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Advancing Cultural Astronomy

Studies In Honour of Clive Ruggles

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Cover image: A photograph of the September equinox sunset at Chankillo © Ivan Ghezzi

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Preface

This volume contains a series of studies on cultural astronomy in honour of Clive Ruggles and his groundbreaking work in the field, written by a selection of his close colleagues. We hope that the volume is both a fitting tribute to Clive and a significant contribution to the further development of cultural astronomy as an academic discipline.

On behalf of the editors, the publishers have made a donation to the Alice Ruggles Trust on publication of this book. For more information about the Alice Ruggles Trust and its work, go to alicerugglestrust.org.

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Clive Ruggles and the Development of Cultural Astronomy

Efrosyni Boutsikas, Stephen C. McCluskey, and John Steele

Clive Ruggles' work has challenged—and ultimately transformed—the way we study the astronomies of other cultures (Fig. 1). Before Ruggles' work, archaeoastronomy was seen by many archaeologists as a not very important ancillary discipline to the field of archaeology (Cotte, this volume) and many of them challenged the validity of archaeoastronomers' claims (Salt, 2015: 213). Clive's earliest work (Cooke, Few, Morgan, & Ruggles, 1977: 131) responded to this scepticism, speaking of the need to convince sceptical "outsiders to believe the claims being made" by archaeoastronomical researchers. His method at that time focused on pre-defining selection criteria, based on the characteristics of the site, and not on any astronomical indication, to determine which alignments were to be measured. These measurements were then converted into astronomical declinations which were used to identify which measured alignments signified possible astronomical alignments. This concern with defining methodologically rigorous procedures is an enduring theme in Ruggles' work, but at this early stage, cultural context played no role in his research, reflecting the common practice of contemporary British archaeoastronomers.

Archaeoastronomy at that time largely consisted of the search for alignments of ancient structures towards positions on the horizon that seemed to be of obvious astronomical significance such as the rising point of the sun at the solstices and equinoxes or the extreme northern and southern rising points of the moon. In its early British version, this practice of "alignment hunting" was usually constructed

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Fig. 1 Clive Ruggles (image courtesy of John Steele)

independently of any other archaeological investigation of a site, with little attempt to situate the findings within broader archaeological and contextual studies. Furthermore, many of the assumed “obvious” astronomical alignments can be criticized for simply being those that are of interest to modern astronomers, which may or may not be the same as what interested other societies. It established its validity chiefly through the search for mathematical precision informed by statistical analysis of a large number of sites. Although Ruggles’ early papers share the same concern with quantitative rigour, he came increasingly to recognize the need for cultural context.

Ruggles was thus among the first scholars to advocate the embedding of archaeoastronomy, which had until the 1980s been largely the preserve of astronomers dabbling in archaeology, within mainstream archaeology and to develop solid methodologies for the study of sites with possible astronomical meaning. He also sought to bring the study of archaeoastronomy into a wider discourse with ethnoastronomers studying living astronomical traditions and historians of astronomy working with written texts and preserved artefacts.

In his investigation of a group of Scottish recumbent stone circles, Clive continued to insist on establishing statistically significant results, but noted they could be combined with other archaeological data to generate cultural hypotheses. The quantitative data drawn from a well-defined sample still came first, but no longer stood by itself. It was now seen as being combined with archaeological evidence to contribute, in some way, to the framing of “cultural hypotheses” (Cooke et al., 1977: S55). As an indication of his early approach, its short title on the cover of the *Journal for the History of Astronomy* was “Objectivity in Archaeoastronomy”. Reflecting that theme, it opened with sections on a “Code of Practice at Megalithic Sites” and “Classification and Selection Criteria”. These two concerns of establishing rigorous standards and dealing with cultural context remained, with differing emphases, the guiding themes of Clive's work.

Clive's evolving approach is further indicated by the suggestive title of the volume of thematic papers from the third "Oxford" Conference at St. Andrews, Scotland, which he edited with Nick Saunders, *Astronomies and Cultures*. Ruggles and Saunders titled their chapter "The Study of Cultural Astronomy", foreshadowing the changing focus of the discipline from archaeoastronomy to cultural astronomy (Tirapios, 2019). Despite their growing focus on the need to understand and describe the concepts by which another culture expresses their notions of reality, they still maintained that statistical rigour was required "for estimating the likelihood that observed patterns have real (and quantifiable) cultural significance" (Ruggles & Saunders, 1993: 15).

At the ninth "Oxford" conference, in Lima, Peru, Clive addressed the increasing role of social theory in our discipline, crediting Stanislaw Iwaniszewski (who also contributes to this volume) with "the first attempt to introduce the topic into the Oxford agenda at Oxford II" (Ruggles, 2011: 7). A new "interpretative archaeoastronomy" addressed issues that Clive now considered to be more fundamental (Ruggles, 2011: 3). He explicitly noted the tension between change and continuity in his own shifting emphasis, conceding that while he had "long since abandoned my insistence of 30 years ago upon a statistical objectivity … I stand by the need for scientific rigor" (Ruggles, 2011: 12) (Fig. 2).

Although many aspects of Clive's research have changed, his concern with employing rigorous criteria to convince the sceptical outsider continues almost 40 years later (Fig. 3). In discussing the evaluation of archaeoastronomical heritage

Fig. 2 Clive Ruggles speaking at the Oxford Conference in Lima, Peru in 2011 (image courtesy of Stephen C. McCluskey)

Fig. 3 Clive Ruggles making a comparative measurement of a village church orientation in Leicestershire in 2002 (image courtesy of Stephen C. McCluskey)

sites (Ruggles, 2015b: 97), he described this concern as lying "at the heart of archaeoastronomical methodology and interpretation". As he saw it, "[E]stablishing the credibility of the archaeoastronomical interpretations is crucial to any assessment of their value". In a more general presentation, rather than stressing a dichotomy between rival approaches, he proposed that the central issue remains "how best … to interpret purely archaeological data (where only this is available) as opposed to how best to integrate diverse types of data (in other cases) in order to identify the most credible interpretations" (Ruggles, 2015a: 355).

1 The Equinoxes

In 1996, about the time of the spring equinox, Clive participated in an archaeological conference on Science and Stonehenge, organised by the British Academy. His paper, an overview of the astronomy of Stonehenge, began with an introduction to the conceptual framework of prehistoric astronomy (Ruggles, 1997a: 205–212). He outlined for his audience the "recipe book", commonly consisting of the solstices, the lunar standstills, and in some cases, the equinoxes, which had frequently been used in archaeoastronomical investigations. He questioned whether the lunar standstills and the equinoxes have any meaning outside the framework of "modern western science and its precursors". He suggested various ways in which prehistoric people may have observed and conceptualized the equinoxes, yet stressed the "fundamental point" that these "bear no relation whatsoever *on the conceptual level* to the modern astronomer's equinox". His recommendation for archaeologists was to avoid using any "recipe book" of significant astronomical targets, but to describe possible astronomical indications in the neutral quantitative terms of astronomical declination.

He soon reworked this critique for the archaeoastronomical community in a methodological essay entitled, "Whose equinox?" For this new audience, Clive elaborated the alternative observational methods by which prehistoric people might have observed and conceptualized the equinoxes, but re-emphasized that none of these would determine our "true" equinox. Significantly, he noted that no systematic studies of groups of monuments of which he was aware showed any evidence of orientations clustering around any of the approximations to the equinox. He concluded that, lacking any plausible models for a culture's cosmological model, it would "probably be helpful if the word 'equinox' were simply eliminated from archaeoastronomers' vocabulary". (Ruggles, 1997b: S49).

Recently, Clive returned to the question of the equinoxes, conceding that in Mesoamerica, where we have a detailed cosmological model and calendrical evidence for counting the passage of days, it is "not surprising that the temporal equinox appears to have been of some significance". Nonetheless, he conceded that while the "equinox" should not remain part of a "recipe book of potential horizon targets", it need not be totally eliminated from our vocabulary. "The equinox … remains useful as a point of reference" for *our* investigations, as long as we do not assume it was "a meaningful point of reference for *them*" (Ruggles, 2017: 134).

As it happens, the question of the equinoxes has become a recurring theme in this volume, as Belmonte and Steele both shaped their chapters around the different concepts of the equinox as evidenced by a wide range of circum-Mediterranean sites (Belmonte) and by Mesopotamian astronomical texts (Steele). Boutsikas studied the orientation of Greek temples in the context of ancient Greek culture for which we know that astronomers defined the equinoxes in terms of the equality of the length of day and night. She concludes that the equinoxes, conceived as the cosmologically significant time when days and nights are of equal length, seem to be "the most likely candidate" for the orientation of Greek Doric temples. Finally, Ghezzi, in his presentation of the Chankillo Solar Observatory and Ceremonial Center, notes several heretofore neglected examples of equinoctial indications at the site. These include observation of equinoctial sunrise in a prominent notch on the distant natural horizon and a replication of this effect on the artificial horizon calendar by equinoctial sunrise in a narrow gap between towers 6 and 7. A third equinoctial effect was found in the light and shadow phenomena produced by sunlight passing through slits in the pillars of the Temple of the Pillars.

If we can generalize from these studies of the equinoxes, it seems that the term continues to be useful for our investigations, both as a guide for comparative investigations of how different cultures conceptualize the equinoxes and for investigations of how the "equinoctial" orientation of a culture's structures may reflect that culture's known cosmological formulation of the equinoxes.

2 Archaeology, Archaeoastronomy, and Cultural Astronomy

Initially known for his work at sites in the British Isles, Clive soon expanded his research to include projects in Africa, mainland Europe, South America, and, most recently, Hawai'i. Among these projects are several that go beyond traditional archaeoastronomy into mainstream landscape archaeology (e.g. mapping Nazca lines in Peru (Ruggles & Saunders, 2012)), ethnography (e.g. investigating traditional time reckoning among the Mursi (Turton & Ruggles, 1978) and Hawai'ian star names (Johnson, Mahelona, & Ruggles, 2015), and combining textual sources with archaeological and ethnographical evidence (e.g. the study of ancient Georgian astronomical heritage (Simonia, Ruggles, & Chagunava, 2008)).

Two studies bear particular mention. With Ivan Ghezzi, Clive undertook a detailed study of the site and landscape of Chankillo in northern Peru. They convincingly demonstrated the presence of clear and deliberate solar alignments incorporated into the design of the site (Ghezzi & Ruggles, 2007, 2011). Provocatively, they described the site as a "solar observatory". The term "observatory" has often been used uncritically by archaeoastronomers to describe a large number of different types of structures. It is problematic for several reasons: aside from the danger of anachronism in applying a modern term to an ancient context, the world invokes the idea of "scientific observation", which was surely not the purpose of most ancient interactions with the sky. It also implies that the function of the structure was first and foremost as a place to make astronomical observations. Clive was of course well aware of these issues—a long and productive conversation about them took place between Clive, John Steele, and several others at a workshop at Durham University in 2005—but made a strong case that Chankillo is one of the few ancient sites where this term can justifiably be used. Ghezzi returns to Chankillo in his contribution to this volume.

In his recent work with Patrick Kirch on an ancient temple system on Maui, Hawai'i (Kirch & Ruggles, 2019), Ruggles has brought the study of archaeoastronomy to its fullest conclusion: as a tool of analysis rather than an end in itself. Instead of trying to primarily reconstruct the astronomical knowledge of the ancient Hawai'i, here Ruggles uses archaeoastronomical evidence from ancient structures in order to address cultural questions about the people who built and lived with them. Archaeoastronomy is no longer an end in itself but has become part of a broader archaeology.

3 Astronomical Heritage

As former president of both Commission 41 on Historical Astronomy and Commission four on World Heritage and Astronomy of the International Astronomical Union, Clive has been at the forefront of efforts to preserve astronomical heritage in all forms. He has taken on the role of connecting the astronomical and archaeological communities with the World Heritage Organization in efforts to obtain World Heritage Status for sites of astronomical significance. Thanks in large part to these efforts, a number of sites have now been awarded World Heritage Status on the basis of the significance of their astronomical heritage ranging from Risco Caldo and the sacred mountains of Gran Canaria to Jodrell Bank Observatory in the United Kingdom.

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Part I
Methodology

Clive Ruggles' classic paper "Whose Equinox?" drew attention to the problem of modern preconceptions of what is a significant astronomical event or phenomenon within the study of cultural astronomy (Ruggles, 1997). Crucially, it highlighted that just because an astronomical event is apparently obvious and significant in our astronomy, it need not be so in other astronomies and worldviews. The papers in this section explore this topic further, arguing that whether or not a phenomenon is significant and how it is defined is culturally dependent, and indeed that different ideas about a phenomenon may even exist within a culture.

Responding directly to Ruggles' challenge to the ambiguous concept of the equinox, Belmonte presents a wide ranging and precise investigation of the variety of "equinoctial" concepts indicated by structures oriented to the "East" in a wide range of cultures in the Mediterranean region and beyond. Rather than reject the term outright, as Ruggles (1997: S49) had proposed, Belmonte prefers "to keep it with different levels of meaning and understanding."

Steele also addresses the issue of the meaning of "equinox" in a different culture. He examines Mesopotamian astronomical texts asking "were the solstices and/or equinoxes defined calendrically, i.e., by their position in the year, temporally, i.e., by the length of daylight, or spatially, either with reference to the place on the horizon when the sun rises or sets or to the intersection of the ecliptic and the celestial equator, or by a combination of these possibilities?" He concludes that in Mesopotamia the solstices and equinoxes were primarily conceived in terms of "the length of day and night: the solstices were the days on which the day was the longest or shortest and the equinoxes were those days when day and night were of the same length. A secondary definition of the solstices was as the days on which the sun rose at its most northerly or southerly point on the horizon; there does not seem to have been a similar definition of the equinoxes referring to the sun rising due east or setting due west."

McCluskey's paper responds to Ruggles' (2015) call for "more sophisticated methods" to assess the credibility of archaeoastronomical sites that "reflect the current state of theory and practice in the discipline." He examines what can constitute a horizon marker—a point on the horizon used to indicate a direction towards an astronomical phenomenon—arguing that what we may at first think of as significant features on the horizon are not necessarily the same as what other cultures consider significant. Discussing the extensive ethnographic evidence for Hopi horizon based observations of the sun, McCluskey proposes archaeological correlates for evaluating the significance of purported archaeoastronomical sites.

In his paper López argues that even the most basic approaches to the sky can be radically different in different societies. Whereas western academic astronomy, based on a worldview that assumes the separation between nature / culture / supernature, understands the events of the celestial space as "astronomical phenomena," using ethnographic evidence Lopez shows that *Moqoit* experience and theories about the cosmos are based on the social relations between diverse intentional beings, which are fundamentally modeled by asymmetries in power (*quesaxanaxa*). He contrasts signs (carrying messages concerning important issues) with phenomena (and their scientific explanations). He points out that in order to address academically how "different cultures construct knowledge about the sky and other areas of existence…, we are impelled to deconstruct the assumptions on which our experience of the world is grounded, in order to understand those cultures according to their own logics."

In the final paper of this section, Shipley shows how the same issue raised by Ruggles of ensuring we do not impose modern western astronomical ideas on other cultures must also be considered when considering ancient texts. Even concepts such as the cardinal directions may have different meanings—and be expressed in different ways in different contexts—in ancient or non-western societies. Shipley's problem as a translator of Greek texts of making the directional terms of a different culture meaningful to a modern, English speaking, audience is analogous to the cultural astronomer's task of making a culture's astronomical concepts intelligible to a modern audience. His concern with unpacking Greek directional terms around the compass is not unlike Ruggles' concern with unpacking the various meanings of the term "equinox" in archaeoastronomical studies.

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What Equinox?

Juan Antonio Belmonte

1 Introduction: Whose Equinox?

> *… it would probably be helpful if the word 'equinox' were simply eliminated from archaeoastronomers' vocabulary …* (Clive Ruggles 1997)

It is an honour and a pleasure to be part of this volume. I first met Clive Ruggles in September 1996 during the SEAC Conference in Salamanca, although I already had several references about his extraordinary work and skills through common friends and had read several of his papers. For a rookie archaeoastronomer as I was then, this was like a fan meeting his favourite rock-star. I could not imagine this would be the beginning of a long lasting collaborative effort and, far more important, camaraderie and friendship. Since then, we have always been in close contact. I would like to emphasize two aspects. The first one was the chance to work at his orders during the edition of the Handbook of Archaeoastronomy and Ethnoastronomy (Ruggles, 2015). The second one has been the efforts to promote the IAU and UNESCO 'Astronomy and World Heritage' initiative (Ruggles, 2017; Ruggles & Cotte, 2010), culminating in the process to declare the interior of the island of Gran Canaria as a World Heritage Cultural Landscape (Belmonte et al., 2018); a process where Clive had put all his skills and knowledge, despite his harmful personal situation. This is a fact that greatly honoured him. Finally, we—a huge multidisciplinary team—were successful in July 2019.

Back to 1996, we had just published our first part of the paper on 'equinoctial markers' in Gran Canaria (Esteban, Belmonte, Schlueter, & González, 1996) and were shocked by a preprint where the whole meaning, and even existence, of the equinox within a cultural astronomy study was questioned. The situation was so problematic that Clive thought it would be adequate and indeed useful to ask himself: 'Whose

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equinox?' (Ruggles, 1997). In this work, he established the difference between the true astronomical equinox ($\delta = 0°$), when the sun crosses the celestial equator, the day midway between the two solstices, sunrise at due-East, or the mid-horizon sunrise point between solstice sunrises, among other possible definitions. All of them were near the same point on the horizon where sunrise occurs but could represent quite different concepts in the worldview of the builders under scrutiny.

The concept of equinox (from the Latin 'equal night', meaning the day when the length of the day and night are equivalent) has a precise meaning within the framework of classical spherical astronomy—derived from Greek sources—that underline our Western religious and scientific tradition. From the scientific point of view, the equinox is the instant when the sun, moving along the ecliptic, crosses the celestial equator and has a declination of 0°. The day of the equinox (either spring or autumn) is considered as the day when this fact happens. Alternatively, the preceding sunrise and subsequent sunset (or vice versa when it occurs at night) could be termed the equinoctial sunrise and sunset, respectively.

A culture's understanding of the equinox can be teased out from how they used that concept. For instance, a decade after Clive's question, González-García and Belmonte (2006) asked themselves 'Which equinox?' when the date and concept of the equinox in ancient Rome at the time of the Julian reform had to be taken into account. The Romans apparently favoured the day midway between the solstices instead of the astronomical equinox itself. This could have obvious consequences when interpreting the archaeoastronomical data of the Roman era as we will later demonstrate. As the reader can imagine, from the perspective of a totally different worldview, finding a concept similar to Western equinox would be far from simple, and as Clive argued, and will be proved later on, 'it could make no sense at all' (Ruggles, 1997).

In the following section, a diachronic, geographic approach to different cultural environments somehow related to our Western world, from the hill of Göbekli Tepe to the Christian churches of the Iberian Peninsula, will be performed, seeking for what could have been the exact meaning of equinox and how a people approached it. This will be completed with a few sketches of alien cultures where this concept has also been claimed. Finally, in the conclusion we will concentrate on how reliable the concept of equinox is and if it still deserves to be preserved in cultural astronomy studies, including archaeoastronomy and ethnoastronomy.

2 Discussion: Which Equinox?

Until recent times, the megalithic monuments in Europe were the archaeological remains earning all the credit for any potential astronomical knowledge of the earliest ancestors of humankind. However, a discovery in southeast Anatolia has changed these ideas. There, on a barren isolated hill called Göbekli Tepe, a team of German and Turkish archaeologists (see Schmidt, 2006 for the discovery) have been excavating a cluster of suggestive cyclopean monuments erected with large, megalithic pillars in the form of a T, within a series of dry-stone enclosures. They were built by a completely unknown pre-ceramic, hunter-gatherer society, beginning more than 11,000 years ago. Individual sanctuaries of this series were built presumably one after—and even upon—the other. Each one of them would have remained in use for centuries, perhaps millennia, but was deliberately buried by the progenies of their own constructors for unknown reasons. This is a very peculiar fact that has certainly contributed to their excellent state of preservation despite of their great antiquity. These monuments are mostly ellipsoidal in form and had megalithic accesses mostly open to the S-SE that might define a preferred orientation (Fig. 1). A series of mutually contradictory ideas have been put on the table (see Belmonte, González-García, Rodríguez-Antón, & Shaltout, 2016).

However, what is undeniable is that between the series of monumental structures, there is one on the top of the hill, which has nearly rectangular walls almost perfectly aligned according to the cardinal directions (Fig. 1). This circumstance alone would force us to think that we are faced with a society that had looked at the sky and used it as a guide to find appropriate ways of orientation in space and, almost certainly, also in time. In this context, additional exercises could be performed, analysing the profuse T-pillar decoration where totemic representations of animals are present. These might remind atavistic constellations, such as Leo, Taurus or Scorpius, that can be recognize in the skies of other evolved cultures in the region several centuries later. Besides, one of the pillars of the cardinally orientated hall, which was framing an altar on the eastern side of the structure, has a representation of a lion; and Leo was rising with the vernal equinoctial sun precisely at east in the epoch of construction of this particular shrine (Fig. 1). Are we facing the genesis of the 'equinox' concept? Was this concept born in the plains of Mesopotamia? This is indeed a most interesting point to be discussed but far from the scopes of this essay (see, however, Steele, this volume).

2.1 'Megalithic' Equinoxes

In the line of argument of the previous paragraphs, Clive has consistently argued that: 'it is far from self-evident, then, that any fundamental concept similar to our equinox had any meaning, let alone any importance, to people in prehistory' (Ruggles, 1997). This is an especially sensitive argument when megalithic monuments are considered. It would be farfetched to focus here on the many different occasions that the equinox has been claimed to explain the orientation of certain megalithic monuments in agreement to what has been termed the 'megalithic equinox' (Ruggles, 1999: 54), seldom interpreted as the day midway between the solstices. Hence, we will concentrate in three major examples: the large tumulus of Knowth in Ireland, the dolmen of Viera in Antequera (Spain), and the temples of Mnajdra in Malta. The tumulus is Knowth is a nice example of data overinterpretation. The two main corridor tombs located inside the tumulus are roughly orientated east and west, respectively, and have accordingly been interpreted as equinoctially

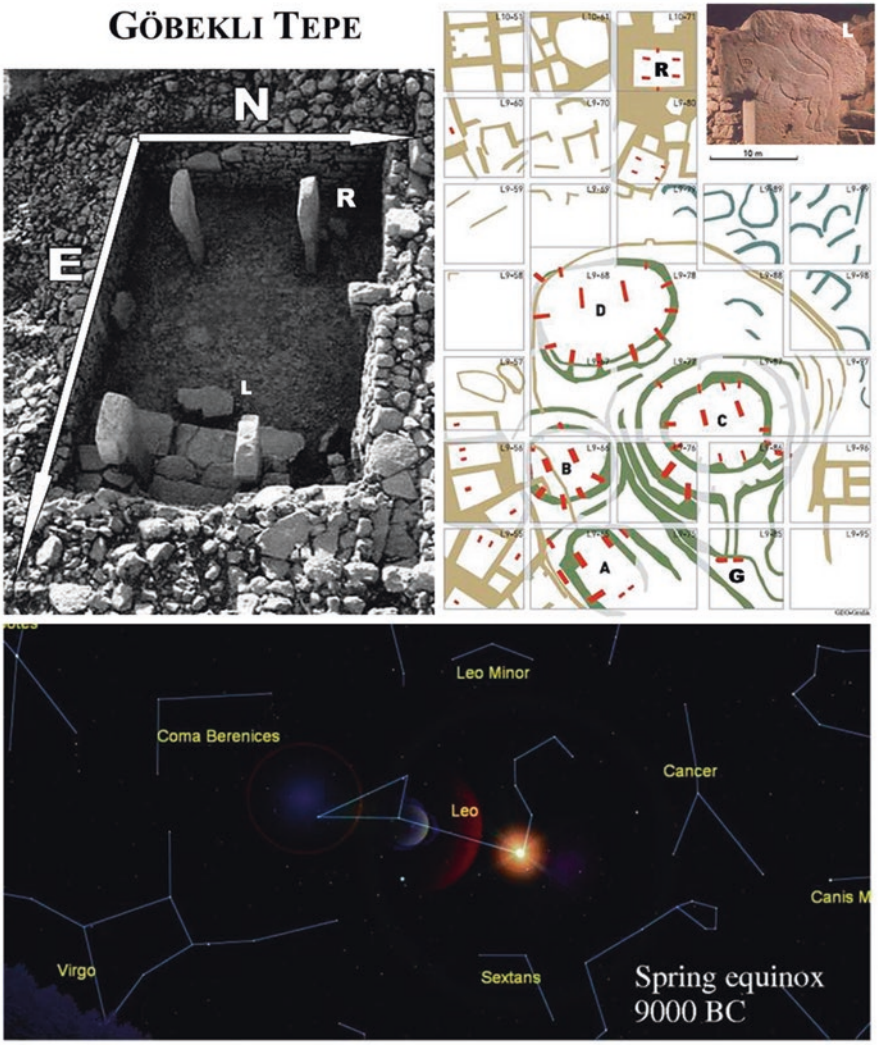

Fig. 1 Composite diagram of Göbekli Tepe. The walls of the rectangular structure (R) built c. 8500 BC in the upper sector of the site are perhaps the first manmade building ever orientated close to the cardinal directions discovered so far. One of the pillars (L) was decorated with an image of a lion. Either by chance or design, the equinoctial sun was easterly rising in conjunction with Leo constellation in that epoch. Adapted from Belmonte et al. (2016)

aligned (Eogan, 1986: 178–179). However, the rough alignment of the corridors and other aspects to be considered has forced a completely different interpretation of the data, discarding any kind of 'equinox' as responsible for the tomb orientations (Ruggles, 1999: 129).

However, there is another interesting case worth discussing. The dolmen of Viera, a megalithic tomb of the mid-third millennium BC integrating the fascinating group of prehistoric tombs in the Antequera Archaeological Park, recently declared as a World Heritage site by UNESCO (Ruiz González et al., 2015), was fist explored by Michael Hoskin in his extensive archaeoastronomical research in the Iberian Peninsula (Hoskin, 2001, and references therein). The initial datum was not very promising (Belmonte & Hoskin, 2002: 77–80) but later observations and, among all, detailed photographic documentation of the dolmen alignment, preparing for the UNESCO candidacy proved otherwise. All in all, Viera was considered, and heartily proposed, as a monument orientated to equinox sunrise. Once more the dichotomy!

Figure 2 beautifully illustrates the problem. The photograph presented there was taken at full-moon the night of the equinox when the declination of our satellite was c. 0°, and hence mimic the exact behaviour of the sun at $\delta \sim 0°$. The alignment seemed perfect. However, the devil is in the details and having a close inspection at the image, a small but still perceptible effect can be ascertained, proving that the photograph was taken slightly off axis (this precision would be impossible at sunrise when strong light and shadow contrasts would preclude such clear perception). If the correct chamber and corridor axis is considered, the moon would have been seen a whole disk diameter to the left of the axis. Actually, the horizon window observable from the chamber would have permitted not only the equinoctial sun light entering the chamber, but also at the day midway between the solstices, and a couple of days before the spring and after the autumn equinoxes.

Fig. 2 'Equinoctial' moonrise on March 21st 2019 on the axis of the dolmen of Viera (Antequera, Spain): The full-moon had a value of the declination of virtually 0°, thus mimicking the behaviour of the sun at the equinox. Photograph by courtesy of Fernando del Pino

Hence, the equinoctial alignment is not as 'precise' and we would desire and perhaps different approaches ought to be considered. Could the moon be the relevant celestial object? Anyway, the lighting phenomenon is very suggestive and will certainly keep attracting people to the site every equinox.

Our last singular case is that of the southern megalithic temple of the three present at Mnajdra in Malta. The peculiar orientation of this temple, the only one of the many prehistoric temples in Malta clearly facing sunrise, has often been termed as equinoctial. Michel Hoskin (2001: 30–31) dismissed this possibility as unreliable but it has remained in the literature and the most serious work on the topic has come back with this possibility (Lomsdalen, 2014: 132). Figure 3 shows a model of the three temples at Mnajdra located at the Malta Archaeological Museum in La Valetta, where the light and shadow effect observable at Mnajdra south can be reproduced. Observing this model (and also on direct observations on site), it is easy to notice that the temple gate was designed to allow the light of the sun entering and illuminating different sacred spots inside the shrine from winter solstice to summer solstice and vice versa. Does this mean that the 'equinoctial' alignment of the temple is just a chance and was forced by the need to lightening the interior every sunrise throughout the year? The answer is not simple. The most recent data (Lomsdalen, 2014; Fig. 5.16) shows that the temple was aligned to $\delta = 0.7°$. This is far from 0° and hence to the true astronomical equinox, but close enough to the value of the sun declination at the day midway between the solstices (c. 0¾°).

Clive had argued that: 're-examination of both the conceptual basis and the actual evidence casts considerable doubt on the idea that any monuments were

Fig. 3 Model of the three megalithic temples of Mnajdra (Malta). Mnajdra I, first to the left, is the youngest of the set, showing the main axis of it oriented towards sunrise at the 'equinoxes' (actually to $\delta \sim 0¾°$). Photograph by Margarita Sanz de Lara, courtesy of the National Archaeological Museum of Malta

deliberately aligned upon sunrise or sunset on dates that happen to approximate to the true equinox, because they were conceived as halfway … between the solstices' (Ruggles, 1997). Apparently, Mnajdra South would contradict this statement, unless the orientation of the axis was a mere byproduct of the general design of the temple, as previously discussed (Fig. 3). Consequently, the day midway between the solstices perhaps had more relevance than the one we might expect, or desire.

2.2 Mediterranean Equinoxes

The first buildings which are arguably orientated close to the astronomical equinox, whenever the eastern horizon in nearly flat, are the funerary temples and related structures (e.g., the Sphinx) of the pyramid complexes of Egypt during the Old and Middle Kingdoms (Fig. 4). Various researchers, including the author of this essay (Belmonte, Shaltout, & Fekri, 2009) have thus claimed for equinoctial alignments in ancient Egypt. However, interestingly, this pattern of orientation could simply be interpreted as the byproduct of an actual interest in due-North and the realm of the imperishable stars, rather than sunrise itself. Only later, this transformed, notably with the solar temples of the 5th Dynasty—and perhaps earlier during the reign of Snefru –, into a true solar relationship, whether or not the ancient Egyptians had a knowledge of the astronomical equinox.

Figure 5 illustrates this possibility. The figure presents the declination histograms of a sample of 330 temples of ancient Egypt divided into a global one (panel a) a three series of independent data on temples of the Old and Middle Kingdoms (when pyramid complexes were built), the New Kingdom and the Late Period up to the 26th Dynasty, and finally of Egyptian temples built during and after the Persian conquest up to the Roman period. The statistically significant peak at the equinox, present in the whole sample which made us define a family of equinoctial

Fig. 4 Equinox at Giza in March 2005. Sunrise in front of the Sphinx (**a**) and sunset behind it at the corner of Khaefre Pyramid (**b**) are clear focal points. Photographs: Juan Antonio Belmonte

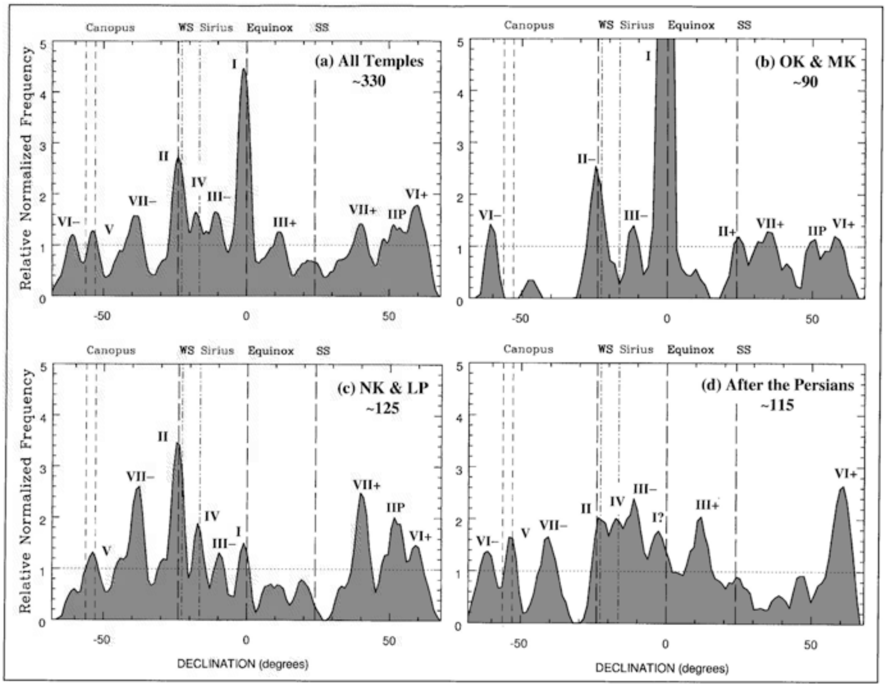

Fig. 5 Declination histograms of the temples of ancient Egypt vs. historical period: (**a**) Complete histogram of a sample of 330 temples showing the seven families of orientation, including family I peak close to 0° declination. (**b**) Temples from the pre-Dynastic period to the end of the Middle Kingdom. (**c**) Temples of the New Kingdom and the Late Period until the Persian conquest. (**c**) Late temples with a dominance of buildings of the Graeco-Roman period. The three series of data plotted in panels (**b**), (**c**) and (**d**) are independent of each other. In panel (**b**), the peak of family I climbs to more than 12 but has been cut to keep the same scale in the different plots. Adapted from Belmonte et al. (2009)

orientations (I) is, however, misleading. This comes from the huge peak related to the orientation of the temples adjoining the pyramids from the 4th to the 12th Dynasties, as clearly demonstrated in Fig. 5, panel b. I am now nearly convinced that this peak, and what it represents, is the results of simple geometry applied to the pyramid complexes, where the pyramid was the first building to be aligned to the north and the realm of immortality. Later on, the shrines associated with the complex, the so-called funerary and valley temples, would be built with an axis perpendicular to the northern one, indeed facing sunrise (solar eschatology was concomitant to the stellar one since the 4th Dynasty), but perhaps facing sunrise at the equinoxes just by chance.

The idea would be reinforced by the fact that, in later epochs, as in the glorious New Kingdom, the 'equinoctial' family is hardly significant or, even worse, during the architecturally splendorous Ptolemaic Period, not easily identifiable (Fig. 5, panel d). This was an epoch when the concept of astronomical equinox was already well-known but it seems to be absent from contemporaneous, traditional Egyptian architecture.

Hence, if the true equinox had no relevance in the orientation of monuments of the megalithic phenomenon, neither in those of other western mother cultures, as ancient Egypt was, where should we look for it, if anywhere. The mathematical concept of equinox was fully developed in the Hellenistic world. Instruments like the sundial of Ai Khanoum, from the third Century BC, clearly reflects it (Hannah, 2009: 121), and perhaps even earlier in the first uses of a gnomon attributed to Anaximander in the sixth Century BC (Hannah, 2009: 69). However, as Hannah (2009: 71) argues, the knowledge of the equinox is not reflected at all in Hesiod's *Works and Days* two centuries earlier.

Consequently, it is not surprising to notice that early Greek temples in the Balkan Peninsula and the Aegean islands lack any sort of equinoctial pattern (Bousikas, 2007–2008). This is, for example, the case for the temple of Apollo at Bassae which is orientated north-south instead of east-west as would be expected for a solar deity, among many others studied in Boutsikas' PhD work, under Clive's supervision. This was a sort of unexpected outcome at the land where classical astronomy had been presumably born and developed and the term equinox invented.

However, the situation is different when we moved to the western shores of the Mediterranean Sea. Figure 6 shows two interesting cases of equinoctial orientations, combined with conspicuous topographic landmarks. On the one hand, the temple of Apollo (Temple C) at Selinunte (Sicily) faces a distant peak where the sun sets at the equinoxes ($\delta \sim -0¼°$). Built in the mid-sixth Century BC, it would be one of the first Greek temples with such an orientation (Belmonte & Hoskin, 2002: 204). Why? We do not have the answer but Selinunte was built in an area of Sicily under strong Punic influence and when the city was conquered by the Carthaginians in 409 BC the area was devoted to the cult of the supreme divine couple of Carthage integrated by Ba'al Hammon and Tanit, so Punic influence cannot be discarded. In this sense, other temples of the city, such as the impressive Temple E, also faced the distant topographic landmark but they were clearly not equinoctial (Belmonte & Hoskin, 2002: 205).

Interestingly, on the other hand, this same Punic influence can be ascertained across the sea, in Mactar (Tunisia). In data taken in Africa Proconsularis (Belmonte, Tejera, Perera Betancor, & Marrero, 2007), where Punic, Roman and local (Numidian) traditions intermingled, there is one relevant peak centred at c. 0°. This could be associated with a substantial number of temples devoted to the sun, or deities of solar character, spread throughout the region. This is beautifully illustrated in Fig. 6b, where the equinoctial rising sun can be seen along the axis of the Apollo temple in Mactar. This temple was built upon an early temple dedicated to Ba'al Hammon, the supreme deity of Carthage which was somehow assimilated by the Numidian kings to the Sun. Although the temple orientation is certainly equinoctial, the presence of a notch in the distant horizon, where the sun would have risen a couple of days after the spring equinox (or before the autumn one), and hence at the day midway between the solstices, opens an interesting question.

Fig. 6 Land and skyscape interaction: (**a**) Alignment of Temple C at Selinunte (Sicily) built between 580 and 530 BC, presumably dedicated to Apollo, it was the oldest of the city: sunrise at the 'equinox' was produced over a distant, remarkable topographic landmark ($\delta \sim -0½°$). (**b**) The equinoctial rising sun of March 21st 2002 follows the axis of symmetry of the Sun (Apollo in Roman times) temple in Mactar (Tunisia). The phenomenon is observable close to a notch in a distant mountain which could have been used as a close-equinoctial marker. Photographs by Juan A. Belmonte

Few studies, if any, have been performed in the shores of Levant that can offer a clue of an 'equinoctial' custom perhaps imported from the Middle East (see Steele, this volume). Hittite data shows a preference for near due-east orientations (González García & Belmonte, 2011) and, as we will see later on, Nabataeans played with the concept of equinox (sun entering the 'sign of Aries') and aligned their sacred structures accordingly. However, it is still in the West where some more clues could be ascertained. An example of that are Iberian sanctuaries.

For more than two decades, César Esteban (2016) has been analysing the importance of the equinox in the Iron Age Iberian culture of Mediterranean Spain. He has discovered that more than one third of the explored shrines had equinoctial 'markers'. Some of them are very precise, such as El Amarejo (Fig. 7). However, the vast majority show a remarkable preference for the day midway between the solstices (which he terms the 'temporal midpoint between solstices' and abbreviates as TMPS) when the sun declination is between +0.3° and +1°. Iberian culture developed between the sixth and first centuries BC and most of these 'equinoctial' sanctuaries are dated in that epoch. Esteban (2016) supports a possible Punic-Greek (from western Greeks) inspiration for the use of equinoctial markers in the Iberian ritual, an influence which is also reflected in many other aspects of the culture, such

Fig. 7 Sunrise at the Iberian sanctuary of El Amarejo (September 21st 2004 when the Sun had a declination of 0°9′ (i.e., c. true equinox): The sun climbs the cliff of Montaña Chinar. This would be the most accurate 'equinoctial' marker for Iberian sanctuaries. Adapted from Esteban (2016). Courtesy of César Esteban

as writing. He is possibly right, although the preference for the time midway instead of the astronomical equinox leaves doors open for other possibilities.

A discussion on the equinox in the pre-Hispanic culture of the Canary Islands may follow the same line of argument. Research in Grand Canary has shown that the equinox was an important milestone in the time-keeping system of the ancient Canarians as was reflected in the conquest chronicles and the archaeological record (Esteban, Belmonte, Schlueter, & González, 1996, 1997). Considering the Amazigh ancestry of these populations this may have important connections to the origin of these populations (Belmonte, Perera Betancor, & González-García, 2019). A Roman influence (see below) has been advocated due to the early Roman presence in Proconsular Africa after the defeat of Carthage in 146 BC, although an earlier Punic influence cannot at all be discarded.

The term 'equinox' is clearly used in the chronicles, but it is ignored what this concept meant for the pre-Hispanic society. The work for preparation of the UNESCO candidacy of 'Risco Caído and the sacred Mountains of Gran Canaria Cultural Landscape' as a World Heritage site (Belmonte et al., 2018) did not clarify the situation despite Clive's role as a scientific advisor of the team was fundamental on the discussion. Of the sites within the property, the sanctuary at Roque Bentayga may suggest an astronomical equinox relationship (Fig. 8, see also Esteban et al., 1996), although the day midway between the solstices—other important time-marks of their calendar—cannot be discarded as proven by other sites in the island (Esteban et al., 1997). However, the astronomical phenomenology present at Cave 6 in Risco Caído indicates that the first and last days when sunlight enters the cave though a very peculiar oculus are—with the margin of a day—March 19 and September 25 in

Fig. 8 The *almogarén* (sanctuary) of Roque Bentayga (**a**), a pivotal element for UNESCO's 'Risco Caido and the sacred Mountains of Gran Canaria' Cultural Landscape. At the equinoxes, sunlight crosses an artificial notch and device (**b**), illuminating the large central circular cup-mark of the sanctuary (**c**). At autumn equinox 2018, a member of our team made a libation for the success of the candidacy (**c**). Prof. Ruggles and the author were present at the event. Photographs by Juan A. Belmonte (**b**) and by courtesy of the Gran Canaria Council (**a** and **c**)

the Gregorian calendar, respectively. During autumn and winter months, it is the full-moon which periodically illuminates the interior of Cave 6 (Cuenca Sanabria et al., 2018). This clearly divides the year between two dark and bright halves. All in all, present data does not offer further clues of the actual conception of the term equinox for this ancient society and if they brought it with them in the process of colonization—perhaps under Roman or Punic influence—or if they developed it locally according to environmental needs. The solar hierophany at Mactar (Fig. 6) would support the first possibility.

It is worth noticing that, although the astronomical definition of equinox was certainly known in Rome, it was not applied for the reform of the Republican calendar introduced by Julius Caesar in 46 BC. This was performed to adjust the year and festivities to the seasons, and Caesar certainly carried out his reform with the problem of the equinox in mind. Probably, for the Romans of the end of the Republic, there were varying definitions for equinox, but March 25th was accepted as the canonical date for the vernal equinox by both Caesar and Augustus. Under this consideration, the sense of equinox used probably was the day that marked the middle of the time