen in precizen, kot se je prvotno domnevalo.

KLJUČNE BESEDE: Inki, astronomija, Intimachay, Machu Picchu

Introduction

The Inca state, or Tawantinsuyu, was the final and relatively short period of cultural development of the Central-Andean territory that had lasted many thousands of years. Many of the achievements of that civilization, popularly associated with the Inca, had much earlier origins. Leaving open the question of the Incas' place of origin, it is assumed that during the period between the twelfth and thirteenth centuries AD, a semblance of a state was established with its centre in Cuzco. By the beginning of the fifteenth century, the Inca had taken over an area of approximately 100,000 sq. km. By 1532, they had conquered lands along the Pacific, in the Andes, and in the jungle ascending to a height of about 200 m. a. s. l. This ranged from the Ancasmayo river in Colombia to the river Maule in Chile, altogether 1.0 to 1.5 million square kilometres (the difference in estimates is due to a dispute over the spread of Inca authority in some of the areas).

The imperial calendar played an important role in managing such a large and diverse country. It facilitated the coordination of administrative, economic, and religious-ceremonial functions of importance to the Inca. The imperial calendar, however, was not the only time measuring tool used in Tawantinsuyu. There is evidence of the existence of other systems with a different genesis and purpose.

Apart from whether the calendar system was metropolitan or provincial, observation of celestial bodies, primarily the Sun, certain stars (e. g. the Pleiades; Aveni, 1981; Zawaski, 2007), and the Moon, was necessary for its practical functioning.

While certain chronicles describe different observation systems, in particular horizontal ones, they also mention gnomic observations. However, archaeological traces of such devices are extremely elusive. Discussion continues to this day regarding such basic issues as the existence, location, and practical application of the so-called *sukanka* system which includes pillars or similar constructions meant to be used for astronomical observations in the capital of Tawantinsuyu, Cusco, and its immediate vicinity (see Bauer and Dearborn, 1995).

It should also be noted that, when discussing devices used for tracking the movement of celestial bodies, two different categories of objects are considered:

- Those aimed at an approximate orientation towards, due to religious and ceremonial reasons, the rising or setting of the Sun at some important moment in its annual transition across the horizon. Examples of objects belonging to this category include the often mentioned *sukanka* on mount Picchu, west of Cusco, and a corridor orientated in the same direction leading towards the main square in Ingapirca, Ecuador. What was of importance in these cases was not so much precise astronomical observation but rather creating a visual effect for the masses of faithful gathered in the squares.
- Those which may be called 'astronomical instruments', intended for use by a narrow group of priests-astronomers, mentioned in some sources.

The latter category of objects was very scarce, but Intimachay in Machu Picchu appears to be an example.

Figure 1: Machu Picchu. The arrow points to the location of Intimachay within the site (image: GoogleEarth).

The cave of Intimachay (Machu Picchu)

Intimachay is a small cave situated on the eastern terraces of Machu Picchu (Fig.1). It is a rather empty space accidentally left between natural formations of big granite blocs constituting most of the Machu Picchu hill. However, this natural cavity has been intentionally reshaped to serve for some interesting activities, and these are the main topic of this article (Fig. 2).

Figure 2: Intimachay. View of the cave from the east side, indicating window E, specially constructed for astronomical observations (photo: Jacek Kościuk).

The cave has already been the subject of archaeological and astronomical analysis carried out by Dearborn, Schreiber and White (1987). They claim that:

> Sunlight will enter the cave at first gleam and penetrate to the back wall of the cave only for a very few days before and after the solstice. Because of the finite diameter of the sun, part of the limb of the sun can shine into the cave shortly after first gleam for about 10 days before and 10 days after the solstice. (…) We have found that not only is Intimachay suitable for observing the December solstice, but considerable effort was expended to make it so. The uniqueness of the structure and the precision of the alignment argue strongly that this alignment is not accidental. (Dearborn, Schreiber & White 1987: 350 - 351)

To illustrate their conclusions, the authors used a schematic plan (Fig. 3, top) and a reconstruction of the horizon seen from the window/tunnel, based on photographs ‘registered using points recorded with a transit, and oriented using solar observations’ (*ibidem*, see also Fig. 2, bottom).

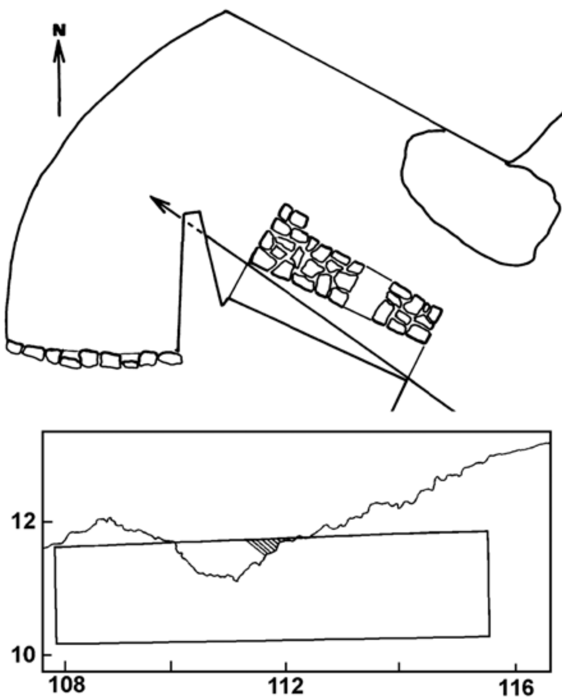

Figure 3: Intimachay. Top: schematic plan of the cave according to Dearborn, Schreiber and White (1987: 347). Bottom: view of the horizon from the Eastern Window according to our predecessors’ reconstruction; the marked area corresponds to the point of the rising sun on the day of December solstice (Dearborn, Schreiber & White 1987: 350).

In August 2012, we examined Intimachay again, as part of the Peruvian-Polish programme of 3D laser scanning of Machu Picchu. The project also includes precise orientation of the site and the establishment of a permanent reference network for further research. At first, 80 reference points were set up and stabilized on the area of Machu Picchu. Using Total Station, they were measured by precise triangulation. The orientation of the whole network was done in two steps. First, GPS[1] was set up at 8 points of the network, and static observations were recorded for the period of 6 hours. Observations were referenced to 4 GPS permanent stations of the IGS[2] Network and calculated coordinates were written in UTM 18S standard. The next step was to adjust coordinates of our 80-point trigonometric network to 8 points calculated by the GPS method. The resulting network orientation error, in the very worst case, does not exceed +/- 1 arc minute. An additional approximately 1 arc minute orientation error could have been added when referencing the scanner position used to survey the Intimachay sanctuary to the nearest points of the reference network. Taking into consideration the worst-case scenario, when both errors accumulate, the final orientation error for Intimachay cave should not exceed +/- 2 arc minutes.

This ongoing project includes study of the most relevant Inca ceremonial structures at Machu Picchu from an archaeological and astronomical point of view. With respect to the results obtained by our predecessors, we note some differences in measurements as well as several new observations adding to our knowledge and understanding of the importance of Intimachay.

When approaching the cave, one can notice that the whole façade consists of two distinct parts: natural (although precisely chiselled) rock, both on the northern and southern façade ends, and two dry masonry walls built from granite stones in the centre (Fig. 2). The first wall, built from roughly regular ashlars,[3] is approximately 1.4 m thick and was erected between two rocks on its southern and northern ends covering the natural entrance to the cave. One may enter the cave only through a door opening (ca. 1.4 by 1.7 m) at the northern end of the wall. A massive granite block (ca. 0.75 x 1.6 x 2.85 m) which slopes downward serves as a lintel. Above the lintel, the walls rise a further 2.3 m, forming a retaining wall for a terrace situated further up.

The second wall was attached to the first one at roughly a right angle with a clearly visible joint, indicating that the walls were erected during independent building operations. It cannot be determined whether they were only technological phases or separated by a longer span of time, but a noticeable difference between stone materials that were used may point to the latter alternative. Although the faces of each stone are also carefully dressed, the stones themselves are of very irregular shape, with many small irregular stone bits inserted between bigger pieces, all resembling a spider-web rabble wall. Only corner blocks and those of the uppermost layer are of a more regular ashlar like

[1] Four sets of Trimble R6 GNSS equipment kindly provided by Peruvian partners, Dirección Regional de Cultura-Cusco, has been used.
[2] International GNSS Service
[3] The foot of the wall the bond resembles the so called 'squared coursed rubble'.

shape. The whole wall rises only about 2,0 m and ends with a kind of a small, 0.8 by 1.4 m, platform. The wall was built against the afore-mentioned natural rock on the southern edge of the cave front. However, before the wall in question was executed, the rock had been carefully modelled by cutting a kind of a shelf or step running alongside the whole northern face of the rock (Fig. 4, left).

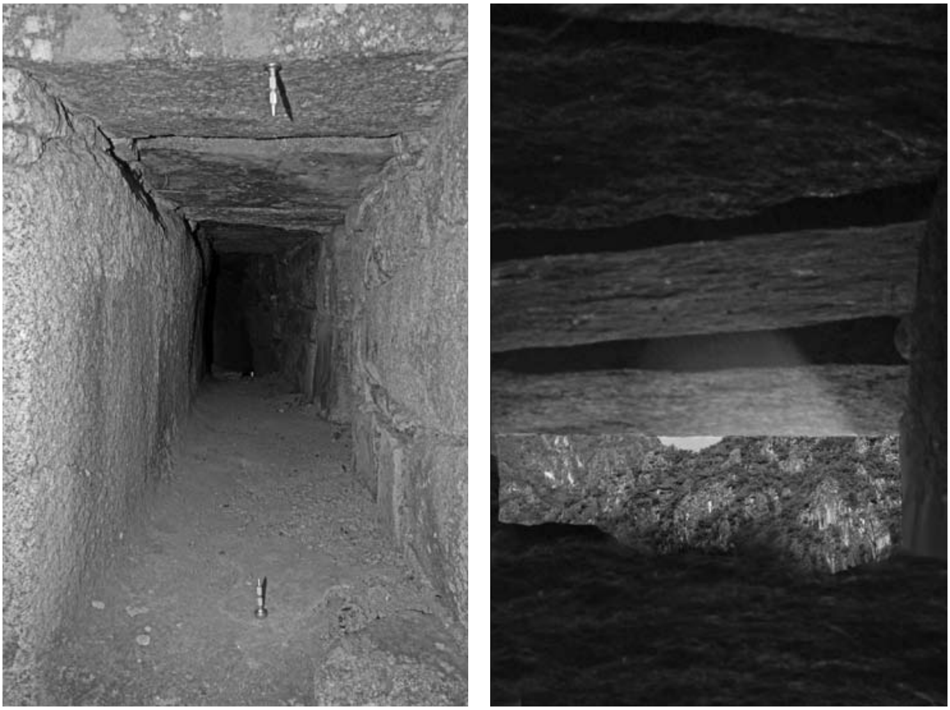

Figure 4: Intimachay, the Eastern Window. Left: interior; note the precisely chiselled and polished natural rock on the left and on the bottom, and an adjoining wall forming the right wall and ceiling. Right: photograph taken from the interior through the Eastern Window, with a view of the horizon (photos by Jacek Kościuk).

Together with the newly attached wall a kind of window/tunnel was formed, orientated E-W. Our predecessors described this feature, but did not discuss the possible function of the second window, which we describe as the Northern Window (Figs. 5 and 7).

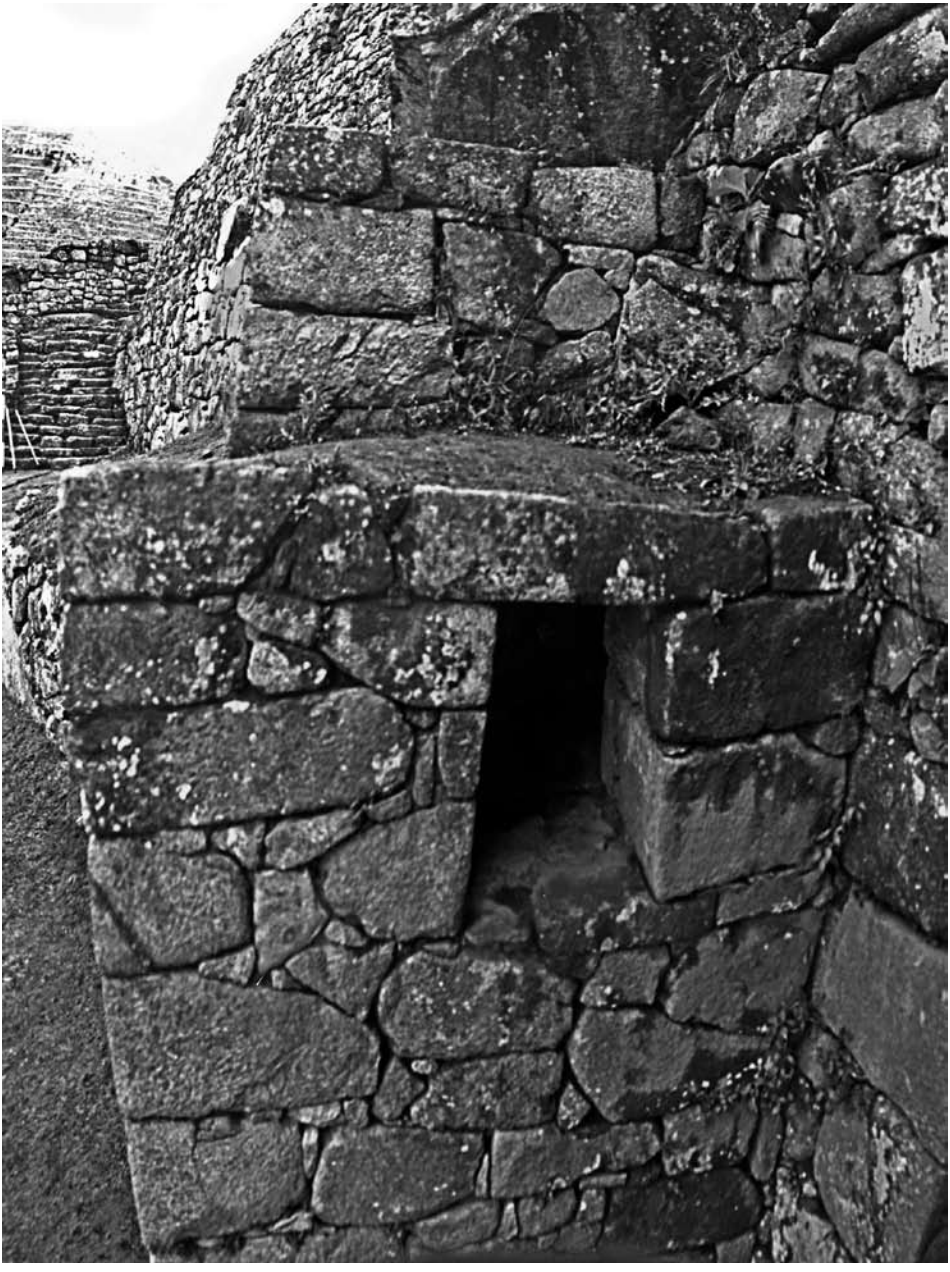

Figure 5: Intimachay, the Northern Window (photo by Jacek Kościuk).

This Northern Window is of similar width and height as the Eastern Window. However, it does not light the entire long tunnel but rather only a fragment of its southern sidewall. Dark, vertical, and fairly regular streaks are visible on this wall, exactly opposite the Northern Window (Fig. 6, right). The dark colour is most likely the result of the presence of lichens, but the regular arrangement of the streaks suggest that they spread over some parts of the rock surface which offered a more favourable environment for growth. At present, it cannot be determined whether vertical grooves had been carved into the surface of the wall or some other kind of a scale marked with organic or mineral 'paint' was formed. The question of the origin of the streaks requires further petrographic and biological analyses.

Figure 6: Intimachay, the Northern Window (photos by Jacek Kościuk). Left: view of the horizon from the interior. Right: dark, vertical, fairly regular streaks visible on the stone wall.

It can be deduced from the plan of Dearborn, Schreiber and White that the view of the horizon from the axis of that window is obstructed by a large stone (Fig. 3, top). In reality, this stone was intentionally flattened by the ancient builders, and a fairly large portion of the horizon can be seen from the window (Fig. 6, left). The builders also took a lot of care in flattening the natural rock at the threshold of the cave entrance. It is well levelled with two shallow and neatly cut steps leading into a triangular shape landing inside the cave (Fig. 7).

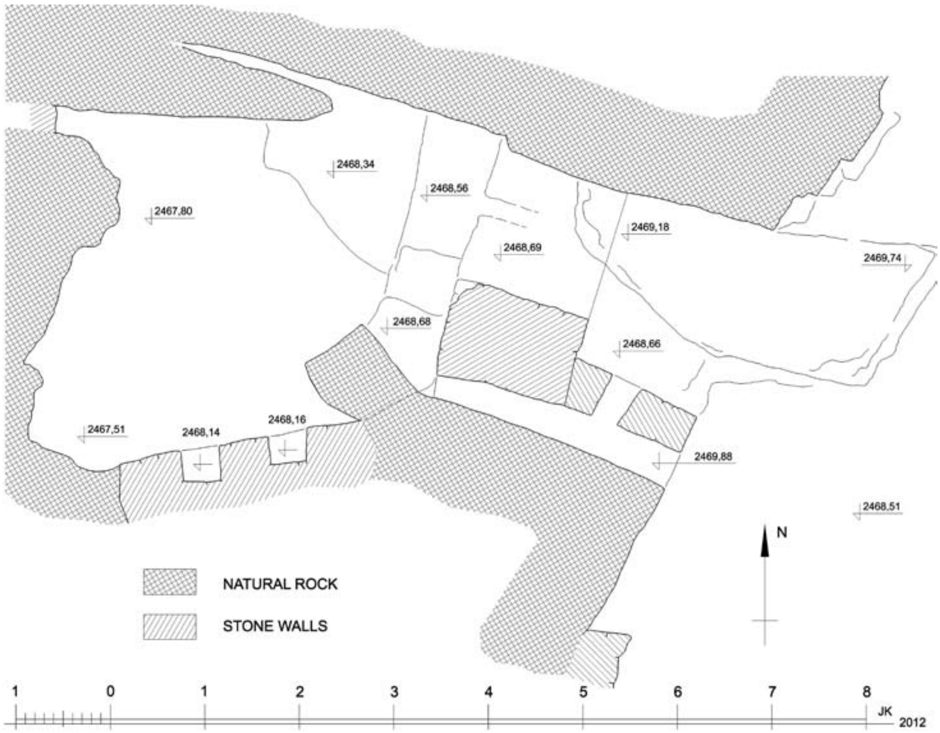

Figure 7: Intimachay, plan of the cave based on 3D laser scanning carried out in August 2012 by C. Medina Alpaca and Jacek Kościuk.

This short flight of steps has a kind of extension which leads to the south and also terminates with a small platform. Standing on this platform and squeezing one's head between the back of the front wall and a big granite block hanging from the cave ceiling, one can look through the eastern tunnel window. At the left hand corner of window sill there is a small and roughly shaped cut-out. Only if one's eye is placed exactly at this position, a portion of the eastern horizon is visible through the window tunnel (Fig. 8).

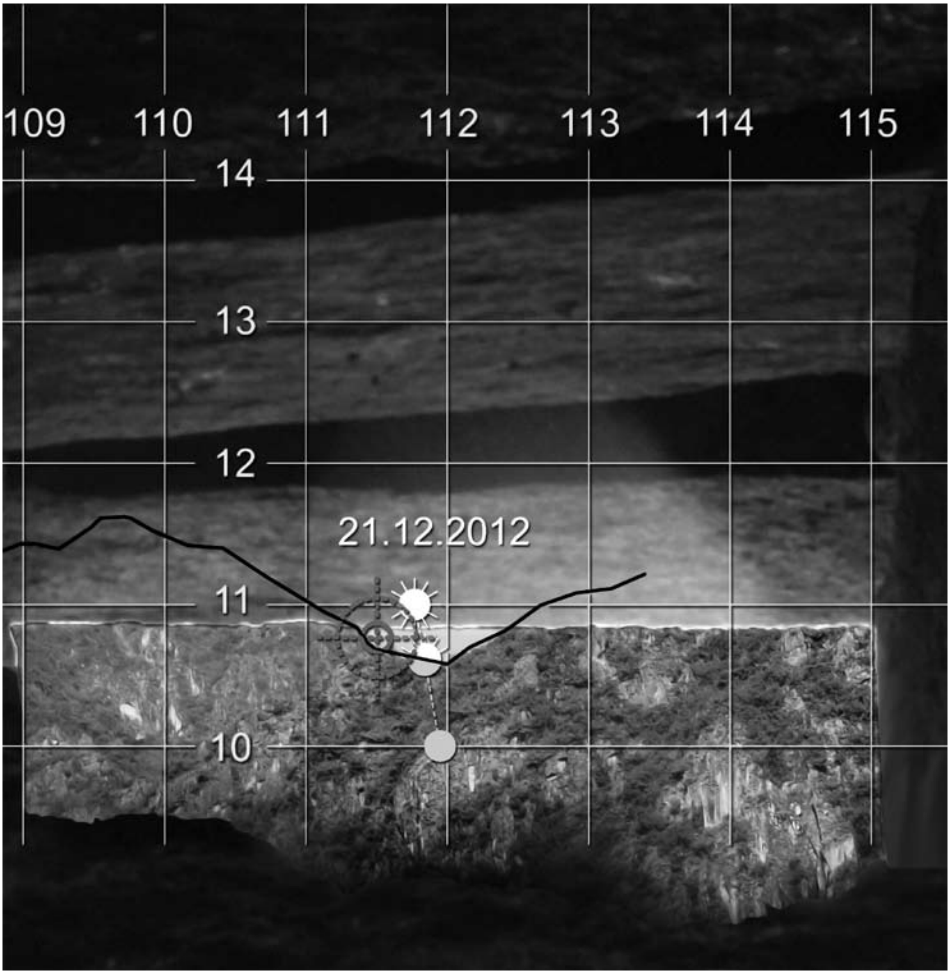

Figure 8: View of the horizon from the interior through the Eastern Window, with a degree grid and calibrated height. The orientation is given in degrees counting clockwise from the North. The position of the rising Sun on 21/12/2012 was reconstructed by M. Ziółkowski and J. Kościuk using Cartes du Ciel 3.6 software (Copyright Patrick Chevalley).

The cave interior has a very irregular shape (Fig. 7) which differs from that presented by Dearborn, Schreiber and White (Fig. 3, top)[4]. On the back wall of the cave, just opposite the entrance, are two narrow fissures between big irregular blocks of granite.

[4] One must remember, however, that we were lucky to use 3D laser scanner not available yet at the time our colleagues had surveyed the cave using conventional and much less precise equipment.

At least one of them terminates with a blockage erected from roughly rectangular ashlars. Also, the ceiling of the cave has a very irregular shape. Natural rock slopes down in a western direction meeting the earth floor alongside the southern portion of the cave's western perimeter. The floor at this part of the cave is roughly 1 m lower than the above described landing at the entrance. The northern end of the cave attracts visitors' attention with a well-constructed wall with two niches. The wall is erected from roughly regular blocks set with clay binder. Both niches are ca. 40 by 50 cm in size and ca. 35 cm deep (Fig. 7).

The shape of the entrance steps, the blocking of fissures and especially the southern wall with two niches give rise to a suspicion that the cave interior played some significant role in the activities performed there. The most important aspects, however, are the two tunnel windows evidently serving for astronomical observations.

Results of new astronomical analysis of Intimachay

With a precise 3D model of the cave, oriented to the above-mentioned precision +/- 2 arc minutes in relation to geographical directions, we completed a series of photographs of the horizon using a Sony α65 camera. We then conducted angular calibration of the photographs with the use of theodolite measurements of the height of the horizon in intervals, on average, of 10-15 arc minutes. When dealing with larger differences in height (e. g. mountain slopes), we narrowed height measurements, taking them in intervals of 5 angular minutes. This allowed for the reconstruction of the horizon line, in which an error of of +/- 2 arc minutes may be assumed, taking into account the possible lack of precision arising from placing the theodolite in a spot not precisely the same as that from which the pictures were taken. Therefore, taking into account the maximum declination resulting from the combined vertical orientation and height, precision of the orientation we calculated may be assumed to be approximately +/- 4 arc minutes (Fig. 8).

Further astronomical analysis was done with the use of the 'Cartes du ciel' (Skychart) v. 3.6 software (Copyright by Patrick Chevalley). To avoid a discussion of the fundamentals of adopting one or the other Intimachay construction date, we based our reconstruction of the astronomical function on the contemporary epoch (AD 2005-2012). Regardless of whether Intimachay was built in (for example) AD 1400, 1450 or 1500, the changes that took place since that time in the observed positions of the Sun and Moon are negligible. Further, a simple field verification of the correctness of the model of the functioning of Intimachay is possible, performing observations *in situ* at dates we provide.

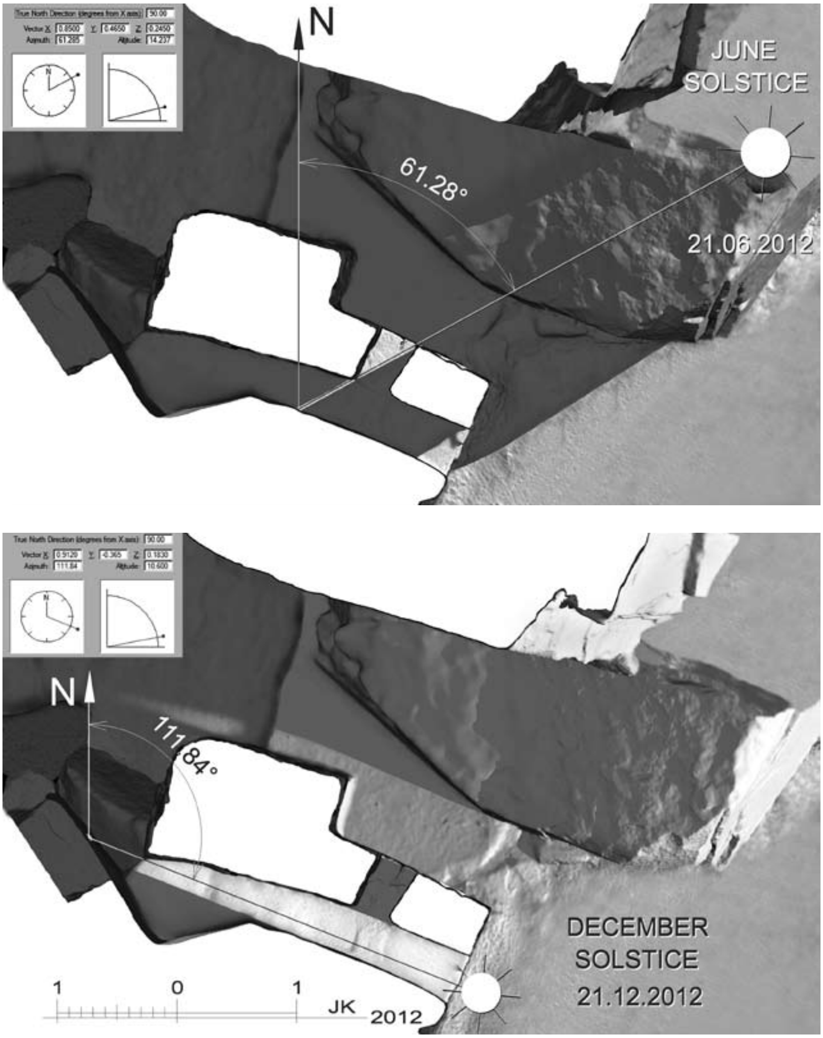

Figure 9: Intimachay, computer simulation of the lighting of Eastern and Northern windows. The positions of the Sun in 2012 were reconstructed by M. Ziółkowski and J. Kościuk, using Cartes du Ciel 3.6 software (Copyright: Patrick Chevalley).

In spite of the differences in the shape of the cave described above, we can confirm the findings of our predecessors, indicating that the window-tunnel (or Eastern Window) served for the observation of the rising Sun during the period of December solstice (Figs. 8 and 9, bottom). It is worth noting that, due to the specific position of both windows, other phemonena could also have been observed:

(1) A ray of the rising Sun falling diagonally through the Eastern Window during the Equinox will be visible through the Northern Window against the above-mentioned 'scale' made of dark streaks (Fig. 10, top).
(2) A beam of the rising Sun during June Solstice will fall through the Northern Window and will also light up the tunnel wall in the part covered by the afore-mentioned 'dark streaks' (Fig. 9, top).
(3) Significant to the theme of this article, a ray of the Moon rising at the Major Northern Lunistice will also fall through the Northern Window (Fig. 10, bottom).

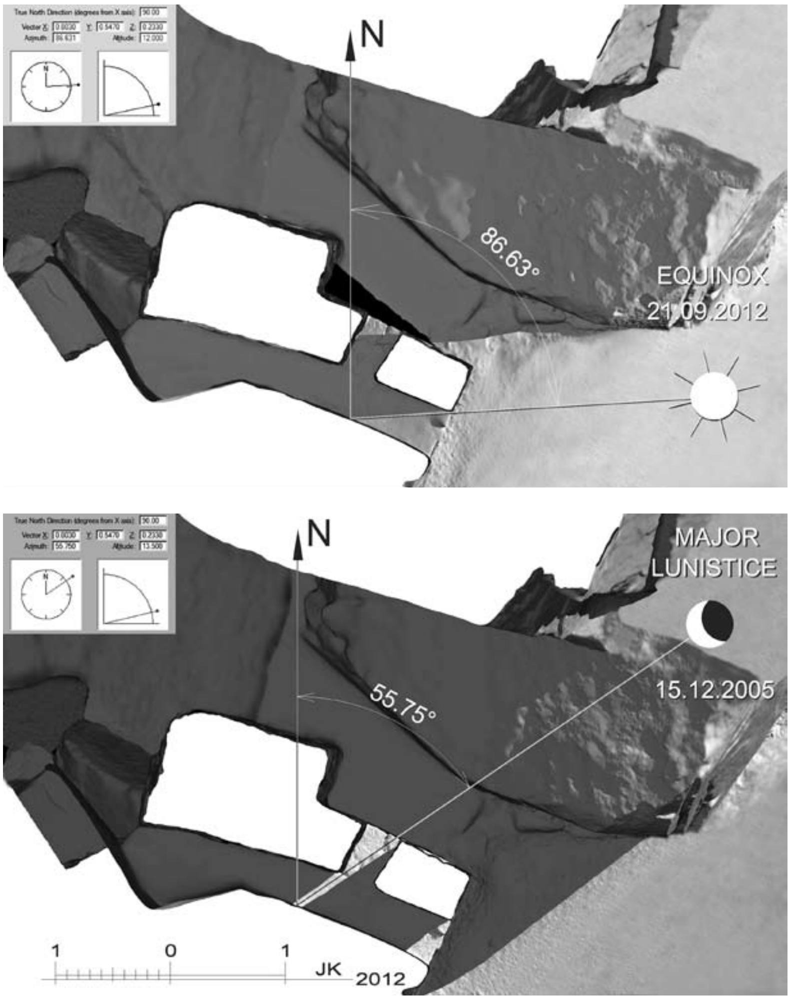

Figure 10: Intimachay, computer simulation of the lighting of Eastern and Northern windows, by M. Ziółkowski and J. Kościuk, using Cartes du Ciel 3.6 software (Copyright: Patrick Chevalley).

Conclusion

In studies devoted to Inca methods of horizont observations, researchers have not taken into account the existence of lunar orientations. Instead, they have focused their attention almost entirely on the position of the Sun and the Pleiades (Aveni, 1981; Zawaski 2007). In more recent publications on the subject, only one article provides evidence for the existence of a major lunar standstill orientation in the Ushnu in Huanuco Pampa (Pino Matos 2004). A more accurate analysis of some well-known sites, which up until now have been interpreted only as solar observatories, may provide evidence of their function as lunar observatories. Such it seems is the case with Intimachay in Machu Picchu, which was indeed an astronomical observatory, but one far more complex and precise than was previously believed.

Acknowledgement

Our thanks for their assistance to the personnel of the Machu Picchu National Park and in particular Eng. Cesar Medina Alpaca, Head of the 3D scanning project of the site, and Ms. Dorota Kozińska for translating this text into English.

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Africa and Asia

Swastika: The Forgotten Constellation Representing the Chariot of Mithras

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Abstract
The swastika is an ancient symbol that has been used by various ancient cultures. There is no convincing theory about the origins of the swastika. In this paper the author suggests how this symbol is related to a group of stars visible in the northern hemisphere. The author suggests the constellation formed by this group in relation to Mithraic myths as a support for the possibility of early awareness of astrological changes caused by the axial precession of the Earth. The research is based on a comparative study of ancient Iranian sources and Roman Mithraic iconography. The result suggests that the symbol of the swastika, along with several other symbols, can reveal a code for better understanding Iranian and Roman Mithraic myths and their early connections. This research is an original contribution to the field that represents a step towards revising previous theories on Mithraism.

KEYWORDS: Mithraism, Iranian studies, swastika, precession of equinoxes, Roman antiquity, Archaeoastronomy

POVZETEK
Svastika je star simbol, ki so ga uporabljala številna starodavna ljudstva. O njenem izvoru ni prepričljive teorije. V članku avtor predlaga, da se svastika povezuje s skupino zvezd, vidnih na severni polobli. Zveza med konstelacijo, ki jo tvori ta skupina, in mitraističnimi miti navaja na možnost, da so bile astrološke spremembe, ki jih povzroča precesija Zemljine osi, znane že zgodaj. Raziskava temelji na primerjalni študiji starodavnih iranskih virov in rimske mitraistične ikonografije. Rezultati kažejo, da lahko svastika skupaj z nekaterimi drugimi simboli razkrije ključ za boljše razumevanje iranskih in rimskih mitraističnih mitov ter njihove zgodnje povezanosti. Raziskava je izvirni prispevek k preučevanjem, ki vodijo k reviziji prejšnjih teorij o mitraizmu.

KLJUČNE BESEDE: mitraizem, iranske študije, svastika, precesija enakonočij, rimska antika, arheoastronomija

Mithraism

The modern term 'Mithraism' replaced the terms 'the mysteries of Mithras' or 'the mysteries of Persians' in antiquity. 'Mithras' is the name of the Indo-Iranian god 'Mithra', adopted into Greek. Because of the secret nature of this cult in Roman antiquity, almost no considerable written narratives or theology from the religion survive, but fortunately hundreds of materials related to Mithraism have been preserved. The most important artefact is a repeated bull-slaying scene, which leaves no doubt that this figure conveys the core divine message of the cult. The majority of the research on Roman Mithraism focuses on interpreting the physical evidence, while the definition of Roman Mithraism remains problematic and controversial. Despite the fact that the Romans believed in an Iranian origin for this cult, finding its origins has been one of the controversies among 20th century scholars.

The first surviving record of the name 'Mithra' dates back to 1400 B.C., spelled 'Mi-it-ra', in the inscribed[1] peace treaty between the Hittites and the Hurrian kingdom of Mitanni in Asia minor (Theim 1960). In Iranian mythology the god Mithra appears in the Avesta, the sacred texts of Zoroastrianism. The second longest *Yasht* (a collection of hymns) of the Avesta is named after him and has 146 verses. In this part of the Avesta, which is considered to preserve pre-Zoroastrian myths, Mithra appears to have *Varahran* (*Bahram* in modern Persian), a divinity associated with victory, as a companion. *Varahran* here is described as a boar with iron teeth running in front of Mithra's four-horse chariot, fighting for him.[2]

The first major scholarship on Roman Mithraism was published in 1894–1900 by Franz Cumont. Cumont believed that Roman Mithraism is the 'Roman form of Mazdaism' (Beck 1987: 298), and that the god Mithra came to Rome together with a large representation of the Mazdean pantheon. Cumont's theories remained widely accepted until the first International Congress of Mithraic studies in 1971. In this congress, John Hinnells and R. L. Gordon posed severe criticism of Cumont's theories. Hinnells argued that Cumont's reconstruction of Mithraic iconography is not supported by Iranian texts and is in fact in conflict with known Mazdean theology (Hinnells 1975: 294). Gordon claimed that Cumont forced the available material and evidence to conform to his model of Zoroastrian origins. He suggested that Roman Mithraism was an entirely new religion with no Persian origins (Gordon 1975: 215f). Yet none of these scholars proposed a new model to explain Roman Mithraism.

Michael Speidel, another scholar, associates some of the figures of tauroctony[3], or Mithras' slaughter of a bull, with figures of the zodiac, and the others to figures on the

[1] The name appears together with four other divinities as witnesses and keepers of the treaty. In Indic culture, 'Mitra', as it exists in Sanskrit, is a divinity of the Rigveda, distinguished by a relationship to Varuna, who is the protector of Rta, the principle of cosmic order and the regulator and coordinator of the universe.

[2] In another collection of hymns in the Avesta, the Gathas, which are associated with the words of Zoroaster himself, Mithra means 'oath'.

[3] In this scene a man wearing a Phrygian cap (generally accepted as the figure of Mithras) kills a bull. The bull always faces towards the right and the bull slayer turns his head while killing the bull. In the elaborated form, usually a dog, a snake, a cup, and a raven appear in the scene. In this scene a scorpion is attached to the bull's genitals. Two other men wearing Phrygian caps are standing one on each side with crossed legs, and bear torches in different positions. Some times a complete zodiac is depicted on top of the scene, and, rarely, a lion is also present sitting in the middle.

celestial equator (Speidel 1977). David Ulansey later suggested Taurus and Scorpios as the equinoctial constellations around the second millennium B.C., but argued that Speidel's model for the equatorial constellations is not convincing. He suggested instead that Mithras corresponds to Perseus, and believed that this concept originated in Asia Minor and developed in Rome as a new cult (Ulansey 1991).

Swastika

Each of these theories suffers from a self-referential hypothetical nature and does not draw an acceptable framework to describe the reason for selecting these constellations, or explain their vital symbolic meaning in Mithraic theology. In addition, they have missed an important symbolic element, the swastika, which mysteriously appeared in a Mithraic tauroctony scene. According to M. J. Vermaseren, a counter-clockwise swastika has been well preserved on a tauroctony scene found at Ghighen, in modern Bulgaria, and is now in the national museum in Sofia (Vermaseren 1956-1960: Mon. 2247). In another Mithraic artefact (fig. 1) from Italy, a clockwise swastika is depicted on a bronze statue along with two six-rayed star signs (Vermaseren 1956-1960: Mon. 765). Despite the rarity of this symbol in Roman Mithraic artefacts, this instance should not be ignored.

Figure 1: Left: Tauroctony found at Ghighen (CIMRM 2247). Right: Mithraic artefact with swastika (CIMRM 765).

The swastika is a symbol used by several ancient cultures. The swastika as a sacred symbol is well-known in the east, found commonly in the Indus valley around 2500 B.C. It remains a religious symbol in Hinduism and Jainism, and is widely in use. It has also been found in bronze and iron age cultures around the Black sea, Caspian Sea, and south-west Iran. In Buddhism it is known as *yung drung* and is the graphic representation of eternity. In Chinese and Japanese the word represented by swastika in writing is a homonym of the number 10,000, and is commonly used to represent the whole of creation. It is also present in Greek architectural motifs, cloths, coins, and artefacts dating back to the 8th century B.C.

What makes the swastika interesting in the context of Mithraism is the wide use of this symbol in the east, particularly in ancient Iran and India, coinciding with the Mithraic tauroctony. Interestingly, the swastika was known as 'the chariot of Mithra' in Iran (Bakhtvartash 2001: 139; Ghiasabadi 2003: 36). In the *Mihr Yasht* of Avesta, Mithra is described as having a celestial quadriga pulled by four heavenly white horses, who have front hoofs made of gold and back hoofs made of silver (*Mihr Yasht,* Verses 112,124,125,136). His chariot is decorated with the stars and his bright face is like the star Sirius (*Mihr Yasht,* Verse 143). He hears with his thousand ears and watches with his thousand eyes, always standing on the high end of the sky, restlessly, in the north, arising above the *Alborz* mountain.[4] He appears before the sunrise and after the sunset and touches both ends of the ball-shaped earth, and he watches everything between the earth and the sky (*Mihr Yasht,* Verse 95).

This leaves no doubt that the seat of Mithra and his quadriga is a celestial body in the sky close to the celestial north pole.[5] If we look out in a clear night sky in the northern hemisphere to the constellation Draco, we can recognize a clockwise swastika (Fig. 2). Its center is Zeta Draco (HIP83895), and it consists of four wings: 15 Draco-Pherkad-Zeta Ursa Minor, Eta Draco-Theta Draco-Edasich, 26 Draco-Gramium-Rustaban, and Omega Draco-Phi Draco-Upsilon Draco-Atlantis; and it has four stars as companions: Kokab, HIP78189, Etamin, and Epsilon Draco (Fig. 3).

The counter-clockwise swastika in the tauroctony scene of Ghigen is the mirror image of the celestial clockwise swastika because tauroctony is a symbolic projection of the celestial bodies. Also, other symbolic figures such as Taurus, Canis minor, and Scorpio which appear together in most of tauroctony scenes are always projected as mirror images of the celestial constellations.

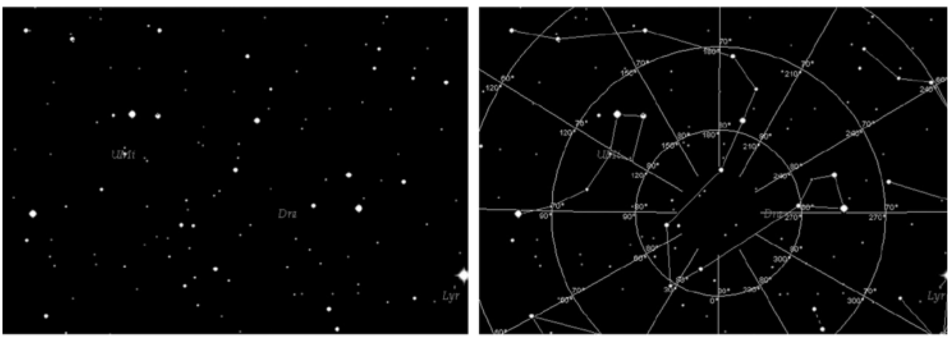

Figure 2: Stars around the north ecliptic pole.

[4] Alborz is now the name of a chain of mountains in northern Iran, but in ancient times the name referred to the whole chain of mountains from Pamir to Anatolia. This verse identifies the location of the celestial body of Mithra in the north sky.

[5] R. M. Ghiasabadi related Mithra to the north celestial pole and the four horses to the four bright stars of Ursa Minor pulling the sky around the pole once a day (Ghiasabadi 2003: 36,57).

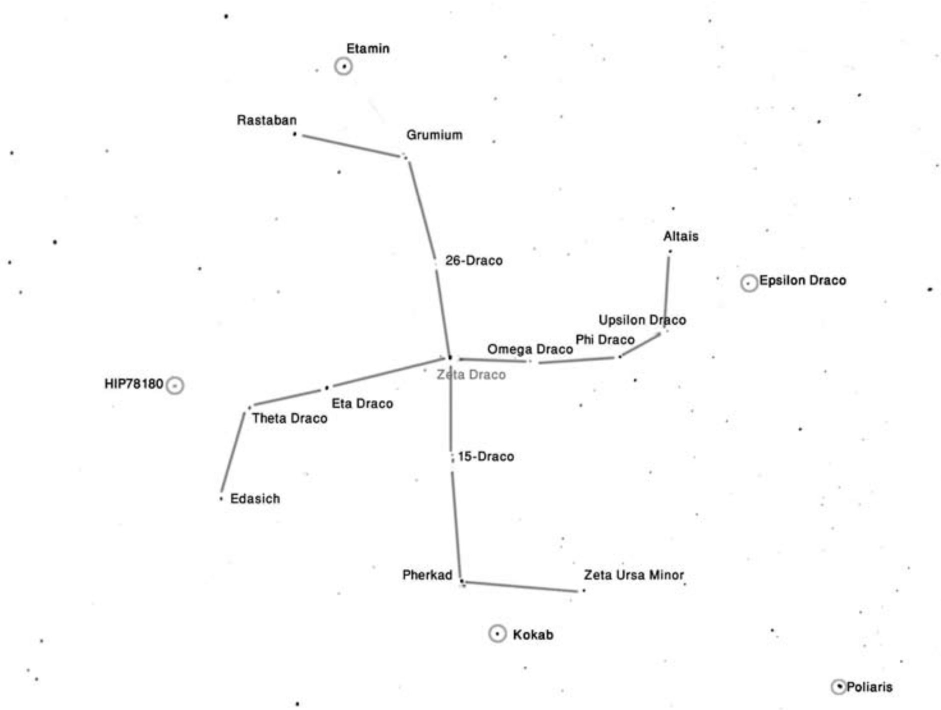

Figure 3: The celestial Swastika.

Zeta Draco is the closest star to the north ecliptic pole and the center of the zodiac in the star map. Because the axial precession of the earth takes place around an axis perpendicular to earth's orbit around the sun, ecliptic poles serve as the precessional poles of the earth, too. Therefore, Zeta Draco is not only the star of the north ecliptic pole, but also represents the north precessional pole. It is the only star which never changes its path in the north sky; instead, the north celestial pole and other celestial bodies rotate clockwise around this point (almost one degree every 72 years). The ecliptic pole as the center of the zodiac would have been known to ancient civilizations, even if one does not admit that the precession was known until the Greek astronomer Hipparcus.

Symbolism in Tauroctony

As an observational consequence of precession, the constellations of the zodiac remain on the ecliptic but shift backwards almost one sign every two millennia (30 degrees every 2160 years), which are known as an astrological age. Each astrological age is named after the zodiac sign(s) rising or setting on the equinoctial points[6] in that age, representing

[6] The points on the horizon where the sun rises/sets during the equinoxes, or the intersection of the ecliptic and celestial equator.

the sign(s) of the spring or fall equinox. The precession forces all the constellations to change their position – except the swastika, which spins slowly round in its clockwise direction around Zeta Draco. In this great change the family of signs of the zodiac stays on the ecliptic while the family of the constellations representing the east rising stars or the celestial equator changes its members in each age. The latter family gains a new pair of zodiac constellations on its intersection with the ecliptic (which become the symbol of the age), accompanied by one other constellation which 'passes over' the celestial equator at the same time. I suggest that this phenomenon provides a framework for decoding the secret of the cosmic imagery of the Mithraic tauroctony.

Here is the explanation: Knowing that, in addition to the planets and the moon and the sun having their cyclical movement, the cosmos appears to have its own great cycle rotating around the ecliptic pole, one can make a simple astrolabe in which its background image showing the constellations rotates around the center of the ecliptic circle (Zeta Draco), while the two circles of the ecliptic and the equator of the astrolabe remain fixed. This is the secret to simulating the cosmos during the great year: by rotating the astrolabe thirty degrees, or one sign of the zodiac, for each astrological age, one reveals the star map of that age. By rewinding this cosmic clock and tracking back the motions of the celestial bodies, one can see that the beginning of each age corresponds to the arrival of a new pair of zodiac signs at the intersecting points of the two circles of this astrolabe. Another constellation, which I call the 'forerunner', also intersects with the equatorial circle and rises on the east just before the sign of the age. Surprisingly, the forerunner constellations of successive ages correspond with the constellations depicted in the tauroctony.[7]

The forerunner constellation of each age joins the new zodiac pair in the east, metaphorically overthrowing the sign of the previous age. Corvus comes with Leo-Aquarius, Crater with Cancer-Capricornus, Hydra with Gemini-Sagittarius, Canis Minor with Taurus-Scorpius, and Orion with Aries-Libra. More precisely, the brightest star of Orion, Betelgeuse (Alpha Orion), intersects with the celestial equator, overthrowing the brightest star of Taurus, Aldebaran (Alpha Taurus), commencing the age of Aries. Correspondingly, in the tauroctony, the man who overthrows the Bull with Scorpius attached to its genitals could be Orion – or the god Mithras incarnated as Orion, as the hero of the age of Aries.[8] This imagery might even have been developed from a basic astrological framework derived from the east by the Greeks and Romans. The message of this image is the awareness of the coming of the new age, Pisces-Virgo (two fish and a virgin). This age commenced around 1 A.D., when the edge of Pisces (the segment between Omicron

[7] Spiedel contemplated their relationship with the equator in the ancient sky, but this set of constellations (Corvus, Hydra, Crater, Canis Minor, and Orion) never appears fully as the equatorial constellations. For example, Canis Minor should not appear in the taurectony according to Spiedel's framework, but it does. Ulansey also rejects Spiedel's theory of Mithras-Orion because of this fact (Ulansey 1991).

[8] In addition to Taurus and Scorpius, which are always present in the taurectony as zodiac signs, a lion, which could be Leo – the Solstitial sign of the age of Taurus – often appears in the middle of the scene. A relation between this lion and the lion-headed god of Roman Mithraism is also possible.

Pisces and Eta Pisces) reached the equinoctial point (the intersection of the ecliptic circle and celestial equator) and Spica, the brightest star of Virgo, reached the celestial equator and rose in the east (fig. 4).

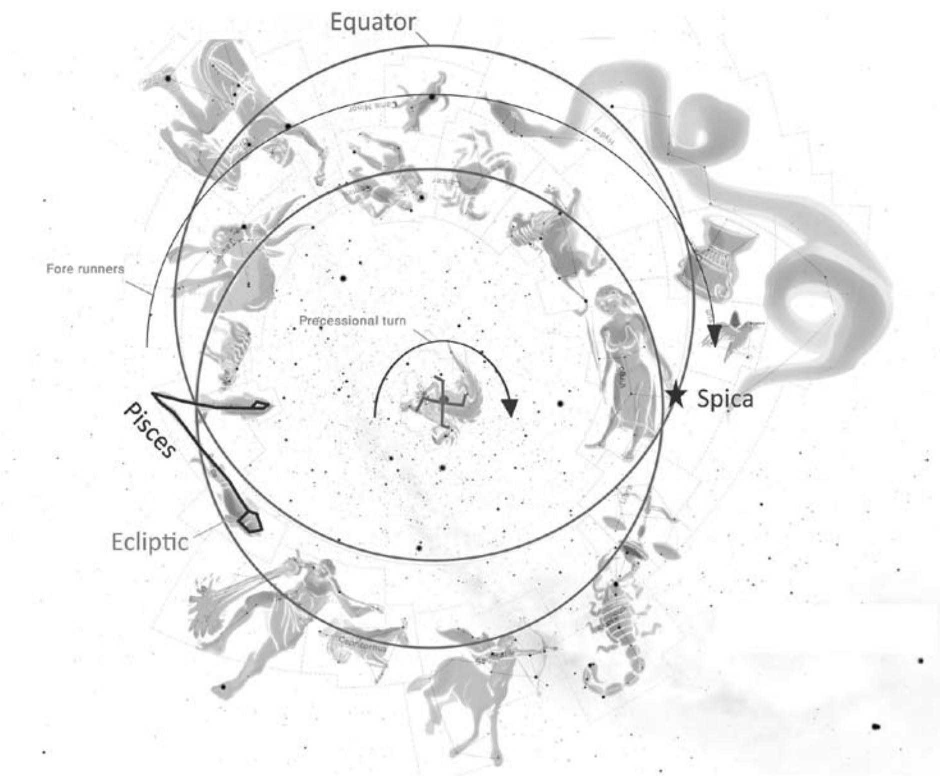

Figure 4: The proposed Mithraic astrolabe. The precessional rotation in the sky of the northern hemisphere from 10500 BC to 1 AD.

The tauroctony proposes the start of this cosmic clock in the age of Leo-Aquarius (10,500 B.C. – 8000 B.C.), represented by the constellation Corvus, and the only missing age in this imagery is Pisces-Virgo, which was yet to come. In this binary system the great cycle of the world sums up to 12 millennia. The concept of the great year, or 12,000 years consisting of six ages, half evil and half peaceful, is a Zurvanite belief in ancient Iran.

Zurvan is the concept of time, supreme god, and primordial creator deity in the Iranian cult of Zurvanism. The name 'Zurvan' may be discerned on tablets dating back to the 12th century B.C. Zurvan is referred to in two forms: '*Zurvan Akarănak*' (the god of infinite time) and '*Dirang Xutăy*' (the god of finite time). Iranian Pahlavi sources tell that material creation evolved from the infinite to four elements, then to a second form of mixing of these primary properties, and finally to the fully developed cosmos. This form exists for twelve thousand years after which the whole is taken up to the infinite again (Zaehner 1955: 266). According to another report (from Eznik of Kolb, an Armenian writer of the fifth century), Zurvan wished to have a son, with the name Ohrmazd, who would create heaven, earth, and all beings. After offering sacrifice for a thousand years Zurvan began to ponder and doubt if he should wait. While doing so, Ohrmazd and Ahriman were conceived: Ohrmazd (Ahura-Mazda, the good god of Mazdean theology) from Zurvan's thousand years of sacrifice and Ahriman (evil) from Zurvan's doubt. In finite time and space, which exists for 12000 years, there is a battle between good and evil. There is also a treaty between Ohrmazd and Ahriman to keep the balance and prevent Ahriman from ruling for more than half of the ages.[9] The mediator[10] who keeps the treaty is Mithra (Zaehner 1955: 101).

Chariot of Mithra

Now we can draw a scheme to understand the cosmic image of Mithra and its symbolism. Mithra is the god of cosmic order, the divinity who keeps the treaties, the god of vast pastures, who rises on the north sky, never sleeps, and watches everything with his thousand eyes. His chariot is the swastika driven by four white horses running smoothly through the ages of time.

If we look more carefully at the proposed celestial swastika, we can even draw the star map of the four horses of this constellation pulling the swastika (or the 'cross' of swastika) on its clockwise direction around the center, as shown in the figure (fig. 5). The story of the four horses of Mithra is copied in the so-called Song of Magians preserved by *Dio Chrisostom* and cited by Cumont, Reitzenstein, Nyberg, and Zaehner.[11] According to Cumont, the myth is genuinely Magian in origin.[12]

In Cumont's account of the story, 'the supreme god drives a chariot drawn by four steeds which turn ceaselessly round in a fixed circle.' (Cumont 1956: 116-118). Zaehner states that: 'The myth speaks of Zeus as the first and perfect charioteer of the perfect chariot. This chariot which is the cosmos, is guided by the one charioteer and proceeds on its course throughout "unceasing periods of eternity". Men can only see the course of the sun and Moon, but "can not grasp the movement of the whole". Each horse is sacred to one of four mythical figures: Zeus, Hera, Poseidon, and Hestia …' (Zaehner 1955: 226). And Cumont goes on to describe the story in detail:

[9] Dark and light cycles are usually 1000 years long, for example the evil rule of Zahhak in Iranian myths.
[10] After the third century, Mihr (Mithra) was often presented as identical to the sun, where as in the Avesta he is clearly distinguished from the sun.
[11] Zaehner believes this song is evidence for the divinization of the four elements in Zurvanism and fits in a fourfold structure that repeats in this worldview.
[12] He believes the charioteer Zeus in this myth is the supreme god Zurvan, and the four horses represent the four elements.

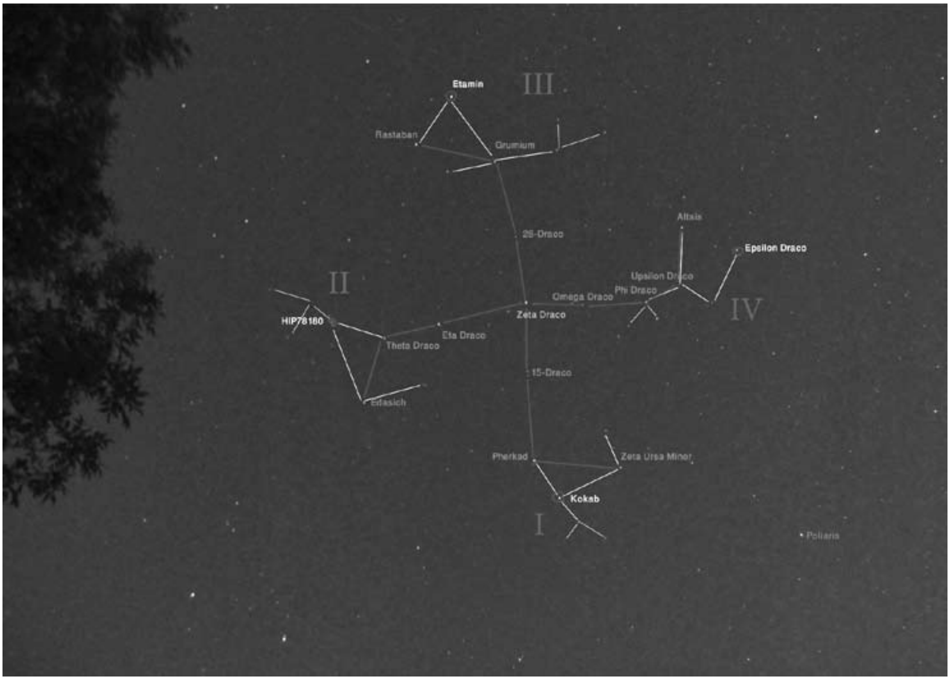

Figure 5: The celestial quadriga.

The first [of these horses], which bears on its shining coat[13] the signs of the planets and constellations, is sturdy and agile and traverses the circumference of the fixed circle with extreme velocity; the second, less vigorous and less rapid in its movement[14], wears a sombre robe, of which one side is illuminated by the rays of the sun; the third proceeds more slowly still; and the forth turns slowly in the same spot, champing restlessly its steel bit[15], whilst its companions moved round it as round a stationary column in the center. The quadriga turns slowly and unimpeded, regularly completing its eternal course. But at a certain moment the fiery breath of the first horse falling upon the forth ignites its mane, and its neighbour, exhausted by its efforts, inundates it with torrents of perspiration. Finally, a still more remarkable phenomenon takes place, the appearance of the quartet …

[13] 'Shining coat' may refer to the star Kokab – the brightest star among the four companion stars of the celestial swastika.

[14] The details of the story about the first horse being agile and rapid and the second horse being less rapid are possibly because the angle of 15Draco-Zeta Draco-Eta Draco is smaller that the angle of Eta Draco-Zeta Draco-26 Draco. Thus it seems that the first horse wearing the shiny coat (Kokab) runs faster than the second horse that wears a somber robe (HIP78180, the least bright star among the four companion stars of the celestial swastika).

[15] The suggested figure of the fourth horse turns in the same spot instead of continuing on the circular path of the celestial swastika.

The details of this story coincide with the graphic and geometric forms of the horses in the proposed star map of the figure for the four horses of the swastika. There is a bronze age statue of a Charioteer found in Serbia with the symbol of swastika and also some Roman artefacts show four horse-heads shaping a counter clock-wise swastika while the horses move the swastika in clock-wise direction (fig. 6). Regardless of finding direct connections between the latter instances and the Mithraic cult, they show that, in the west, the swastika could represent the four-horse chariot running clock-wise around a stationary column.

Figure 6: Left: A bronze age statue of a charioteer with three swastikas, City museum of Vrsac, Serbia (source: www.muzejvrsac.org.rs). Right: Roman bronze brooch showing four horses of swastika (source: www.antiquesnavigator.com).

In Roman artefacts, Mithras is shown as the charioteer of the quadriga. In another image, Mithras spins the cosmic sphere in his hand, and in another he holds the cosmic sphere in one hand and turns the zodiac with the other (fig. 7). This image resembles a Greek mosaic of Aeon, the god of time, turning the circle of the zodiac. Even more interestingly, a zodiac mosaic from the 6^{th} century in the core space of a synagogue at Beth Alpha shows the four horse chariot in the middle of the zodiac, and a charioteer with a six-ray crown (fig. 8).[16]

[16] Considering the rarity of astrological graphics in the Jewish tradition, this zodiac is significant and, while potentially suspect of imitating an older Roman graphic, should convey an astronomical message. In the middle of the zodiac is the charioteer on a quadriga and four horses. There are four other figures at the corners. The charioteer has a crown with six rays and around the chariot are the moon and the stars. The chariot has two wheels, each consisting of six parts of dark and light colors.

Figure 7: Left: Mithras running the quadriga (CIMRM 943). Middle: Mithras spinning the cosmic sphere (CIMRM 506). Right: Mithras turning the Zodiac and the cosmic sphere (CIMRM 985).

Figure 8: 6th Century mosaic pavement of Beth Alpha synagogue (source: www-spof.gsfc.nasa.gov).

In Roman artefacts the constellation of swastika is depicted as a four-horse chariot of Mithras. Representing the north ecliptic pole (the center of the ecliptic circle), this four-horse chariot often symbolically serves the Sun or Helios who runs on the ecliptic circle. The affiliation between Mithras and Helios could be explained in this way. The cross of Zodiac is a well-known symbol. The ring of Mithra or a circle depicted on this cross possibly is the path of the star of Mithra (Zeta Draco). This path is the circular path, of apparent daily rotation of Zeta Draco around the north celestial pole. This circle remains in the same place during the astrological ages, while the celestial north pole changes position because of axial precession.

In Christianity we often see the image of Jesus appearing the middle of a zodiac with his twelve companions. The image of Christ also coincides with the cross and circle. If we take the cross as the short form of the swastika (or the celestial quadriga), then Jesus would be the successor of Mithras, born when Pisces reaches the equinoctial point and Spica, the brightest star of Virgo (the virgin) and the symbol of wheat or the house of bread (the literal translation of Bethlehem), reaches the celestial equator and rises in the east. The story of three Magi wearing Phrygian caps, like the three men in the tauroctony, sounds Mithraic: their following the star in the east towards Bethlehem to inaugurate the birth of Jesus could be a story about the astronomical observation of Spica in order to determine its arrival on the celestial equator to announce the beginning of the age of Pisces. This is the age in which mankind was saved and gifted a loaf of bread and two fish by their virgin-born savior (in the christian account).

This fact might be a tenet of Roman Mithraism: the wonder of the new astrological age which was believed to be the last age of the universe. It represents the problem of finding a new mythical hero for the age of Pisces, in which the god Mithras is incarnated. It is the age of the final battle between good and evil.

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DNA, Wine & Eclipses: the Dakhamunzu Affaire

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Abstract

In a recent book, Dodson (2009) has presented an updated impression of the Amarna period, in heavy contrast to the ideas lately defended by Krauss (2008) and other authors such as Reeves (2002) or Gabolde (1998; 2005). Dodson uses the recent archaeological and epigraphic sources to offer a state of the art version of this fascinating historical period where he defends Ankhesenamun as the Dakhamunzu of the Hittite texts (the Egyptian queen who wrote to king Suppiluliuma asking for a husband), and the filiation of Tutankhamun as son of Nefertiti and Akhenaten. Dodson keeps the old chronology situating the ascent to the throne of this latter king c. 1553 BC. However, in the last few years there has been a crucial revolution of various aspects in the understanding of the Amarna period. This revolution includes: new evidence from Hittite sources which make Tutankhamun a contemporary of Mursili II (Miller 2007), a new length for the reign of Horemheb (van Dijk 2008), and the important data yielded by DNA analysis of the Amarna period family (Hawass et al. 2010). All this new information has been gathered together with the astronomical evidence of this period: the hypothetical solar orientation of Akhetaten main temple at the moment of the foundation of the city and a possible eclipse of the Hittite sources. These new data have allowed the implementation of a new theory which offers a completely different picture of the period and a new chronology for the late 18th Dynasty (see also Belmonte 2012).

KEYWORDS: archaeology, archaeoastronomy, chronology, DNA, Amarna period

POVZETEK

Pred kratkim je Dodson (2009) podal najnovejša spoznanja o obdobju Amarne, ki močno odstopajo od idej Kraussa (2008) ter drugih avtorjev, kot so Reeves (2002) in Gabolde (1998; 2005). Dodson je na podlagi najnovejših arheoloških in epigrafskih virov podal novo verzijo tega fascinantnega zgodovinskega obdobja, v kateri zagovarja, da je Ankhesenamun pravzaprav ista oseba kot Dakhamunzu iz hetitskih tekstov (egiptovska kraljica, ki je pisala kralju Suppiluliumi s prošnjo za moža) in da je Tutankhamun sin Nefertiti in Akhenatena. Ustoličenje slednjega Dodson, v skladu s staro kronologijo, postavlja v čas okoli 1553 pr. n. št. Toda v zadnjih letih je prišlo do revolucionarnih sprememb v razumevanju amarnskega obdobja: gre predvsem za nove hetitske vire, po katerih sta bila Tutankhamun in Mursili II sodobnika (Miller 2007), za drugačno dolžino kraljevanja Horemhe-

ba (van Dijk 2008) ter za pomembne rezultate analize DNK družine amarnskega obdobja (Hawass et al. 2010). Astronomski podatki, ki ta nova dognanja nadgrajujejo, vključujejo hipotetično solarno orientacijo Akhetatenovega glavnega templja v času osnovanja mesta in možni mrk, omenjen v hetitskih virih. Vsa ta nova spoznanja so omogočila postavitev nove teorije, ki podaja povsem drugačno sliko tistega časa ter spremenjeno kronologijo pozne 18. dinastije (glej še Belmonte 2012).

KLJUČNE BESEDE: arheologija, arheoastronomija, kronologija, DNK, obdobje Amarne

State of the question

A text inscribed on one of the border steles (the X, but also in the K) reflects the first visit of king Akhenaten to the site of his new city, the 'Horizon of the Disc' or Akhetaten, in order to perform the foundation ceremonies on the 13th day of the 4th month of Peret of his 5th year of reign. Presumably, This moment was also the one chosen to hold on the ceremony of the stretching of the cord that would give rise to the location and orientation of the chief temple of the new city, known today as a the small temple of Aten (Luc Gabolde 2009). The main axis of the temple points to a single element of the landscape, a valley that recalls the hieroglyphic sign for mountain. This topographic reference dominates the geographic environment of the great circus of cliffs where the city was erected. The text suggests that this element is perhaps the 'horizon of the disk' itself, which would be in the origin of the name of the city (see Figure 1).

Figure 1: The axis of the small temple of the god Aten, the solar disk, in Tell el Amarna is oriented to a particular notch on the horizon where the sun rises at the end of February and October, perhaps in representation of the ancient name of the city: Akhetaten, the 'Horizon of the Disk'. Adapted from Belmonte (2012).

With the axis of the small temple of Aten oriented to an azimuth of c. 103½º (Belmonte and Shaltout 2009: Appendix II), the phenomenon shown in fig. 1 could be observed between February 19 and 20 in the proleptic Gregorian calendar, equivalent with the margin of a day to IV Peret 13 of the year 1335 BC. In fact, the adjustment is possible in any of the four years centred in 1335/6 BC, considering the dynamics of the Egyptian calendar, and taking into account certain margins of error, perhaps a couple of years before or after. If this is correct, we would have a key archaeoastronomical date that would fix year 5 of Akhenaten in 1335±4 BC. However, if the majority of the chronologies are analyzed (see, e.g. Hornung, Krauss and Warburton 2006), these have fixed the reign of Akhenaten between 1353/1 and 1336/4 BC, so that his year 5 would fall around 1348 BC. Hence, we would certainly be facing a problem.

However, van Dijk (2008) has re-excavated the tomb of Horemheb, and analyzed the fragments of wine jar seals scattered on site, discovering that the reign of this king should be reduced to no more than 15 years, which would mean a reduction of about 12/13 years in the chronology of the Amarna period. This fact alone would situate year 5 of Akhenaten in a very suitable 1335/6 BC. However, things are not always as simple as one would desire, and not all scholars have accepted the reduction of the reign of Horemheb, since an alteration of the chronology of the Amarna period implies a series of factors that involve not only the Egyptian sources, but also others such as the ones of the Hittites, the Babylonians and the Assyrians, making of the issue a very complicated puzzle.

Recently, Aidan Dodson (2009) has published a new book, with the suggestive title of 'Amarna Sunset', where he enters in full in the critical period under consideration, this epoch being the lead reason for his work. His nuclear idea is that there is a son of the king, who clearly appears in the archaeological record referred to as:

'The son of the king, of his own body, his beloved Tutankh(u)aton',

according to a relief found in Hermopolis but possibly brought from Amarna together with other building material. This prince was born around year 7 or 8 of his father's reign who, according to Dodson, would necessarily be Akhenaten. He would also be a son of Nefertiti, since King Ay called Tutankhamun his son (for grandson). From this we also learn that Nefertiti would have been a daughter of Ay.

There is a particularly thorny issue, the Dakhamunzu affaire, which has much to do with the relative chronology of the period and which can potentially lead to a quite significant interchange of numbers. The majority of manuals of History of Egypt that can be purchased in bookstores today tell the story in the following way:

Around year 3 or 4 of his reign, the young king Amenhotep IV started a major religious reform in the company of his consort, the 'great royal wife' (Weret Hemet Nesu in Egyptian) Nefertiti. According to this reform, the Sun disk, Aten, one of the manifestations of Ra-Horakhty, became the supreme deity of the country. In year 5, he founded a new city, Akhetaten, where he moved his court shortly afterwards. In that period, the king changed his 'Son of Ra' name from the traditional Amenhotep to Akhenaten, 'the one who is beneficial to the disk'. In those years, Akhenaten and Nefertiti had a total of 6 daughters. Meritaten, the eldest one, would have been born around year 4.

Subsequently, around Akhenaten's year 15, queen Nefertiti disappears from the scene, either by natural death or a fall in disgrace, and Akhenaten chose a close relative as coregent (a younger brother or a secondary son of his, according to different variants) who died shortly after a very brief reign, after the death of Akhenaten in year 17. This king, known as Semenkhkare (also Neferneferuaten) would have had the eldest daughter of Nefertiti and Akhenaten, Meritaten, as great royal wife, and would unsuccessfully try an approach to the clergy of Amun. After his death at an early age (in his twenties), and after various vicissitudes, he would be buried in tomb KV55 in the Valley of the Kings.

Once Semenkhkare was dead, the throne would have passed to other very young, almost a child, son-in-law of Akhenaten: Tutankhaten (a son of the King, according to Dodson), married to princess Ankhesenpaaten. Soon after, the young royal couple would have changed their names to Tutankhamun and Ankhesenamun and left the court of Amarna for Thebes (or Memphis). Tutankhamun would have carried out the return to traditional cults and have died very young, around the age of 18, after only 9 years of reign.

After the death of the king without children, his widow Ankhesenamun would take a surprising decision: she decided to write (as Dakhamunzu) to her people's worst enemy and the most powerful ruler of her time, Suppiluliuma, king of the Hittites, asking for a son to become her husband and king of Egypt. After many doubts, the Hittite King would have sent his son Zannanza to the south, to learn soon after that he had been killed. The actual powers of Egypt, in particular the 'god's father' Ay and general Horemheb, had dismantled the plot of the dowager queen. The former would be proclaimed Pharaoh, perhaps forcing the young widow to marry him. After a short reign of 4 years, Horemheb succeeded Ay and made every effort to erase the traces and memory of all his predecessors.

However, since the beginning of the seventies there have been many voices which have been raised against these ideas proposing new alternatives. These were published in a series of articles initiated by the groundbreaking writings of Harris (1974), who confirmed the existence of a female king with the name of Ankh(et)kheperure Neferneferuaten. These new hypotheses postulated substantial changes in the dynamics of the period, coming first to the proposal that the dowager queen who wrote to Suppiluliuma would be the powerful, and still-alive, Nefertiti upon the death of her husband Akhenaten. This hypothesis and others that followed did not reach the general public. The discussion was reduced to the academic circles who engaged in endless arguments where the same evidence was sometimes used to defend an idea but also its opposite, and where new arguments were defended with greater ferocity the weaker they were.

Actually, the general opinion has not changed much so that the Hittitologist Trevor Bryce, one of the leading specialists in the field and author of reference manuals on the Hittite Empire (Bryce 2005), has claimed the following on the subject of the dowager queen: 'the Pharaoh whose sudden death (sic) brought to this petition was called

Niphururiya (sic) in the annals. This is the precise way of expressing in cuneiform Tutankhamun's prenomen Nebkheperure. Though a number of researchers have attempted to identify the concerned Pharaoh with Akhenaten, the case of Tutankhamun remains with difference as the strongest'. The puzzle is of such extent that Miller (2007) has argued that 'there is currently no reconstruction of the period that fits all the available evidence at the same time'.

However, the key terms here are the two names mentioned in the Hittite sources: Nibkhururiya and Dakhamunzu. On the one hand, the name Nibkhururiya has been seen as the transcription into cuneiform script of the name of accession to the throne as Dual King of Egypt (*nesu bitty*) of Tutankhamun, Nebkheperure, and this has been the majority's opinion to date. However, a considerable number of prestigious specialists returned, at the end of the 20th Century, to the hypothesis that the term should refer to the name of Akhenaten as Dual King, Neferkheperure. The debate was still plainly open at the time of starting this research. On the other hand, there always has existed a consensus in identifying Dakhamunzu not as a name but as the Hittite transcription for the Egyptian term 'Ta Hemet Nesu', i.e. 'The wife of the King', to whom the source also mentions as 'queen of Egypt'. Another complicated issue is the personality behind Dakhamunzu within the complicated history of the Amarna period. There have been various candidates:

1. Ankhesenamun as Nebkheperure's widow, the traditionally accepted and, apparently, only apparently, the easiest one.
2. Queen Nefertiti as widow of Akhenaten, but just as Great Royal Wife.
3. Nefertiti as ruler Ankhetkheperure Neferneferuaten upon the death of her husband when she would have taken the throne as 'King' Semenkhkare (proposed by Harris in the early 1970s).
4. Nefertiti as Ankhetkheperure, but on the death of Semenkhkare, a variant of the previous one.
5. Meritaten as widow of her father Akhenaton, proposed by Krauss in the seventies for the first time. This is the most breaking hypothesis, but has now been abandoned by its mentor who now defends the idea of....
6. Nefertiti as regent queen upon the death of her husband.
7. Meritaten as Ankhetkheperure, but upon the death of her husband Semenkhkare.
8. Kiya, a dark queen of the period. A practically abandoned theory and...
9. The most recent, proposed by Allen (2009), for whom Dakhamunzu was princess Neferneferuaten Tasherit, fourth daughter of Akhenaten and Nefertiti, converted in coregent of her father and acting as queen Neferneferuaten, widow of her father. This idea, while suggestive, is very difficult to maintain due to various historical problems (e.g. a small girl writing to the most powerful king of his time) and will not be further discussed.

Each of these ideas has had its champions and its fierce detractors so that the debate reached a climax in the first decade of the 21st century with the publication of three books of prestigious Egyptologists (Nicholas Reeves 2002; Marc Gabolde 2005; and Aidan Dodson 2009), to which the work of Krauss (2007) should be added. These works include absolutely incompatible exclusive theories (see Figure 2), despite all of them are supposedly based on the same facts and refer again and again to the same evidences.

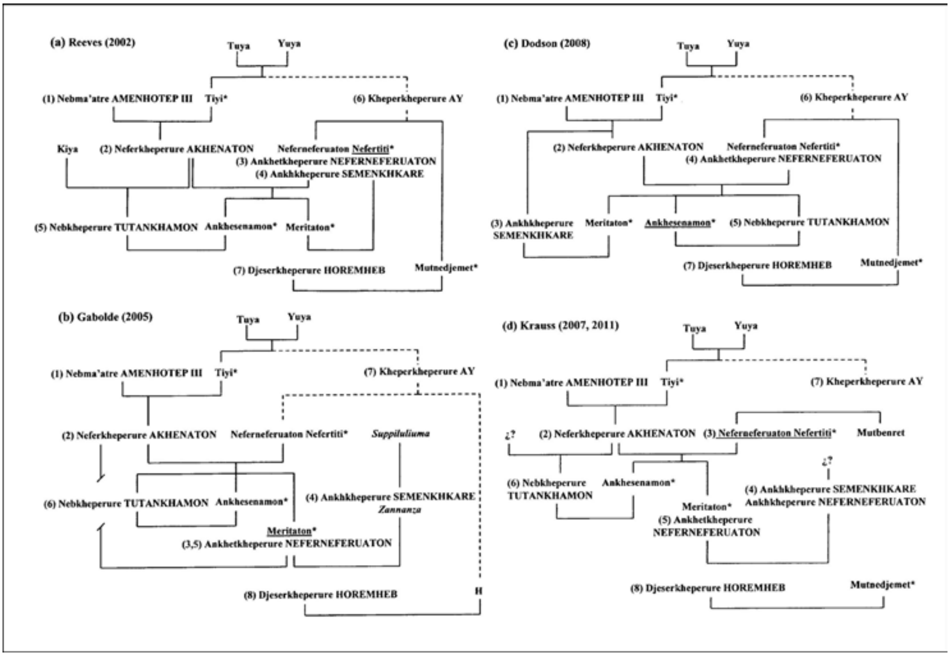

Figure 2: Family tree of the Amarna period according to four different analyses advocated by renowned Egyptologists during the last decade. The name of the person identified with the Dakhamunzu of the Hittite texts according to each of the authors is underlined. The numerals indicate the order of the sovereigns (uppercase). Note the disparity of opinions. The asterisk indicates a 'great royal wife'. See the text for more details.

For example, one of the proposals with more predicament today, to the extent that it can be found in the most recently published manual on the subject (Laboury 2011), the one of Marc Gabolde (1998, 2005, 2009), could be summarized as follows: once her father and husband, Akhenaten, has dead, 13-year old queen Meritaton, alias Dakhamunzu, would have planned a plot to set aside her younger brother Tutankhaten, still a child, from the throne which rightfully would corresponded to him. She would on the way deceive the king of the Hittites when she lied about the fact that there was no son of the late king. She thus would bring a Hittite prince to reign next to her with the name of Semenkhkare, who was probably murdered shortly after. Once this obscure personage was dead, she culminated her usurpation of power clothing herself with the royal titles as 'king' Neferneferuaten, ruling alone for at least three years.

On the contrary, according to Reeves (2002), Dakhamunzu would be the queen Pharaoh Ankhetkheperure Neferneferuaton, alias Nefertiti (see Figure 3), who in a certain sense would have usurped the rights of succession to a son of the king, Tutankhaten, born to a secondary wife (possibly the evasive Kiya, now deceased), who at this moment was in Memphis under the care of his foster-nurse Maya. Consequently, he was easy to hide from the eyes of the Hittite ambassador. The usurpation, however, would not be complete since the reigns of Tutankhaten and Ankhetkheperure would run in parallel. Once the queen Pharaoh was dead, or removed, in year 4 of king Nebkheperure, he would change his name to Tutankhamun, thus putting an end to the heresy. The rest, according to Reeves, is already known history.

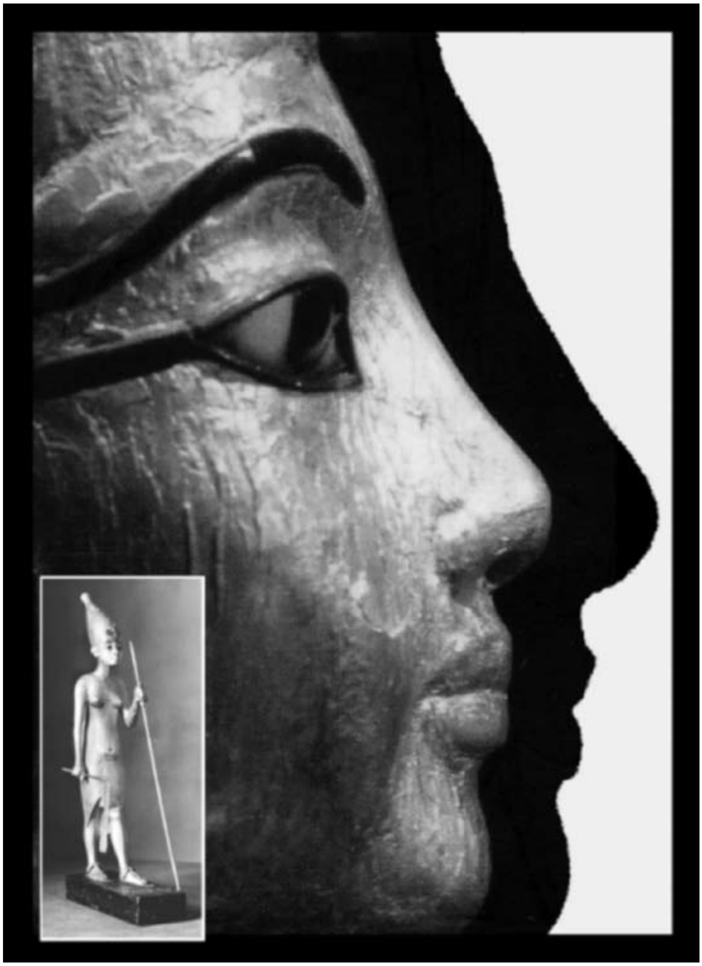

Figure 3: Face profile of a golden statuette (bottom left) found in the tomb of Tutankhamun (KV62) that certainly represents a female king (possibly Ankhetkheperure), compared to the one of the famous bust of Nefertiti, showing an amazing resemblance. Diagram of the author.

Finally, Krauss's (2007) nuclear hypothesis is that the great royal wife Nefertiti Neferneferuaten would have been promoted to an almost royal rank in a moment difficult to specify at the end of the reign of Akhenaten. She appears represented in a number of steles with a clear female anatomy and wearing the blue crown upon her head in the company of her husband. This new position would be, however, lower than the one of a true Pharaoh. All these small monuments remained unfinished, suggesting that they were made shortly before the death of Akhenaten, or even after his death, in an attempt to justify a powerful but still questionable status for Nefertiti. In other words, these steles make an obvious reference to a changing and perhaps unstable political situation.

Once her husband had passed away in the late summer of year 17, after having reigned in Akhetaten for at least 13 years, the queen would have assumed power in the capital, acting as regent for a possible candidate for the throne who is difficult to ascertain. She would have taken the opportunity to devise her plot and write to Suppiluliuma as Dakhamunzu, i.e. 'the wife of the king' Nibkhururiya who had just died. Her assertion that there was not a son of her lord could mean that the existing children of the king (at least Tutankhaten, perhaps Semenkhkare) were not 'legitimate' but secondary children of Akhenaten, and therefore were not in the immediate line of succession.

Between bickering and dimes, time passed and either the plot was discovered and aborted, or perhaps the regent queen died, and Zannanza was murdered. At this moment the throne would be occupied by the son-in-law of Nefertiti, and husband of her eldest daughter Meritaten, under the name of Dual King Ankhkheperure, Son of Ra Semenkhkare Djeserkheperu, as attested in the decoration of the tomb of Merire ii.

Subsequently, Krauss argues that Semenkhkare changed his name to the one of Neferneferuaten for unknown reasons, assuming as belonging to a male all those names and titles of this ruler where feminine endings do not appear. The new name of the king would be a tribute to queen Nefertiti (although, curiously, she had plotted against him shortly before) and showed his fidelity to the worship of the Sun disk. This king would have ruled at least 3 years, as attested by the labels of various products found at Amarna –wine jars in particular–, and by a hieratic inscription in the Theban tomb of Pairy which refers to the god Amun. In this period, the king would have also tried an approach to the clergy of this deity and a return to old traditions.

Semenkhkare/Neferneferuaten would have died in his third year of reign, and his 16-year old wife, Meritaten, imitating her mother, would have assumed power. However, this time she gave herself an almost complete list of royal titles as Dual King Ankhetkheperure, Son of Ra Neferneferuaten 'akhet en his', i.e. 'who is beneficial to her (deceased) husband' (Gabolde 1998). This queen Pharaoh must have been on the throne enough time as to prepare magnificent funerary regalia that would be usurped shortly after by her successor Tutankhamun. In this period, the inscription where Tutankhaten appears as 'son of the king' would have been registered, which might suggest Ankhetkheperure could have acted as a regent of her younger brother who was still a child.

After her death, or disappearance, Nebkheperure Tutankhaten would have ascended to the throne with Ankhesenpaaten as great royal wife, leaving Akhetaten after his first year of reign. He also changed his name of Son of Ra to Tutankhamun, clearly reflecting his return to the orthodoxy. In this line of argument, Krauss supports the new highest dates for the reign of Horemheb (14/5).

Krauss's hypothesis is smart in the sense that it explains most of the variables and the existing evidence for the period. Otherwise, he is not conclusive in those questions where the subject is not clear, as the ownership or not of the KV55 body either to Semenkhkare or Akhenaten. However, Krauss does not analyze the nature of the name of Semenkhkare, which as suggested by Gabolde (2005) appears to be a chosen name and not a birth name. Besides, his reasoning does not explain the fragment of a wooden box found in the access to the tomb of Tutankhamun (KV62) where the titles of Akhenaten, Neferneferuaten, and the great royal wife Meritaten appear together (see Figure 4), unless Akhenaten was dead and his name had been added for respect.

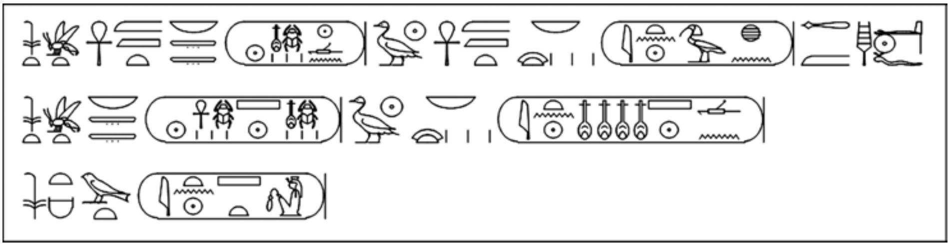

Figure 4: Titles of the three rulers consecutively referred in a fragment from a box found in the access to the tomb of Tutankhamun (KV62). According to the more logical reading of the inscription, queen Meritaten would have acted as a great royal wife of the coregents Akhenaten, her father, and Neferneferuaten, and therefore her identification with the latter makes it almost impossible. Graph of the author.

However, my largest concern on the hypothesis of Krauss is that it openly confronts to the 'principle of economy', one of the formulations of Ockham's Razor: 'the solution to a problem that needs fewer variables is more likely to be true'. The idea of Krauss (Figure 2) needs three rulers of the same name, Neferneferuaten, succeeding to the throne one after the other: a regent queen acting with the powers of a sole ruler, a king, and a queen Pharaoh. Perhaps, as we will discuss later, all them may actually have been just a single person.

The new evidence

The annals of the Hittite King Mursili II, son and second successor of the great Suppiluliuma, contain the mention of a solar omen that could have resulted in a threat to the life of the king. This omen allegedly took place while the king was campaigning in the land of Azzi, to the northeast of Anatolia in his 9 or 10 year of reign. It is a well known fact from Hittite texts, that eclipses were considered as omens of the death of the sovereign, and as a rite of avoidance, they used the figure of the substitute king. Therefore, it sounds reasonable to see an eclipse of the Sun in this omen and consequently analyzed all possibilities within a proper reference time frame.

In the traditional chronology, the beginning of the reign of Mursili II is settled shortly after the affaire Dakhamunzu that would supposedly have occurred after the death of Tutankhamun c. 1324/3 BC. Hence, Mursili is normally assigned dates between c. 1321–1295 BC, while his father's reign was fixed between c. 1360 and 1322 BC lasting close to a length of 40 years, since it is known that he was a contemporary of Amenhotep III.

Within these premises, there was a total eclipse produced in June 24 1312 BC that would be a serious candidate for the solar omen which would have been visible in northern Anatolia, (see Figure 5). An advantage of this eclipse is that the eclipse would have darkened the skies over the land of Azzi regardless of the value of ΔT under consideration, and there is even a possibility that it had been total in the Hittite capital, Hattusha.

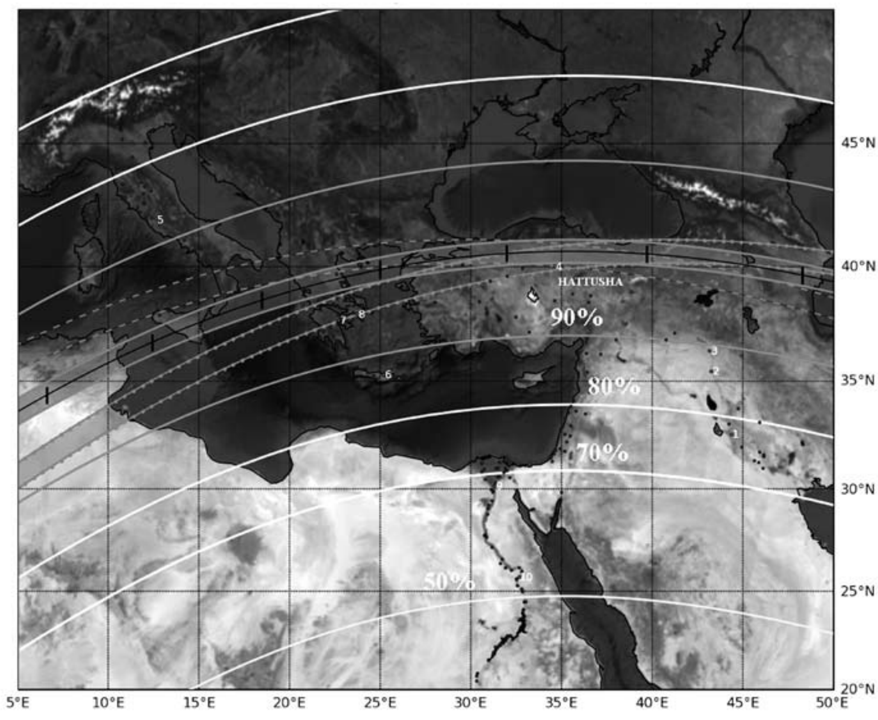

Figure 5: Graphical simulation of the band of totality of a solar eclipse occurred on June 24 1312 BC, which was visible in northern Anatolia, and might be the bad omen mentioned in Hittite sources in the year 9 or 10 of the reign of Mursili II. Note that this result is independent of the value of ΔT under consideration. Image of the author, adapted from a graphic courtesy of Rita Gautschy [http://gautschy.ch/~rita/archast/archast.html]

Therefore, there was a perfect astronomical event that may allow the setting of a point of reference for the Hittite chronology and, incidentally, for the rest of their neighbouring countries, including Egypt. However, the traditional chronology cannot be sustained anymore and we would have to see how to fit this astronomical date within the new time frame. However, before doing that, we are going to study in detail a new finding that has been added to the discussion, but not from the world of Egyptology, but from the seemingly distant Hittitology studies.

Miller (2007) has presented a new translation of a historical Hittite text (KUB 19.15+Kbo 50.24) found in the annals of Mursili II where there is an epistolary exchange between this sovereign and a high-ranking Egyptian individual called Armaya. Apparently, this person is not the king because he is never referred to by Mursili as LUGAL or LUGAL.GAL, which is the terminology used in Hittite diplomatic correspondence to refer to kings or great kings. The letters reflect border problems, extending for a significant period of time between years 7 and 9 of Mursili II, and clearly indicate that the two sides were not on very good terms,

The hypothesis defended by Miller, and supported by classical sources, is that Armaya must be equivalent to the future king Horemheb who was acting as a sort of regent or viceroy, and as Commander in Chief of the Egyptian armies in Asia, before he became Pharaoh. There is no record of any individual of this name who could write to the great king of Hatti, before or during the reign of Horemheb, who was not the king himself. Therefore, Ockham's razor forces to accept Armaya as the Hittite term for Horemheb and that he was not the king of Egypt in years 7 and 9 of Mursili II. This meant a chronological revolution because, among other things, forces that Tutankhamun reportedly died during the reign of Mursili and not that of Suppiluliuma.

As Stempel (2009) has stated, the evidence defined through the new translation of this important text still will have opponents, but as they will not be able to contradict the arguments of Miller, their voices should not play any role in the debate from now on. One thing that has become clear is that the equation that equals Nibkhururiya with Tutankhamun (and for practical purposes, also with Semenkhkare) must be excluded, after the works of Miller (2007) and van Dijk (2008), which demonstrate that the Generalissimo Horemheb and the Hittite King Mursili II were contemporaries and the reign of the former must be reduced to 14/5 years, respectively.

The identification of Nibkhururiya with Neferkheperure Akhenaten must be considered a proven fact, and therefore Dakhamunzu should be Nefertiti after the death of Akhenaten, or perhaps Meritaten, although this second possibility is much less probable as it will be shown.

The arrival of DNA

Between 2007 and 2009, a multidisciplinary team, led by the Egyptologist Zahi Hawass and the molecular biologist of the University of Tübingen Carsten Pusch. (Hawass et al. 2010), has carried out a very interesting and novel research project on a group of mummies of the Amarna period that could have been related in one way or another with king

Tutankhamun. The research was done by two independent laboratories, one in the Cairo Museum of Egyptian Antiquities and one in the Faculty of Medicine of Cairo University, and included a team of international experts acting as external evaluators of the research process.

The DNAs obtained from the mummies were sequenced and 8 independent haplotypes, or genetic autosomic markers, were compared, plus 16 sections of the DNA of the Y chromosome (which is transmitted from male to male) and an indeterminate number of markers of mitochondrial DNA (which is transmitted only by females). Chromosome sequences were compared for a total of 4 men (3 of them well known: Tutankhamun, Amenhotep III and his father-in-law Yuya, and one unknown: the controversial body of KV55) and five women (one of them known: Lady Yuya, mother of queen Tiyi, and 4 unknown: the old lady and the young woman that were found in the tomb of Amenhotep II −KV35EL and KV35YL, respectively− and two severely damaged mummies of young women, possibly from late 18th Dynasty, found in KV21). Two female foetuses found in the tomb of Tutankhamun (KV62) must be added to the list.

The results of the analysis of the DNA of the Y chromosome demonstrated that Amenhotep III, Tutankhamun and the individual from KV55 shared the same parental descent lineage, so they were almost certainly of the same family. However, the autosomic markers would be the ones that would provide the most valuable information, driving to the following conclusions: (1) KV35EL is almost surely a daughter of Yuya and Tuya and therefore must be queen Tiyi, as had been suspected for a long time. (2) Tutankhamun was a son of KV35YL and the KV55 male, who in turn (3) was a son of Amenhotep III and Tiyi. In addition (4), KV35YL was very probable also a daughter of Amenhotep III and Tiyi and, therefore, a full sister of the KV55 male, and indeed of Akhenaten. Finally, (5) the two female foetuses found at KV62 were quite possibly daughters of Tutankhamun and perhaps, also daughters of the KV21A lady that had signs of being queen Ankhesenamun. The big question that remained was who were the male of KV55 and the young lady of KV35 (aka KV35YL).

In addition to the genetic analysis, a bone analysis of most of the mummies was carried out by computerized tomography. Among them was queen Tiyi, who gave an age of around 50 years. However, KV35YL gave an estimated age between 25 and 35 years, slightly higher than the one previously estimated. It is not known who might be this high-rank princess who would give birth to future king Tutankhamun. Nefertiti should, in principle, be dismissed since, even in the very unlikely event that she could be a daughter of Amenhotep III and Tiyi never mentioned in the sources, this premise is highly unlikely because Nefertiti is never named with the title 'king's daughter', which was ostensibly used by those queens who also were daughters of a previous king. Under these circumstances, the hypotheses of Gabolde and Dodson, who make of Tutankhamun a son of Nefertiti, should be quarantined.

Amenhotep III and Tiyi had four known daughters: Sitamun, Isis, Henutaneb and the elusive Nebetiah. Two of them were 'great royal wives' of their father. It would also be reasonable to consider the case of the king's daughter Baketaten, perhaps another child of Tiyi, and the only one present in Amarna reliefs, who arrived as an 8 year old child but who could well have given birth to Tutankhaten with about 16 years of age around the year 12 or 13 of the reign of her brother and have died in her twenties before the ascent to the throne of her son who never mentioned her.

The new bone analysis (Hawass et al. 2010) of the KV55 male revealed a beginning of arthritis in the lower limbs, and bone problems in the spine, that would give an age closer to 40 than to 25 as it was presupposed for decades, although the margin of error of this type of estimates is still very wide and these statements have recently been questioned. In any case, this new age range, coupled with the fact that he was a son of Amenhotep III and Tiyi, meant that the most viable candidate for the body of the KV55, according to Hawass and his team of molecular biologists, was no other than Akhenaten.

This implies that Akhenaten was the father of Tutankhaten through his full sister, Lady KV35YL, who should therefore be a queen (it is unthinkable a lower rank for a daughter of Amenhotep III married with the king), but a queen not confirmed so far either by the epigraphic sources or in the archaeological record. This would also mean that the king had a son 'of his own body', a legitimate heir, to succeed him after his death. This fact raises more than one uncertainty about how to solve the Dakhamunzu affair between the two possible candidates: Neferneferuaton Nefertiti or her daughter, and Tutankhaten sister, Meritaten. There are indeed a series of unsolved questions within the present context.

A new hypothesis

In March 2010, the independent researcher Kate Phizackerley published an article on the web, intended to create controversy, but prepared in a very diligent way, about the material published by Hawasss and his team on Tutankhamun's family genetic markers. The author does not usually rely on internet material because of the difficulty in evaluating the offered information, which lacks of any kind of peer review process. However, this work caught my attention from the outset by its seriousness.

My surprise would be substantial when I realized that what was written in Phizackerley's paper not only were sensible statements but that this was a potentially revolutionary material that could alter –in fact altered– all mental schemes elaborated during months of hard work. This positive opinion about the article was not only mine but also of a number of specialists for whom the new analysis not only better interpreted genetic data but also fit to the historical facts. Phizackerley discoveries are not many but are crucial for our analysis. Figure 6 describes the global DNA analysis results, as were published in the original work of Hawass et al. (2010), including Phizackerley's arguments, which are mostly impeccable.

GENETIC MARKERS

INDIVIDUALS	D13S317		D7S820		D2S1338		D21S11		D16S539		D18S51		CSF1P0		FGA	
Tuya (KV46)	9	12	10	13	19	26	28	35	11	13	8	19	7	12	24	28
Yuya (KV46)	11	13	6	15	22	27	29	34	6	10	12	22	9	12	20	25
Tiyi (KV35EL)	11	12	10	15	22	26	28	29	6	11	19	22	9	12	20	28
Amenhotep III (KV35)	10	16	6	15	16	27	25	34	8	13	16	22	6	9	23	31
Male (KV55)	10	12	15	15	16	26	29	34	11	13	16	19	9	12	20	23
Female (KV35YL)	10	12	6	10	16	26	25	29	8	11	16	19	6	12	20	23
Tutankhamon (KV62)	10	12	10	15	16	26	29	34	8	13	19	19	6	12	23	23
Female (KV21A)	10	16	*6*	*13*		26		35	8		10			12	23	
Female (KV21B)	10				17	26			11	13				12		
Female Fetus I (KV62)	12	16	10	13	16		29		8			19		12	23	
Female Fetus II (KV62)	10		6	15		26	29	35	8	13	10	19		12	23	

Figure 6: Results of the study of autosomic DNA carried out in several mummies of the late 18th Dynasty by Hawass et al. (2010), including the ideas of Kate Phizackerley (highlighted in gray tones). From the analysis of the alleles of the former, the affiliation of Tutankhamun through his parents, the male of the KV55 tomb and the female KV35YL, who in turn would be brother and sister, can be proposed. Of the latter, it can be argued that if the two KV62 foetuses were the daughters of Ankhesenamun (perhaps but not necessarily KV21A) and she, in turn, was a daughter of Akhenaten and Nefertiti, then the male of KV55 can not be Akhenaten. Alleles in italics are a prediction, and were not identified in the original DNA sample. See the text for more details. Diagram of the author, adapted from the original data of Hawass et al. (2010).

The basic idea is the following: if the two female foetuses are daughters of Tutankhamun (what seems certain) and his wife Ankhesenamun (likely as well as reasonable), then the body of KV55 cannot be Akhenaten! The reasoning is simple and has to do with the haplotype (genetic marker) D7S820. Both foetuses have pairs of alleles (10,13) and (6,15), respectively, for this marker. If Tutankhamun was their father, who has the pair (10,15), this obliges that their mother must have the pair (6,13), as every unborn child will inherit one allele from each of her parents. This has been indicated in italics in Figure 6 associated with Lady KV21A, who, as we have seen, is believed to be Ankhesenamun. However, it should be noted that this is a prediction and not a result of the original genetic study that did not provide any result for KV21A in this marker. The mother of the girls, if she was Ankhesenamun, must have inherited any of these two alleles (6) or (13) of her father, presumably Akhenaten. Consequently Akhenaten must have had in his genetic background one of the two. However, the male of KV55 has a pair (15,15). Therefore, he cannot be Akhenaten. The reasoning is simple and brilliant.

The obvious conclusion is that Tutankhamun was the son of a stem of Amenhotep III and Tiyi, which must therefore be a brother of Akhenaten, possibly a younger one. Who could be this unknown individual? Phizackerley's proposal is simple and reasonable and it had already been suggested by Allen (2009): the younger brother would not be other but Semenkhkare, the enigmatic king of the period who, on the other hand, had already repeatedly been assigned the body of KV55 (a body for which the age at death is far from having been agreed). It is highly probable that she is right.

Who would be the mother of Tutankhamun? Nothing changes: she remains to be Lady KV35YL. If we only take into account the genetic evidence, she most likely remains (a simple calculation shows a probability of c. 90%) as a full sister of Akhenaten and the KV55 male (i.e. Semenkhkare). However, Phizackerley shows that we can not ruled out the possibility of a granddaughter of Amenhotep III and Tiyi, suggesting her identification with Meritaten. The equation would be perfect since Tutankhaten would be a son of the enigmatic young royal couple of the Amarna period formed by Semenkhkare and Meritaten. However, in my opinion, the researcher could be wrong in this particular case because it is virtually impossible from the historical point of view that Meritaten was the mother of Tutankhaten because she would have been around 9 years old at the time of the alleged birth of her son.

However, Krauss (private communication) has called my attention to the fact that the ages of the daughters of Akhenaten are usually calculated on the basis of the epoch that each of them appears represented in reliefs and mentioned in the sources. This is an inference that is far from being proven. For this reason, it is remotely possible that Meritaten, or even the second daughter Maketaten, had been born long before their first appearance, even before the advent to the throne of her father. That could make either of them the mother of Tutankhaten. In particular, Krauss suggests that Maketaton could be the mother of the young prince who died when giving birth to him, as suggested by certain representations of the Amarna royal tomb. Perhaps Maketaten could be Lady KV35YL and initially was betrothed with Semenkhkare, who later joined Meritaten after the death of her younger sister. However, the absence of Semenkhkare in the images of the funeral of the young princess contradicts this opinion.

Finally, there is a statistical argument which makes that possibility fairly unlikely. While it is true that genetically speaking Lady KV35YL may be a daughter of Akhenaten and Nefertiti, this will oblige that she would have inherited all paternal alleles of each of the haplotypes only from her grandfather Amenhotep III and none from her grandmother Tiyi; a possibility of one vs. eight. It should be added that Nefertiti should have passed to her daughter all her alleles inherited from Yuya and Tuya, which would confirm her as their granddaughter, but none of her other genetic pole. This seems again unlikely. In fact, when most of the variables are taken into account, the probability that both things happen at the same time is smaller than 6%, which does not invalidate the hypothesis but makes it very improbable.

Therefore, it is still better to assume that Lady KV35YL is a young daughter of Amenhotep III and Tiyi but that, instead of having been married with her brother Akhenaten, she would have been the wife of her younger brother, the man of the body of KV55, possibly Semenkhkare. This solves one of the problems that had been raised: the existence of a queen in the period of Amarna, wife of Akhenaten and in addition mother to a male heir, of which there is no record at all. The princess could marry her brother and give birth to Tutankhaten much earlier than her husband, if he is Semenkhkare, came to the throne of Egypt, either as a co-ruler of Akhenaten, as seems reasonable, or as an independent king as suggested by Krauss and others. In the first case, she could have been in the shadow of the great royal wife Meritaten, who brought the rights to the throne to Semenkhkare; in the second, it is very possible that she was already dead before that moment.

I would like to stress that this historical framework (see Figure 7) is based on two premises: (1) the female foetuses are daughters of Ankhesenamun, indeed in addition to Tutankhamun, and (2) that she actually was a daughter of Akhenaten. If any of these assumptions fail, the building crumbles. We will see that there is additional evidence in Phizackerley's analysis of the first, while the idea that Ankhesenamun was not a daughter of Akhenaten is a mere historical speculation, possible but improbable. The new evidence comes from details of the diagram of genetic markers that had once more escaped their initial investigators.

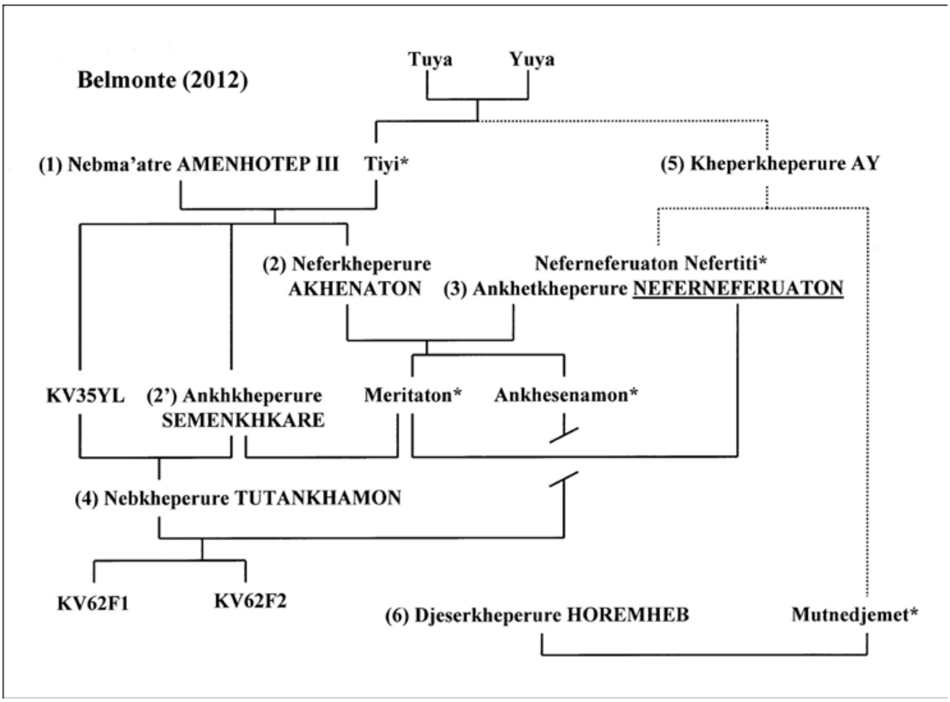

Figure 7: Final work hypothesis reflecting the family tree of the Amarna period, including the new proposals from DNA studies: this is the most likely analysis as defended in this essay. The most reasonable solution to the enigma is that Ankhetkheperure Neferneferuaten, possibly Nefertiti, was the Dakhamunzu of the Hittite texts (although her daughter Meritaten cannot be a priori ruled out). From Belmonte (2012).

Thus, for example, studying allele (13) in D7S820 marker, and allele (35) in D21S11 (marked in light grey in Figure 6), as well as the international distribution of these alleles in the current populations, including that of modern Egypt, Phizackerley suggests that both Lady KV21A (remember that she is probably Ankhesenamun as indicated also by the pair of alleles predicted for the first of these markers including (13)) and her potential daughters, the two female foetuses, may be descendents of Tuya by an independent route to the one of Tiyi. This is consistent with the theories making of Nefertiti a granddaughter of Tuya, perhaps through her father who could have been the 'god's father' and future king Ay. He would supposedly be a son of Yuya and Tuya and, therefore, a brother of queen Tiyi. This could only be confirmed if the mummy of Ay could be identified and also included those alleles in the corresponding markers.

Finally, Phizackerley shows by the analysis of allele (16) in the autosome D13S317 that it is possible that Lady KV21A, perhaps queen Ankhesenamun, and one of her no-born daughters have descended from Amenhotep III by an independent route to the line established by Semenkhkare (the male of KV55) and his son Tutankhamun, the baby's father. This is only feasible if the transmitter of the allele D13S317-(16) had been Akhenaten who, once again, and for the second time, cannot be identified with the body of KV55 who has the pair (10,12). Although this argument is not as strong as the previous one, because Nefertiti could have independently provided allele (16) to her daughter, it substantially reinforces the new ideas, and makes futile the hypothetical adultery of Nefertiti.

Therefore, the more logical historical framework, as it appears to us once Phizackerley's ideas have been analysed, and applying the principle of economy, could be summarized as follows, once we add the archaeological and epigraphic evidence analysed throughout this essay (Figure 7):

Around year 3 of the reign of Amenhotep IV, who soon after changed his name to Akhenaten, queen Nefertiti entered the scene, giving birth shortly after to her first daughter, princess Meritaten. In year 5, for reasons not yet established, the king founded a new capital, Akhetaten, where the royal family moved in the following years. During this period, prince Semenkhkare, younger full brother of the king, married his sister princess KV35YL, who we must identify with one of the daughters of Amenhotep III and Tiyi, perhaps Baketaten, the only one of them mentioned in Amarna (although it has been suggested than she could instead be a daughter of Akhenaten by Kiya, Laboury 2001: 322). Shortly after, around year 10 or 11, the princess had a son by the name of Tutankhuaton (sic). His mother could die shortly after (in their twenties) and the little prince was given to the care of a maiden named Maya, perhaps in Memphis, where it is possible that the young family lived (this last is a historical speculation).

The reign of Neferkheperure Akhenaten reached a peak in year 12 when the great durbar is celebrated. This was a festival which, however, supposed the decline of the royal family in the form of a plague, possibly brought by a foreign delegation. In the following years, several members of the royal family died and the situation became worrisome, perhaps dangerous. Given that the royal couple had only begotten daughters, Akhenaten decided to join his younger brother Semenkhkare to the throne in order to stabilize the situation and guarantee the succession. Semenkhkare also had a small son, a fact which also guaranteed the future. This child is indeed Tutankhuaton, the 'son of the king' Semenkhkare. Akhenaten associated his brother, the new king Ankhkheperure Semenkhkare Djeserkheperu, with Meritaten, his eldest daughter, which, in the context of the new reign, assumed the title of great royal wife.

Unfortunately, once again, the plans of Akhenaten were distorted and his young coregent died after a short period in which he hardly had time to leave a mark in history: a vineyard to his name, a few faience rings, some friezes and little more. Given the increasingly critical situation, Akhenaten decided to associate his wife and companion of a lifetime to the throne, queen Neferneferuaton Nefertiti (name adopted c. year 8) who took the crown (in particular the blue one, with which she is frequently represented). At an undetermined moment (possibly at the death of her husband, although this is debatable) the sovereign adopted the name of Dual King Ankh(et)kheperure mery(t) [plus diverse names of her husband], Son of Ra Neferneferuaten mery(t) [plus diverse names of her husband], sometimes with feminine endings, others without them. In this period, Meritaten would continue with her functions as great royal wife, a position that she possibly kept after the death of her father.

After the death of her husband Nibkhururiya (Neferkheperure), in year 17, Nefertiti, as Dakhamunzu, wrote to the Hittite king Suppiluliuma asking for a son to become king of Egypt in her company. In that letter, Dakhamunzu informed the Hittite king that she and her late husband have not had sons, a fact which is corroborated by the Egyptian envoy Hani shortly after. This is rigorously true since the young prince Tutankhuaton is not the son of the royal couple and is not therefore in the direct line of succession. However, the plan was disrupted and the Hittite prince Zannanza was killed along the way without stepping on Egypt.

Ankhetkheperure then took absolute power and began to count her own regnal years, using different sovereign nicknames in successive years. She also adopted at an undetermined moment the epithet 'beneficial to her [deceased] husband'. This new name will be the one that would accompany her nomen Neferneferuaten in the elements manufactured for her royal funerary regalia.

After her third year of government, the sovereign disappeared and the 'son of the king' Semenkhkare, prince Tutankhuaten, ascended to the throne with the name of Nebkheperure Tutankhaten, married to princess Ankhesenpaaton, daughter of the deceased sovereign, possibly at her instigation to guarantee the succession. However, her husband's nephew and son-in-law, or rather their advisors and tutors, are responsible for erasing the memory of the sovereign usurping her monuments, notably the funerary regalia.

In order to confirm his right to the throne, the young king, or his advisers, brought to Thebes the bodies of the father, the mother and the grandmother of the king –i.e., Semenkhkare, Lady KV35YL and Tiyi, respectively–, who possibly were buried in Amarna, and made them re-buried in a tomb without decoration in the Valley of the Kings, KV55. Nebkheperure seals scattered around the place demonstrate this. Among the materials brought from Amarna is part of the regalia of his grandmother and of the recycled funerary atrezzo (coffin and canopic vessels) of a secondary wife of his uncle

Akhenaten (apparently initially recycled for the latter), which could be used to bury his father Semenkhkare in a precipitated way.

At a later date, KV55 would be sacked, the mummies of the mother and the grandmother of Tutankhamen displaced (they would end as we know in KV35 after do not know how many vicissitudes), and the coffin of Semenkhkare profaned and his names in the cartouches deleted, giving path to the mystery of his identity. Other possibility is that only the corpse of Semenkhkare was moved to KV55, with a heterogeneous funerary regalia, while his sister-wife and his mother would be directly transferred to the tomb of Amenhotep III in the West Valley, from where they would be transferred once more centuries later, along with the mummy of the latter, to their final resting place in KV35. The truth is that, without more data, little more can be discerned between these two possibilities, although recent evidence suggests the latter hypothesis as the most plausible one (Laboury 2011: 349).

In year 4 of his reign, Nebkheperure changed his Atonian name by one more in touch with the new times, Tutankhamun. His wife would do the same, being renamed Ankhesenamun. In his 9 or 10 years of reign, Tutankhamun would not have any son, only two abortions buried with him in KV62, and at the time of his death, his great-uncle, and maternal grandfather of his wife, the 'god's father' Ay would rise to the throne under the name of Kheperkheperure, as last alive male member of the royal family and father of the 'king' Ankhetkheperure. After a short reign of little more than 4 years, Ay died and the throne passed to his possible son-in-law, Horemheb, married to Mutnedjemet, alleged sister of queen Nefertiti (here a doubt remains because Mutnedjemet is never named as 'king's daughter or sister'). After a reign of 14 or 15 years, Horemheb died and was buried in his tomb in the Valley of the Kings with numerous amphorae of wine from his last vintage. Ramesses I ascended to power and the rest is known history.

We may wonder what happened with the body of Akhenaten (if he is not the male of KV55 as has been defended here). This is mere historical speculation but the most reasonable is to think that he would remain in Amarna, in his tomb of the Royal Valley, and that the body would be possibly destroyed when the tomb was looted, their funerary regalia scattered, and his sarcophagus broken in small fragments, in order to erase from memory the 'enemy of Akhetaten'. In my opinion there is little hope of recovering it. With respect to the queen Pharaoh Ankhetkheperure, alias Nefertiti, we must be happy that part of her magnificent funerary regalia and furniture possessions have come to us because they were usurped for his successor, Tutankhamun. This is more of waht can be said for many other kings of Egypt. And her body? Perhaps one day the sands will unveil their secrets.

This section can not be completed without coming back to other theories that have been previously discussed. According to the new findings, Gabolde's and Reeves's proposals, notably the one on Semenkhkare –as Zannaza and Nefertiti, respectively–, would have to be abandoned altogether. Dodson's ideas must be severely reformed to conform to the new evidence presented here. However, from Gabolde's hypothesis we must keep the question of why a sovereign adopted two names of coronation, as prenomen and nomen, when ascending to the throne. It is obviously the case of Semenkhkare.

One possible answer is that the prince had originally a name that remembered the cult of the traditional gods, in particular to the partners of the Theban triad, as for example Ahmose (the oldest brother of Akhenaten, who predeceased his father Amenhotep III, was named Thutmose). In order to ascend to the throne he had to replace it with a new name, more appropriate to the new times, which only included the name of the solar demiurge.

With respect to the theory of Krauss, it can not be fully abandoned. It is possible, although unlikely, that Nefertiti acted as Dakhamunzu when she only was regent queen, as neither Semenkhkare nor Tutankhuaton were her children or of her husband. Only once the plot was discovered, Ankhkheperure Semenkhkare would have ascended to the throne and would have been associated to the 'heir' of the throne, princess Meritaten, as great royal wife. Besides, his right to the throne as the brother of the previous king would be obvious. Subsequently, the new king could change his name to Neferneferuaten, perhaps after the death of his mother-in-law. All in all, this theory has yet to explain various aspects that do not fit.

However, in the light of the new evidence, it is difficult to accept that, at the death of king Semenkhkare-Neferneferuaten, his legitimate son and heir, Tutankhaten, already 10 years old, did not directly ascend to the throne of Egypt, i.e. without intermediaries. This would leave very little space for the activities of Semenkhkare's widow, 'king' Ankhetkheperure Neferneferuaton Akhet in His, alias Meritaten, her rise to the throne and for the elaboration of such expensive funerary regalia that would be usurped shortly after by his cousin and stepson, condemning her to oblivion. Here, Ockham's razor should take precedence.

Conclusion

The research centred on the Dakhamunzu enigma needs a cocktail of various evidences to find a viable solution. The contribution of archaeology and chronology has been crucial to set the length of the reigns, in particular that of Horemheb. Astronomy has provided the pillars on which the time-frame is settled, particularly when combined with epigraphy. Both disciplines have placed in their proper context the reign of Mursili II through the identification of a solar eclipse of the year 1312 BC as the bad omen, mentioned in the sources, and through a correct reading of the annals which makes Mursili a contemporary of generalissimo Horemheb, and therefore of king Tutankhamun, whose reigns would have been almost parallel. Finally, molecular biology has allowed the determination of family ties among the individuals involved in the affaire with a very high degree of probability.

The results of this approach are summarized in Figure 7 and Table 1 where the family tree and the chronological framework of the era, that seem to be more probable in the light of recent scientific advances, are presented.

Table 1: New chronological table proposed for the last rulers of the 18th Dynasty and the beginning of the 19th, based on the most recent genetic, archaeological and historical evidence, the correlation with the Hittite rulers and five astronomical dates: three lunar ones, a solar alignment and a solar eclipse. In this context, the sovereign Ankhetkheperure Neferneferuaton, name of ascension to the throne of Nefertiti, would be Dakhamunzu in all likelihood.

King	Years	Dates	Great Royal Wife
Nebma'atre Amenhotep III	37	(1378-1342)$^{-3}$	*Tiyi*
Neferkheperure Akhenaten	17	(1341-1325) $^{-3}$	*Nefertiti Neferneferuaten***
Ankhkheperure Semenkhkare	?	(1328*-?)$^{-3}$	*Meritaten*
Ankh(et)kheperure Neferneferuaten**	3	(1324-1322)$^{-3}$	*Meritaten*
Nebkheperure Tutankhamun	10	(1321-1312)	*Ankhesenamun*
Kheperkheperure Ay	4	(1311-1308)	*Tuy*
Djeserkheperure Horemheb	14	(1307-1294)	*Mutnedjemet*
Nebphetire Ramses I	2	(1293-1292)	
Menma'atre Sethy I	11	(1291-1280)	
Usirma'atre Ramses II	67	(1279-1213)	

(*) Tentative date based on the decoration of Merire ii tomb. (**) The same person.

Certainly, this does not mean that this is THE answer to the enigma, definitive and indisputable, and it would not be surprising that when reading these lines, new findings have nuanced or corrected the doubts that could arise from the current model. For example, if it is confirmed that Lady KV21A is Ankhesenamun and it could be scientifically demonstrated that she was not a daughter of Akhenaten, and not as a simple historical speculation, then the whole building could collapse. Although I consider this possibility as unlikely, it can not be 100% ruled out.

It should be noted that radiocarbon dates estimated by Manning (2006), for samples of animal bones of the Amarna period, placed this period between 1336 and 1320 BC, in absolute agreement with the dates proposed in table 1. These dates are very similar to those proposed by Krauss and Warburton (2009) who only show discrepancies in the personalities of the individuals involved in the aftermath of the affaire Dakhamunzu, immediately after the death of Nibkhururiya Akhenaten. Astronomy supports the new chronology but does not help to decide on the independent reign of Ankh(et)kheperure or if she was queen Nefertiti resurrected or not, although the reconstruction raised here suggests so.

In particular, it is suggestive to be able to confirm the time frame when the alignment of the Temple of Aten was performed during the foundation ceremonies of the new city of Akhetaten in year 5 of Akhenaten, around 1337 BC (Figure 1). Also suggestive is the confirmation of the total eclipse of the sun of June 24 1312 BC –on dates close to the summer solstice, a singular milestone in the Hittite world– as the bad omen cited in year 9 or 10 of Mursili II in the Hittite sources (Figure 5).

This essay has tried to show how the observation of the sky, associated with the latest advances in archaeology and epigraphy, and together with a young science such as molecular biology, can be combined to solve an enigma, the one of Dakhamunzu, which has been in the head of a whole plethora of brainy Egyptologists for generations. I think that the objective has been achieved, or maybe not?

When this paper was going to print, the author had a most interesting epistolary interchange with Marc Gabolde. He has proposed a very interesting, possible but with very low probability, genetic scenario (still unpublished) in order to save his ideas from the preliminary results of DNA. According to him, on the one hand, Lady KV21A would be queen Mutemwia, Amenhotep III's mother, and a hypothetical sister of Yuya, and, on the other hand, KV35YL would be a daughter of a couple formed by a sibling of Tuthmosis IV and Mutemwia –thus a brother or sister of Amehotep III– and one of Yuya and Tuya, respectively. Hence the male of KV55 and KV35YL (Akhenaten and Nefertiti, respectively, according to Gabolde's new proposal) would not be brother and sister but very close cousins sharing all four grandparents. If any of the two little daughters of Tutankhamun was not a child of Ankhesenamun, his hypothesis for the period would still be possible. However, Gabolde will still need to explain how a very young, and extremely cynical, Meritaten was able to deceive Suppiluliuma and hide his brother and legitimate heir Tutankhaten from the king ambassador's eyes.

As suggested by Krauss, we must take it easy because it seemed that every single Egyptologist that has been trapped by the Amarna period is as crazy as king Akhenaten himself.

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The Star of Bethlehem and Luke's Shepherds: an Exploration of the Astrological Features of the Two Nativity Stories

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Abstract
A considerable amount of the research into the 'Star of Bethlehem' has assumed that it was a unique celestial event. Such an approach, however, has overlooked the possible celestial information contained in the other features of both nativities of the gospels of St. Matthew and St. Luke. This paper considers these other attributes. It adopts an archaeoastronomical and astrological approach to both narratives using the sky for the period of 07–06 B.C.E. as a primary document, as well as the Mesopotamian and Hellenistic astrological literature of the time. In the case of the Matthean pericope — the stories in Matthew's gospel — this approach suggests that the Star of Bethlehem is the title of a story rather than a single bright apparition. In the case of Luke's pericope it reveals that the attributes of the shepherds, angel, and the notion of a manger or a place for animals can be viewed as a Mesopotamian-influenced sky-watching discourse.

KEYWORDS: Star of Bethlehem, Astrology, Nativity

POVZETEK
Več raziskav Betlehemske zvezde izhaja iz predpostavke, da je bil to enkraten nebesni dogodek. Vendar pa tak pristop ne upošteva nekaterih nebesnih podatkov, ki jih vsebujejo opisi Kristusovega rojstva v evangelijih po Mateju in Luku. V članku obravnavamo te podatke z arheoastronomskim in astrološkim pristopom, pri čemer kot primarni vir uporabljamo podatke o nebu za leti 7 in 6 pr. n. št., upoštevamo pa tudi mezopotamsko in helenistično astrološko literaturo tistega časa. V primeru odlomka iz evangelija po Mateju pokažemo, da je Betlehemska zvezda prej naslov zgodbe kot pa enkraten pojav. V primeru odlomka iz evangelija po Luku pa se je izkazalo, da so atributi pastirjev, angela ter pojem jaslic oz. hlevčka lahko oblike opisa neba, kot so ga tolmačili Mezopotamci.

KLJUČNE BESEDE: Betlehemska zvezda, astrologija, Kristusovo rojstvo

The discussion around Christ's birth mythology connected to the Star of Bethlehem is a well-ploughed field. Mark Kidger (1999: 20) lists three themes contained in these discussions: the 'star' was a miracle, or a political construct, or a real celestial event. However according to Nicola Denzey (2003: 211), the theme of a political construct also contains the other two themes of miracle and celestial event. She argues that the collapsing of these themes was motivated by the desire of the largely anti-astrological early Christian writings to distance Christ's birth from any astrological association. Denzey (2003: 216-7) points out that the earlier Christian writers used Matthew's text to link Christ's birth to the messianic prophecy of Balaam (Numbers 24.17): 'A star shall come forth out of Jacob and a sceptre shall rise out of Israel…' (RSV). Denzey maintains that rather than the 'star' being a traceable celestial event, the 'star' was as a miraculous event, real or otherwise, used as a political construct to promote the cause of Christianity. In contrast, Tim Hegedus (2003: 91) considers that the 'star' *was* real and was viewed as astrologically significant which propelled Ignatius of Antioch (c.35–117) to reframe it. Ignatius wrote in his *Letter to the Ephesians* 19.2 that the Star of Bethlehem was as such that 'all the other stars together with the sun and the moon become a chorus for the star, and it outshone them all with its light.' Hegedus (2003: 91) points out that for Ignatius the 'star' was a miracle that 'set people free from the bonds which held them fast, including magic and astrological fate.'

There is an important corollary to the argument of the 'star' being a celestial/astrological event rather than solely a miracle. If the star was real, then it offers the possibility of being able to trace an approximate date of birth for Christ. However, researchers engaged in this line of investigation tend to look for a suitable event that was visually spectacular to warrant the Ignatian description of the Star of Bethlehem. This paper also takes this latter path; however, 'spectacular' is not pursued in a visual sense but rather in an astrological sense. For as Denzey (2003: 220) points out, 'modern scientific interpreters of the Star of Bethlehem consistently miss this point,' that the significance of any celestial event, if it did occur, needs to be judged through the lens of the astrological discourse of the Magi rather than the modern notions of spectacular. Hegedus (2003: 83,87), agrees and also considers that the astrological tradition which viewed the star as significant belonged to the astrology of the Magi and also, as noted above, the prophet Balaam. As Hegedus puts it, Ambrose of Milan (330–397) cited these Magi as the ancestors of Balaam while Origen of Adamantius (184/5–253/4) made the association explicitly:

> …those who were then living in Mesopotamia, among whom Balaam had a great reputation and who are known to have been disciples in his art. It is said that the race of Magi descends from him, and that their institution flourishes in eastern lands, and that they [the Magi] had copied among them all of Balaam's prophecies.

Thus, following Hegedus' argument, the astrological potency of any 'star' would be defined by the astrological traditions of the eastern lands of Mesopotamia.

However, before exploring this Mesopotamian style of astrology and its relationship to the two nativity stories of Christ's birth it is useful to visit some other opinions around the nature of the 'star'. Historically it is accepted that Christ was born before the death of King Herod. Herod's death is generally acknowledged as being around 04 B.C.E. (Hoehner 1989: 107) and thus any celestial event needs to occur some years before that date. Following Ignatius' lead Origen suggested in *Contra Celsum,* 1.58, that the 'star' was a comet. Some thirteen hundred years later Johannes Kepler (1571-1630) re-opened the debate when he speculated that the Star of Bethlehem was linked to a rare conjunction of Mars, Jupiter and Saturn. He calculated that such a conjunction of the three superior planets (Mars, Jupiter and Saturn), which he witnessed in 1603, also occurred in 07/06 B.C.E. and was rare enough — 796.4 years between occurrences — to warrant the story of the 'star' (Sachs and Walker 1984: 43-44). Kepler's argument was supported by David Hughes (Hughes 1979) and later by Paul Maier (1989: 119). However, Martin Wells (2009: 3) argues that Kepler's argument has been misrepresented for, 'Kepler never suggested that the triple conjunction [three planet conjunction] was the Star of Bethlehem and only believed that the Star had been a nova that the conjunction of 7–6 BCE had created.' Another strong candidate for the 'star' was the triple conjunction — occurring three times — of Jupiter/Saturn which happened in 07-06 B.C.E. (Brown 1993: 611-2; Sinnott 1986; Ferrari–D'Occhieppo 1989: 48-49). This triple conjunction of Jupiter and Saturn occurred immediately *before* the three planet conjunction noted by Kepler. Other scholars promote the idea that the 'star' was a supernova (J.Tipler 2005).

In contrast Michael Molnar (1999) uses the evidence of an Antioch coin. He suggests the year 06 B.C.E. for the appearance of the 'star' due to the fact that the coin appeared to celebrate the passage of Jupiter through the stars of Aries while being twice eclipsed by the moon. Citing Claudius Ptolemy (c. 85–165) and the Roman lawyer/astrologer Firmicus Maternus (c.330), Molnar argues that this event would have been of sufficient importance for astrologers to announce a sovereign birth and Jupiter as the Star of Bethlehem.

Throughout these diverse arguments the idea of a single bright heavenly object has blinded researchers and prevented them looking for celestial information amongst the other attributes of the two gospel stories. There is an unquestioned assumption that the Magi are real individuals carrying real gifts of gold, frankincense, and myrrh. Any discussion about the nature of the shepherds in Luke's pericope is focused on the first century B.C.E. herding habits of shepherds around Jerusalem (Kidger 1999: 63). Similarly the announcing angel who appears as a bright apparition to the shepherds is largely ignored and the cattle, manger, and stable settings are assumed to be historical (Crossan 1991: 372) or used to imply Christ's humble origins (Brown 1993: 418ff). However, as Charles Harrison (2009: 12) argues, to understand great art, whether image or story, all of the components of the piece must be considered. In applying Harrison's common sense suggestion to the nativity stories all of the attributes of these stories can potentially form part of the heavenly witness to the birth of Christ. Thus Matthew's pericope can be viewed as one single canvas – star and story attributes – and combined to produce a different view of the Star of Bethlehem. Additionally Luke's pericope, approached using the same methodology, allows for questions to be asked around the possible heavenly nature of the shepherds and the cattle.

Revisiting the Gospel Nativities

There are two different stories of Christ's nativity. According to Wells (2009: 17-19), the gospel of St. Matthew is commonly accepted to have been written between 75 C.E. and 90 C.E. with the caveat that such dating is speculative as it is based on associations with external events. Wells (2009: 39) points out that there are debates on whether Luke's gospel drew on Matthew's or on a common first century source. However, he stresses that both gospels record 'the witness of the heavens to Jesus' birth'. In Matthew's text (2.1-11) the narrative is focused on the protagonists, the gift-carrying Magi, and their interaction with King Herod. The 'witnessing by the heavens' is by the appearance of the Star of Bethlehem. Matthew's gospel (RSV) states,

> Now when Jesus was born in Bethlehem of Judaea in the days of Herod the king, behold, there came wise men from the east to Jerusalem, saying, Where is he that is born King of the Jews? For we have seen his star in the east, and are come to worship him.

Hegedus (2003: 83) suggests that seeing the star in the east would more correctly be translated from the Hebrew as seeing his star 'at its rising'. After their encounter with Herod they secretly depart to travel to Bethlehem. As they leave Jerusalem,

> … lo, the star, which they saw in the east, went before them, till it came and stood over where the young child was…. And when they were come into the house, they saw the young child with Mary his mother, and fell down, and worshipped him: and when they had opened their treasures, they presented unto him gifts; gold, and frankincense, and myrrh.

The gospel by Saint Luke (Luke 2: 1-20) gives a different narrative (RSV). Luke's gospel is, as Wells (2009: 45-46) puts it, 'peaceful and low-key' in contrast to Matthew's 'threat driven' narrative filled with the tension of Herod's reaction to the new born child.

> And there were in the same country shepherds abiding in the field, keeping watch over their flock by night. And, lo, the angel of the Lord came upon them, and the glory of the Lord shone round about them: and they were sore afraid. And the angel said unto them, Fear not: for, behold, I bring you good tidings of great joy, which shall be to all people. For unto you is born this day in the city of David a Saviour, which is Christ the Lord. And this shall be a sign unto you; Ye shall find the babe wrapped in swaddling clothes, lying in a manger.
>
> … And it came to pass, as the angels were gone away from them into heaven, the shepherds said one to another, Let us now go even unto Bethlehem, and see this thing which is come to pass, which the Lord hath made known unto us. And they came with haste, and found Mary, and Joseph, and the babe lying in a manger. And when they had seen it, they made known abroad the saying which was told them concerning this child. And all they that heard it wondered at those things which were told them by the shepherds.

There are differing arguments by scholars concerning these two pericopes. Hegedus, as cited earlier, sees Matthew's pericope as an attempt to link Christ's birth to the messianic prophecy of Balaam. However, Michael Goulder (1989: Vol 1., 249) argues that Luke's gospel was written as a reaction against the political undertones of Matthew's pericope. In considering Luke's nativity story, scholars view the shepherds in three ways: as symbolising Christ's humble origins (McNicol et al. 1996: 64); as the notion of the Lamb of God; or as Christ's birth being announced by the symbolic role of 'everyman'/ the shepherds (Brown 1993: 418ff). In contrasting the two pericopes Ed Sanders and Margaret Davies (1989: 290) argue that Luke's pericope was 'closer to Hellenistic history writing than that of Matthew and Mark.' This is an argument carried forward by Michael Crossan (1991: 372) who considers that Luke's pericope is a form of prophetic historical narrative. That the two gospels are a form of history is also the argument voiced by Kenneth Bailey (1995: 363-7) who considers that both Matthew's and Luke's gospels were transmitted through time as oral history, repeated tales, before finally being committed to writing by the latter part of the first century.

In brief, in Matthew's text it is the Magi who announce the birth of the new king. This announcement is based on the Magi's astrological interpretation of a bright star which they have been following. Upon arriving in Jerusalem they ask about the whereabouts of the new king. They then leave by secrecy to follow the star and arrive in the 'house' of the new born king to whom they give gifts. The Luke pericope contains very different elements. These elements include shepherds, an angel, cattle, and a manger and, to reiterate an earlier point argued by Crossan, Luke's pericope is suggestive of a more prophetic historical narrative. For Luke it is the shepherds who announce the birth to the world, not the Star of Bethlehem.

Astrology at the time of the Nativity

James H. Charlesworth (1983: Vol 1., 479) suggests that, 'Astrological speculation could well have been linked with Jesus' birth by Jewish Christians well before Matthew wrote his account of the 'star'. The first point to consider in exploring these 'astrological speculations' is that Christ was born at night. This point seems to be largely overlooked by scholars, yet a night setting allowed Ignatius to link Christ's birth with the star of Balaam's prophecy as one needs the darkness of night to reveal the glory of any 'star'. However, ascribing a night birth retrospectively for such a potentially divine figure is questionable as, generally, a day birth carried more prestige. At that time the sun was viewed as divine (Hegedus 2007: 12) and as Nicholas Campion (2008: 258-9) notes, the sun was associated with 'sustained imperial power'. The Roman emperor Augustus (63 B.C.E.–14 C.E.) who was the emperor at the time of Christ's birth, was said to have been born at sun rise (Barton 1995: 35). The Emperor Nero (c.37–63 C.E.) who wished to be seen as a solar deity, was also accorded a dawn birth (Snyder 1964: 506). Thus ascribing a nocturnal setting for the birth of Christ removes the potentiality of the divine options available for a diurnal birth. However, a night birth would be the choice if the story-tellers were recalling the view of the sky at night.

Yet Raymond Brown (1993: 173) asserts that Matthew's pericope contains no astrology. Citing Claudius Ptolemy, he states that the 'principle of astrology is to establish a horoscope based on the sign of the zodiac that is rising in the eastern horizon when a person is born.' He assumes that the astrology of the day was purely horoscopic, yet this is not the case. To appreciate the problem and with an awareness that it is the Magi who ascribed astrological significance to the 'star', it is worth looking at some Mesopotamian/ Babylonian based astrology.

The sky as narrative was a part of the Mesopotamian sky lore of the seventh century B.C.E. The planetary movements in relationship to each other as well as the constellations were reported in a poetic, anthropomorphic manner. For example, a letter written in the seventh century B.C.E. titled the 'Rising of Venus' states 'What is this love by which Ishtar loves the king my lord and has [sent] the very best to the king my lord!'(Hunger 1992: Paragraph 27). Here Hunger equates Venus with the goddess Ishtar. Such a personification of the planets was not unusual. In her discussion on this form of celestial divination, Francesca Rochberg (2004: 39) argues that the moon, sun, and the planets could all be referred to using 'anthropomorphic personification'. Rochberg (1998: 44) also comments that the synodic phenomena were of key importance in this style of astrology. For Venus and Mercury, this was their visibility as a morning rising or evening setting phenomena, while for Mars, Jupiter and Saturn, the key times were when they were in the positions of morning rising or setting, or acronychal (evening) rising or setting.

It is this style of Mesopotamian visual astrology that, Campion argues, persisted into the development of Hellenistic astrology of the first century C.E. Campion (2008: 173) comments that 'different forms of astrology emerged, some naturalistic, others magic. Some assumed a Pythagorean cosmos ruled by number, others maintained direct observation of the sky'. This argument is also made by Michael Astour (Astour 1966) who argues that early Hebrew cosmology drew on Mesopotamian origins; furthermore Rochberg (1998: 2) points to elements of 'transmission and borrowing from Mesopotamia found in specific elements of Greek astrology'. Jim Collins (2010: 8) comments that based on evidence from Jewish and early Syriac traditions, this mixed style of astrology with its visual sky narratives was known to the early Jewish and Christian authors. Moreover in considering the influence of Mesopotamian thinking on Hellenistic astrology David Pingree (1998: 131) states that the 'tradition of celestial omens continued into medieval Sogdian' [astrological literature]' a script which remained in use until around the tenth century. Also supporting this argument A.J. Sachs (1976: 379 ff) points to the last cuneiform astrological texts being dated between 31C.E.–75 C.E. Actual evidence of Mesopotamian influence on Greek horoscopic astrology is seen in the work of the first century astrologer Titus Pitenius. Roger Beck (2010: 6) notes Pitenius who in his delineation of a horoscope referred to the constellation of the Swallows, a Mesopotamian constellation. Hence at the time of Christ's birth and the century that followed in which the gospels were written, astrology was still a loose mixture of the Hellenistic horoscopic and anthropomorphic Mesopotamian sky narratives.

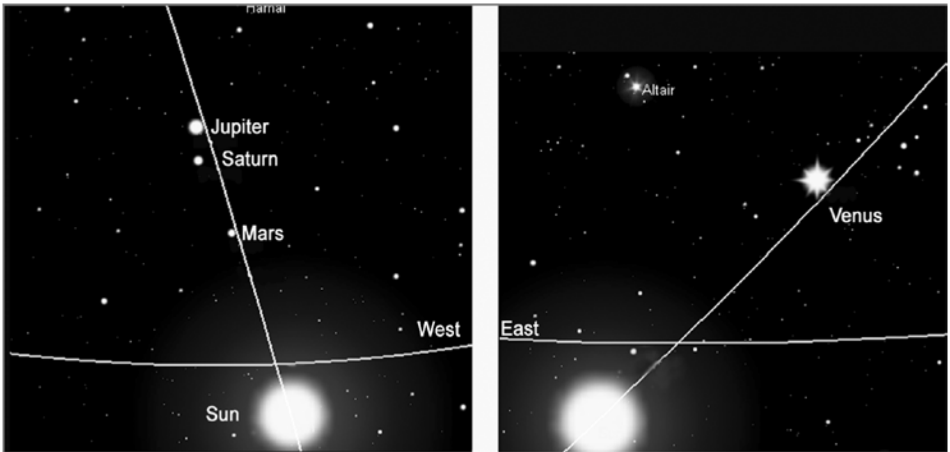
In returning to Matthew's text, Simo Parpola (2001: 102) states that this Mesopotamian style of astrology would have been the astrology used by the Magi in Matthew's pericope. He points to the existence of four clay Mesopotamian cuneiform tablets dated from 08 B.C.E. which list the forthcoming Jupiter/Saturn conjunction. Hegedus also agrees with Parpola that this was the style of astrology used by the Magi of Matthew's text. Hegedus (2007: 202) states that the astrological tradition of the Magi was focused into astrological omens such as the rising of a star or planet for, 'It was this more ancient form of astrology, rather than horoscopic astrology, in which the Magi were engaged'. With these arguments in mind, if the Star of Bethlehem was a spectacular astrological event, then it would not conform to Brown's expectations of a Greek horoscopic tradition but more logically be represented in the literature as a story drawn from an oral tradition based on a Mesopotamian narrative style of astrology with its anthropomorphising tendencies.

The Celestial Events of 07 to early 06 B.C.E.

When one stands on the Temple Mount in Jerusalem one can technically gain a clear 360^0 view of the horizon and thus the heavens. The height above sea level is around 745 meters and one is surrounded by mountains of a similar height which are set at a distance of 1 to 2 kilometres. The exception to this is when one looks east to south east where the view is unbroken for 50 to 70 kilometres. From this location Bethlehem, at 775 meters above sea level, lies to the south east at a bearing of 203^{0}44' and a direct distance of around 9 kilometres (see Figure 2).

We know that Herod had access to priests and scribes for, as Matthew (2.4) wrote, Herod drew on the 'chief priests and scribes of the people' to ponder the announcement made by the arrival of the Magi (RSV). In 07 and early 06 B.C.E these priests and scribes would have been able to witness an unusual series of celestial events. The beginning of 07 B.C.E commenced with Jupiter and Saturn lying within 7^0 of each other, being seen as the heliacal rising event— returning to visibility by being observed to rise just before the sun — of the spring equinox. As the year progressed towards the summer solstice, Jupiter and Saturn could be seen culminating (in the south) at dawn. As the winter solstice arrived Mars began to move towards Jupiter and Saturn so that all three superior planets were in a line in the western sky and seen to be following the setting sun. Mars, setting first, was only 45^0 from Jupiter and Saturn. This in itself was not visually spectacular. However, it heralded a forthcoming spectacular astrological event. Within a few months Mars had moved to within 6^0 of Jupiter and Saturn. This clustering of all three superior planets last occurred in 802 B.C.E. It is reasonable to believe that the scribes and/or priests in Jerusalem would have been aware of this unprecedented celestial event.

In addition, another sky event was unfolding. Venus was a bright morning star from early December 07 through to April 06 B.C.E and as the three superior planets drew together in the west at sunset, Venus, as a morning star, shone brightly in the east at sunrise. These two celestial events were actually straddling the sun (see Figure 1) and thus, due to the movement of the sun, the three planets would be seen to follow the bright Venus. The three planets would, firstly, be observed setting in the west at sunset and then they would disappear, only reappear later in the east, somewhat separated, but rising before the sun.



The Sun surrounded: the acronychal observation of the rare 06BC cluster and the bright Venus at dawn
Early February 06BC, Jerusalem

Figure 1: The Straddling of the Sun in early 06 B.C.E. The three planet cluster 'followed' the sun, as they could only be seen when low in the west and setting. At dawn, rising before the sun, a bright 'hovering' Venus was the morning star (also see Figure 2 for more details concerning Venus).

Adding to this dynamic, Venus as the bright morning star was in the midst of one of its irregular retrograde loops and may have been viewed by the priests and scribes of Jerusalem as moving in unexpected ways. Venus has an eccentric retrograde pattern which is only repeated every 243 years. The particular retrograde loop with which Venus was engaged gave it a unique set of visual features. When it rose, like any pre-dawn planet at that time of the year, its rising point moved southward along the horizon. Additionally, every night it was also seen to move southward over the top of the distant mountains via its diurnal movement. From early December 07 B.C.E and over the next few weeks Venus rose and grew in radiance to achieve a magnitude of -4.6. By late December Venus was gaining an altitude of around 35^0 before being lost in the light of the rising sun. By February 06 B.C.E, as the three superior planets drew within 6^0 of each other, Venus began to emphasise one particular azimuth (see Figure 2). At every consecutive predawn, Venus rose and 'paused' when it reached the same bearing before being lost in the sun's light. This 'hovering' behaviour was caused by Venus moving retrograde towards the sun's position at a speed which maintained the necessary angle of separation to allow for a constant azimuth to be achieved by Venus each night. Adding to this event, and due to the particular retrograde loop in which Venus was engaged, the radiating morning star also appeared to lose altitude while holding this bearing. Thus the observation of Venus over its retrograde period was that it appeared as a bright morning star of magnitude –4.6, and moved southward over respective mornings. Then by January at successive dawns it appeared to hover on the azimuth bearing of 139^0–143^0 and by mid-January it began to drop down from an altitude of 35^0 to that of 25^0 on that *very* bearing. Venus did not 'hover' directly over Bethlehem which was 60^0 of azimuth to the south of the Venus hover-point when viewed from Jerusalem. However, Bethlehem may have been the most logical settlement lying to the south of Jerusalem, as it was already cited by the prophecy of Micah (5 1.2) which stated that from Bethlehem a ruler of Israel would come forth. Indeed Brown (1993: 516) argues that the evidence for Christ's birth to have occurred in Bethlehem is weak and that the event was located there retrospectively to link the birth with the Micah prophecy.

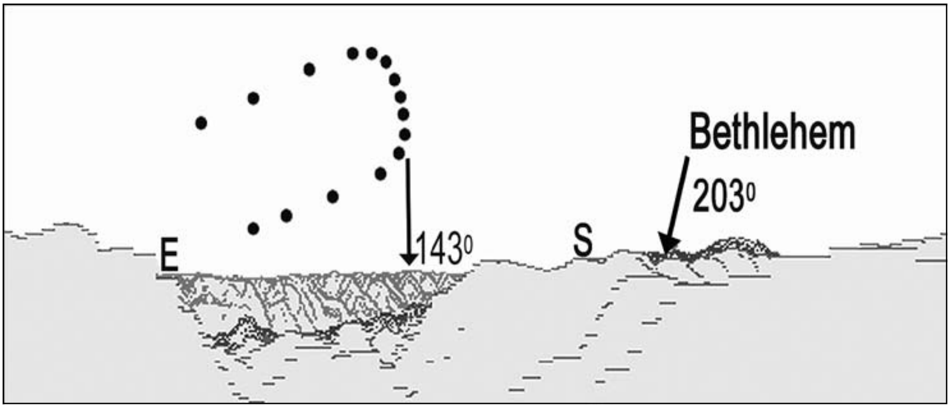


Figure 2: View from the Temple Mount, Jerusalem to the south/east. The position reached by Venus at sunrise (sun 5^0 depression below the horizon) from 1 Dec 07 to 24 March 06 B.C.E. Each marker is separated by seven days from the previous. Venus, at a magnitude of around -4.6, rose, moved south and then hovered and lowered over an azimuth bearing of around 143^0. The altitude scale is compressed.

Matthew's Version of the Nativity – Star and Magi

If these gospel stories are, as Bailey suggests, oral history or repeated tales within the different Jewish/Christian communities, then the identity of the Magi in Matthew's text can be reconsidered. Matthew tells the reader that the Magi, who have been following a bright star, arrive in Jerusalem and announce to Herod that a new king has been born. This, as a historical fact, is dubious. As Wells notes (2009: 267), Herod was in the last few years of his reign and had become so paranoid that he had already murdered his wife and son for fear that they were going to overthrow him. Additionally, at this time the practice of astrology was being challenged under Roman law (Cramer 1996: 238). Thus any astrologer traveling through a Roman province would, logically, have been discreet. With Herod's paranoia, his murderous reactions, and the current Roman law all in mind it suggests that Matthew's claim that the 'wise men' go to Herod's court and pronounce that the King of the Jews has been born is, at the very least, questionable.

A further point to note concerning the identity of the Magi is the fact that they are carrying gifts for the new-born king. Within the early Hellenistic astrological traditions we find a theme of planets near the sun giving pover to the sun. In his *Tetrabiblos* Ptolemy defined the term *doryphory* — spear bearers — used when planets were grouped around a luminary and deemed to bestow power to that luminary (Ptolemy 1969: Bk. III Ch.V). Although Ptolemy wrote some fifty to seventy years after the time of the gospels, he drew his astrological thinking from earlier authors. As Mark Riley states, 'the general procedures found in the *Tetrabiblos* are quite similar to those found in all ancient astrological writings'. Furthermore as Owen Gingerich (2002: 70-71), argues Ptolemy's goal within astrology was to bring its already established techniques under the control of mathematics. Hence Ptolemy's astrological techniques potentially derived from astrologers such as Berosus (c.375 BCE), the Babylonian priest considered to be the first to introduce natal astrology into Greece, (Schmidt and Hand 1994: 50) or Geminus (1st BCE) who wrote on astrological aspects and star phases, similar to Ptolemy's later work on star phases (Schmidt and Hand 1994: 50). In returning then to Ptolemy's writing on the *doryphory* it can be assumed that he was discussing an already established astrological technique. The origins of such a tradition, could well have been the planetary phases (synodic phenomena), noted by Rochberg earlier, within seventh century Mesopotamian astrological practice. Ptolemy wrote of the *doryphory* that if it was made up of the three superior planets of Mars, Jupiter and Saturn, then the level of empowerment that could be bestowed on the luminary was sufficient to mark the birth of a great king (Ptolemy 1969: Bk IV Ch III).

With this in mind, combined, as already discussed, with the nature of the astrology of the period and the actual sky events of that time, an alternative reading of Matthew's text can be explored. One can speculate that the priests and scribes of Jerusalem witnessed the 'arrival' of the Magi or wise men by witnessing the unprecedented arrival of the three superior planets setting after the sun. They did not come from the east as they were acronychal settings; nevertheless the eastern origins of the Magi may have been a reference to astrology being knowledge that came from the east, as noted earlier by Origen, or alternatively, that the three planets were heading towards the east. Matthew then informs the reader that the Magi follow the 'star' to find the new king. Indeed by March 06 B.C.E the three superior planets had disappeared from view – possibly explaining the reference to the Magi leaving Herod's palace in secret – and then later around the following May/June they reappeared in the 'house' of the new king, in the east, rising before the sun. The idea of the 'house' of the king, if viewed astrologically, would be the statement that the Magi had moved into the place or sign in which the sun was located (Valens 1994: i). Having arrived in the sun's house, the Magi now act as 'spear-bearers' and give their 'gifts' to the sun.

Looking at the story historically one can propose that the scribes and/or priests of Jerusalem noted the astrologically spectacular clustering of the three superior planets, the bright Venus and the movement of the three planets to 'follow' the Venus. At some point the scribes inform Herod of a threat to his rule, basing their argument in the astrology of the Magi. The three planets, with their worrying implications, then disappear for a period only to reappear in the east rising before the sun. The paranoid Herod reacts to the scribes' reading of the sky and orders the massacre of the male children under two years old. This act effectively embeds the story into the Jewish community's oral history and thereby plants the seed for Matthew's pericope.

Thus the 'Star of Bethlehem' becomes the title of a story, a sky narrative of planets rising and setting, coming and going, which become embedded into the oral history of the community by the actions of a ruthless king.

Luke's version of the Nativity – Shepherds and Cattle

Luke's narrative is quite different but it is also a story of the 'witnessing by the heavens' of Christ's birth. Luke's version of the nativity may also be based in a Mesopotamian informed sky. There were eighteen constellations that made up the Mesopotamian sky, and three of these seem to be the focus of Luke's pericope. The constellation Orion was known as the True Shepherd of Anu (Rochberg 2004: 108) where Anu either referred to the stars which occupied the ecliptical belt or all the stars of the heavens, thus Orion was the shepherd of the 'flock' of the stars. Orion is situated south of the ecliptic with Aurgia, the Charioteer, above it to the north. The hook of Aurgia was considered to be the Crook of the True Shepherd of Anu (Black and Green 1992: 54) (Figure 3). From a Mesopotamian perspective this part of the sky was a large image of a shepherd and his crook which stretched across the line of the ecliptic. In the seven century B.C.E. the priest Bullutu wrote of a bright Venus in the Crook as follows: 'the foundation of the throne will become stable'(Hunger 1992: 73). Another letter of the same era warns the king of a potential rival when it was noted that a bright Venus 'radiated' the stars of the True Shepherd, translated here by Hunger as Orion: 'If the stars of Orion keep gaining radiance: an important person will become too mighty and commit evil — Venus stands in front of Orion'(Hunger 1992: 143). The shepherd with his crook was a powerful sky entity and activity within it, such as crescent moons or a bright Venus and/or planetary movement among these stars, spoke of disruptions and/or an outsider gaining power. Next to the True Shepherd of Anu stood the Great Bull of Heaven or the Cosmic Bull, the constellation Taurus (Rochberg 1998: 28). Celestial events which occurred amongst the stars of the Bull foretold of great success or great disaster, for it was considered to be a storm god (Black and Green 1992: 47-50) who created new pathways through disruption. In this way the heavenly Bull was seen as a cosmogonic constellation.

As already discussed story-telling was a part of the astrology of the first century C.E. In returning to Beck's (2010: 3) discussion of the Greek horoscope from 81 C.E by the astrologer Titus Pitenius, Beck shows that Pitenius was acting as story-teller, and spoke of 'the planets as agents *doing things*' [Beck's italics]. Beck (2010: 6) specifies that

> Titus Pitenius enriches the celestial story by personalizing the adventures of the seven [planets], each along his or her own path. He does this, not as an astronomer would do, by specifying latitude as well as longitude, but by introducing stars and parts of constellations near which or through which the planets pass.

The astrologer Titus Pitenius was thus echoing his Mesopotamian astrological roots from the seventh century B.C.E. In such dynamic story-telling astrology Erica Reiner (1999: 28) claims that 'predictions were made based on one planet approaching another, or nearing, reaching, or passing another' such that the planet's journey produced a sky narrative. Beck shows that Pitenius, some seven hundred years later, has taken the same approach, using the imagery of the constellations like stage sets into which the characters (the planets) produce the natal story by traveling backwards and forwards, and meet or pass above or below one another while weaving in and out of the different settings of the stage. This is what Beck (2006: 153-164) defined as 'star-talk' in his discussion on Roman Mithraism.

Returning to Luke's gospel with this star lore in mind, other options for interpretation of the story are apparent. Luke reports that shepherds see a bright angel, and are informed by this heavenly event that a new king is born in a manger. In searching for celestial events occurring amongst the stars of the Shepherd, the evening of 30 April 07 B.C.E. reveals a promising sky story. It was the beginning of a new month as the crescent moon was visible just after sunset (Figure 3). [This particular month was going to contain a visible lunar eclipse which notably was not referred to by Luke]. However, as the sun set, the evening star which had been growing in radiance for some time, hung amongst the stars of the True Shepherd of Anu and was emphasised by the crescent moon. Additionally the sun, symbolic of the king in Mesopotamian astrology, was located in the Bull of Heaven. Such a combination could speak of a new king emerging who was empowered and a threat to any established order. To report this sky narrative one would talk of a radiating bright light

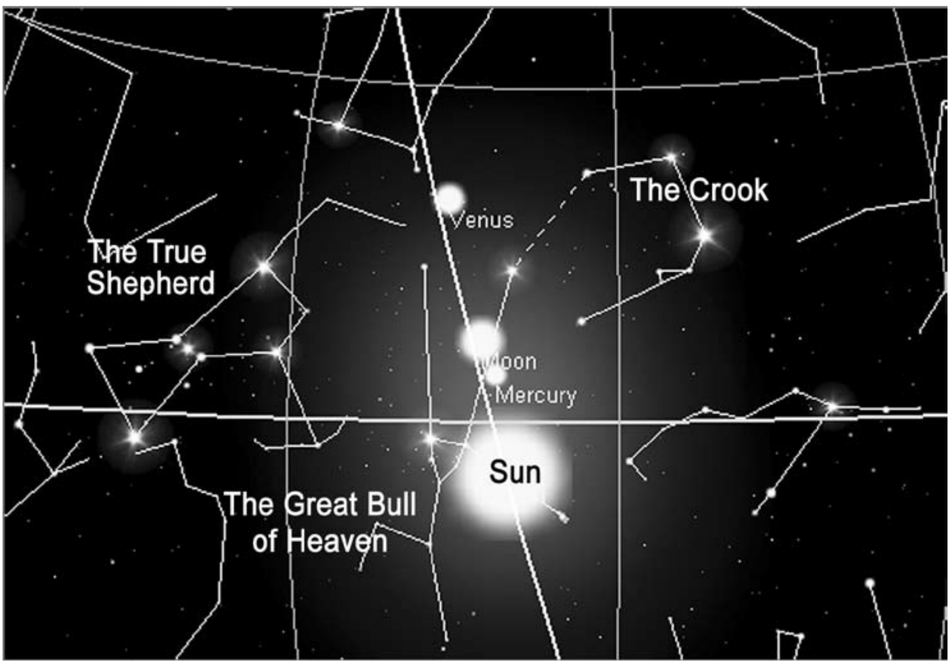


Figure 3: The crescent new moon of 30 April, 07 occurred with an evening star Venus at magnitude -3.92 in the stars of the True Shepherd of Anu, while the sun, the king, sat in the stars of the Great Bull of Heaven.

amongst the stars of the Shepherd and a new king located with cattle or in a place of animals. To be sure, this sky story is not the great sky narrative reflected in Matthew's account. However, awareness of the contemporary cultural view of the sky suggests that Luke's narrative may be a more localised sky description of the events at that time.

In sum, this paper speculates that the two nativity pericopes of Matthew and Luke are two distinct astrological narratives. This speculation is based on a consideration of the two gospel stories through the cultural milieu of the astrology of that period. Luke's narrative is suggestive of a birth 'horoscope' using what Beck would define as 'star-talk' and carried forward in an oral tradition until finally placed into text in the late first century. Matthew's pericope relates to the observation by advisers in Herod's court of an astrologically spectacular sky narrative which became embedded into oral history through the paranoid actions of Herod. This drama was, within a few generations, politicalised by Ignatius, resulting in the story being symbolised, or collapsed, under the title of the *Star of Bethlehem.*

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A Solar Eclipse in 700 BC Observed in Jerusalem and Southern Sweden

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Abstract
The enigmatic situation in Jerusalem during which the shadow temporary moved 10 steps back on King Ahaz' sundial, can be explained by the partial solar eclipse on 29 July 700 BC (*2 Kings 20:8-11* and *Isaiah 38:7-8*). This event occurred during the attack on Judah by the Assyrian King Sennacherib, ca. 701 BC, described on cuneiform prisms found in Nineveh. According to the author's calculation the shadow receded 8.5 arcminutes due to the eclipse of the sun's northern hemisphere. The steps on the sundial corresponded to arcminutes.

This solar eclipse was total in southern Sweden. It may have been depicted as a rock carving on a stone inside a Late Bronze Age tomb at Tjärby, in the province of Halland. In a nearby bog, at Nackhälle, a ceremonial bronze shield from the same period was sacrificed. The main motif is a series of concentric circles, earlier identified as symbols for total solar eclipses. At Fröslunda, in the province of Västergötland, 17 similar shields, packed in reed, and C^{14}-dated to 725 ±75 BC, were sacrificed in shallow water.

The synchronous occurrence of both receding shadow and eclipse depiction is a unique high precision test of the parameters used in the author's computer program for solar eclipses.

KEYWORDS: Solar eclipse, sundial, rock carving, bronze shield, lunar sidereal secular acceleration

POVZETEK
Skrivnostni dogodek v Jeruzalemu, med katerim se je na sončni uri kralja Ahaza senca začasno premaknila za 10 razdelkov nazaj, lahko pojasnimo z delnim Sončevim mrkom dne 29. julija leta 700 pr. n. št. (*2. knjiga kraljev 20:8-11* in *Izaija 38:7-8*). Ta dogodek se je zgodil med napadom asirskega kralja Senaheriba na deželo Juda okoli leta 701 pr. n. št., ki je opisan na klinopisnih prizmah, najdenih v Ninivah. Po avtorjevih izračunih se je senca na sončni uri umaknila za 8.5 kotnih minut zaradi mrka Sončeve severne poloble. Vsak razdelek na sončni uri je ustrezal eni kotni minuti.

Ta Sončev mrk je bil na južnem Švedskem popoln. Možno je, da je upodobljen na kamnu, najdenem v poznobronastodobnem grobu v Tjärbyju, v provinci Halland. V bližnjem močvirju, pri Nackhälleju, je bil najden obredni bronasti meč iz istega obdobja. Vodilni motiv na njem predstavljajo koncentrični krogi, že od prej poznani kot simboli popolnega Sončevega mrka. Pri Fröslundi v provinci Västergötland je bila v plitki vodi

najdena daritev 17 podobnih ščitov, zavitih v trsje, ki so bili z metodo C^{14} datirani v leto 725 ±75 pr. n. št. Sočasen pojav premikanja sence na sončni uri in upodobitve Sončevega mrka je edinstven test visoke natančnosti parametrov, uporabljenih v avtorjevem računalniškem programu za Sončeve mrke.

KLJUČNE BESEDE: Sončev mrk, sončna ura, gravura v kamnu, bronasti ščit, Lunina siderska sekularna akceleracija

Part I: Partial solar eclipse in Jerusalem on 29 July 700 BC

Introduction

In 722/1 BC the Assyrian King Shalmaneser V (727-722 BC) conquered Samaria, the capital of Israel, known as the northern kingdom. At this time there were two kings in Judah, the southern kingdom, — Ahaz and his son Hezekiah — who ruled as co-regents. Judah was a vassal to Assyria and forced to pay an annual tribute. After the death of Ahaz in 715 BC, Hezekiah became the sole regent of Judah, formed alliances with Ashkelon and Egypt and refused to pay tribute to Assyria.

Approximately 701 BC, the Assyrian King Sennacherib (705-681 BC) attacked and destroyed 46 fortified cities of Judah. The Jewish account is given in the Old Testament books of *Isaiah*, *Chronicles* and *Second Kings*. The Assyrian account is preserved on *Taylor's* and *Sennacherib's Prisms*. Also the war is mentioned by Herodotus in his *Histories*.

In the evening of 29 July 700 BC, there was a total solar eclipse in southern Sweden. As a reaction to this dramatic event, a rock carving may have been made and a magnificent bronze shield was sacrificed in a nearby bog in the province of Halland. In the province of Västergötland 17 similar bronze shields were sacrificed together in a shallow bay of Lake Vänern.

This was the Late Bronze Age in Sweden with no written sources preserved. However, from archaeological finds we can draw the conclusion that people worshipped the sun.

This solar eclipse was only partial in Jerusalem, but it caused nevertheless a miraculous retrograde motion on Ahaz's sundial.

The following descriptions are taken from the *English Standard Version* of the Old Testament texts and the dates are given in the Gregorian Calendar.

The Jewish account of Sennacherib's invasion

When Hezekiah refused to pay the tribute, he had good reason to expect an invasion from Assyria and prepared Jerusalem for a siege. He blocked the springs outside the city to deprive the Assyrians of water and built a tunnel to the Spring of Gihon to provide the city with fresh water. The old city walls were repaired, new towers were constructed and a new outer reinforcing wall was erected.

While Sennacherib was besieging the city of Lachish, Hezekiah sent a message to him offering to pay tribute in exchange for an Assyrian withdrawal (*2 Kings 18:14*).

Sennacherib ordered one of his field commanders, Rabshakeh, to march up to Jerusalem. In an attempt to demoralize the Jews, Rabshakeh announced to the people on the city walls that Hezekiah was deceiving them, and Yahweh could not deliver Jerusalem from the king of Assyria. However, Hezekiah did not surrender and Rabshakeh returned. When Sennacherib heard that King Tirhakah of Ethiopia and Egypt prepared his army to support Hezekiah, he sent new messengers to Hezekiah, saying: 'Do not let your God on whom you rely deceive you by promising that Jerusalem will not be given into the hand of the king of Assyria.' (*2 Kings 19:10*).

The situation for Jerusalem was threatening and Hezekiah clad himself in sackcloth. However, the prophet Isaiah assured Hezekiah that the city would be delivered and Sennacherib's army destroyed (*2 Kings 19:32-36*). Hezekiah did not pay the tribute until Sennacherib had returned to Nineveh. There is only a minor difference in the amount of the tribute: The Bible lists it as 30 talents of gold and 300 talents of silver (*2 Kings 18:14*); in Sennacherib's annals it is 30 talents of gold and 800 talents of silver.

Daniel D. Luckenbill (1924) and others speculate about a possible second attack on Judah by Sennacherib. William H. Shea (1999) suggests that a second attack took place in 688 BC, but there is no support for this idea either in the Old Testament or in Sennacherib's annals.

The Assyrian account of Sennacherib's campaign

The *Taylor* and *Sennacherib Prisms* give detailed descriptions of important events during Sennacherib's campaign against Judah. The *Taylor Prism*, from 691 BC, was discovered in the ruins of Nineveh in 1830 (Mitchell 1988). The *Sennacherib Prism* dates from 689 BC (Luckenbill, 1924) and record that Sennacherib destroyed 46 of Judah's cities and trapped Hezekiah in Jerusalem 'like a caged bird'. It states that Sennacherib returned to Assyria where he received a large tribute from Judah.

The Assyrian records are not always reliable due to the common Assyrian propaganda of their own invincibility. Nothing is said about the mass death mentioned in *2 Kings 19:35*. However, this story is corroborated by the Greek historian Herodotus who may have used independent Egyptian sources, the Chaldean historian Berossus, and the Jewish historian Josephus. These authors also corroborate the Old Testament's suggestion that Jerusalem was victorious rather than defeated.

Sennacherib's disaster in Egypt according to Herodotus

The Greek historian Herodotus (Godley 1920) wrote in his *Histories*, ca. 450 BC, about a divinely-appointed disaster destroying an army of Sennacherib (2:141):

> when Sanacharib, king of the Arabians and Assyrians, marched his vast army into Egypt … Sethos, then, relying on the dream, … marched to Pelusium, which commands the entrance into Egypt, and there pitched his camp. As the two armies lay here opposite one another, there came in the night, a multitude of field-mice, which devoured all the quivers and bowstrings of the enemy, and ate the thongs by which they managed their shields. Next morning they

> commenced their fight, and great multitudes fell, as they had no arms with which to defend themselves. There stands to this day in the temple of Vulcan, a stone statue of Sethos, with a mouse in his hand, and an inscription to this effect – 'Look on me, and learn to reverence the gods.'

F. L. Griffith (1900) identified the Pharaoh as Taharqa before his succession, with Sethos his Memphitic priestly title, as governor of Lower Egypt and high-priest of Ptah. As governor he was responsible for the defense against the expected attack by Sennacherib.

Josephus' *Jewish Antiquities*, Book 10, verses 21-23 (Whiston 1737), relate an account by the Babylonian historian Berossus, in which he claims that a disease caused the death of 180,000 men in the Assyrian army led by Rabshakeh.

The author's hypothesis about the cause of Sennacherib's disaster

Sennacherib's attack took place in the fourteenth year of Hezekiah's reign (*2 Kings 18:13*). Since 715 BC was his first year, Sennacherib's attack took place in 702 BC.

The reason for the retreat of Sennacherib is described in *2 Kings 19:35*: 'And that night the angel of the Lord went out and struck down 185,000 in the camp of the Assyrians …'

The author has in an earlier paper (Henriksson 2007) identified 'the sword of the angel of the Lord' as Comet Encke. In *2 Kings 19:35* the 'sword' is missing in the text, but this word may be implied because the angel of the Lord 'needed' a sword to strike down 185,000 men.

Comet Encke appeared unusually bright in the western evening sky in February 702 BC (Figure 1). It may not be just a coincidence that the disaster of Sennacherib took place in 702 BC, while Comet Encke dominated the night sky.

In the author's opinion it is much easier to believe that the Assyrian king and his troops became frightened by the appearance of an unusually bright comet in the sky rather than Herodotus' explanation that a multitude of field-mice devoured all the quivers and bowstrings of the enemy, and ate the thongs by which they managed their shields.

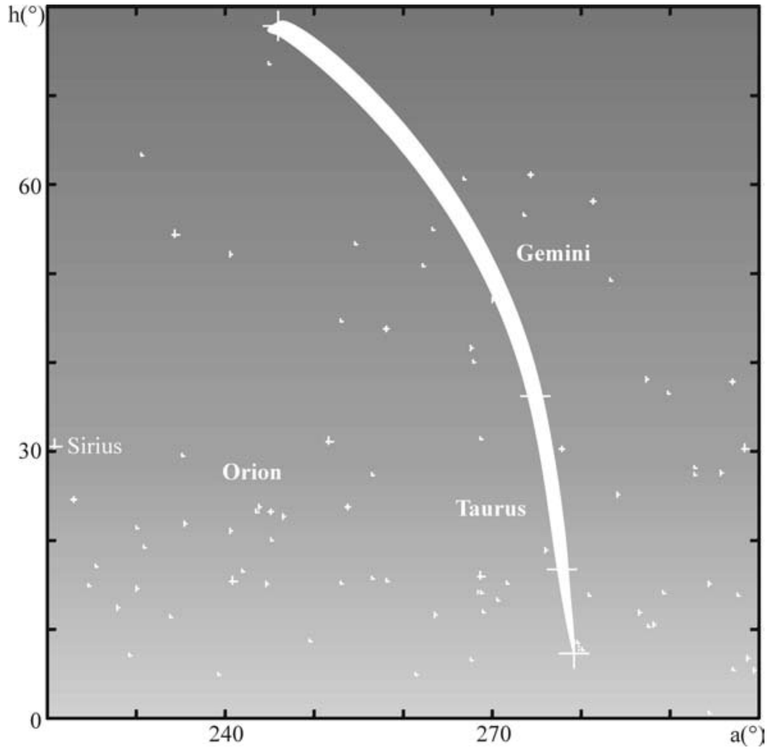

Figure 1: Comet Encke on 7 February, at 22.00 local mean solar time in Jerusalem. The distance from the earth was 0.181 AU and the calculated length of the tail is 0.3 AU. The displayed stellar magnitudes are brighter than 4.0.

Hezekiah's Illness and Recovery

Sometime after Sennacherib's retreat to Nineveh the situation was still very critical for Hezekiah in Jerusalem, and Isaiah told him that he should soon die (*2 Kings 20:1*). However, before Isaiah had gone out of the middle court, the word from the Lord came to him that he should return and tell Hezekiah: He will be healed and the city will be delivered out of the hands of the king of Assyria (*2 Kings 20:4-6*).

> *2 Kings 20:8*. And Hezekiah said to Isaiah, 'What shall be the sign that the Lord will heal me, and that I shall go up to the house of the Lord on the third day?'
> *2 Kings 20:9*. And Isaiah said, 'This shall be the sign to you from the Lord …: shall the shadow go forward ten steps, or go back ten steps?'
> *2 Kings 20:10*. And Hezekiah answered, 'It is an easy thing for the shadow to lengthen ten steps. Rather let the shadow go back ten steps.'
> *2 Kings 20:11*. And Isaiah the prophet called to the Lord, and he brought the shadow back ten steps, by which it had gone down on the steps of Ahaz.

There is a complementary description in *Isaiah 38:8*: 'Behold, I will make the shadow cast by the declining sun on the dial of Ahaz turn back ten steps.' This is a short non-technical description of the completely unexpected movement backwards of the sun's shadow on a sundial constructed by Ahaz or his astronomers.

There exist alternative translations of the original Hebrew word for the division on the sundial. The general word 'steps' has been used above, but alternatives such as 'degrees', 'lines' and 'hours' also appear. The Septuagint renders it by the Greek word for 'steps'.

King Ahaz' sundial

Humans have probably used simple vertical rods or gnomons to tell the time of day from shadow-lengths as early as pre-historic times.

As the sun moves across the sky, a thin rod casts a shadow on a scale with hour-lines recording time. According to Herodotus (Godley 1920), (*Book 2, 109:3*): '…. the Greeks learned the art of measuring land; the sunclock and the sundial, and the twelve divisions of the day, came to Hellas from Babylonia and not from Egypt.'

Herodotus distinguishes between *sunclock* and *sundial*. The type of 'sundial' described above was most likely what Herodotus called 'sunclock'. Ahaz' sundial, on the other hand, corresponded to a much more sophisticated type of sundial that not only showed the time of day, but also the date in the calendar.

The most famous sundial of this kind was the *Solarium Augusti*, in ancient Rome. This type of sundial utilizes the sharp tip of a gnomon's shadow, similar to the shadow-tip of a vertical rod or an obelisk. The light receiving surface is normally a plane and the path of the shadow-tip, called *declination line*, traces out a conic section such as a hyperbola or an ellipse.

The earliest documented sundial seems to be 'the dial of Ahaz' constructed during Ahaz reign (726-715 BC).

Ahaz was influenced by ideas from Babylon and he had an alliance with the Assyrian King Tiglath-Pileser. He had seen an impressive altar in Damascus and wanted to have a similar one constructed in Jerusalem.

The sun moves 10 steps on the Ahaz' sundial

It must have been the apparent declination of the sun in its yearly motion that turned backwards on the Ahaz' sundial in front of the astonished eyewitnesses. From this we know that the miracle on the dial of Ahaz happened after the summer and before the winter solstice. 'So the sun turned back on the dial the ten steps by which it had declined' means that the observers had seen how the declination of the sun at first diminished in an unexpected way and then finally increased again with the same amount. These steps cannot be equivalent to *degrees* because then the sun must have changed its orbit. However, if the 10 steps correspond to 10 arcminutes (') it is possible to explain the observed effect by an obscuration of a considerable part of the northern disc of the sun, with a diameter of 30', by a partial solar eclipse with a sufficiently great magnitude.

The sundial of Ahaz allowed determining the position of the sun's shadow on a scale divided in at least 10' steps. This precision could have been achieved if a thin vertical gnomon with a small ball on its top was placed in the middle of a narrow window and the shadow was followed in a dark room.

If the room had one window with a gnomon in the eastern, southern and western wall, the sun's day line could have been followed during the morning, noon and evening hours respectively. The day line for the morning and evening observations could be engraved on the western and eastern wall respectively, and on the floor for observations around noon.

A calendar device in the Palace of Knossos, from about 1900 BC, was very sensitive to the sun's declination around the equinoxes. When the upper limb of the sun became visible above a ridge, at a distance of 750 m and altitude 10.3°, its first rays hit the bowl-like surface of a stone in the floor at the inner end of an 11 m long corridor which could contain water. The width of the first reflection on the wall from the pool of water changes, since the sun has a different declination at the moment of sunrise every year, due to the length of the year being ca. 365 ¼ days. An extra day must be added every fourth year to ensure the first reflection occurs at the day of autumn equinox (Henriksson and Blomberg 2011). During this day, it is easy to follow the motion of the shadow of the doorway on the floor and the walls of the corridor (Figure 2).

Figure 2: The rays from the upper limb of the sun, 10 seconds after sunrise, illuminate the Corridor of the House Tablets in Knossos in 1996. Left: On 21 September, the day before autumn equinox. Right: On 22 September, the day of autumn equinox, with a distinct reflection at the left end of a lenticular depression cut in the wall behind. The water surface in a shallow alabaster bowl in the floor reflects the light. This depression has the same size and position as the reflected light. (From a video film with time from an atomic clock.)

The partial solar eclipse in Jerusalem on 29 July 700 BC

There was a partial solar eclipse at sunset in Jerusalem, on 29 July 700 BC (Figure 3). Close to maximum phase the northern hemisphere of the sun was eclipsed and the center of light was shifted to the southern hemisphere, reducing the apparent declination. On a solar calendarium, with the sun's daily motion during the year marked by lines, one for every day during the spring and autumn half year, the sun at first seemed to move more than half a day forward and then move back again to its correct day line.

A calculation of the sun's center of light, including the effect of the limb darkening of the solar disc, showed that the maximum shift was 8.5'. The shadow on Ahaz' sundial moved 10 steps. The sun's limb darkening was calculated according to the formula by Arthur Eddington. This shift is more than half the distance of 14.9' between the day lines for the actual date.

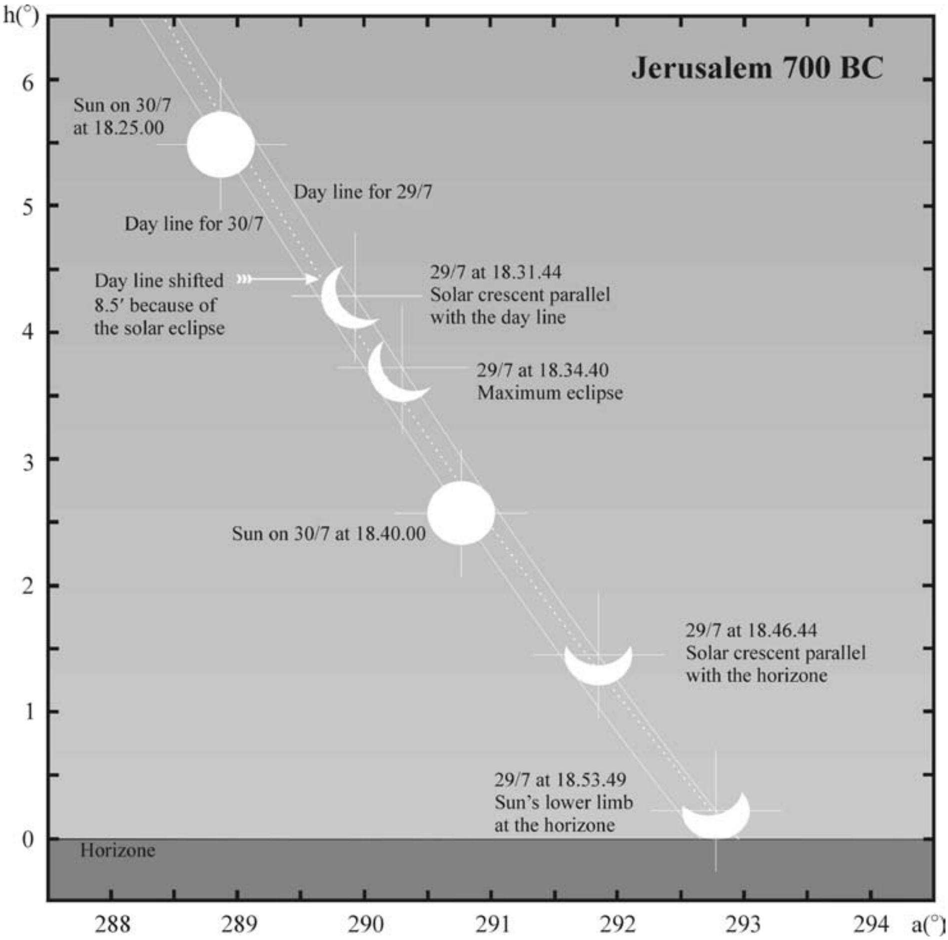

Figure 3: Partial solar eclipse in Jerusalem at sunset, on 29 July 700 BC. The times given are local mean solar time. Close to maximum phase, the northern hemisphere of the sun was eclipsed and the center of light was shifted 8.5' towards the southern hemisphere which appears as a lower declination. The shadow on the Ahaz' sundial moved at first 10 steps forwards and then 10 steps backwards (Isaiah 38:7-8).

Prediction of the solar eclipse

Isaiah promised, that on the third day there will be a miraculous sign on Ahaz' sundial (*2 Kings 20:5 and 8*). This could not be a magical trick that could be performed at any time because they must wait until the third day. On his way out from the royal palace, Isaiah may have met an astronomer who told him about the solar eclipse on the third day and its effect on the Ahaz' sundial. This prediction is 115 years older than the celebrated prediction by Thales from Miletos of the total solar eclipse in 585 BC, recorded by Herodotus (Godley 1920).

But how could they correctly predict the effect on Ahaz' sundial? Isaiah could have written down any number because he had no reason to believe that somebody in the future was able to calculate the circumstances of this solar eclipse and even the magnitude of the effect on Ahaz' sundial. The simplest explanation is that the astronomers at the court of Hezekiah predicted this partial solar eclipse precisely and made a correct observation of the motion of the sun's shadow on Ahaz' sundial. Finally, Isaiah correctly reported this.

Hezekiah and the Babylonian Envoys

When Sennacherib became king in Assyria, Merodach-Baladan, king of Babylon, sent an embassy to Hezekiah in an attempt to form an alliance. However, before the end of 703 BC, Sennacherib marched south and defeated the Babylonian forces, but Merodach-Baladan escaped. Sennacherib made a new attempt to catch Merodach-Baladan in 700 BC who then fled to Elam.

The arrival of the envoys from Merodach-Baladan is mentioned directly after the story about the miraculous sign on Ahaz' sundial on 29 July 700 BC. The purpose for the visit was to deliver letters and a present to the sick Hezekiah (*2 Kings 20:12*).

The *2 Chronicles* give a second reason to send envoys to Hezekiah that is relevant to this paper: 'But when envoys were sent by the rulers of Babylon to ask him about the miraculous sign that had occurred in the land …' (*2 Chronicles 32:31*).

The commentators of the text consider this 'miraculous sign' as an astronomical phenomenon. The author suggests that Merodach-Baladan may have heard about the miraculous motion of the shadow on the Ahaz' sundial. The miraculous sign may also have included the bright appearance of Comet Encke in February 702 BC when King Tirhakah's Egyptian army miraculously killed 185,000 men from the army of Sennacherib.

Part II: Total solar eclipse in southern Sweden on 29 July 700 BC

Introduction

The second part of this paper deals with pictorial evidence. The idea is that ancient people wanted to preserve unusual celestial events by drawing pictures with characteristic details to support their own memory and to be able to transfer knowledge to future generations.

The solar eclipse on 29 July 700 BC gives a unique possibility to compare the reaction in Jerusalem and Scandinavia: The first, a society that kept written records; the second, a society with, according to the author's interpretation, a long tradition of engraving rock carvings to memorize important celestial events since the beginning of the Bronze Age. However, pictures without explaining texts must be interpreted. From a great sample of rock carvings the author has discovered common principles that have been successfully compared with calculations of important astronomical phenomena such as total solar eclipses, the appearances of the bright Comet Encke, and an extremely bright supernova (Henriksson 1999, 2005).

The frame of reference is six calendar ships along the ecliptic. All of them have different shapes and can be identified as constellations created from the brightest stars in such a way that the ecliptic is divided in six equal parts. Each ship corresponds to a double month. The sequence starts at the summer solstice with a ship having an animal head at the stern. It consists of stars in Hydra and Corvus. The part of the ecliptic above this ship corresponds to Cancer and Leo (Figure 4).

The total solar eclipse at Tjärby on 29 July 700 BC

In 1873 a rock carving engraved on red gneiss stone was discovered inside a burial cairn on a Late Bronze Age cemetery at Tjärby, parish of Grimeton, in the province of Halland. The size of the stone is 30 x 40 cm (Ängeby 2008).

The carving depicts what people could see in the sky within the total zone of the solar eclipse on 29 July 700 BC (Figures 4 and 5) with the calendar ship corresponding to Leo-Cancer. The position of the sun in the ship and the ship's angle in relation to the horizon fits very well with the circumstances during the total solar eclipse on 29 July 700 BC.This is the latest of the sample of rock carving of a total solar eclipse identified by the author according to the rules that were established more than one thousand years earlier. The only deviation is the totally eclipsed sun not being depicted as concentric circles. Since the diameter of the sun is only 4 cm, the artist has probably chosen for technical reasons the general solar symbol, a ring-cross.

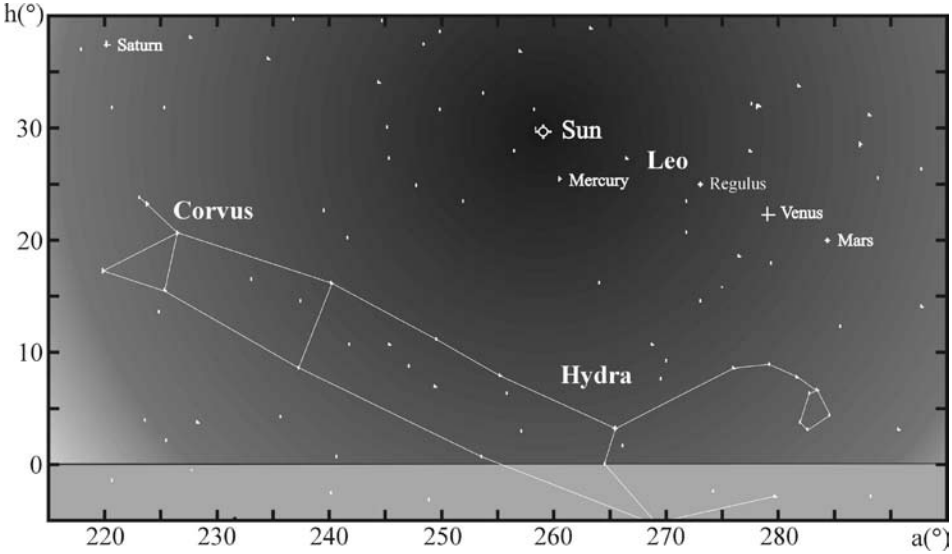

Figure 4: The total solar eclipse on 29/7 700 BC, at 16.21.14 local mean solar time at Tjärby, Grimeton's parish in Halland. The totally eclipsed sun was situated above the mid-point in the Leo-Cancer ship (Displayed magnitudes are brighter than 5.0).

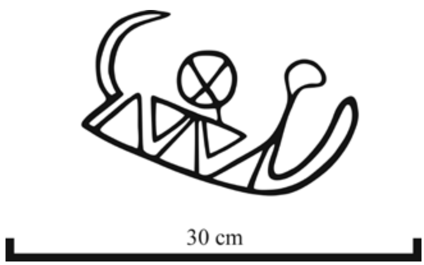

Figure 5: Rock carving on a stone inside a burial cairn on the Late Bronze Age cemetary at Tjärby, in the province of Halland (After Burenhult 1973).

The sacrificed Nackhälle shield

A great ceremonial bronze shield was discovered in 1865 at Nackhälle, parish of Spannarp, in the province of Halland (Figure 6). It had been sacrificed in shallow water in *Stora Mosse*, which means *The Great Bog*. The burial cairn with the rock carving at Tjärby is situated only about 700 m from *Stora Mosse* (Ängeby 2008).The main decoration on the shield consists of great concentric circles, three inner circles and two outer dotted circles. There exist also five small concentric circles, each with three circles between two parallel dotted lines perpendicular to the edge of the shield.

According to the author's interpretation, concentric circles were the dominant symbol for total solar eclipses on the Swedish rock carvings during the Bronze Age.

Between the two outer great dotted circles there is a frieze with 15 birds similar to swans. The shape of these birds is very similar to the brightest stars in the constellation Leo, where the total solar eclipse on 29 July 700 BC, took place (Figure 4).

Figure 6: Late Bronze Age bronze shield of Herzsprung type, from Nackhälle. Diameter 70.5 cm (Photo G. Henriksson).

The 17 sacrificed shields from Fröslunda

At least 17 ceremonial bronze shields were discovered in 1985 in a dried-up bay of Lake Vänern, at Fröslunda, Sunnersberg's parish, in the province of Västergötland (Hagberg & Jacobzon 1988). These shields are somewhat smaller but of similar type to the shield from Nackhälle (Figure 6).

Nine ceremonial shields have been found in Denmark and approximately ten at different places in Europe.

The Fröslunda shields were packed in reed that has been C^{14}-dated to 725 ±75 BC, which indicates the year for their sacrifice in water (Lihammer 2010). This date is in very good agreement with the date for the total solar eclipse on 29 July 700 BC.

However, these shields are older than 700 BC, being of Herzsprung type and were manufactured during the 9th-8th century BC. They may have been made to celebrate the great total solar eclipse on 5 July in 858 BC, which was depicted in at least ten rock carvings in southern Sweden. There are striking similarities between the total solar eclipses in 858 and 700 BC because they both took place in Leo and in the evening hours before sunset. There were no other total solar eclipses in southern Sweden during this period.

The best preserved of the 17 bronze shields from Fröslunda has a diameter of 60 cm and depicts great concentric circles: three inner and three outer dotted circles. It also shows 53 minor concentric circles in the space between the great circles, each consisting of three circles.

The main investigator, Ulf Erik Hagberg, invited the author to contribute to the final publication of the shields from Fröslunda. Unfortunately, Hagberg died during the spring of 2012, before the publication was finished. This paper is written to publish parts of the author's contribution to this investigation.

Ulf Erik Hagberg was Director of the National Historical Museum in Stockholm 1988-97.

Conclusions

The successful identification of observations of the same solar eclipse at such distant places as Jerusalem and southern Sweden is a very good test of the formulas used in the author's computer program including the new calibration of the secular acceleration of the longitude of the Moon. There exist no alternative solutions and all relevant criteria are fulfilled by the proposed identification.

The computer program was finished in 1985 and used modern parameters except for the longitude of the sun and the moon. These formulas were developed by Carl Schoch (1931) and were calibrated against ancient observations of solar eclipses dating back to 1335 BC.

In 2011 the author performed a new calibration based on 33 total solar eclipses dating back to 3653 BC. All these eclipses can be calculated with the sidereal lunar secular acceleration, -30.13"/cy^2, without the fitting parameter introduced by Schoch.

The lunar secular acceleration –25.85"/cy^2, determined by the Lunar Laser Range (LLR) measurements (Williams *et al.* 2008) must be corrected for the relativistic precession of the geodesic, -3.84"/cy^2, to determine the sidereal lunar secular acceleration of –29.69"/cy^2. The small difference of –0.44"/cy^2 between the corrected LLR-result and the author's new calibration has the same order of magnitude as the effect predicted by Gia Dvali *et al.* (2003) in a modified theory of gravity.

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Sulgi's Eclipse

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Abstract

There is a long-standing controversy regarding the chronology of Mesopotamian events before the Fall of Babylon at the raid of Mursilis I. Events after that are dated via the 762 BC solar eclipse and written sources. However, the Fall of Babylon breaks the continuity. Events before that are generally dated via Sulgi's Eclipse. The controversy among different chronologies comes mainly from the fact that Babylon was destroyed and empty for a while, but it is not known for how long. The four Chronologies differ in the date of the Fall of Babylon. There are at least two ways to fix the pre-fall chronology. The first is to find an event that occurred at the same time as the Fall of Babylon; the Second is to date Sulgi's (Lunar) Eclipse. Both have difficulties. *Sulgi's Eclipse* is a *total lunar eclipse*; it *started after moonrise* and *occurred in the month of Simanu* (May-June), possibly between *2151 BC and 1951 BC*. Because Assurbanapli's Library contains a tablet in which the Kassu King Agum-kakrime declares restoration activity in Babylon, and Astour identifies him as the ninth King on King List A, the gap of Mursilis' Raid and the midpoint of Agum-kakrime's reign can, although with some uncertainty, be estimated by calculating a possible total lunar eclipse.

KEYWORDS: history of astronomy, eclipses, Saros series, chronology

POVZETEK

Polemika o kronologiji dogodkov v Mezopotamiji pred padcem Babilona zaradi vpada Mursilisa I. traja že vrsto let. Kasnejši dogodki so datirani na podlagi Sončevega mrka iz leta 762 pr.n.št. in pisnih virov. Padec Babilona pa prekinja to kontinuiteto. Dogodki pred padcem so običajno datirani na podlagi Sulgijevega mrka. Polemika med različnimi kronologijami je večinoma posledica dejstva, da je bil Babilon po uničenju nekaj časa prazen, ne ve pa se, koliko časa. Štiri kronologije ponujajo različne datume za padec Babilona. Za datiranje dogodkov pred padcem obstajata vsaj dva načina. Prvi je poiskati dogodek, sočasen padcu; drugi je določiti datum Sulgijevega (Luninega) mrka. Oba načina sta težavna. *Sulgijev mrk je popolni Lunin mrk*; *začel se je po vzhodu Lune* in *se je zgodil v mesecu Simanu* (maj-junij), nekje med *2151 in 1951 pr.n.št*. V Assurbanaplijevi

knjižnici je tablica, na kateri kasitski kralj Agum-kakrime govori o aktivnostih za obnovo Babilona, Astour pa ga identificira kot devetega kralja na Listi kraljev A, zato lahko – z določeno mero negotovosti – določimo vrzel med Mursilisovim vpadom in sredino Agum-kakrimove vladavine preko izračuna morebitnega Luninega mrka.

KLJUČNE BESEDE: zgodovina astronomije, mrki, ciklus Saros, kronologija

Introduction

There is a long-standing controversy regarding the chronology of Mesopotamian events before the Fall of Babylon at the raid of Mursilis I. Events after that are dated via the -762 solar eclipse and written sources. However, the Fall of Babylon breaks the continuity. Events before that are generally dated via Sulgi's Eclipse which was preserved in the omen collections, although Amissaduga's Venus Tablets are used too. The controversy among different chronologies comes mainly from the fact that Babylon was destroyed and empty for some time, but it is not known for how long.

The four Chronologies differ, of course, in the date of the Fall of Babylon, but the uncertainty relative to this event is not large (Table 1).

Table 1: The Four Chronologies, the Fall.

Chronology	Long	Middle	Short	Ultra-Short
The Fall	1651	1595	1531	1499

There are at least two ways to fix the Pre-Fall Chronology. The first is to find an event that occurred at the same time as the Fall of Babylon, and the second is to date Sulgi's (Lunar) Eclipse. Both have difficulties. That the Kassu Dynasty ended in 1155 and is anchored with the 763 solar eclipses has never been seriously doubted. However, it starts outside the geographical area of Babylon, and the midpart is basically illegible. On the other hand, Sulgi's Eclipse is lunar, so there are several candidates. Statistics can be applied on the damaged King List A, and the best current techniques can be applied to the total lunar eclipse. Suggestions for this are between 2151 BC and 1951 BC. In the Omen Literature, it was determined to be total; it started after moonrise and occurred in the month of Simanu (May-June). Because Assurbanapli's Library has a tablet in which the Kassu King Agum-kakrime declares restoration activity in Babylon, and Astour identifies him as the ninth King on King List A (Astour 1986; Chrisholm 1911), the gap of Mursilis' Raid and the midpoint of Agum-kakrime's reign can be calculated, although with some uncertainty, as in Table 2.

Table 2: The Four Chronologies, the Gap.

Chronology	Long	Middle	Short	Ultra-Short
The Gap	93±16	37±16	-27±16	-59±16

Since the average of the ruling years for kings with illegible years is 20.5, the Ultra-Short chronology may be in conflict with this reconstruction. Short is marginally possible; Long is possible but maybe too long. The Middle one is probable.

Astronomical computations enable astronomers to calculate dates and paths of future and past eclipses with great accuracy. Some ancient eclipse records have been particularly significant to astronomers and historians as they enabled certain historical eras and events to be dated accurately.

NASA Eclipse Bulletins for century intervals between 2000 BCE and 1901 BCE (Espenak *et al* 2009) were used for the identification of Sulgi's Eclipse. For the remaining specified period between 2151 BCE and 2000 BCE, total lunar eclipses were calculated from the lunar Saros series -12 – +8.

Sulgi's Cronology and the Reconstructed King List A

There are more old sources concentrating on King List A (Chisholm 1911; Weidner 1926; Davidson et al. 1924; Roberts 1923) than modern (Astour 1986; Oppenheim 1977). For numbers that cannot be constructed, average and mean deviation are from the statistics of King List A; reconstructed years are noted with asterisk (*) (Table 3).

Sulgi's Total Lunar Eclipse

A *lunar eclipse* occurs when the Earth passes between the Moon and the Sun, and the Earth's shadow obscures the Moon or a portion of it. A lunar eclipse can only occur when the Moon is full. Obviously, even though there is a full moon each month, a lunar eclipse does not always occur because the Sun is not *exactly* in line with the Earth and the Moon. The Moon's orbit is actually tilted five degrees more than that of the Earth. Otherwise, there would be a lunar eclipse each month.

From earliest times, ancient people were drawn to the permanence of the heavens. Over time, early societies attached religious and spiritual significance to the regular motions of celestial bodies. When an astronomical event such as an eclipse took place, most ancient people believed it was the action of a divine being. When the rays of the Sun or the glow of the Moon were extinguished, early societies believed this was a terrible omen and that some type of disaster was imminent.

In the dawn of civilization, astronomy flourished in Mesopotamia, the plain between the two great rivers Tigris and Euphrates. Like Chinese and Egyptian astronomers, Babylonian astronomers observed the motions of the Sun, Moon, and planets carefully and kept records of celestial events. They have also been credited with remarkable contributions to ancient astronomy.

Astronomical computations enable astronomers to calculate the dates and paths of future and past eclipses with great accuracy. Some ancient eclipse records have been particularly significant to astronomers and historians as they enabled *certain historical eras* and *events to be dated accurately*.

The best known eclipse cycle, which comes in families, is the *Saros*, a period of 6585.322 days. It is useful for predicting the times at which nearly identical eclipses

Table 3: The Reconstructed King List A; In Note: [1] is (Chisholm 1911), [2] is (Astour 1986), [3] is (Oppenheim 1977), [4-6] is (Weidner 1926; Davidson et al 1924; Roberts 1923)

Nr.	King	Starting yr	Last yr	Midpt ±	Note
1	Gandaš	1732	1707	0	[3]
2	Agum I	1706	1685	0	[3]
3	Kaštiliaš I	1684	1663	0	[3]
4	Abirattaš	1662	1654*	0	[1], [4-6]
5	Kaštiliaš II	1653*	1633*	5	[1]
6	Urzigurumaš	1632*	1611*	8	[3]
7	Harbe-šipak	1610*	1590*	12	[3]
8	Tiptakzi	1589*	1569*	14	
9	Agum-kakrime	1568*	1547*	16	[1], [2]
10	Burnaburiaš I	1546*	1525*	17	[4], [5]
11	Kaštiliaš III	1524*	1503*	18	[4], [5]
12	Ulamburiaš	1502*	1482*	18	
13	Agum III	1481*	1460*	16	
14	Karaindaš	1459*	1439*	14	[3]
15	Kadašman-Harbe I	1438*	1418*	12	[3]
16	Kurigalzu I	1417*	1396*	8	[3]
17	Meli-Šipak I	1395*	1375	5	[5]
18	Kadašman-Enlil I	1374	1360	0	[3]
19	Burna-buriaš II	1359	1333	0	[3]
20	Kara-hardaš	1333	1333	0	[3]
21	Nazibugaš	1333	1333	0	[3]
22	Kurigalzu II	1332	1308	0	[3]
23	Nazi-Maruttaš	1307	1282	0	[3]
24	Kadašman-turgu	1281	1264	0	[3]
25	Kadašman-Enlil II	1263	1255	0	[3]
26	Kudur-Enlil	1254	1246	0	[3]
27	Šagarakti-Šuriaš	1245	1233	0	[3]
28	Kaštiliaš IV	1232	1225	0	[3]
29	Enlil-nadin-šumi	1224	1224	0	[3]
30	Kadašman-Harbe II	1223	1223	0	[3]
31	Adad-šuma-iddina	1222	1217	0	[3]
32	Adad-šuma-usur	1216	1187	0	[3]
33	Meli-Šipak II	1186	1172	0	[3]
34	Marduk-apla-iddin	1171	1159	0	[3]
35	Zababa-šumu-iddin	1158	1158	0	[3]
36	Enlil-nadin-ahé	1157	1155	0	[3]

will occur. The earliest discovered historical record of the Saros is that of the Chaldeans (ancient Babylonian astronomers). The origin of the *Saros* comes from the recognition that 223 *synodic months* is approximately equal to 242 *draconic months* which is approximately equal to 239 *anomalistic months* (Csillik *et al* 1999).

After one *Saros*, the Moon will have completed roughly an integer number of synodic, draconic, and anomalistic months, and the Earth-Sun-Moon *geometry will be nearly identical*. The Moon will have the same phase, be at the same node, and have the same distance from the Earth. In addition, because the Saros is close to 18 years in length, the Earth will be nearly the same distance from and tilted to the Sun in nearly the same orientation (same season). A complication with the Saros is that its period is not an integer number of days. It contains close to a multiple of one-third of a day. As a result of the Earth's rotation, for each successive Saros, an eclipse will occur about 8 hours later in the day. This means that the region of eclipse will shift *westward* one third of the way around the globe. In the case of an eclipse of the Moon, the next eclipse might still be visible from the same location as long as the Moon is above the horizon. However, if one waits three Saroses, the local time of day of an eclipse will be nearly the same. This period of three Saroses (54 years, 1 month, or almost 19756 full days), is known as a *triple saros* or *exeligmos* (from the *Greek* phrase 'turn of the wheel').

Each Saros series starts with a partial eclipse (the Sun first enters the end of the node), and in each successive Saros, the path of the Moon is shifted either northward (when near the descending node) or southward (when near the ascending node).

NASA Eclipse Bulletins for century interval between 2000 BCE and 1901 BCE (Espenak *et al* 2009) were used for the identification of Sulgi's Eclipse. For the remaining specified period between 2151 BCE and 2000 BCE total lunar eclipses were calculated from the possible lunar Saros series 12 – 8 (Table 4). The period between Saros members can be known from the NASA Catalog by taking a member of a searching Saros (found between 2000 and 1901), and then using a numerical program to calculate the retrograde motion of the examined members from that Saros cycle.

A *Hipparchus lunar eclipses pair* is two consecutive lunar eclipses separated by an interval of 345 years and a few days (used by Hipparchus to verify traditional Babylonian periods). Such 345-year eclipses reoccur at an almost identical time of day, elevation, and celestial position.

Example for a Hipparchus lunar eclipses pair, from NASA Eclipse Home Page:

28 June 1954, 4:23 TD, Saros 8, Total Lunar Eclipse, latitude: 23° S, longitude: 121° E.

06 June 1609, 4:13 TD, Saros 33, Penumbral Lunar Eclipse, latitude: 24° S, longitude: 90° E.

Eight total lunar eclipses were found which correspond to the search criteria (started after moonrise), using the Hipparchus lunar eclipses pair. These were: (HP1): 1954.06.28 BCE; (HP2): 1965.07.29 BCE; (HP3): 1980.05.17 BCE; (HP4): 1994.08.19 BCE; (HP5): 2048.07.17 BCE; (HP6): 2067.07.16 BCE, (HP7): 2150.07.04 BCE, (HP8): 2121.06.13 BCE (Table 4).

Eight lunar total eclipses were found which correspond to the months May-

Table 4: Examined Saros Series -12 – +8.

Saros Cycle	Saros Member	Years of Eclipse (BCE)	Possible as Hipparchus Pair
8	29-31	1990, 1972, 1954	*1954*
7	33-36	2019, 2001, 1983, 1965	*1965*
6	31-38	2084, 2066, 2048, 2030, 2012, 1994, 1976, 1958	*2084, 2048, 1994*
5	19-29	2131, 2113, 2095, 2077, 2059, 2041, 2023, 2005, 1987, 1969, 1951	
4	22-32	2142, 2124, 2106, 2088, 2070, 2052, 2034, 2015, 1998, 1980, 1962	
3	25-35	2135, 2117, 2099, 2081, 2063, 2045, 2027, 2009, 1991, 1973, 1954	
2	17-27	2236, 2218, 2200, 2182, 2164, 2146, 2128, 2110, 2092, 2074, 2056	
1	28-35	2085, 2066, 2048, 2030, 2012, 1994, 1976, 1958	
0	29-40	2150, 2131, 2113, 2095, 2077, 2059, 2041, 2023, 2005, 1987, 1969, 1951	
-1	29-39	2142, 2124, 2106, 2088, 2070, 2052, 2034, 2016, 1998, 1980, 1962	*1980, 1962*
-2	33-43	2135, 2117, 2099, 2081, 2063, 2045, 2027, 2009, 1991, 1973, 1955	2045, 1991
-3	36-46	2146, 2128, 2110, 2092, 2074, 2056, 2038, 2020, 2002, 1984, 1966	2110, 2056
-4	36-47	2157, 2139, 2121, 2103, 2085, 2067, 2049, 2031, 2013, 1995, 1977, 1959	2157, 2121, 2103, 2067
-5	30-32	2150, 2132, 2114	2150
-7	46-56	2136, 2118, 2100, 2082, 2064, 2046, 2028, 2010, 2000, 1973, 1955	
-8	48-53	2147, 2129, 2111, 2093, 2075, 2057	
-9	51-58	2140, 2122, 2104, 2085, 2067, 2049, 2031, 2013	
-10	52-58	2150, 2132, 2114, 2096, 2078, 2060, 2042	
-11	56, 57	2143, 2125	
-12	59	2136	

June in the period between 2151 BCE and 1951 BCE near the town of Ur (latitude: 37N, longitude 47E). These were: (E1): 1962.05.28 BCE; (E2): 1991.06.17 BCE; (E3): 2045.05.15 BCE; (E4): 2056.06.15 BCE; (E5): 2084.06.25 BCE; (E6): 2103.06.25 BCE, (E7): 2110.05.13 BCE, (E8): 2157.05.23 BCE.

Table 5: Sulgi's possible eclipse via month Simanu.

Nr.	Date (BCE)	TD	Greatest Eclipse	Saros/ Memb	Type	Hipparchus pair (HP)	Note
1.	25.05.2084	12:44	Africa	6/31	T	21.06.1739	E5
2.	28.05.1962	09:31	Africa	-1/39	T	23.05.1617	E1
3.	15.05.2045	14:00	Indian O.	-2/38	T	11.05.1700	E3
4.	17.06.1991	10:00	Indian O.	-2/41	T	13.06.1646	E2
5.	13.05.2110	9:00	Indian O.	-3/38	T	10.05.1965	E7
6.	15.06.2056	8:00	Indian O.	-3/41	T	12.06.1711	E4
7.	23.05.2157	7:00	Indian O.	-4/36	T	19.05.1812	E8
8.	25.06.2103	8:30	Africa	-4/39	T	21.06.1758	E6

Solar eclipse predictions are based on Terrestrial Dynamical Time (TDT), but the position of the central eclipse path still depends on Universal Time (UT). The difference between TDT and UT is a parameter known as Delta T or ΔT. If the Stephenson model (Stephenson *et al* 1986) is accepted, the best Sulgi's eclipse predictions purely from the Delta T point of view are in the 8 candidates which may be seen in Table 5. Accepting the Meeus-IAU model, just E8 total eclipses would be invisible (Stephenson *et al* 1986; Morrison *et al* 2004; Liu *et al* 1992).

Conclusion

Sulgi's death in the Middle Chronology was in 2047±few years BCE. With shifts (+56, 0, -64, -96 years) in the chronologies, Eclipse 6 (E6) is exactly positioned in Long. Eclipse 3 (E3) would need a two-year motion backward from the death in the Middle, and Eclipse 1 (E1) a 7 year backward motion from the Short. Ultra-Short does not match the present best NASA tables. From the Hipparchus eclipse pair's point of view, the best eclipses may be seen in Table 6.

From an astronomical point of view (the Hipparchus eclipse pair via month *Si-manu),* Sulgi's Total Lunar Eclipse description corresponds very well to the HP1, HP3, HP7, HP8 eclipses, and for the Middle Chronology, the HP5 eclipse.

Table 6: Sulgi's possible eclipse via Hipparchus eclipse pair.

Nr.	Date (BCE)	TD	Saros Nr.	HP Date (BCE)	TD	Saros Nr.	Note
1.	28.06.1954	4:23	8	23.06.1609	4:13	33	HP1
2.	29.07.1965	3:15	7	25.07.1620	2:36	32	HP2
3.	17.05.1980	2:13	-1	13.05.1635	2:25	24	HP3
4.	19.08.1994	3:45	6	14.08.1649	3:26	31	HP4
5.	17.07.2048	4:00	6	13.07.1703	3:59	31	HP5
6.	16.07.2067	3:30	-4	13.07.1722	3:21	21	HP6
7.	04.07.2150	6:30	-5	30.06.1805	6:19	20	HP7
8.	13.06.2121	5:00	-4	10.06.1776	4:52	21	HP8

Appendix: Statistics of the King List A

Statistics are as follows: Block A is Kings 1-4. Block B, and the totally illegible numbers are 5-9 & 11-17. Block C is 10 & 18-36, again legible. C1 consists of ones not shorter than six years, while C2 are not longer than three years. No king is between these, and C1 & C2 show quite different behaviors.

For the legible,

N = 24

<x> = 13.37 years

σ_x = 9.9 years.

For others,

N = 12

<x> = 21.33 years,

and σ_x cannot be determined. The means are quite different for (A+C) & B. However, separating 4 blocks yields a new table (Table 7).

Table 7: Statistics of King List A.

Group	<x>	Σ	Δ	N
A	19.75	7.41	5.24	4
B	21.33	?	?	12
C1	16.86	7.89	2.28	14
C2	1.00	1.10	0.55	6

Here, σ is the standard deviation, and δ is the standard error of the mean. Blocks A and C1 do not differ significantly, nor does the mean of B. Thus, there is no statistical evidence for rejecting <x>=21.33 years, σ_x=7.67 years (A+C1) for the 12 unreconstruable, and then δ=2.43 years. Consequently, Gandaš starts in 1732, and Agum-kakrime rules around 21 years with the midpoint at 1557±16. This is the basis of Table 3.

Appendix B: The Ultra-Short Chronology and the Tell Muhammad Tablets

It should be noted that founders of the Ultra-Short Chronology investigated their chronology in the context of eclipses and found no contradiction. Findings in this article may be in contradiction with this, and this should be clarified.

Gasche *et al* (1998) provide a seminal paper on the Ultra-Short Chronology, and Banjević (2006) criticizes their lunar eclipse conclusion. Gasche *et al.* indicate that two Tell Muhammad silver loan contracts from the 38th year of the resettling of Babylon are in agreement with their chronology. Banjević claims that the tablets are inconclusive for chronologies; only one mentions the eclipse, and the other the 38th year. One of the two contains an impossible day for the eclipse.

Gasche *et al* mention two tablets that have an interesting dating convention including three lines of dating. The first two lines identify the year in two different ways, and the third is the month & day. These are loan contracts, so the year is very important for calculating interest. Tablets Nos. 92134, 92139 & 92722 are dated in the first line from Year 38. Tablet 92722 indeed does not mention the eclipse and has no third line and is thus irrelevant. However, the other two include in the second line the lunar eclipse as part of the dating. As for the third line, Tablet 92134 mentions Abu 10, and 92139 dates as Nisannu [lacuna]. While in Babylonian calendars Day 10 is indeed impossible *for any eclipse*, the third line is not the date of the *eclipse* in any regard but the date of the contract. The eclipse is mentioned in a somewhat flowery style, but these are no astronomical records at all.

It seems evident that there was a lunar eclipse in the 38^{th} year which is 1462-x in the Ultra-Short Chronology; x is positive, but according to Gasche *et al* for only a few years. There are indeed good total eclipses around 1455. Lunar eclipses are frequent, and in a few years even total eclipses occur around *any* date. While we do not agree with Banjević regarding the removal of tablets from the analysis, we do agree that there is sound agreement with other chronologies.

Lunar eclipses are so frequent that they cannot be used '*in themselves'* for dating but rather only together with other historical sources. Middle Chronology + the Kassu List are consistent with Sulgi's eclipse; Ultra-Short + the King List are not. If strong enough arguments are found for Ultra-Short, then anyone may have doubts about the King List. However, the Tell Muhammad tablets themselves are consistent with Middle or Short chronologies (Gasche *et al* 1998; Banjević 2006).

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The Orientation of the Bronze Age Temple of Pella, Jordan: the dying god Baal and the Rituals of the Summer Solstice

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Abstract

We present an analysis of the orientation of the Bronze Age Temple of Pella obtained by the authors in the winter of 2011. The site, famous for its huge ancient Roman ruins, has revealed on its lower acropolis the remains of a large sacred building built in the 19th century BC. This Middle Bronze Age temple was continually used and restored until the end of the Iron Age in the first millennium BC. The temple has a typical Southern Levant Bronze Age style of architecture characterized by a single elongated rectangular room with an entrance on the shorter side flanked by two antis. Some findings recovered in the temple in each architectural phase identify the worshipped deity as Baal, Lord of the Tempest, the dying god who defied Mut (Death) in Ugaritic Mythology. Considering the orientation measurements, it seems clear that the entrance has an orientation to the summer solstice sunrise, a moment which in Near Eastern cultures was clearly linked to the festivity of dying deities associated with wheat harvesting in a general vision of the summer months as the time when there was a confluence of worlds both 'Above' and 'Below'.

KEYWORDS: Pella, Bronze Age, summer solstice, Baal

POVZETEK

Predstavljamo analizo orientacije bronastodobnega templja v Pelli, izmerjene pozimi leta 2011. Na tem najdišču, slavnem zaradi obsežnih ruševin iz rimskih časov, so bili znotraj spodnje akropole odkriti ostanki večje sakralne zgradbe iz 19. stoletja pr. n. št. Tempelj, postavljen v srednji bronasti dobi, je bil neprekinjeno v rabi in obnavljan do konca železne dobe v 1. tisočletju pr. n. št. Gre za tipično južnolevantsko bronastodobno arhitekturo, z enim samim podolgovatim pravokotnim prostorom, z vhodom na krajši stranici ter dvema antama ob straneh. Nekatere najdbe, povezane s posameznimi gradbenimi fazami svetišča, razkrivajo čaščenje boga Baala, gospodarja neviht, umirajočega boga, ki se je po ugaritski mitologiji zoperstavil Smrti (Mut). Na podlagi meritev sklepamo, da je vhod usmerjen k točki Sončevega vzhoda ob poletnemu solsticiju, trenutku, ki je bil v bližnjevzhodnih kulturah nedvomno povezan s prazniki umirajočih božanstev in žetvijo pšenice, v sklopu pojmovanj o poletnih mesecih kot času, v katerem se spajata svetova 'Zgoraj' in 'Spodaj'.

KLJUČNE BESEDE: Pella, bronasta doba, poletni solsticij, Baal

During December 2011, the authors spent three weeks measuring the orientations of many ancient buildings, temples, and megalithic monuments of Jordan[1]. Among these monuments was the main Middle Bronze Age temple of Pella, a city that later became part of the Roman Decapolis on the Eastern bank of the Jordan River.

The site, located near the modern Arabic village of Tabaqat Fahl, is mentioned in Egyptian records since the 19th century BC and named Pella in the Hellenistic Period. Between 1994 and 2001, the Australian Archaeological Mission directed by Prof. Stephen Bourke excavated in Pella an extended sacred area on the principal Northern mound showing occupational levels from the Early Bronze to the Iron Age (Bourke 2003; 2004). The site occupies three main hills with a permanent spring at the centre of the site. Pella is located in the deep Jordan Valley, on its eastern side, at 50 m below sea level (Fig. 1). The topography of the site is characterized by the presence of a seasonal river which crosses the settlement[2]. Good environmental conditions, the presence of fresh water, and the proximity of the Jordan Valley have permitted the permanent occupation of the site since the Chalcolithic Age (V millennium BC) to the Roman, Byzantine, and Islamic periods. This is seen in the huge remains of the ancient city of the Decapolis which extends into the valley around the main spring[3].

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[1] See for other results of the campaign Belmonte *et al.* 2013.

[2] The seasonal river, the wadi Wadi Jirm el-Moz, runs between Jebel Abu el-Khas, Jebel Sartaba and Tell el-Husn, the three mounds where the pre-classical site, and the Roman city was then settled (see Bourke 2003: fig.1).

[3] The first building constructed in the site is a huge rectangular terrace named Wall 48 discovered in Area XXXIID, with a three step staircase leading up to the centre. This seems to have had a sacred purpose (Bourke 2003: 338, fig. 5).

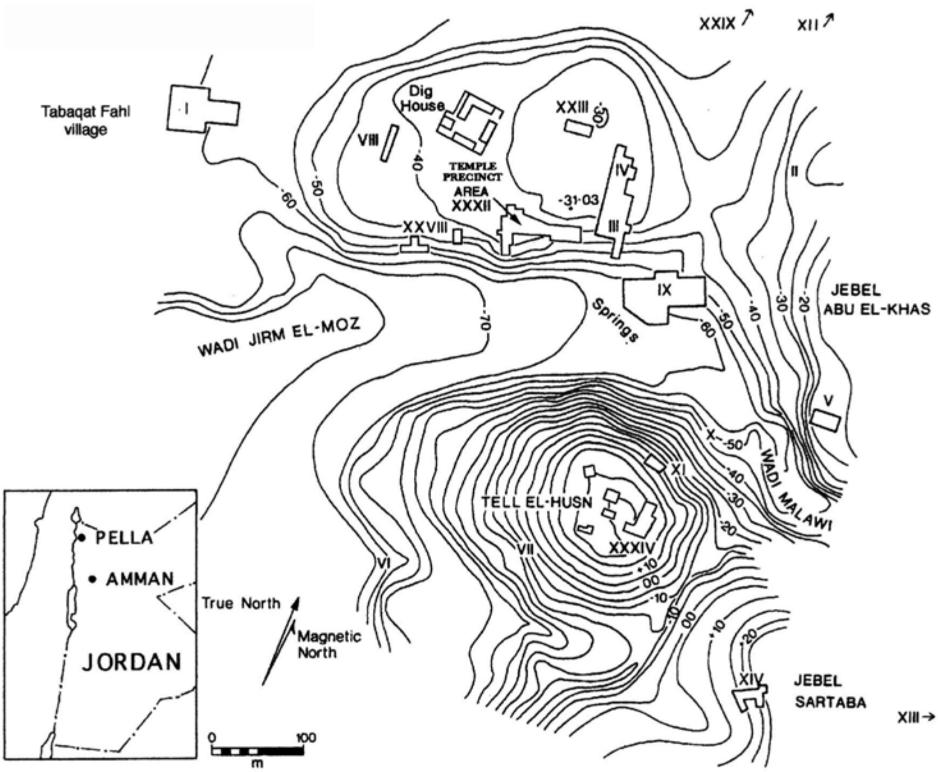

Figure 1: Topographic map of Pella (from Bourke 2004: fig. 1).

The sacred area of the Bronze and Iron Ages (Area XXXII) shows impressive continuity as a centre of cultic life of the settlement (Fig. 2). The first chronological phase of the main large (32 by 24 meters) 'fortress temple' is related to the Middle Bronze Age (1800-1450 BC). It is a typical 'temple *in antis*' with a single wide entrance on the eastern side (Figure 3a). Its walls were made by a two-row stone foundation and probable mud-brick elevation (Bourke 2004: 4). The *cella* is a simple rectangular space with the door on the eastern shorter side, a paved mud brick floor, and no dividing walls. No ritual objects of any kind were found inside the temple. The massive rectangular shape of the building, with two buttresses flanking the entrance, fits well in the so called 'empty-box' temple form found for the Middle Bronze Age in several sites on the western side of the Jordan Valley[4]. Various architectural interventions were made in the Late Bronze Age I (1450-1350 BC). However, the external rectangular shape of the building, and in particular the location and the orientation of the main entrance, were not modified. First,

[4] Such as the temples of Shechem, Megiddo and Hazor (see Mazar 1992: 211).

the inner space of the *cella* was divided in two by a mud brick wall that was oriented north-south thus obtaining a smaller room on the western side of the temple. Second, the floor inside the new space of the *sancta sanctorum* was completely redone. The ancient floor was removed to a depth of 1,5 m, then refilled with medium sized stones, and lastly sealed with a lime plaster floor surface of a yellow white colour. Third, two large 5×5 m square towers were built on stone buttresses that flanked the Middle Bronze Age entrance of the temple (Bourke 2004: 7f). At the end of this period, a strong earthquake probably destroyed the building. It was then rebuilt in the Late Bronze Age II (1350-1150 BC)[5]. In this second phase (Fig. 3b), the temple was reduced in dimension, and the northern wall was moved five meters to the south. All the walls of the building were rebuilt with a stone foundation and mud brick elevation reducing their dimensions and narrowing the entire structure. The floor of the *sancta sanctorum* was also re-laid, and two small basalt column bases flanked its entrance which was narrowed and re-centred to the south. The main entrance of the *cella* to the east was also provided with a new central colonnade revealed by three column bases. The wooden remains found near the basaltic stone bases indicate wooden columns, of which the central one was the largest, sustaining the main weight of the structure. The Sidney University archaeologists also hypothesize that in this second phase, the two external square towers of the first temple phase collapsed and were no longer reconstructed (see Bourke 2004: 8-9). Thus, in this second phase, the general shape of

Figure 2: Picture of Pella, from east. There is evidence on the centre mound of excavation Area XXXII (photograph by A. César González García).

[5] The Eastern, like the Western flank of the Jordan Valley, is a strong seismic area, a fact noted by continuous traces of earthquakes visible in the ancient pre-classical and classical buildings in the Jordanian archaeological sites.

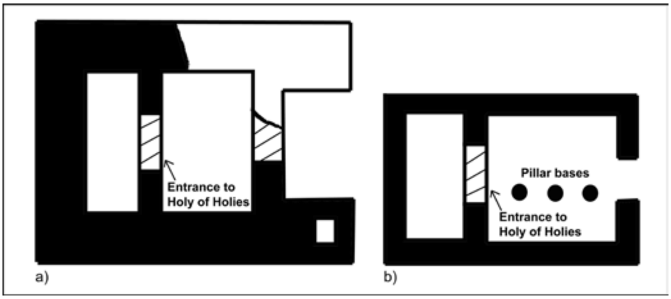

Figure 3: a) First phase of the Middle Bronze Age temple; b) Second phase of the Late Bronze Age II temple (from Bourke 2004: fig. 3).

the temple, the direction of the main entrance, and the presence of the *sancta sanctorum* did not change; the architectural innovations were just the reduction of the dimensions and the presence of the two colonnades[6].

In December 2011, we made field measurements of the main axis of the Middle Bronze Age temple (Fig. 4) which had remained the same till the later phase of the Late Bronze. The azimuth was 68.75°, and the elevation was 8.5°. This corresponded to a declination of 22.5° ± 0.75°. The orientation towards the Jordan valley was 248.75°, and the elevation was -0.5°. However, after inspecting the archaeological data, mainly the consistency in the use of the same orientation pattern throughout the history of the temple, this direction was discarded as a main target, and we assumed that the temple axis was pointing towards the north east with a declination of 22.5° ± 0.75°. This is consistent with the direction of the sunrise in the Summer Solstice during the 2nd millennium BC when the temple was erected.

What could be the explanation? In order to understand the choice of the temple orientation, it is important to look at the deity worshipped and the rituals performed inside the sacred area. Thus, we first inspected the temple archaeological findings in different phases. Despite the absence of ritual *paraphernalia* inside the Middle Bronze building, a series of plastered sealed bins of vessels were discovered near the temple. These votive deposits have two main important characteristics: First, among the bins there are some vessels that can be easily recognized as Egyptian importations such as a faience lid or a calcite jar (Bourke 2004: figs. 9:1-11, 10:1-3). Second, in the pottery shapes that include juglets, plates, and miniature vessels, there are a series of rough-finished ceramic funnels, usually related to funerary libations for ancestor worship (such as the ones discovered in contemporary tombs deposits in Pella and, for example, in the Megiddo MB cemetery; see Bourke 2003: fig. 16). Another interesting finding in the Middle Bronze Age bins is a

[6] This shape change in the third phase, during the Iron Age, when, after huge destruction of the Bronze Age temple, not clearly recognized as natural (caused by another stronger earthquake) or human (caused by war), the structure was completely rebuilt and shows many architectural differences: the building main axis changed orientation, and the entrance, always facing East but no more in axis with the *sancta sanctorum*, was located on the long side of the temple. All these features and the findings of this last phase reflect a radical change in the rituals and religion of the Iron Age settlement (see Bourke 2004: 10-11).

Figure 4: Orientation measurements on field in 2011 (photograph by A. César González García).

unique locally made gypsum bowl with four miniature bull heads applied along the rim (Bourke 2004: fig. 10:4).

The numerous findings of the Late Bronze Age in the foundation deposit, recovered under the *sancta sanctorum* plastered floor of the second phase, attests to the various cultural influxes and political contacts of the settlement elite through the Near East in this period. In fact, in different pits, some Mycenaean ceramic cups were recovered as well as faience cylinder seals of Mitannian Common Style where priests in procession are depicted with the schematic representation of the sacred Mesopotamian tree among them represented in the artistic symbol of the 'Bouquet Tree' (Bouke 2004: fig. 11:2). Among the foundation deposits there was also a necklace of semi-precious stones and two glass objects (an ingot and a plaque) similar to the ones recovered in other temple contexts in the Southern Levant and generally also connected to the Ishtar or Astarte female deity which is connected to the planet Venus and wife of Baal, the storm god in the Cananean tradition (Bouke 2004: fig. 11:3-4). Another object related to the Levantine god Baal recovered in the foundation pits was a small bronze spearhead (Bouke 2004: fig. 11:5) interpreted by the excavators as a miniature harpoon, symbol of Baal, as well as the Egyptian god Seth during the ruling of the Asian or Hyksos Dynasties (XIV-XVII, 1649-1552 BC). Together with this object, a unique bronze strip was also found with a modeled frieze of alternating frontal ram and bull heads (Bouke 2004: fig. 11:6).

The offering deposits contained many remains of sacrificed animals together with several cultic vessels smashed inside the pits (Bourke 2004: 16). Among them, the most interesting was a large fenestrated painted stand vessel identified as a cultic incense burner (Fig. 5). On the whole surface of the incense burner, various narrative scenes are depicted and divided into three main registers. The bottom register shows a motif of geometrical triangular elements alternated with small trees present also in the obverse side of the middle register where two trees flank a geometrical element interpreted by the excavators as the symbolic representation of the sacred precinct with several types of water fowl and larger birds standing on the ground line. The reverse of the middle register shows two standing male figures that are probably bearded and clothed with long dresses. Each one holds a so called 'palm spear' which is a sort of a Greek *thyrsus* common in the Late Bronze Age Near Eastern representation of the god Baal such as the famous 'Stele of Baal' from the Ugarit Acropolis (Musée du Louvre, AO 15775). The left figure holds the *thyrsus* with both hands and has a snake between his legs. The second one to the right holds the same object with his right arm and raises his left hand to his mouth in a typical Levantine mourning gesture (known since the Early Bronze Age, for example in Eblaite statues and artistic representations, see Matthiae 2010: Tab. XV). Between the two human figures there are several animals (birds, ibex and mouflon) connected in various ways. The uppermost register shows on the obverse side a garlanded altar, a small bird, and a large tree flanked by two goats. On the reverse side, another large tree is surrounded by several animals such as ibex, mouflon, and water birds. Despite different interpretations given by Bourke (2003: 352f; 2004: 16-18), it is clear that the god represented in this cultic vessel can be associated with the great Levantine god Baal, and in particular with an important ritual of this god, probably done in the Pella temple, perhaps an annual ritual marking changes in season.

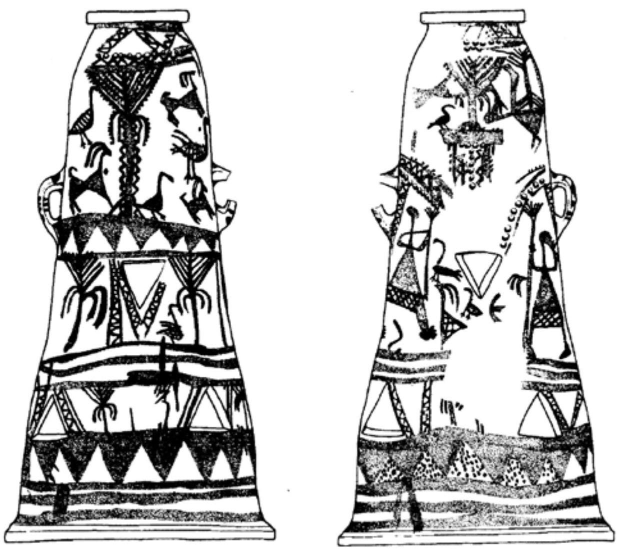

Figure 5: Incense burner from the Late Bronze Age temple of Pella (from Bourke 2004: fig. 12).

Bourke (2004: 4-11) proposes that, during the two Bronze Age historical phases of the Temple, it is possible to reconstruct a change in the worshipped deity and different external cultural influxes from Egyptian, Northern Levantian, and Mesopotamian areas. In particular, in the first phase of the Middle Bronze Age, the architecture shows strong links with the Levantine temple tradition. Bourke (2004: 4) proposes that the sacred precinct was dedicated to El, lord of the Early Cananean pantheon. In the Late Bronze Age I, the findings and the first introduction of the *sancta sanctorum* may be seen as a shift to Baal, the main god of the Northern Levantine pantheon and the new titular temple deity. Finally, Bourke interprets the introduction of the two colonnades in the second architectural phase of the Pella Temple as having clear Egyptian influence during the expansion of the New Kingdom, especially under Nineteenth Dynasty pharaohs (1295-1188 BC) such as Ramesses II (1279-1212 BC)[7]. It is important to note that the use of colonnades in front of the temple entrance is a behaviour known also in the Northern Levant since the Early Bronze Age. This may be seen for example in the Ebla Red Temple[8].

With regard to the assignment of local deity worshipped in the Pella temple during its different phases, it is commonly accepted that the god Baal, known since the Middle Bronze Age in the Levant religions, assumed a main role in the pantheon as ruler of the gods. He assumed the powers and attributes of the Amorrean god Hadad (Hurrian Haddu, deity of the storm), of Reshef (god of War), and also of the ancient god Dumuzi (deity that dies and resurrects). This is clearly derived from the Ugarit and Emar texts. In the Late Bronze Age, Baal substituted as leader of the pantheon including the ancient quiescent deities El or Dagan, the last leader attested to in the Eblaite texts since the Early Bronze Age and the first one attested to from the Middle Bronze Age in Mari texts. He took attributions and powers which were linked to the fertility of the land and agricultural activities[9].

Findings from the second archaeological phase of the Pella temple (the symbolic harpoon, the glass gifts, and the scene represented on the painted incense burners and cylinder seals) clearly indicate that Baal was the main deity worshipped in the temple, perhaps together with his female companion Ishtar/Astarte.

It is also important to note that El, in the Late Bronze Age Ugarit artistic iconography (Fig. 6), is represented as an old and wise king sitting on the throne with the *atef* Egyptian crown. This shows its connection, in artistic Egyptian iconography, with the god Osiris, king of the gods, who as god who dies and resurrects, presents a strong connection with the Late Bronze Age Levantine god Baal. Moreover, the constant presence of Egyptian gifts in the Pella temple, since the first construction of the main temple

[7] The cultural and ideological framework of the temple's architectural development proposed by Bourke fits in the history of the Southern Levant during the Bronze Age. We must in fact consider that the Southern Levant during the II millennium BC experienced the alternation of different foreign political powers, in particular the Egyptian, Mitannian and Hittite empires. For this period of Egyptian history, see Grimal 1992: 155-292.

[8] The Red Temple of Ebla, excavated in Area D under the later Middle Bronze Age temple of Ishtar dated to the Early Bronze Age IV and also pertaining to temple *in antis* typology, had four stone bases indicating the presence of wooden columns supporting the roof (Matthiae 2010: 393, Fig. 213).

[9] On this topic, see Durand 2008; Matthiae 2008.

in the Middle Bronze Age, indicates a strong respect for the temple by foreign merchants visiting the settlement. This could be a sign that the deity worshipped in the temple, since the first installation of his cult in the MB settlement, was assimilated as an Egyptian god. In the famous myth of Ugarit, the god Baal was also defeated by Mot, the god of death, and he could save himself and be reborn only with the help of his sister Anat and the Sun god Shapash[10].

Figure 6: Bronze statue of the god El, from the Ugarit acropolis (Xella 1984: 145).

[10] In effect the myth is similar in some aspect to the Isis and Osiris Egyptian myth, see Caquot *et al*. 1974: 239-314.

This huge temple of the Bronze Age was dedicated to a deity that dies and is reborn cyclically and was assimilated as an Egyptian god like Osiris. This deity was identified as El and Baal who were the Lords of the Land in the Levantine Southern and Northern religious traditions. The temple was oriented to the direction of the *sunrise* in the Summer Solstice. At least two other Levantine temples built in the Middle Bronze and perhaps dedicated to deities like El or Baal, fix well with this orientation. These include the temple of Hazor, located on Area A of the Acropolis and very similar in shape to the Pella temple (see Matthiae 2000: 255-257), and the Temple of the Obelisks of Byblos. The orientation of these temples was estimated from acute archaeological maps obtained from Google Earth images and thus need to be confirmed on site. However, both of them seem to be oriented to the Northeast around 64°. In Byblos in particular, all the temples of the sacred area and the more ancient Ba'alat Gebal temple, are oriented in north east direction. Just the Temple of the Obelisk, characterized by the presence of many *betyli* inside the chapel and the front courtyard and probably dedicated to complex ancestor cult, seems to be oriented strictly in the direction of the summer solstice sunrise[11]. In the case of Ugarit, the main temples dedicated on the acropolis to Baal and Dagan have their main entrance oriented to southwest. These temples have a peculiar T shape, with the cella larger and oriented perpendicular to the ante-cella that has an axis azimuth of about 78°. The temple of Baal in particular had a high altar sited on the roof of the temple. From the text, we know that different rituals based on animal sacrifices were performed by priests looking to the sky (see Xella 1984: 60-64). Considering the mountains (about 800 m high) that surround the East side of the settlement, it is possible that these temples have altars on the cella roofs oriented to the Summer Solstice sunrise. However, this hypothesis must be checked by precise on site measurements.

A further comparison can be made with the Phoenician temple of the VIII-VI Century BCE in Iberian colonies (Caura, Abul, 'El Carambolo', etc.) dedicated to Melqart (Baal). All of these temples, studied by Escacena Carrasco (2009), seem to have solstitial orientations[12].

Looking to the calendars known in the Near East during the Bronze Age, the Summer Solstice festivals occurred in 4th month, between June and July. This month had associations in Mesopotamia (and also in Emar and Mari in the Northern Levant) to cultic festivities dedicated to the dead, ancestors, and dying gods like Dumuzi or Baal (see Cohen 1993: 454f).

After the Summer Solstice, the longest day of the year, the Sun starts to decrease its presence during the day until the shortest day of the year, the winter solstice. Each day at the sunset, the Sun god enters the Netherworld and rules from the particular to the universal. After the summer solstice, he starts to pass a longer and longer time in the Underworld than in the Heaven.

[11] Byblos was an important site for the study of religious architecture of the Middle Bronze Age Northern Levant (Matthiae 2000: 186f).

[12] A more recent analyses proposes a different interpretation of the Melqart Spanish temples. See César Esteban and José Luis Escacena in this volume.

Thus, the Summer Solstice was perceived in the mentality of ancient Near Eastern peoples as the starting point of the confluence period between the worlds above and below, when it was possible to communicate with the dead and when it was necessary to perform rituals in order to protect the living from the dangerous spirits of the Netherworld. In this last category, it is the Maqlu ritual (see Cohen 1992: 463-465) that was performed through all the summer from July to August[13]. To the first category belongs the famous Abum or Apum festival, performed mostly between the 4th and the 5th month, when ancestors went out from the Netherworld (see Cohen 1992: 458-462). In this time, banquets were performed in the houses, and funerary offerings were deposited in the graves and also in temples dedicated to the dying gods. It is particularly interesting that Abum was a mound placed over the passageway to the netherworld, and this could indicate the grave or in a more symbolic way the 'mound' as the temple of the god that represents the passageway (see Cohen 1992: 460). Moreover, in the standard Mesopotamian calendar, in use from the Late Bronze to the Iron Age also in the Levant, the 4th month is named Du'uzu or Tam(m)uzu, for the god Dumuzi (see Cohen 1992: 319-321). This god, like Baal, dead and reborn again, is linked to wheat, and the summer period represents his death. Also in this month, different cultic festivals were performed, including female mourners for lamentations and deposits of offering to his temples. Even though in the Ugarit calendar it was during the 7th month, between September and October and around the autumnal equinox, that the most important offering to Baal and the banquets in his temple were performed[14]. it is very probable that during the summer solstice, and in the summer months of the year, other important offerings, related not to the life but to the death of the god, were also deposited in his main temples.

There is a striking parallel with the offering of funerary Egyptian vessels discovered near the walls of the Middle Bronze Age temple of Pella. The typology of these offerings leaves no doubt that the ritual related to their deposition was of a funerary/lamentation type, generally performed during the summer. It is also worth noting that, on the basis of his analysis of the Phoenician temples of the Iberian colonies, Escacena Carrasco (2009) argues that the main festivals dedicated to Melqart were held at the solstices.

In this way, the orientation to the sunrise of the summer Solstice for the temple of the dying god Baal in Pella could be explained as having a calendrical purpose of identifying the moment of the year when important offerings to the dying god must be dedicated to him, and important festivities linked to his cult must be performed in the temple or as a way of performing the rites at the correct time looking in the correct direction. Of course, more investigation and orientation measurements on the Bronze Age temples of Baal in the Levant must be performed in order to extend the statistical confirmation of our hypothesis and also to identify others possible interesting astronomical alignments that may be linked to other important rituals and cultic festivities dedicated to this god.

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[13] Much is written about Maqlu, testifying to the importance of these rituals in Mesopotamia. For examples, see Abusch 2002.

[14] There is a debate among scholars concerning when the main Baal festival was performed in Ugarit. See Cohen 1992: 381-383.

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Astronomical Phenomena in the Development of Political Hegemony in Early Japanese History: An Interdisciplinary Study in Cultural Astronomy

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Abstract
Japan's history in the latter part of the first millennium AD provides a particularly interesting study for astronomy in culture. It was a period when most every political activity centered on the development of hegemonic power in the imperial household, and astronomical phenomena played a central role in these processes. Study of this period also presents an interesting case study in some of the historical methodological difficulties facing researchers in archaeoastronomy and cultural astronomy in Japan. Following discussion of these methodological difficulties, three areas of interdisciplinary study in which astronomical phenomena played a role in development of hegemonic power are reviewed. These include: (1) Use of Indigenous and Localized Star Lore and Legend, (2) Incorporation of Chinese and Korean Cosmology and Geomancy, and (3) Development of Seasonal Events and Festivals.

KEYWORDS: Ancient Japan, cultural astronomy, hegemony, methodology, politics

POVZETEK
Konec prvega tisočletja na Japonskem je zelo zanimiv za astronomske in kulturne študije. V tem obdobju se je večina politične dejavnosti osredotočala na razvoj hegemonistične moči imperija, astronomski pojavi pa so v teh procesih igrali ključno vlogo. Preučevanje tega obdobja predstavlja zanimiv študijski primer zgodovinskih metodoloških težav, s katerimi se soočajo japonski raziskovalci arheoastronomije in kulturne astronomije. Povzemajoč diskusije ob teh metodoloških izzivih prikazujemo tri področja interdisciplinarnih raziskav, pri katerih so astronomski pojavi igrali vlogo pri razvoju hegemonistične moči. To so: (1) uporaba domačega in lokaliziranega zvezdoslovja in legend, (2) vključevanje kitajske in korejske kozmologije in geomantike ter (3) razvoj sezonskih običajev in praznovanj.

KLJUČNE BESEDE: starodavna Japonska, kulturna astronomija, hegemonija, metodologija, politika

Introduction

While Japan's contributions to modern astronomy and astrophysics are numerous, the country has not been noted for significant archaeoastronomical sites or records of ancient astronomical knowledge. Still, many aspects of modern Japan are founded on both physical and cultural structures that reflect ancient times when external astronomical principles were integrated with indigenous tradition and practice. The early period of Japanese history called 'Ancient Japan' (about 300 BC to 784 AD), including what is also called '*Yamato* Japan' (reflecting its primary locale), is significant to the study of astronomy in culture because it was a period in which most every activity centered on enhancing hegemonic power of the ruling elite, and use of astronomical knowledge and practice were an essential part of this process (Ooms 2009: 154-186). It is of further interest because it provides a case study in the methodological difficulties facing research in archaeoastronomy and astronomy in culture within Japan.

Consolidation of power in this early period of Japan's history included several political activities (Kidder 1993; Ooms 2009) which Renshaw and Ihara summarize as:

> … (1) unification of often warring petty 'kingdoms' (along with their local myth, legend and lore) through (2) cooperative efforts of common people in various ways such as cultivating rice (using celestial signs and allegories for seasonal determination of planting and harvesting as well as agriculturally based festivals) in order to (3) establish a singular lineal order of imperial rule (resulting in perhaps one of the greatest national Japanese myths, that of the sun goddess *Amaterasu* and her place as ancestral head of the imperial line) (Renshaw & Ihara 2000: 389).

Astronomical phenomena, both in practical and perhaps more importantly symbolic form, obviously played a central role in these political activities. This article examines ways in which such phenomena were used to enhance the political hegemonic aims of imperial rulers. Following a discussion of methodological issues, three areas are explored: (1) use of indigenous and localized star lore and mythology with primary discussion of the ubiquitous myth of *Amaterasu*, (2) incorporation of Chinese and Korean cosmology and geomancy with concentration on layout of early cities such as *Fujiwara Kyou* as well as use of symbolism in *Takamatsu Zuka* and *Kitora Kofuns*, and (3) development of seasonal festivals and events with particular attention given to *Tanabata* and *Ura Bon*.

Methodological Considerations

General Scholarship

It is only in the past few decades that researchers have been able to penetrate academic boundaries related to the study of Japan's early history. Taking the perspectives of scholars from several disciplines such as history (Brown 1993a), archaeology (Mizoguchi 2002), anthropology (Goodman 2008), political science (Como 2008), and cultural astronomy (Renshaw 2011a), these general methodological difficulties may be synthesized as follows: (1) overemphasis on questions related to imperial descent rather than larger political perspectives, (2) preoccupation with establishing Japanese uniqueness and nationalism relative to other cultures, and (3) tendencies to departmentalize areas of study within both the natural and social sciences rather than adopting interdisciplinary approaches.

Only two generations ago, the myth of imperial rule in Japan was held as sacred and unquestionable. Even for scholars in institutions of higher learning, objective research into imperial motives and realities was impossible. Most research instead concentrated on what were often rather trivial issues of lineage and the establishment of Japanese identity and culture as somehow unique (Nakao 2008). Establishment of Japanese uniqueness relative to other cultures can still be a barrier to objective research. Such is seen in the mass of literature on Japanese uniqueness termed *Nihon Jinron* and an attitude found even among some academics in modern Japan that somehow only Japanese can understand Japan (McCormack 2001, Goodman 2008). Scholars of Japanese history are still frequently unwilling to examine findings in other disciplines; synthesis is often lacking, and boundaries between disciplines are often difficult to penetrate (Renshaw & Ihara 1996, Renshaw 2011a).

Work in Archaeoastronomy and Astronomy in Culture

Research in archaeoastronomy and cultural astronomy has been hampered not only by the above problems but also by what seems an obsession with finding unique sites of alignment and uncovering knowledge of ancient astronomical precision, thus ignoring the broader perspective of astronomical phenomena in social context. Renshaw and Ihara (2000) discuss this problem and the associated sense in Japan that somehow the culture is lacking in archaeoastronomical interest. They provide examples of questionable alignment that some researchers have found with small stones in the historical area of Asuka (*Sakafuni Ishi* and *Iwafuni Ishi*) which are thought to have possible equinoctial or other seasonal association. Such work has failed to provide much of any cultural base for assertions of astronomical use. What is perhaps more significant is that such research has also neglected the more obvious cardinally aligned city layouts of ‘Ancient Japan’ (such as the nearby *Fujiwara Kyou*) which reflect rich cultural and political symbolism in their astronomical association.

A lack of attention placed on what can be called ‘vernacular’ astronomy, that is, astronomy as understood by the common citizen, has also hampered scholarship in cultural astronomy of Japan. Attention has of course been placed on scientific development (or lack thereof) and imports of astronomical knowledge from the continent in ‘Ancient Japan’ (Nakayama 1969, Watanabe 1987, Sugimoto & Swain 1989). However, while there are several extensive collections of star lore (Uchida 1973, Nojiri 1973, 1987, 1988 among others), they have been seen more as anecdotal in nature rather than as a source for understanding the place of astronomy in the lives of common inhabitants. Thus, a rather obvious area of iconography has been ignored, a source reflecting not only the way that astronomical phenomena were used in daily life but in how such use affected political and cultural development of the country as a whole.

Some writers in the history of astronomy in Japan still refuse to incorporate findings and scholarship of other disciplines in their work or even attend to concepts that seem to have found consensus among scholars elsewhere in archaeoastronomy and astronomy in culture. For example, while exact origins cannot be determined, there is overwhelming evidence and scholarship in a number of disciplines establishing the myth of *Amaterasu* as allegory of seasonal change (Krupp 1983: 96-99, 1997: 196-207, Renshaw 2010a) as well as a symbolic icon of political and cultural development (Matsumae 1993, Mizoguchi 2002, Kidder 2007, Ooms 2009). Despite this interdisciplinary work, articles written as late as 2011 can be found that characterize the story as a record of a specific eclipse event and even postulate that real people may have been the personification of the 'deities' (Tanikawa & Soma 2011: 67-69). Such not only narrowly defines the myth and ignores a huge body of interdisciplinary research but also fails to place the myth in any kind of real historical, cultural, or ethnographic context.

Purpose and Methodology of the Article

Remaining sections of this article provide a basic historical critical view of the way in which astronomical phenomena were used in 'Ancient Japan' to fulfill political purposes mentioned early. Drawing on work in several disciplines, a picture emerges which shows how early rulers developed political hegemony by incorporating both 'vernacular' and formal concepts of astronomy and cosmology.

There are a number of interpretations of the concept of 'hegemony' in political and anthropological literature (Howson 2008), and the term is not used here in a strict 'top to bottom' sense. Rather, it incorporates the concept of a process used by early rulers of Japan to form symbols of power through which citizens could identify the legitimacy of imperial rule as well as determine their own appropriate behaviors and duties within the culture. Aspects of this process included use of local lore and legend, incorporation of 'foreign' cosmological principles, and establishment of ritual celebration. Symbolic processes established in this early era of Japan's history formed a base which still underlies much of the culture.

Use of Indigenous and Localized Star Lore and Legend

The aforementioned myth of *Amaterasu* provides an excellent example of how indigenous lore and legend were incorporated by Yamato rulers in order to reinforce their claim to divine rule. Primary versions of the myth may be found in the ***Kojiki*** or 'Records of Ancient Matters' (Chamberlain 1981, Philippi 1968) and the ***Nihongi*** or 'Chronicles of Japan' (Aston 1972). These volumes, considered early national histories, were compiled from a variety of local and indigenous sources and were presented to the imperial court in the eighth century.

The myth recounts the story of the sun goddess *Amaterasu* who quarreled with her brother *Susanowo* (embodying the power of nature) and consequently hid herself in a cave. As an enticement, her jewels were placed on the branches of a sacred tree, and then only after much coaxing of other deities and seeing her reflection in a mirror shown to her (and thinking she saw the image of a rival deity), did she emerge from the cave. Along with clear seasonal referents, there are other astronomical associations in the basic myth. Apart from the solar identity of the goddess, the jewels appear to have had both linguistic and practical association with the Pleiades (see Renshaw 2010a, 2011a) which served as a winter symbol of the sun's return. The mirror symbolically reflects celestial omnipotence, an idea enhanced by cosmological principles later imported from China and Korea that incorporated the concept of imperial rule reflecting celestial rule.

Formally incorporating the myth into a national mythology of imperial hegemony, *Amaterasu* became progenitor of the imperial line. In symbolic form, she (the Great Divinity Illuminating Heaven) dispatched her grandson to rule the islands giving him a sacred sword, aforementioned jewels, and mirror. These three objects became the three sacred treasures of Japan, and of course imperial lineage and consequent political fortune was solidified.

Krupp (1997: 196-207) has written extensively about the political implications of this seasonal myth, and its use by Yamato rulers as a symbol of divine lineage is explicated by many writers including Brown (1993c) and Ooms (2009). Mizoguchi (2008) provides strong archaeological and anthropological evidence for long term survival and ritual behaviors to be at its base, and it was probably held by a number of disparate groups in one form or another for many years prior to its incorporation in formal national histories. The myth in its eighth century form was thus the culmination of centuries of legend distilled into a common form for political purposes.

Until the Yayoi period (about 300 BC. to 300 AD), life in Japan was uncertain both in terms of food and geographical space. Inhabitants were more dependent on resources provided by nature rather than any kind of planned planting or husbandry. Changes in seasons were associated with necessary changes in geographic environment. The coming of winter (with consequent departure of the sun) necessitated movement (generally to the south) for survival, and the consequent return of the sun meant less harsh conditions and movement to less hostile climes (Imamura 1996). Myths at the core of the legend of *Amaterasu* provided a means for understanding, and in crude form a way of predicting, seasonal cycles.

In the Yayoi period and post centuries, a variety of factors (including a more stable food supply) led to less necessity in mobility and a bit more predictability of geographic circumstances. However, indigenous myth such as that of the sun goddess was clearly a part of the 'vernacular' astronomy of Japanese inhabitants. With such acceptance, identification with the myth was quite reasonable for those seeking power, even before the seventh and eighth centuries when it seemed to acquire more solid hegemonic symbolism in the national histories. No longer was the power of survival left to the whims of deities far removed from the land but rather in the direct control (and consequent whims) of those leaders in tangible association with the culture.

Incorporation of Chinese and Korean Cosmology and Geomancy

Cosmological principles, a result of travel to the continent and immigration to Japan, were important not only in the development of calendrical and astronomical reckoning methods (Nakayama 1969), essential for reliable production of rice, but also in further strengthening political hegemony. They provided a symbolic world view in which imperial rulers could occupy the center of power on earth, mirroring their celestial dominance (Ooms 2009: 75-80). Such mirrored symbolism was incorporated not only in the layout of cities but in construction of tombs and in religious motifs of imported Buddhism and placement of more indigenously based shrines.[1]

Several cities were constructed using imported cosmological and geomantic principles, and their basic layout still survives. Remnants and layouts of such may be found with varied visibility in the cities of Dazaifu in northern Kyushu, Osaka, Asuka (*Fujiwara Kyou*), Nara (*Heijou Kyou*), and Kyoto (*Heian Kyou*), the last city to be constructed in such manner. Figure 1 provides a view of the fundamental layout of these cities. Constructed squarely in geomantic form, they were generally founded from a primary survey point in the north on a small hill or mountain representing the celestial black warrior or tortoise (*Genbu*). Natural formations in mountains to the east representing the azure dragon of spring (*Seiryuu*) and to the west representing the white tiger of fall (*Byakko*) framed the setting with the mirrored heavenly river (Milky Way reflection) flowing from the north through the city to its base generally open to the symbolic red bird of the south (*Suzaku*). Imperial rulers were housed in the *Dai Dairi* or imperial enclosure marking their centrality in the earthly mirror of celestial divinity.

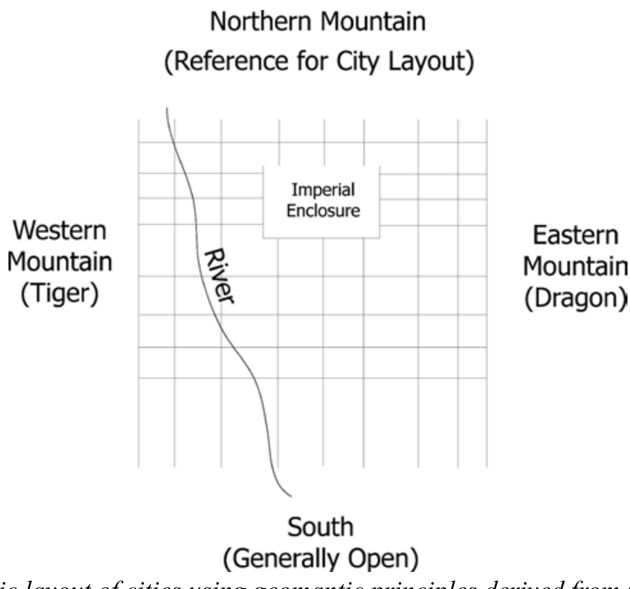

Figure 1: Basic layout of cities using geomantic principles derived from China and Korea. For illustration only, placement and number of streets and avenues is not accurate (Drawing by the Author).

[1] A full explication of cosmological and geomantic principles derived from the continent is far beyond the scope of this article. Extensive discussion of directions, cardinal animals, and moon stations may be found in Nivison (1989), Sun and. Kistemaker (1997), Ho (1985), and the author's website (Renshaw & Ihara 2010). The complexity of Buddhist symbolism is treated well in the collection of Dolce and Campion (2007).

Decorative tombs such as *Takamatsu Zuka Kofun* and *Kitora Kofun* in Asuka near *Fujiwara Kyou* brought an additional symbolism for enhancing the hegemonic position of those in power. While the exact inhabitants of these tombs are unknown, their size and placement relative to other tombs and city layout indicate that they had prestige.[2] Both tombs reveal contact with Chinese and Korean cosmological principles. The four walls contain images of animals of the cardinal directions, and star charts may be found on the ceilings (Renshaw & Ihara 1996; 2002).

Figure 2 shows the square style chart found on the ceiling of *Takamatsu Zuka Kofun*. It is of particular interest in that it provides a celestial corollary to the geomancy mentioned above. Here, the twenty-eight moon stations of the four cardinal animals are represented (seven to a side). *Genbu* (north) is at the top, *Seiryuu* (East) to the left, *Byakko* (West) to the right, and *Suzaku* (South) at the bottom. The celestial 'imperial enclosure' is represented in the center as a pivot point in the North with stars of Ursa Minor representing imperial consorts. This map is a mirrored reflection of celestial divinity on earth.[3] As in the layout of cities, such decoration provided a symbolic setting for reinforcement of the centrality of power in the ruling elite of early Japan.

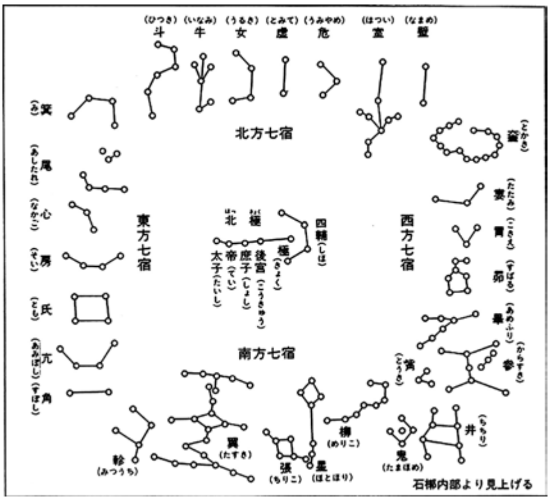

Figure 2: Ceiling Star Chart of Takamatsu Zuka Kofun (Based on Drawing from Nara Cultural Properties).

[2] See the author's website for detailed discussion of Takamatsu Zuka Kofun (Renshaw & Ihara 1996) and Kitora Kofun (Renshaw & Ihara 2002). Ooms (2009: 173-178) provides an interesting discussion of the political implications of the stellar configurations in Takamatsu Zuka Kofun. However, one senses some confusion in his reference to the eighth moon station (the dipper in Sagittarius) as the 'Great Dipper'. It was of course the southern counterpart to Ursa Major (see references in Endnote 1).

[3] The concept of a 'mirror' (previously noted as one of the divine treasures of Japan and certainly sacred on the continent as well) is key to understanding the reversal of east and west in celestial representations (including pictorial representations of the cardinal animals) and geomantic layout The reversal of east and west can be understood if one imagines looking in a mirror. From the perspective of the image 'looking back', left and right (east and west) are reversed, but top and bottom (north and south) are not (again see references in Endnote 1)

As Renshaw and Ihara (2000) have noted, juxtaposition of Chinese cosmological principles on indigenous values and myths was not always easy or peaceful (see also Como 2008). Combining the descendancy of the emperor as a child of the sun goddess *Amaterasu* with the Chinese/Korean concept of imperial rule centered on the north celestial pole obviously required some compromise. Cities and temples aligned in square directional form had to fit within a terrain that had indigenous shrines to varied deity aligned along the flow of natural sites such as sacred mountains, forests, waterfalls, or outcroppings of rocks. However, early imperial rulers found a way to combine the symbolic power of both systems, a process that in many ways has characterized Japanese incorporation of 'foreign' ideas and precepts to modern times. Temples based on continentally derived Buddhist principles often had attendant indigenous shrines, and ritual in one system often became a part of that in the other (Matsumae 1993, Brown 1993c, McCallum 2008). Exact accuracy in astronomical measurement, celestial and stellar representation, or cardinal alignment seemed never to be as important as the use of such symbolism to establish hegemonic power. Thus, the average citizen was surrounded by the symbolism of imperial rule, whether he or she lived in the structured layout of a city or resided in rural and agricultural environs with attendant deities.

Development of Seasonal Events and Festivals

The development of a stable food system in ancient Japan, especially rice, necessitated cooperative behavior among large portions of the populace. Planting and harvesting of this primary staple as well as other agricultural products was dependent upon knowledge of seasonal change and appropriate times for planting and harvesting. Controlling this process was of prime concern to early Yamato rulers, and the establishment of seasonal ritual was a way in which such cooperation could be assured. Prime examples of such seasonal ritual are the lunar based *Tanabata* and *Ura Bon* festivals which integrated imported traditions from China with indigenous legend reflecting values of lineality, vitality, and social optimism (Renshaw & Ihara 2000). Though changed to a solar based calendar in modern times and hence somewhat removed from their seasonal significance, these festivals were originally based on lunar reckoning and coincided with fall harvesting activities. *Tanabata* was celebrated on the lunar seventh day of the seventh month (generally occurring in August), and *Bon* occurred a week later on the fifteenth day of the seventh month.

Told in various forms, the Tanabata legend in its Japanese form recounts the story of the weaving princess *Orihime* (Vega) who fell in love with the cowherd *Kengyu* (Altair). Because *Orihime* neglected her duties, her father the emperor separated the lovers with the Milky Way. They were then allowed to meet on one day a year, *Tanabata*. If it did not rain, they could easily cross the river on that day, but with rain they would require the assistance of the boatman of the moon. Renshaw (2011b) provides more detailed analysis of this legend as it was imported into Japan. In its early forms, *Tanabata* reinforced imperial hegemony not only in its reference to the lineal power of the emperor but also in its strong emphasis on consistent work, such being perhaps more important than romantic love. This ritual festival has always reinforced a strong work ethic necessary not only for harvesting the ripening fields of rice and other agricultural goods but many work related activities considered essential for the success of the culture.

Figure 3: Icons reflecting modern celebration of Tanabata including various harvested vegetables, animals made of rice straw, and many wishes in the form of streamers tied to bamboo branches. Such wishes have traditionally been oriented toward improved work skills but in modern time have included desires for high exam grades among students. Young children in modern Japan may often make wishes for a variety of things not necessarily work related (Photo by the Author).

The ensuing *Bon* (also with Chinese roots) was and is a time for giving reverence and respect to departed ancestors and thanking them both for abundant harvest as well as their not negatively intruding on daily life. This ritual festival, incorporating more Buddhist motifs and traditions, further reinforced the lineal value of respect for ancestors and in particular provided a symbolic rubric through which the lineal descendancy and consequent power of the imperial line could be enhanced. This festival still carries many of these same values, and in combination with other symbolism discussed in this article, has provided a strong rubric for cementing power of Japanese rulers, whether imperial or otherwise, lasting well into the twentieth century.

Conclusions

Understanding complexities in the use of astronomical phenomena for political ascendancy in ‘Ancient Japan’ requires that iconography be viewed in a larger social context. This article has included a discussion of some of methodological difficulties which have historically hampered research of this type in Japan as well as a review of three areas in which contemporary scholarship from several disciplines has contributed to an understanding of such political processes. Though certainly not encompassing all work related to these complex phenomena, it may provide a more holistic rubric through which the place of astronomical phenomena in the social history of Japan can be seen. Perhaps above all and no doubt true for most cultures, it can be seen that archaeoastronomy and astronomy in culture in Japan is not dependent on discovery of precision and spectacular alignment but rather the uncovering of composite interactions of ‘vernacular astronomy’, imported cosmological principles, and complex socio-political processes.

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Research History and Current Issues

Cultural Astronomy and Archaeoastronomy: an Italian Experience

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Abstract
A brief review is given of some recent positive developments regarding the reception of archaeoastronomy by the archaeological institutions in Italy. Discussions and problems that are currently going on in this field are also mentioned, such as the separation of the scientific and humanistic disciplines (i.e. 'the two cultures' problem). Suggestions based on contemporary philosophy are also reported. Finally, 'sky-gazing' is proposed as the place where the two cultures could meet, since, taking Plato into account, sky-gazing could be considered the 'mom' of the human knowledge, and of the scientific and humanistic disciplines.

KEYWORDS: cultural astronomy

POVZETEK
Članek povzema nedavne pozitivne premike pri sprejetju arheoastronomije v italijanske arheološke ustanove. Obravnava s tem povezane probleme in trenutne razprave, na primer o ločevanju naravoslovnih in humanističnih ved (t. i. problem 'dveh kultur'), pa tudi predloge, temelječe na sodobni filozofiji. Članek se zaključuje s predlogom, da je 'zretje v nebo' lahko prostor za soočenje obeh ved, saj je po Platonu opazovanje neba 'mati' vsega našega znanja, tako naravoslovnih kot humanističnih ved.

KLJUČNE BESEDE: kulturna astronomija

Archaeoastronomy and archaeologists
Some years ago, several fundamental problems were pointed out at conferences held at the Accademia Nazionale dei Lincei in Italy (in 1994, 1997 and 2000) which were dedicated to archaeoastronomy and cultural astronomy. These problems are well known, since they are common to our field. Let me begin by discussing the lack of interest shown by archaeologists. In 1997 (and 2000), Gustavo Traversari, one of the few archaeologists who was already very interested in archaeoastronomy, lamented this situation: 'We see that at this Conference archaeologists are almost completely absent. Perhaps they are not interested. I know professors who say that archaeoastronomy is a strange and incomprehensible discipline' (Traversari 1998: 254; 2000: 405). It seems that presently in Italy we are slowly overcoming this problem, and Traversari's view may appear a bit too

pessimistic. Before the Italian Society for Archaeoastronomy (SIA) was founded, in the year 2000, three conferences had been organized at the Accademia Nazionale dei Lincei, and after its founding the SIA met once a year with an increasing presence of archaeologists at its meetings. Our last annual conference was held in 2011 in Bologna and also in the Etruscan town of Misa near Marzabotto. It was organized in conjunction with both of the astronomical and archaeological institutions of Bologna, and at the conference the archaeologists in attendance had the opportunity to expound their theories and views of our field.

Another encouraging piece of news is that SIA is a member of the Italian Institute of Prehistory and Protohistory. This Institute brings together archaeological institutions such as Departments of Archaeology, Superintendences and Museums, and its purpose is to coordinate and promote scientific activity in relation to the study of prehistoric and proto-historic civilizations. Just as an example, in June, 2012, I attended a round table dedicated to the problems confronted by scientific disciplines that contribute to archaeological research (such as archaeobotanics, archaeozoology, dendrochronology, and geoarchaeology). It is understandable that, given the present lack of funds for the Italian culture, the round table was mainly a *cahier de doléances*.

Separation of disciplines

Let me cite a second long-standing problem: the separation of disciplines. In 2000, the astrophysicist Vittorio Castellani said: ‘Please, let me provoke you. I will tell you what interdisciplinarity means in Italy: people meet around a table that have different cultures, different languages, they talk to each other without understanding, then they get up and say: it was an excellent interdisciplinary meeting’ (Castellani 2000: 406). Last year in Bologna archaeologists recognized the existence of the problem posed by the fact that each discipline has its own ‘arrogance’. Every scholar thinks: ‘My own discipline is more important than yours’. There is also the fear of not being properly respected by scholars working in other fields.

From the round-table discussion that took place during the SEAC meeting last year in Evora, I got just such a feeling: European archaeoastronomers are afraid; they are afraid to be considered nothing more than data suppliers by archaeologists. In Italy we are trying to overcome this problem by helping out archaeologists and anthropologists with their investigations, since they are often in need of some help in the interpretation of the data. There is a reason for archaeoastronomers to be, so to speak, altruist, unselfish, and I will try to explain why in Section Sky-gazing.

Let me remind you of the essay ‘The two cultures’ by Charles P. Snow, by quoting a columnist writing in the *Scientific American*. The summer of 2009 ‘marked the 50th anniversary of the famous essay, in which Snow lamented the great cultural divide that separates two great areas of human intellectual activity, science and the arts. Snow argued that practitioners in both areas should build bridges, to further the progress of human knowledge and to benefit society. Alas, Snow’s vision has gone unrealized. […] Many of those in the humanities, arts and politics remain content living within the walls of scientific illiteracy' (Krauss 2009). Negative conclusions were drawn also by other scholars who commented the same essay (e.g. Jardine 2009).

Snow (1961: 17) claimed: 'There seems then to be no place where the cultures meet. I am not going to waste time saying that this is a pity. It is much worse than that'.

Is there really no place? The impressive sight of the starry night sky, far from light pollution, is so breathtaking that one cannot help but draw the following conclusion: there is plenty of 'space' out there. Some time ago, the archaeologist Tiziano Mannoni (2009: 52) said:

> I spent many nights outdoors during the [second world] war, in places with no lights at all, and when seeing all the nights what it was visible, one couldn't help considering and studying the sky. The link with the sky is completely different from that with the earth. There is not a 'physical' relation, but only a visual […] and mental one, that triggers the imagination and thoughts.

Similar statements regarding the differences between the kind of relation that humans have with the sky as opposed to the earth, were already forthcoming from archaeoastronomers. But Mannoni was an archaeologist. When I have had occasion to talk with archaeologists, they have expressed similar views. We have such thoughts because before being astronomers or archaeologists, we are just human beings. Hence, perhaps sky-gazing (or cultural astronomy) could be the place where it is possible to establish a dialogue between the two cultures, since both humanists and scientists are saying the same thing. This point will be discussed further in Section Sky-gazing.

Language and mentality

Western culture

The archaeologist Giovanni Lilliu (1998: 252) strongly criticized some Sardinian amateurs when they used the expression 'astronomical observatory' to refer to a *nuraghe*. He specified that a *nuraghe* was actually just a sort of castle, with some military equipment. We could imagine, however, there were sentinels for night watching, and may be someone was charged also with sky-gazing. The question is what terminology should be used in such a case. This is a very general problem, and also one that exists in archaeology, I guess, since it concerns the terms that should be used when describing the distant past. The term 'astronomy' itself, for instance, is misleading, since astronomy should indicate the scientific study of the sky, understood in a rather modern sense; therefore, when talking about the distant past (i.e. prehistory), sky-gazing would appear more appropriate than astronomy. Sometimes we look far into the past in a way similar to that represented in 'The Flintstones' movie; even if we pay much attention, we cannot avoid to projecting our own world-view back in time.

An analogy is afforded by the ethnological studies of modern-day 'primitive' populations, such as those carried out by Levy Bruhl (1922). It is difficult to translate faithfully the language of the 'primitives' because it requires being able to interpret their thought processes in a way that is consonant with the indigenous cultural frames of reference. And, of course, when attempting to produce reliable descriptions, one is confronted with the problem of having to utilize terms drawn from Western culture, words and expression that are already charged with highly specific meanings, that do not necessarily reflect the cultural conceptualizations native to the frames of reference of the peoples being described. Sometimes even the *logic* of such 'primitive populations' appears to be different from the Aristotelian one touted by Western culture. In other words, it is difficult to understand the 'primitive mentality' since we are studying it from within our Western cultural system. Consequently, there is always the risk of assuming a colonialist-like attitude, by imposing in some way our Western mentality on non-Western populations. In a similar way, when we study the peoples of the past we run the risk of imposing our modern scientific mentality on them. In particular, that may occur when archaeoastronomers try to provide proofs for their own hypotheses concerning the astronomical content of archaeological finds and sites, instead of following the archaeology tenet: let the stones speak for themselves.

The Western mentality seems to be based on a Heraclitean vision of the world ('everything flows'), with absolute space and time as a background. A few centuries ago, Newton assumed time as absolute, well aware of the fact that it was an assumption that couldn't be proved. Today we are educated in the practical every day experience where 'becoming' and absolute space and time are self-evident (the theory of general relativity has not yet entered, so to speak, our everyday life, apart from the GPS system time corrections). To doubt the existence of 'becoming' would be just as absurd as to deny reality. However, those are only assumptions. In the next Subsection we will mention some philosophical discussions about these issues.

A possible help from philosophy

The archaeologist Julian Thomas discussed the possibility of a phenomenological archaeology, beyond the modernist approach that involves the radical separation of culture, nature, mind, body, society, individuals and artefacts:

> I will hope to show that cultural significance and the production of meaning are not encapsulated in any one sutured entity, whether mind, body, society or nature. Identity and meaning are both relational constructions, which emerge through the process of human Being-in-the-world. (Thomas 1996: 30)

With that purpose in mind, he considered the concept of temporality, drawing on Heidegger's philosophy. In such a context he therefore mentioned the phenomenon of 'Being' and 'the way that it has been covered over as a problem since the time of the Greeks'. He used Heidegger's term *Dasein*, which could indicate 'the way the human beings are: Dasein is a way of being' (Thomas 1996: 40).

> World is that which Dasein can cope with. As Dasein carries out its everyday activities, the things of the world show up to it as unconcealed [...] The event of things showing up in this way can be termed as 'clearing'. Human beings, by being linguistic creatures, are engaged in a complex network of relationships, in which the material and the symbolic cannot be disentangled. Their grasp of this network at any given time is limited and regionalised, since it

> spreads out from a located spatial centre. This is the clearing. Dasein *is* the clearing, in that it is not a thing in itself: Dasein itself is a space or process in which things can be made to show up. (Thomas 1996: 69)

According to many scholars, Emanuele Severino is one of the most important Italian philosophers. I will try to recall some of his ideas, as far as I understood them, since they may be of some help in this context. He proposed a different ontology from Heidegger's. He emphasized one of the major conundrums of Western philosophy, that of the Greek sense of becoming: a being-in-the-world is a 'thing' coming from nothing and going back to nothing. He argued (with strong philosophical arguments) that is a 'folly', since every 'being' is 'eternal'. The 'becoming' is the 'folly' of the Western world, because this world has identified 'being' with 'nothing' (e.g. Severino 1995; unfortunately, there are few translations of his books). Instead of the 'clearing' discussed by Thomas, he has proposed a sort of 'circle of the coming into sight' (*cerchio dell'apparire*) in which the beings get in (become 'visible' as being-in-the-world) and from where they get out (not more 'visible'); however, the beings never are nothing, they are eternal. This picture may sound familiar to physicists since it reminds of the four-dimensional space-time of special relativity. There are seemingly some connections with Anglo-American eternalism (for a philosophical discussion of 'time', see e.g. Turetzky 1998); however, the 'circle' of Severino was not inspired by physics, since it would be actually an unavoidable consequence of the deep (abysmal) philosophical meaning of 'being'.

Severino suggests going back to Parmenides, and then finding another way, different from that of 'becoming' followed by Greek (and then by all the Western world) philosophers. Before that happens, however, it is necessary that the present world dominated by the 'technic' (or technology; *tecnica*) go ahead, along its (long) way until waning (*tramonto*). The technic should not be understood in a negative sense at all. Its undisputed domain is an unavoidable consequence of modern nihilism, the extreme outcome of 'becoming', since in the last centuries all higher metaphysical absolute values, such as 'God' and 'truth', were not able to resist the philosophical criticism levelled at them and succumbed (note that in this Subsection we are dealing essentially with philosophical issues).

It seems to me that the big problems mentioned in the present paper, such as the separation of disciplines, the limits of the western mentality, and also the radical separation remarked by Thomas, are strictly related to our way of thinking based on the Greek sense of 'becoming'. The idea that 'things' come from 'nothing' and go back to 'nothing' permeates all of Western culture. More generally, 'things' can be (and therefore are) 'nothing', i.e. they can be ignored, excluded or nullified; this is a necessary approach, for example, in the scientific method and reductionism. Probably we should summarize the problematic situation we are experiencing as the conflict between 'separation' and 'relation'. Maybe Severino's ideas could be of help in this context, since they would allow us to see the world under a different light, though the way they could help effectively is a program whose feasibility has yet to be demonstrated.

Sky-gazing

Often it is possible to read sentences where mathematics, or philosophy, is defined as the mother of sciences, or the mother of knowledge. Nevertheless, it seems to me that 'sky-gazing' could be considered the 'mom' of human reflection, of human knowledge, and of all the disciplines, including mathematics and philosophy, since it triggers imagination and thoughts, as suggested by astronomers and archaeologists. Note that I mean mom rather than mother, and, of course, I mean a standard (good) mom. Moreover, note that mom's house is the place where 'children' now adults (the disciplines) can convene, leaving outdoor arrogance (at least, usually it is left outdoors). Cultural 'astronomy', in a broad sense, could be such a house, since it deals with sky-gazing (of every epoch), and therefore it could be the place where the 'two cultures' could meet.

It may appear that I appeal to emotional rather than rational intelligence; note however that it is intelligence anyway. In any case, apart from the word 'mom', what I am saying is not new. Plato wrote:

> Vision, in my view, is the cause of the greatest benefit to us, inasmuch as none of the accounts now given concerning the Universe would ever have been given if men had not seen the stars or the sun or the heaven. But as it is, the vision of day and night and of months and circling years has created the art of number […] and has given us not only the notion of Time but also means of research into the nature of the Universe. From these we have procured philosophy […] in all its range. (Plato, *Timaeus* [47a]; translation: W.R.M. Lamb).

We might conclude, therefore, that sky-gazing is the mom of mathematics, 'the art of number', and philosophy, 'in all its range'. Further interesting concepts are expressed in *Epinomis*:

> […] for why should we not believe the cause of all the good things that are ours to have been the cause also of what is far the greatest, understanding? And who is it that I magnify with the name of God? Merely Heaven [...] That it has been the cause of all the other good things we have, we shall all admit; that it likewise gave us number we do really say. […] In bespangling itself and turning the stars that it contains, it produces all their courses and the seasons and food for all […] And thence, accordingly, we have understanding in general, we may say, and therewith all number, and all other good things […] Now let us go on to inquire into the question of how we learnt to count in numbers. Tell me, whence have we got the conception of one and two […]? Among such things, what one more singularly beautiful can a man behold than the world of day? Then he comes to the province of night, and views it; and there quite another sight lies before him. And so the heaven, revolving these very objects for many nights and many days, never ceases to teach men one and two, until even the most unintelligent have learnt sufficiently to number; for that there are also three and four and many. (Plato's school, *Epinomis* [976e; 977a, b; 978b, c, d]; translation W.R.M. Lamb)

Heaven should have a lot of patience, such as a mom with her child, if it has to wait even for the most unintelligent man.

Once again, the plain conclusion would be that sky-gazing is the mom of human knowledge and then of the disciplines: they are her daughters. But what about archaeoastronomy? Is it a discipline? In my opinion, it is not a subdiscipline of archaeology as was stated by the archaeologist Colin Renfrew (2007: 184). In my opinion it would not be even a scientific discipline; certainly it is not hard science. It is a set of astronomical, mathematical and statistical methods lent to archaeology and anthropology, and these scientific methods must be applied rigorously, on a case by case basis. Therefore, archaeoastronomy helps or serves archaeology; however, it is not at all a servant of archaeology. Archaeoastronomy is a practical manifestation or, so to speak, a practical expression of 'mom' who operates through archaeoastronomers. Everybody knows that mom is not a servant, that she is altruistic and asks nothing in return. She helps in this way her adult children, the various disciplines, even today.

As far as I know, up to now nobody has succeeded in defining archaeoastronomy as a scientific discipline, with its own tenets and principles. I suspect that such an attempt would be nonsense. Why nonsense? Because mom can't be the daughter of herself.

Conclusion

I do not pretend to convince people here. I mentioned long-standing, secular problems that are deeply rooted in our world, and pretending to propose credible general solutions to them would be just foolish. What I tried to do has been to offer some reflections, with the hope they could be of some help.

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Education, Archaeoastronomy and the Outdoor Classroom: Lessons from the Past

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Abstract

Exploring ancient sites and our heritage is an exciting journey into our past. It inspires our imagination and helps us reflect on our current situation. However, understanding ancient societies can be full of misconceptions and misinterpretations which only too often evoke a 'primitive' view of the past or, on the contrary, the existence of all-knowing ancestors or extra-terrestrial intervention. This is especially the case when dealing with knowledge we would in modern times relate to astronomy. As highlighted in the 2011 SEAC meeting, the on-going archaeoastronomy research has to go hand-in-hand with an educational approach allowing the general public to fully engage with the field of archaeoastronomy. We compare recent case studies based upon educational projects that have embraced archaeoastronomy and included the general public in Portugal and the United Kingdom. The goal of our preliminary work is to shed light upon aspects of the outdoor classroom and critical place based learning in enabling participants to be critical as well as remove misconceptions. One outcome has been that all the cases illustrate certain similarities with the Rites of Passage model. Identifying beneficial aspects of this model can then be carried forward into bespoke outreach sessions ensuring a long lasting legacy.

KEYWORDS: archaeoastronomy, education, outdoor classroom, rites of passage

POVZETEK
Raziskovanje starodavnih najdišč ter naše dediščine predstavlja vznemirljivo potovanje v našo preteklost. Spodbuja našo domišljijo in nam pomaga osvetliti našo trenutno situacijo. Razumevanje preteklih družb pa je pogosto polno napačnih predstav ali interpretacij, ki variirajo vse od 'primitivnega' pogleda na preteklost pa do obstoja nekakšnih vsevednih prednikov ali izvenzemeljskih posegov. To še posebej velja za pretekla znanja, ki jih danes uvrščamo v astronomijo. Kot je bilo že poudarjeno na konferenci SEAC 2011, je pomembno, da se nova arheoastronomska spoznanja odražajo tudi v izobraževalnem sistemu, saj ta omogoča celovito vključitev javnosti. V članku primerjamo nedavne primere izobraževalnih projektov za splošno javnost na Portugalskem in v Veliki Britaniji, v katere je bila vključena arheoastronomija. Namen naše študije je osvetliti vidike učilnic na prostem in učenja na ključnih prostorih, ki razvijajo kritičnost in pomagajo k odpravi napačnih pojmovanj. Ena izmed ugotovitev je, da vsi preučevani primeri odražajo podobnosti s t. i. modelom obredov prehoda. Koristne vidike tega modela lahko prenesemo v posebej prilagojene tečaje popularizacije in tako zagotovimo dolgotrajni učinek.

KLJUČNE BESEDE: arheoastronomija, vzgoja, učilnica na prostem, obredi prehoda

Introduction
Ancient monuments offer us an insight into the mind-set of cultures that built and used them. They have always inspired visitors to imagine how they were built and used. Archaeoastronomy has uncovered a multitude of approaches to uncover the wide variety of how such monuments illustrate the beliefs linking sky and culture. However, the general public has struggled to fully appreciate the understanding of astronomy in prehistoric cultures. As a result there are common misconceptions e.g. when imagining how such monuments were constructed. Frequently the builders of such monuments were thought to be either of alien nature (Däniken 2010) or of a lost culture (Joseph 2010) both possessing knowledge that ancient cultures, perceived as savages, would never be able to have acquired. The looming end of the world prophecies for 2012 brings these ideas ever more to our attention.

At this point archaeoastronomy faces a big challenge in providing educational opportunities for the general public to discover their misconceptions and understand the key concepts uncovered by archaeoastronomy. Just offering topical lecture series might not be enough. Recent educational research has illustrated how outdated our linear causality model used in education is (Kollmuss & Agyemann 2002: 241ff). It ignores key aspects such as critical and system thinking. Especially when aiming towards a transformation of the learner, emotional awareness is a key factor to develop a deeper understanding of the material discussed. The actual process of gaining an insight is far more cyclic and reflective with emotional responses at its heart. As a consequence rather than delivering a meaning or fact, the learner should be able to negotiate the meaning for himself (Wenger 1998). This is an interactive process practiced between learners and teacher as a community. Such communities of practice described by Wenger (1998) operate at their most efficient when in an informal learning and teaching environment, such as the outdoor classroom. One educational model utilising the outdoor classroom and critical education is critical place based learning (Gruenewald 2008: 8ff) that identifies the importance of Place and its multitude of meanings to the learner, some of which have been discussed by Brown & Canas (2010: 161). Place is now seen as a location for dialogue and a time for confrontation. The outdoor with all its properties creates an emotional impact on the community of learners (Brown, Johnson and Brittain 2012).

In this paper, we will first introduce three case studies of different educational programs that convey the essence of archaeoastronomy to a wide audience. Then our research method is presented leading on to our preliminary results stated as common themes and differences. These findings then allow us to discuss the Rites of Passage model that might shed light upon common themes in the three cases and offer, in its modern educational interpretation, an innovative way for archaeoastronomy education.

Studied Cases: Peak District

Within the Peak District National Park several educational programs have been organised that cover outdoor learning experiences for school groups (Brown, Neale & Francis 2011: 84ff), trainee teachers, and also the general public. One of the most successful programs was 'Astronomy in the Park' delivered by the Peak District Dark Sky Group (http://www.peakdistrict.gov.uk/looking-after/darkskies). The group consisted of members from the Nottingham Trent University (lecturers and students), Peak District National Park Authority (including rangers), as well as several local astronomy associations. The aim of the project was to develop and support light pollution awareness within the local communities and generate a need to become active and prevent light pollution. To achieve this goal, several small and large scale events were organised including the installation of permanent light pollution interpretation panels. A typical small scale event took place in a small village at the boundaries of the National Park offering both dark skies and light polluted parts of the sky. The village is in close proximity to Stanton Moor that has a rich cultural heritage including Bronze Age stone circles and burial monuments (Barnatt & Smith 2004: 37). The event started with a planetarium session in the village hall conveying basic astronomy knowledge and leading on to light pollution and its effects. Visitors were then led onto the moor while being informed about the landscape history. On site, there was the opportunity to explore objects in the night sky with telescopes provided and manned by amateur astronomers as well as hear more about the history of the moor itself (see Figure 1). Most of the activities took place in the late evening and early night allowing visitors to experience the site during night time conditions.

Figure 1: A group of visitors exploring the ancient Nine Ladies stone circle at Stanton in Peak. Note the group of amateur astronomers in the background.

These events targeted the general public and focused to some extent on local village members. All the activities had at their heart the message that cultural heritage is always linked to the night sky. Participants were encouraged to discuss and debate their views on light pollution with the many different representatives of the Dark Sky Group in an informal environment at their own time. To trigger discussions we relied upon experiences and stimuli provided by the landscape, darkness and visible light pollution, as well as practical observing.

Studied Cases: APIA

The archaeological summer camps planned by APIA (Portuguese Association for Archaeological Investigation – www.apia.pt) consisted of a fortnight of on-site activities ranging from field lectures and archaeological work to tours. The summer camps were aimed at two distinct audiences, with distinct goals: firstly to archaeology students, to gain fieldwork practice, and secondly for adults with an interest in history, archaeology and/or heritage. Both would include a half a day field lecture on archaeoastronomy as well as, weather permitting, a stargazing night.

Two locations were offered but the overall structure of the summer camps were the same: participants were lodged near the archaeological hub of the location, both of which are in the Portuguese country-side, and transported to and from the archaeological and historical sites (see Figure 2 for the landscape in which such locations are situated). Food and drinks would also be provided.

Figure 2: SEAC2011 delegates visiting some of the sites that APIA summer school participants would work at and explore.

The general goal is for participants to learn the basic skills required to conduct successful archaeological fieldwork including: general knowledge of different chronological settlements, artefact identification and analysis, identification and mapping of rock art engravings and archaeological survey in several locations. The afternoons were occupied with tours to the area: students would be taken to other important archaeological sites in the region whereas adults' tour would have a special emphasis on architecture, history, nature and the excellent food that Portugal is famous for.

The archaeoastronomy component of the summer camps would have also been tailored to the participants. Students of archaeology would learn how different cultures (including our own) engage with the celestial sphere and how that can be crystallized into their material culture, in monuments or in art. Students would leave the summer camp with the necessary knowledge and skills to be able to 'think archeoastronomically', and apply them in their future careers. Interested adults would be doing the summer camp more for fun than for training, so the aims here would be to unfold the world of archaeoastronomy to then: focus on the basics and in case-studies of different cultures, with which they could engage, rather than train them in surveying to scholarly standards.

Studied Cases: BRIDGES

BRIDGES was designed to bring the exploration of ancient sites to the classroom. The idea is to 'bridge' the ancient knowledge about celestial movements with modern tools for science teaching. The project was built in a course like model, using the Inquiry Based Science Education (IBSE, Rocard et al. 2007: 9) as a methodology, e.g. exploring how long it would take to drag stones used for the erection of Stonehenge illustrated by a group of students in Figure 3. The target audience is mainly school communities, an objective reached through the construction of a support network for educators and students. Training sessions are designed to encompass the curriculum needs of the specific age grades and disciplines using

Figure 3: School students during an activity to model the transport time for stones used to build Stonehenge.

archeoastronomical sites as a tool for teaching. The content of the training events consist of basic topics of astronomy, handson activities on site and ICT transfer of the acquired knowledge. Schools are invited to reproduce in the school environment a replica of a local or known site such as Stonehenge, Cromeleque de Almendres, etc. The training events are designed in accordance with the Galileo Teacher Training Program criteria for training sessions and participants integrated in this global network of astronomy educators. The criteria are: Address elementary themes and/or concepts of astronomy; use resources that address at least three types of activities, such as naked eye or small telescopes observations, hands-on activities, and new technologies, including robotic telescopes and data mining.

The main purpose and trigger for this idea was the mystery and curiosity surrounding ancient monuments and their existence and construction, but also the misconceptions and fundamental topics about astronomy that can be addressed such as: seasons, latitude, eclipses, etc. These are magical places that can spark the imagination of the students and engage them in fruitful thinking about our ancestors and the scientific method as well as the 'whys and hows' of a culture that we are still barely touching.

Educators are invited to participate in a hands-on training session where they learn about examples of tools and resources that can be used to achieve the goals of this project. The training has ICT devoted sessions that explores tools such as image processing and planetaria software. Additionally, there is a field trip to an archeoastronomical site, whenever possible, where measurements are taken. The idea here is to replicate what researchers do in the field. The tools and the data are the needed ingredients for the next step in the IBSE cycle. The main objective now is to reproduce the sense of a scientific discovery so the activity is structure in a way that provokes the curiosity and engages participants in creative discussions. Participants are invited to create their own lesson plans where a 6 stage Guided Inquiry is used as a teaching model (Lazoudis et al. 2010: 6): Define the question to be investigated, acquire data, propose a solution, design and implement a plan, collect evidence and draw conclusions, share and communicate the results. Educators have now all the necessary materials for the implementation of this archaeoastronomical pedagogical scenario at hand that will help to reproduce the scientific method.

Research Method

To cast some light upon common themes and different approaches chosen by the programs utilising the archaeoastronomy and cultural astronomy theme, we have selected an opportunistic sample of the above described cases in which all three authors were involved and had detailed in-case knowledge. Each author is then treated as a single individual (referred to in this paper as D, F, and R) working within the group and not representing the opinion of all involved. Although this might have introduced a certain bias upon emphasising intended goals rather than achieved outcomes, it did offer a quick and deep insight into some cases that were very different in geographic location as well as audience and delivery method. It also avoided a lengthy re-iteration within each case to have a generally agreed response.

To capture responses from D, F, and R a semi-structured open-ended questionnaire was sent to each individual and the written responses were then coded and analysed. The questions listed in Table 1 covered four main topics with respect to the educational programs, i.e. cases, the individuals were involved in: Personal view, details of program, Learning and Teaching (L&T) environment, and mode of delivery.

Table 1: Open ended questions in questionnaire.

Question number	Question category	Question in questionnaire
Q1	Personal view	Why are you engaged in archaeoastronomy?
Q2	Personal view	What for a personal impact has the work had on you? (Views on world/teaching methods)
Q3	Details of program	What are the aims of your individual program and who are you targeting?
Q4	Details of program	How are you intending to achieve the aims?
Q5	L&T environment	Why are you carrying out your programs on site?
Q6	L&T environment	Could you carry them out within only a lecture room or class-room to the same extent?
Q7	Model of delivery	How are you engaging the participants?
Q8	Model of delivery	Can you describe the most memorable or impressive experience you or your participants have had when carrying out or setting up the program?

The responses to each question were condensed and key themes or ideas were identified and used to define the coding. Therefore we used the grounded theory approach (Glaser & Strauss 1967) where the responses themselves inductively base our coding system on empirical theory. To ensure that common themes or differences that were evident after the coding were well founded, we presented the individuals with the findings and gathered feedback that further clarified the opinions of the different individuals.

Results

The condensed responses to each of the eight questions are presented in Table 2. Only individual D reported of actual experiences delivering the educational program. Both programs developed by F and R were not delivered yet and therefore both could not comment on memorable experiences.

Table 2: Condensed response of participants to questions from Table 1

Question	Peak District (D)	APIA (F)	Bridges (R)	General Themes
Personal Q1	-Amateur astronomer -Fascinated by basic observing -Loved geometric beauty -Worked in educational archaeoastronomy project -Combined observatory & monuments	-Life-long interest in astronomy & ancient cultures -Came naturally to me -Clear human-sky link	-Powerful tool -Inspire students -Beauty of science -Get students started	-Simple methods (Q1+Q2) -Bridges did not have long interest/ new
Personal Q2	-Became aware: landscape carries meaning -Can be used for education now and in past -Became aware: Place + outdoor classroom	-Made me realize: simplicity in celestial mechanics -Observing and predicting with simple tools -Fantastic and amazing: skyscape to tell stories -Rocks ones world-view -Rethink whole teaching process	-Not exposed to practical implementation	-Transformative (edu.): Aware, realize, rock, rethink -Only when practicing
Program Q3	-Awareness of light pollution -Generate need for conservation -Targeting locally: Visitors, community, schools	-STUDENTS: -Training -Learn about cultures + sky → monuments, alignments -Knowledge+skills → think+apply -ADULTS: -Fun -Unfold world of archaeoastronomy -Engage with case studies	-Teachers as promoters of tools and methods -Tools to engage -Understanding about heaven -Heavens influence on daily life	-Contrast: Human ↔ sky Vs Sky → Human (bridges) -Contrast: Tools, Training – Generate need -All target educational inst. → propose change
Program Q4	-Striking locations -Emotional response + awareness -Lead to action + transformation	-Hands-on approach -Night-time observations - Surveying/fieldwork -Complemented by seminars to deepen knowledge -Adults more seminars	-Training -Support	-All include practicals Contrast: -Emotional response (incl community) Know+Train (teaching inst.)
Environment Q5	-Real -Allows for exploration (also at night) -Enjoy wonders -Tour of site	-For fieldwork -Sites are away from light/cities → dark/horizon -Immerse in site -Excision from everyday life -Empathise with prehistoric people -Past environment -Interesting experience	N/A	-Other experience Either night or rural/dark -Immerse & explore ! Real but (vs.) removed !
Environment Q6	-Also in halls but only informative	-NO! -Essentials come alive outside -Experience not only visualise -Cannot experience simplicity being intuitively (only seems complicated)	-Yes but better to mix	-Would be limiting -Inside only informs/visualizes
Delivery Q7	-Give astronomical information (planetarium) -See lightpollution outside -Hear about landscape history/ monument on site -Explore by themselves -Offer to observe by astronomers (amateurs)	-Essentials come alive outside -Experience not only visualise -Experience simplicity being intuitive (only seems complicated)	N/A	-Explore/experience -Concepts come alive (e.g. light pollution)
Delivery Q8	-No stars only clouds -Owl hooting -Poor visibility -Churchbells -Seeing clear signs of light pollution	N/A	N/A	N/A

There are several common themes apparent. In most of the individuals the involvement in cultural astronomy or archaeoastronomy has caused a personal transformation that seems to be reflected in the format of the developed educational programs. Furthermore, all programs seem to target as one of their audiences educators therefore maximising the impact of the programs. Additionally, all activities are removing the participant out of their usual environment by either using a non-urban environment and/or carrying out the activity at night-time. F states that the '…*excision from one's familiar environment further helps the immersion into the new, and past, environments*.' This is also commented on by D that visitors '…*become aware that they can explore sites at night*…' therefore implying they have never done this before.

However, D, F and R all state different opinions when linking the sky and culture. Although they see that there is a link each of them sees the directionality reflected in a different way: D states that individuals will become aware of how cultural (human) heritage extends to the sky and uses the '… *cultural heritage to link to light pollution* [i.e. the Sky]'. Therefore, he sees both being interconnected but stresses more the cultural influence on the sky. F sees this sky-culture link as an interaction or bi-directional link and that we can'... *learn how different cultures (including our own) engage with the celestial sphere and how that can be crystallized into their material culture*…'. R sees this very differently, highlighting '… *the heavens and its influence on our daily lives*', seeing the sky as an influence on culture.

The actual emotional dimension within the three programs is still unclear and requires further research. But it seems to be implicitly contained in each program, since they emphasise experience and exploration. Both of these activities will trigger an emotional response, especially when carried out in a non-formal environment unfamiliar to the participants.

Discussion

The major difference between the three interviewees was on the relationship of sky and culture. As mentioned above, all three share different views, but these views can, perhaps, be understood through their own experiences and agendas. Both F and D expressed a certain bidirectionality between sky and culture, although D focuses more on how culture influences the sky. Given D's interest and active involvement in the Dark Skies project (http://www.peakdistrict.gov.uk/looking-after/darkskies), it would seem natural that the dramatic influence of modern culture on the visualization, and thus the perception, of the sky would be highlighted by him. On the other hand R mentioned only the opposite relationship: how the sky influence our lives. R was the only one of the interviewees that was not previously exposed to, or had prior experience of, outdoor archaeoastronomy events. Since F and D both mention this as an epiphanic experience (as is clear in their answers to Personal Q2: D '[b]*ecame more aware of how the landscape carries a powerful meaning.*' and F mentions it '... *rock*[s] *one's world-view, and make*[s] *oneself rethink the whole teaching process.*'), the lack of such an experience on R's part might explain the observed difference.

In all studied cases the experience of being in an *other* place was highlighted. This is a place other than the usual hangouts of the participants: their home, work or school environments. This mixing of time spent outside of a participant's social sphere with the transformative educational process has been linked and interpreted with recourse to Van Gennep's framework for 'rites of passage'.

Rites of passage are rites '*which accompany every change of place, state, social position and age*' (Turner 1967: 94). Van Gennep articulated the details of such rites from various ethnographies of small-scale, pre-industrial societies and, in the process, identified three stages common to all (Van Gennep 1960). These were: 1) separation, when the initiate is separated from the community; 2) transition, or liminality, which is the period of transformation; and 3) reintegration, during which the initiate is reincorporated into the community but now in a new role (e.g. as an adult).

Educators, especially those interested in outdoor activities, picked up on the similarities between this framework and their own experiences (Bell 2003) and developed what is known as the 'Rite of Passage model' (ROP model henceforth). The first two stages are indeed replicated by outdoor education activities in that the students are separated from society and taken into places they don't typically see (e.g. woods, rivers, deserts). The liminal state of transition is replicated by situations in which the normal code of conduct, rules and coping mechanisms no longer apply (Bell 2003: 44). The challenge, however, lies in a successful and lasting reintegration stage. (Bell 2003: 45-7).

Cushing has identified several 'socio-cultural assumptions' of the ROP model that '*no longer hold true for most* […] *students*.' (Cushing 1999: 28). These are given in the societies studied by the anthropologists, or at least in their view of the societies they study, but, in the modern world they no longer hold true and this affects the efficacy of the ROP model.

The first assumption identified by Cushing is that the environment the student returns to is a good environment to sustain transformation in. The second, and related, one, is that the model assumes clearly defined and individualized social roles, namely that the student/initiate is transferred from one social role to another. In contemporary society '*there are few clear moves from position a to position b*' (Cushing 1999: 28), instead there is a blurring and/or overlapping of roles. A third assumption is the conservative notion that the elders, or in the outdoor education scenario the educator, not only is an authority but that he is seen as an authority by the initiates/pupils. In this way, Cushing notes, the ROP model fails to understand resistance, 'except as a negative', and thus fails to deal with it in a positive and proactive manner. Cushing concludes that these inherent assumptions of the ROP model might be part and parcel of why the reintegration phase is so difficult to achieve (Cushing 1999: 28-9).

The model suffers from an over-reliance on Van Gennep's framework, whereas anthropology has moved considerably further since then. The ROP model might need to be re-thought or, at least it should be updated to reflect the latest on anthropological thought. For example Victor Turner's works focus on the liminal period, the second stage of Van Gennep's framework, and this might be very helpful to help understand what is meant to occur in the second stage of a ROP educational model (Turner 1967), especially if the assumptions identified by Cushing are to be overcome.

Leach extended the application of Van Gennep's stages into the festivals that punctuate the yearly calendars of many societies. These rites '*are techniques for changing the status of the moral person* [in the Durkheimian sense] *from profane to sacred*' and back again (Leach 1961: 184). What Leach is noting is that the ROP framework can also be found in other anthropological institutions, all of which involve transformation and a period of separation from normal affairs. However, in the case of festal rites, the actor who is undergoing the transformation does not necessarily assume a new role in the community. In other words the transformation need not be permanent – that is a characteristic of the rites of passage but not of all applications of the ROP framework.

Conclusion

In this paper we have outlined the importance to develop an educational framework that allows participants to critically engage with archaeoastronomy and its key statements. This can then be applied to create a fuller understanding of ancient societies removing common misconceptions currently crystallised by the 2012 phenomena.

Three cases of educational programs embracing archaeoastronomy were presented and compared using a grounded theory approach and an open ended questionnaire. All programs include the outdoor classroom as an essential component and value the potential of its non-formal learning and teaching environment. Since only one program had delivered their program by the time this paper was written, there is only limited evidence of an emotional engagement. But implicitly non-formal environments will generate emotional responses vital for the outdoor classroom; this assumption will be part of future work. Our preliminary work has also illustrates that the three cases see the sky-culture link as an important topic but there are at least two very different ways of perceiving its directionality: Bidirectional or sky influencing culture. Possible reasons have been discussed and might include a missing personal transformation while engaging in archaeoastronomy or a stricter focus upon ICT.

The most important finding has been our common approach similar to the rites of passage including at least the first two phases of the ROP model. The discussion has highlighted that the actual transformation achieved needs not be as rigid or permanent as envisaged by Van Gennep and that the third phase of reintegration will need further work. As a response to these findings a new project is taking place within the Peak District called 'Dark Sky Communities' that builds upon the impact created by 'Astronomy in the Park'. The project tries to establish a community driven out-group to which the participants of the in-group can relate to and that develops a feeling of responsibility to spread the word and maintain the achieved transformation.

All our work has indicated the power of the outdoor class room and the importance to critically engage with the place it is located in. To achieve this, the ROP model has shown valuable aspects that will allow creating innovative and long lasting experiences, thereby shaping the general publics' understanding of ancient cultures. Future educational programs targeting archaeoastronomy should focus upon creating liminal experiences and supporting the reintegration.

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How odd is odd? Studying Astronomers

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Abstract
Cultural astronomy remains broadly defined so as to include the history of astronomy, sociology of astronomy, and anthropology of astronomy. Since 2006, I have embarked on a series of research projects focused on astronomers in the United States and South Africa. My projects have included surveys, ethnography, oral history, and making films (Holbrook 2012; Holbrook submitted; Murillo et al. 2012; Tapia 2009). Doing research on this scientific community has not been without challenges methodologically and personally. Methodologically, data collection was an issue. In one of the projects our primary means of data collection are ethnographic oral history interviews lasting from one to three hours with individual astronomers. Originally students working on the project had to adjust to astronomy culture and to interviewing people much more senior. Also, they needed a handbook of astronomy jargon to understand what the astronomers were talking about. Even as a cultural insider, I was not up to date on all the new astronomy satellites and new telescope projects; so I too had to learn and relearn the intellectual trends in astronomy over the last dozen years. However, as a cultural insider I had more success at establishing rapport and at pushing people beyond their comfort zone to provide more honest answers. I will discuss the advantages and disadvantages of working within one's own culture and how in some ways our sample is biased. Every project begins with hypotheses that are to be tested, however, what I find most delightful is discovering something completely unexpected. Thus, a rogue's gallery of my research projects with the associated unusual finding will be presented.

POVZETEK
Po najširši definiciji kulturna astronomija vsebuje zgodovino astronomije, sociologijo astronomije in antropologijo astronomije. V letu 2006 sem začela z nizom raziskovalnih projektov, v katerih proučujem astronome Združenih držav Amerike in Južnoafriške republike. Delo je obsegalo raziskave, etnografijo, ustno izročilo in izdelavo filmov (Holbrook 2012; Holbrook oddano; Murillo et al. 2012; Tapia 2009). Proučevanje te znanstvene srenje je bilo polno metodoloških, pa tudi osebnih izzivov. Metodološko je bil največji izziv zbiranje podatkov. V enem od projektov smo podatke zbirali z intervjuji, anketiranje vsakega astronoma pa je trajalo od ene do treh ur. Študentje, ki so izvajali ankete, so se morali priučiti astronomske tematike – potrebovali so celo slovar astronomskega žargona, da so lahko razumeli povedano – in se prilagoditi dejstvu, da so izpraševali precej

starejše osebe. Čeprav sem insajderka na tem področju, tudi sama nisem bila povsem na tekočem z vsemi novimi astronomskimi sateliti in novimi teleskopi; zato sem se morala poučiti ali obnoviti znanje o astronomskih intelektualnih trendih v zadnjih letih. Po drugi strani pa mi je insajderstvo omogočilo več uspeha pri navezovanju stikov ter pri potiskanju ljudi prek okvirov njihove cone udobja, kar je dalo bolj pristne odgovore. V članku obravnavam prednosti in slabosti pri delu z lastno kulturo in opozarjam, da je naš vzorec v nekaterih pogledih pristranski. Vsak projekt se začne s hipotezami, ki jih želimo preveriti, toda moje največje veselje predstavljajo nepričakovana odkritja. Članek prikazuje zbirko mojih raziskovalnih projektov, skupaj z njihovimi nenavadnimi izsledki.

Why study astronomers?

What are some good reasons to study astronomers? To learn what the history books do not tell you! Humans are complex bundles of emotions, thoughts, experiences, and actions; they are not stationary and often contradict themselves. When portraying scientists in various non-fiction forms such as in documentaries, in history books, etc., they become two-dimensional and their complexity is lost. Also of importance, astronomers and other physical scientists primarily operate in a reductionist mode. This means that they usually simplify information to make it more manageable and focus mainly on the bottom-line. In terms of scientific thought, process, practice, etc., again the true complexity is lost in the retelling. Though there is a very attractive elegance to simplicity and bottom-line thinking; the real world, the real scientific world, is messy, complex, difficult, non-linear, etc. There is the issue of 'setting the record straight' that is collecting multiple narratives of the same events in order to unravel a sequence of events and behind the scenes actors. There is also the opportunity to witness events first hand when studying astronomers, if a researcher is present during significant decisions, discoveries, etc.

There are benefits to studying astronomers including demystifying the lives of astronomers and what they do in order to attract more students. There is the opportunity to show the actual application of the scientific method rather than the imagined one and to capture what is often overlooked in historical accounts such as the role of funding, children and spouses, professional networks, research teams, career decision-making, and chance.

My personal decision to study astronomers was motivated in two parts. The first was that most of my students wanted to study gender issues in astronomy among astronomers rather than indigenous astronomy. I supported these students, however, found that the data they collected was of limited value in part because I knew their informants and knew that what was collected was a sanitized version of events if not an outright lie. This was less the case if they focused on astronomy students rather than PhD astronomers, that is, their data was better the closer the informants were to their own age. The second was that I was asked to join a collaboration studying astronomers by Sharon Traweek at UCLA (Reid & Traweek 2000; Traweek 1988). She needed a cultural insider who was also a social scientist, so I joined as her co-investigator in 2009.

'Studying Up' & Studying Across: Data Collection

'All participant observers confront their personal limitations and the limitations imposed on them by the culture they study (Bernard 2011: 281).'

The idea that the data collected is in some part dependent upon who is doing the collecting is not new in the social sciences (Bernard 2011: Chapter 12; Mead 1986). As mentioned in the last section, my students collected more accurate data from people closer to their own age, which is a familiar phenomenon in the social sciences (see Corbin Dwyer et al. 2009). In addition to age differences there are physical differences that may influence the data as well as differences in economic class, social power, and knowledge. The roots of anthropology embraced the study of indigenous people by Europeans which is embedded in a power structure such that Europeans assumed that they were wealthier, more moral, smarter, wiser, and so on. They chose to 'study down', that is to study people and cultures that they believed were not superior to them. This was especially true in terms of scientific knowledge; the anthropologists usually knew more about scientific findings especially medicine than the populations that they studied. In financial terms, they tended to study poorer and non-urban communities.

When anthropologists decided to study physical scientists, they had to study people who did not fit that traditional power structure. Physical scientists know more about science and often get paid much more than anthropologists. Laura Nadar used the term 'studying up' to capture this new anthropological realm (Nadar 1972). Anthropologists have also made the move from studying 'exotic others' to studying their own culture, that is anthropologists of a certain ethnicity will in some cases study people of their own ethnicity. For example, an anthropologist who is from New York City and Jewish may chose to study Jewish people in New York City. This is captured in the 'insider-outsider' debates in the social sciences. The debate focuses on what are the benefits and problems with being a cultural insider or a cultural outsider for social science research (Fay 1996; Naples 1996; Merriam et al. 2001; Corbin Dwyer et al. 2009).

Dependent upon the project, I occupied all possible positions in the power structure between anthropologist and informant: I sometimes have to 'study up' when I was interviewing observatory directors, studying across when I was interviewing other astronomers, and studying down when I was interviewing astronomy students. Likewise, I was both a cultural insider having been trained as an astronomer, and a cultural outsider having been trained as a social scientist.

As a cultural insider, I found that I knew where to start with most informants and knew how to probe sensitive issues in a way that I did not find with my team members. Thus, my insider status, I saw as an advantage for the most part: I knew the language of astronomy and how to frame questions, I knew how to act like and astronomer, and I had a lot of insider knowledge. On the other hand, I would get angry and not be able to show it when I was collecting data when people would speak in ideals and hypotheticals as if they were solid facts. Also, there was the emotional toll of hearing about horrible things and keeping secrets. I would also get data fatigue which was from simply needing to process the huge amount of information that I was gathering.

Overview of projects with their major hypotheses

Three of my projects include studying astronomers. The first is a large scale survey project titled 'The Sky in Our Lives.' The primary hypothesis of the project is that as with ancient people, contemporary people have a relationship with the night sky. However, we do not know the details of that relationship. The survey consists of five sections: Demographics, The Sky in Our Lives Long Answers, Noctcaelador Index, Astrology Survey, Attitudes towards Astronomy. In printed form, the Survey is over ten-pages, however it can be found online through search terms 'Sky in Our Lives Beta' or https://t.co/RbjY7den). The Survey is not specific to astronomers, but because I circulate primarily within the astronomy community many astronomers have done the survey since 2006.

Population	Number of People
Male	203
Female	136
Total People	339
Astronomy Connection	**Number of People**
Astronomy Grad Student	31
Astronomer (PhD)	37
Amateur Astronomer	32

'Semistructured interviewing works very well in projects where you are dealing with high-level bureaucrats and elite members of a community— people who are accustomed to efficient use of their time. It demonstrates that you are fully in control of what you want from an interview but leaves both you and your respondent to follow new leads. It shows that you are prepared and competent but that you are not trying to exercise excessive control (Bernard 2011: 158).'

The second project focuses on South Africa's national program to transition more students into astrophysics and space science doctoral programs. They were having problems retaining specific populations of students leading to my hypothesis: The lack of the success of certain groups of students is due to that aspect of astronomy culture which privileges those 'closest' to EuroAmerican culture and insists upon all students acculturating to this ideal. Two months of fieldwork including classroom teaching was completed in 2010 with two additional visits in 2011. The primary means of data collection was semi-structured interviews that were digitally recorded. I had access to 73 digitally recorded interviews which were transcribed for analysis.

The third project is focused on American astronomers and their use of large-scale databases with a particular focus on women and underrepresented groups. The hypothesis is that women and minority astronomers build their professional networks and navigate their careers differently from the majority. As with the South African project, we use semi-structured interviews as our primary means of data collection. This project is a team project, whereas with the South African project I worked alone. As a team we have attended conferences where we observe astronomers and presented our research to astronomers. Our team has collected 127 digitally recorded interviews with astronomers.

Unusual findings

The Sky in Our Lives Survey taken by 37 PhD astronomers and several more astronomy PhD students showed that many astronomers claim a religious tradition. The popular myth is that physical scientists are atheists is reinforced by the popular works of authors such as Richard Dawkins (Dawkins 2006), Carl Sagan (Sagan 1995), and others (Nanda 2012). However, in this very small population that I sampled atheists and agnostics were not the majority among the astronomers or the PhD Students.

Astronomers' Religions	40 Total
Christian	7
Christian	7
Atheist	6
None	4
Agnostic	4
Jewish	3
Blank	2
Buddhist	1
Traditional	2
Protestant	1
Eclectic	1
Hindu	7
Catholic	7
Unitarian	1

The question asked in the survey was 'My spiritual/religious tradition is (Buddhist, etc.)' with a blank space provided to write their answer. Table shows the responses which were free form and it can be seen that most astronomers were some Christian denomination. Three claimed at least two religions bringing the list to 40 rather than 37 responses. Using the same table but putting in the data for the graduate students the results shift only slightly but it remains true that most of them are not Atheist or Agnostic.

Astronomy Grad Students	28
Christian	14
Atheist	3
None	6
Agnostic	0
Jewish	0
Blank	2
Buddhist	0
Traditional	2
Protestant	0
Eclectic	0
Hindu	1
Catholic	0
Unitarian	0

This result is found to be very disturbing for those astronomers who are Atheists and never fails to get a discussion going about the topic or critique of my data collection method. Both are ways of dealing with a result that makes no logical sense to certain astronomers.

Another unusual finding is from my study of the national astronomy program in South Africa. South African astronomy is dominated by Europeans, Americans, and a handful of others, very few are actually South African. By very few, the number is on the order of a dozen or so. Of these only three PhD astronomers are Black South Africans, the remainder are White South African. Thus, when I began studying the South African astronomy culture, I found that it was just EuroAmerican astronomy culture transported to South Africa. Thus, the acculturation of the South African students and the transculturation of the instructors and administrators was important for the success of the program.

Also, from the South Africa study and the USA study of astronomers, I found that the astronomers performed Whiteness (Steyn 2004). In the USA, when confronted with the superior performance of Asian and Asian American students, the White astronomers would say 'They are very smart, but not creative.' In South Africa, when the White South African students were confronted with the superior performance of the foreign African students, they would say 'They are brilliant at maths and physics, but we are better with computers.' Both phrases were ways to recoup their notions of White intellectual superiority in the face of the challenge presented by non-Whites (see Ditomaso et al. 2007).

In my study of USA astronomers, there was a narrative that I heard from a few women astronomers that were deliberate attempts to explain away the bad behaviors of their male colleagues and mentors. Thus, the women would know that what had happened or what they had witnessed was bad and could have a negative impact on the women involved, but they would then verbally 'spin' the situation so that it did not sound as bad or in fact was a positive thing. This reframing of events so that they appear to be more positive is called 'positive reappraisal' and in psychology is a known coping mechanism (for example see Shiota & Levenson 2012). 'Stereotype threat' is another psychology term that captures the negative effect that group stereotypes can have on individual performance (Steele and Aronson 1995). Thus, if a young woman is reminded of the stereotype that women are not good at mathematics before a math test, she will do worse. Surprisingly, women who practice positive reappraisal as a coping mechanism are more resilient against stereotype threat. Thus, positive reappraisal, which in some sense is deluding oneself, can be seen as a positive for surviving a hostile environment.

Conclusions

Studying astronomers using participant observation and semi-structured interviews is challenging and time-consuming. It is slow research. In addition, it is expensive research because it is so time-consuming. In contrast, it is fairly straightforward to collect survey data, but ultimately further interviews and discussion is needed to ensure that the interpretation of the data is correct. Studying astronomers though odd can be rewarding in that much can be learned about success strategies and the culture which can translate to help future students of astronomy. Finally, such research can reveal surprises and noteworthy unusual findings.

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