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Advances in Understanding Megaliths and Related Prehistoric Lithic Monuments

edited by: **Terence Meaden**

Issue dedicated to the session

"Standing Stones and Megalithic Monuments in Context"

XVII UISPP World Congress, Burgos, 1-7 September 2014

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Front cover image: *Sunset at Drombeg* (photo by G.T Meaden).
Title image: *Modern aboriginal knapper in Kimberley, NW Australia* (by Val Waldorf, based on a photograph).
Back cover image: *A flint knapper* (by Georgeta Simion).

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Foreword from UISPP

Luiz Oosterbeek

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UISPP has a long history, starting with the old International Association of Anthropology and Archaeology, back in 1865, until the foundation of UISPP itself in Bern, in 1931, and its growing relevance after WWII, from the 1950's. We also became members of the International Council of Philosophy and Human Sciences, associate of UNESCO, in 1955.

In its XIVth world congress in 2001, in Liège, UISPP started a reorganization process that was deepened in the congresses of Lisbon (2006) and Florianópolis (2011), leading to its current structure, solidly anchored in more than twenty-five international scientific commissions, each coordinating a major cluster of research within six major chapters: Historiography, methods and theories; Culture, economy and environments; Archaeology of specific environments; Art and culture; Technology and economy; Archaeology and societies.

The XVIIth world congress of 2014, in Burgos, with the strong support of Fundación Atapuerca and other institutions, involved over 1700 papers from almost 60 countries of all continents. They contribute with new advances into understanding the human past and its cultural diversity. This is what UISPP (www.uispp.org) is for, and this is also why we are currently engaged in contributing for the relaunching of Human Sciences in their relations with social and natural sciences, namely collaborating with the International Year of Global Understanding, in 2016, and with the World Conference of the Humanities, in 2017.

The next two congresses of UISPP - in Paris (June 2018) and in Geneva (2020) - will confirm this route.

Luiz Oosterbeek
Secretary-General
l'Union Internationale des Sciences Préhistoriques et Protohistoriques

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Editorial: Advances in Understanding Megaliths and Related Prehistoric Lithic Monuments

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Standing stones and megalithic monuments are impressive remains from a remote prehistoric world that for the British Isles began some 6000 years ago and led to a cultural flowering that peaked in the Late Neolithic and Early Bronze Age with the rise of fine megalithic monuments like Newgrange, Knowth, Drombeg, Maeshowe, Avebury and Stonehenge. Nearby on the European continent, what may be called an era involving megalithic culture had begun a few centuries earlier (as at Carnac and Locmariaquer), and still earlier in the Mediterranean lands and islands (*e.g.*, the Tarxien Temple in Malta), south-eastern Europe, the Near and Middle East, and India beyond.

Antedating and contemporary with the well-known grand megalithic edifices, many thousands of lesser monuments were built worldwide using standing stones in the form of the first chambered long barrows, court tombs and *allées couvertes*. Preceding them, it is likely that a range of simpler constructions would have been raised such as single standing stones and perhaps the first stone rows or dolmens, most of which have left little evidence for us to date them. Erection of single stones and stone settings like these continued for many centuries, and after 3000 B.C.E. stone circles became numerous in Britain and Ireland. Unhappily, and perhaps relatively quickly towards the middle of the second millennium B.C.E., the European Megalithic Age was ending and knowledge of the purposes and uses of the megalithic monuments came to be lost.

Since then, many prehistoric settings and monuments have disappeared forever, but we may be grateful for those that survived despite their battered condition caused by extremes of weather, lack of maintenance, human misunderstanding, and, for some, landscape or sea-level changes. Another misfortune is that the builders in their illiteracy left nothing in writing about the meaning and use of their much-loved constructions, although occasionally there are clues by way of associated finds of bones, pottery, grave goods, artifacts and artwork, and, it should be noted, various clues in the form of lithic symbols, images and alignments. It is further helpful that in some parts of the world, including India and Madagascar, megaliths continue to be raised to this day - for this permits interviews with tribal devotees. In the Americas too one can discuss current understandings with descendant natives about ancestral rites, functions and traditions.

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In this issue of the journal the attention of some authors has been directed at symbols and images that have been incorporated into the structural detail of the lithic settings under review. These authors and others have noted how some arrangements, in part or in whole, were sited in the landscape to align with cosmic features, particularly the points of sunrise for certain dates of the year, and, for a few, with solar settings. Additionally, there are stones that were selected for their shape, or had their shape modified, or carvings sculpted on them. Overriding everything is the perception that the mentality that led societies to shift great megaliths was a susceptibility to acquire beliefs and fears in a world of danger and uncertainty in which people eternally struggled with the troubling realities upon which agricultural success depended. Above all, there were the vicissitudes of inconstant weather and land fertility that led to endless hope that they could be controlled through religious observance and practice.

This study reports advances in matters that lead to an improved understanding of the reasons why stones were so important in the lives of megalithic societies, and that sometimes parallels appear in faraway continents despite a lack of interaction by human contact. It is thought this may be due to factors emanating from the psyche, resulting in comparable views of aspects of Nature and the Cosmos related to life, gender and fertility.

The first paper is an in-depth study of the stones of the Drombeg circle in the west of County Cork in Ireland. A new survey of the stones, together with knowledge of the precise directions of sunrise, reveals couplings between stone pairs that were planned into the lithic layout but had not been noticed or appreciated in modern times - in fact not even witnessed since the last users of the stone circle in the Bronze Age. Each coupling is by shadow between pairs of standing stones that offer male or female features. Every time the shadow from a nominally male stone falls upon either one or other of two female stones - moreover this was arranged to happen “always at sunrise” on particular dates of the year. Photographic proof is presented. The primary purpose appears to be calendrical because encoded in the planning of the stones are the eight traditional dates of the agricultural year 45 or 46 days apart commencing with the winter solstice.

Similar interactions that involve shadow casting at sunrise take place at Knowth, Newgrange, Avebury and Stonehenge. At Avebury, as at Drombeg, stones are positioned such that the dates of the known traditional agricultural festivals are deliberately built into their structures. At Knowth the principal celebrations take place close to the equinoxes, at Newgrange at the winter solstice sunrise, and at Stonehenge primarily at the summer solstice sunrise and (this is a new discovery) the winter solstice sunrise. Avebury and Stonehenge are treated in a second paper in this issue of the journal.

Next, Dr. Kate Prendergast considers aspects of near-equinoctial events at sunrises and sunsets at the great megalithic monument of Knowth. Consideration is given to problems stemming from the non-matching of 28 or 29-day cycles of the moon with the annual cycle of the sun. Was there a Neolithic attempt to correlate varying lunar-solar timings in the region of the equinoxes several millennia before the calendrical problems that concerned the Judeo-Christian moveable feast of Easter?

The studies in North America by Herman Bender in the state of Wisconsin are valuable for the rediscovery of landscape stone-patterning of a type called petroforms or lithoforms. This is the careful positioning of stones in order to create on the surface of a chosen terrain images in outline produced by placed stones as seen from above. The stone setting called ‘Starman’ exemplifies this well. It echoes Indian folk tales of a human body image on the landscape that repeats the tribally perceived image of a man among the stars of the celestial vault. The idea may also embody the perception that stones in the landscape whether natural or artificially positioned internalize a supernatural ‘spirit’, and were therefore sacred.

Drs. Cicilloni and Cabras consider the landscape positioning of 90 dolmen structures of various types in the middle of Sardinia using GIS methodologies that embrace viewshed and cost surface analysis. This may lead to improved interpretations as to what particular placements had meant to the dolmen planners.

A major target is to understand some of the practical factors and spiritual thinking that were held by communities in the prehistoric world - and why.

For Britain and Ireland, the last of the peoples who knew about such matters had died by about 1500 B.C.E. when the megalithic monuments came to be abandoned at around what is commonly taken as the transition from the Early Bronze Age to the Middle Bronze Age. These peoples have long been dead. Such problems of prehistory are similar for the megalithic peoples of the continent of Europe and the Near East. By contrast, in the Americas and the subcontinent of India one can usefully interview surviving natives and tribal peoples and learn how significant that lithics in the landscape were to preliterate communities.

Further research and surveys by the editor have been achieved subsequent to the Drombeg project. Similar results were obtained at Bohonagh Stone Circle in County Cork and the first of the stone circles in north-east Scotland to be studied. The latter include the recumbent stone circles at Loanhead of Daviot, East Aquhorthies, Tyrebagger (Dyce), and Aikey Brae. All told, a considerable advance in knowledge of the archaeoastronomy of Neolithic and Early Bronze Age stone circles has been achieved. At these and other sites analyzed by the author the recumbent stone receives a medial shadow at the summer solstice from a carefully positioned megalith whose outline purposefully hints at male symbolism... and additionally at every monument there is a perimeter stone standing at the south-east that casts a shadow caused by the winter solstice rising sun on to a standing stone at the north-west classifiable as female. The visible stone-to-stone union is memorably striking. In every case shadow-casting stones have features that convey the concept of the male principle, while the receptive stones bear feminine symbolism. Because of their intelligent positioning these and other select stones take part in the annual round. In all, an eight-part calendar of the full year is represented, devised by the shrewdness and ingenuity of the astronomer-priests.

Some authors find that major features of the megaliths can be explained using concepts that invoke a belief scenario involving an Earth Mother and a Sky Father. It is well known that almost everywhere in the world when time and populations proceed from illiterate prehistory into recorded history, Earth Mothers or Mother Goddesses were widely present in documented legends and tales. This intimates that such divinities were likely present, too, in the preceding final stages of unwritten prehistory. Depending on which region of the world is treated, this transition to literacy took place in the Bronze Age or the Iron Age or later. Ultimately, aspects of religious belief appear to help explain how Stonehenge, Avebury, Drombeg, Knowth, Newgrange and Loanhead of Daviot among others were planned and built to exalt fertility notions at a high level of devotion.

Some stone arrangements further reveal positioning that suggests they were erected for fertility rites in which astronomy was helpful and for some of which necessary. In India among traditional customs of the tribals, the Sarhul continues to be an annual fertility festival in which an ancient belief of marriage between the Sky Father and Earth Mother is still upheld today, with the expectation that the fertility of farming lands and livestock is again renewed. In East India a similar fertility festival, three days long and known as the Ambabuchi, is celebrated at the summer solstice by Hindus. In North-East India where the practice of megalith erection after death endures, many such monuments are dedicated to Mother Earth.

All in all, the principal research thread was to evaluate the purposes and uses of standing stones, whether positioned singly or in settings, or whether raised as principal structural components in great monuments - and this with the further objective of advancing our knowledge of the lives of the communities worldwide that raised and used them. Access to existing native sources in North America and India have contributed towards a better understanding of the lithics and megalithics of Ireland, Britain and the continent of Europe.

G. Terence Meaden
Guest editor

Drombeg Stone Circle, Ireland, analyzed with respect to sunrises and lithic shadow-casting for the eight traditional agricultural festival dates and further validated by photography

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Abstract:

A new survey of Drombeg Stone Circle and accurate analysis of shadow effects beginning at particular sunrises of the calendar year has led to a breakthrough in the understanding of lithic symbolism and the intentions behind the construction of this and other Irish monuments including Knowth and Newgrange that also have astronomical alignments.

At Drombeg specific standing stones play critical roles at sunrise for all eight of the festival dates as known traditionally and historically for agricultural communities and as now inferred for prehistoric times following the present observation-based analysis.

Crucial for Drombeg in the summer half of the year is the positioning of a tall straight-sided portal stone such that its shadow at midsummer sunrise encounters an engraving on the recumbent stone diametrically opposite. During subsequent minutes the shadow moves away allowing the light of the sun to fall on the carved symbol. It is the same for sunrises at Beltane (May Day), Lughnasadh (Lammas), and the equinoxes when shadows from other perimeter stones achieve the same coupling with the same image, each time soon replaced by sunlight. For the winter half of the year which includes dates for Samhain, the winter solstice and Imbolc, the target stone for shadow reception at sunrise is a huge lozenge-shaped megalith, artificially trimmed. Moreover, for 22 March and 21 September there is notable dramatic action by shadow and light between a precisely positioned narrow pillar stone and the lozenge stone.

As a result, at sunrise at Drombeg eight calendrical shadow events have been witnessed and photographed. This attests to the precision of Neolithic planning that determined the stone positions, and demonstrates the antiquity of the calendar dates for these traditional agricultural festivals. Discussion is held as to what the concept of shadow casting between shaped or engraved stones at the time of sunrise may have meant in terms of lithic symbolism for the planners and builders. This leads to a possible explanation in terms of the ancient worldview known as the *hieros gamos* or the Marriage of the Gods between Sky and Earth.

Keywords: Drombeg; *hieros gamos*; Knowth; Neolithic calendar; Newgrange; solstice sunrises

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1. Introduction

During the 2500 years of the Neolithic and Early Bronze Age of Britain and Ireland, megaliths played a huge role in the communal lives of the early farming peoples who raised and used the stones.

An early practice was the preparation of a sacred area of land by digging a circular ditch thus creating a contiguous circular bank. This was the birth of a simple earthen monument termed a henge (like the Priddy Circles in Somerset). Introducing a ring of vertical timbers improved and emphasized the visual concept whether set inside a ditch-and-bank ring (as at Woodhenge) or used alone (as at Sarn-y-bryn-caled (Powys) and Seahenge (Norfolk)). An extension of the idea led to the raising of stones in a circle, with or without a henge because this provided longtime endurance with enhanced dramatic beauty as at Drombeg or majesty as at Stonehenge.

Stones were often selected for the shape of their lithic outline (as at Drombeg and Avebury) or for natural marks on them resulting from geological processes (Drombeg, Stone 1). Sometimes, shapes were improved by tooling (*e.g.*, Stonehenge) to satisfy criteria deemed important to the sculptors - while at times, symbols were carved on selected stones (as extensively at Knowth and Newgrange). Additionally, alignments to solar risings or settings were featured, sometimes in relation to a standing stone positioned outside the monument. This includes Stonehenge (Cleal *et al.* 1995: 269-270) and Knowth (Eogan 1986: 47, 65, Plates 9 and 15). In this paper examples are introduced and explained through advances made by the present research at Drombeg.

Best progress at interpreting the ancient meanings comes from studying stone circles that are complete or little damaged. Drombeg Stone Circle is an appropriate candidate because most of its principal stones have survived and remain in position.

The foremost earlier work achieved at Drombeg was that of the excavator Fahy in 1957-58. Although his paper (Fahy 1959) is primarily about the details of the excavation, he made helpful interpretation too. Fahy’s numbering system for the 17 circumferential stones is used in the present paper.

2. Methodology

Drombeg Stone Circle stands within two kilometres of the ocean near Glandore in County Cork, south-west Ireland (Figure 1). One of the 17 circumferential stones is recumbent. The latter bears engraved rock art symbols, while portal Stone 1 has natural images resulting from geological processes. These are discussed along with their relationship to the rising sun and the positions of other stones. Shapes are discussed for their outline lithic symbolism and positioned settings. Most important are a huge lozenge-shaped megalith and adjacent pillar stone whose outlines were meaningfully modified and positioned to work at the equinoctial sunrises. Helpful comparisons are made with near-equinoctial stones at Knowth.

Research visits were made at various times of the day for study and surveying, because of which it came to be realized that the crucial times of day that could help in resolving the meanings of the design scheme were at sunrise on certain dates of the traditional agricultural year. Corroboration by photography was achieved with a Sony high-quality single-lens digital reflex camera.

The previously best-known astronomical alignment at Drombeg is that observed at the winter solstice, when the sun sets into a prominent notch on the south-western horizon. The portal stones, numbered 1 and 17 by Fahy (1959), each stand two metres high and face outwards to the north-east or inwards towards the south-west. The sunset alignment bisects the gap between these stones, crosses the centre of the circle, bisects the recumbent stone, and continues to the V-notch on the hill half-a-kilometre distant where the sun sets in midwinter week (Figure 2). Somerville (1909) was first to record this in print.

Figure 1. South-eastward view of the Drombeg stones an hour after sunrise, 19 June 2013. Author's photograph.

Figure 2. The sun setting into the hillside V-notch in line with the recumbent stone, close to the winter solstice 2012. Author's photograph.

2.1. The plan of Drombeg Stone Circle

It was essential to have an accurate plan of the stone circle, so a new survey was carried out by the author (Figure 3). The 10 crucial perimeter stones at Drombeg have specific features due to their shape or position, and are the stones that take part in the action. In the plan these are shaded. Tallest are the straight-sided portal Stones 1 and 17, each two metres high.

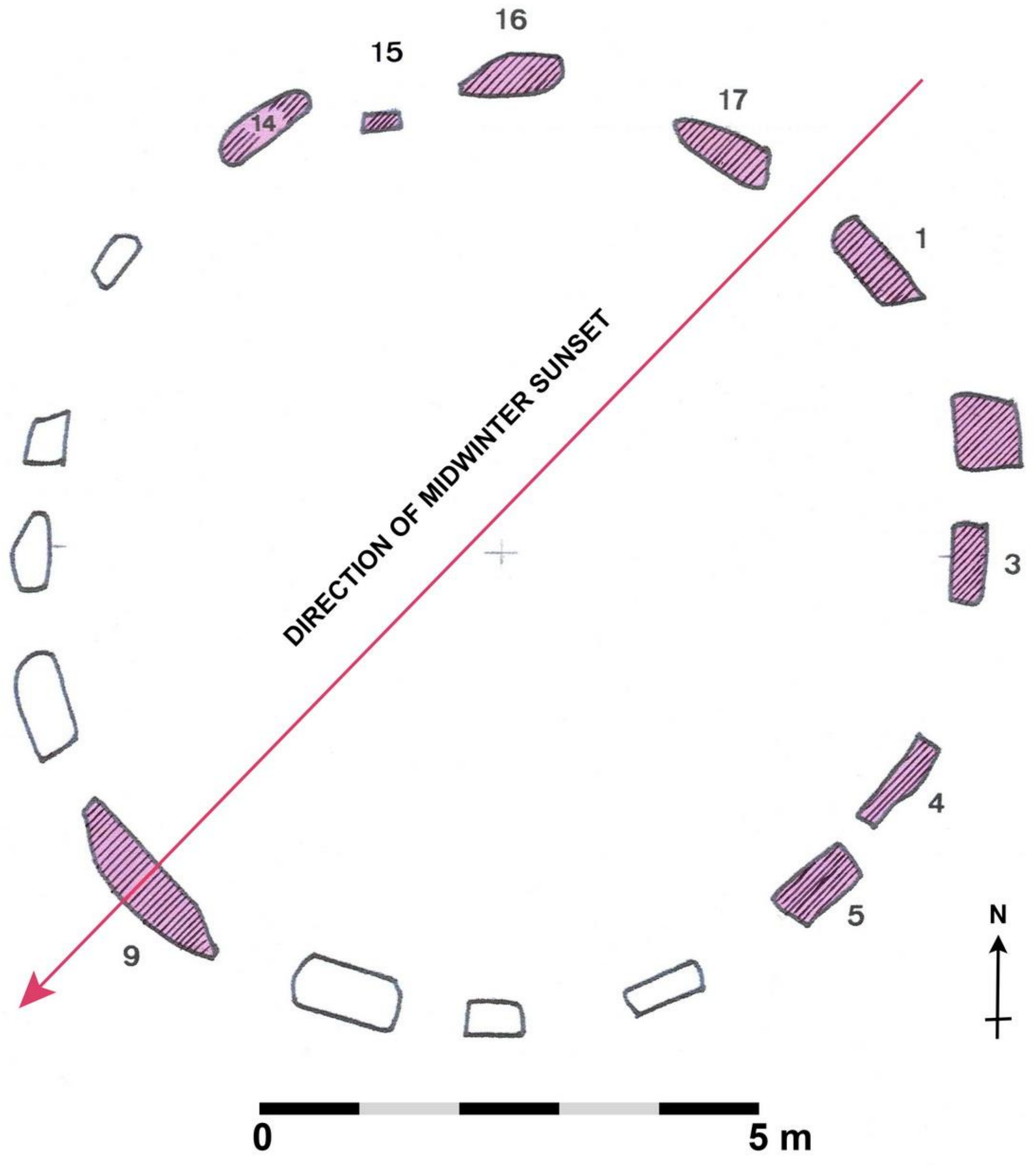


Figure 3. The author's 2012 survey of the stones of Drombeg. The functional stones discussed in the text as calendar stones are shaded. The ceremonial axis bisects the gap between the tall entry portals (Stones 17 and 1) and the art-bearing recumbent Stone 9. Note how the narrow pillar Stone 15 is deliberately offset. Reasons for this are discussed in Sections 3.4 and 4.4.

2.2. A general note on ancient calendars

It is demonstrated in this paper that particular megaliths at Drombeg were selected for size and shape and precisely positioned such that depending on season the rising sun would cast light on them allowing their shadows to fall upon other placed stones. A range of specific, recognizable, action spectacles results for certain dates of the calendar year.

On the basis of there being 365 days in the year, it is appropriate to consider the operation of a day-counting calendar in which 21 December is regarded as Day 1 and 20 December as Day 365.

By quartering the full year, Day 92 is found to be 22 March, Day 183 is 21 June, and Day 275 is 21 September. These provide the calendar dates for the spring first quarter day, the midsummer solstice, and the autumn third quarter day respectively. It is important to note that the prehistoric people probably did not define the equinoxes in the way that we do - namely, as precisely equal day, equal night. This is largely because they had no clocks divided into minutes, whereas the day-counting method lends itself to a straightforward division of the 365-day calendar and resolves the equinoctial day-selection conundrum (Heggie 1981: 91; Ruggles 1999: 148-150).

Bisection of the foregoing four dates gives the cross-quarter dates that we call 5 February, 6 May, 6 August and 5 November. The resulting eight dates are 45 to 46 days apart. It establishes and justifies a practical calendar for Drombeg and other prehistoric sites based on the cosmic cycle. Communities only needed a sky-watcher to maintain a day count on their behalf throughout the year - for example, by using a tally stick that was marked daily. The author has constructed and used such a tally stick cut with 92 notches for experimental day marking through the entire year. By this means any or all of the eight principal calendar dates could be ascertained and encoded into the stones of Britain and Ireland's stone circles, as demonstrated by this research for Drombeg.

Indeed, it is proposed and it has been found that these are the eight relevant dates for best witnessing effects at sunrise at Drombeg under clear-sky conditions. The modern observer should be aware that minor differences in shadow production and timing can result depending on by how many days the optimum dates are missed due to obscured sunrises.

3. Description of the principal stones

Before dealing with the phenomena at sunrises on the dates of the eight traditional agricultural fairs and festivals, the defining features of the image-bearing stones and shaped symbol stones are described.

Interpretation of the Drombeg images and their interaction with the rising sun (Sections 3.1 and 3.2), as also their shapes (Sections 3.3 and 3.4), may provide insight into the beliefs of the community.

3.1. Recumbent megalith

Stone 9 with its flat upper surface lies recumbent. It stands on the south-western arc of the circle (Figures 1, 2, 3, and 4), nearly 210 mm long, 90 mm above ground level, and up to 45 mm thick.

One cup mark, diameter 50 mm, is neatly round and shallow. A second cup mark is elongated, 92 mm by 64 mm, and 19 mm deep.

Nearby is a trapezoidal line-carving 298 mm long (Figure 4, Figure 5). The outline is 184 mm wide at one end and 100 mm wide at the narrow end, the boundary being a pecked groove 6 to 8 mm deep. It encloses another cup mark pecked into a natural fissure that elongates the artificial depression medially. Although one can never be sure what the sculptor meant by this, one may suggest that the feature as a whole could have the character of a vulva which, by comparative traditional symbology (compare with Figure 6 for Palaeolithic examples), helps to attribute a feminine quality to the stone. Neolithic examples of this type of carving exist too.

Figure 4. The flat upper surface of the recumbent stone, Stone 9, looking south-east with rock-cut images of two cup marks and a suggested vulva. The next figure is a tracing of these features as viewed from the opposite direction. Author's photograph.

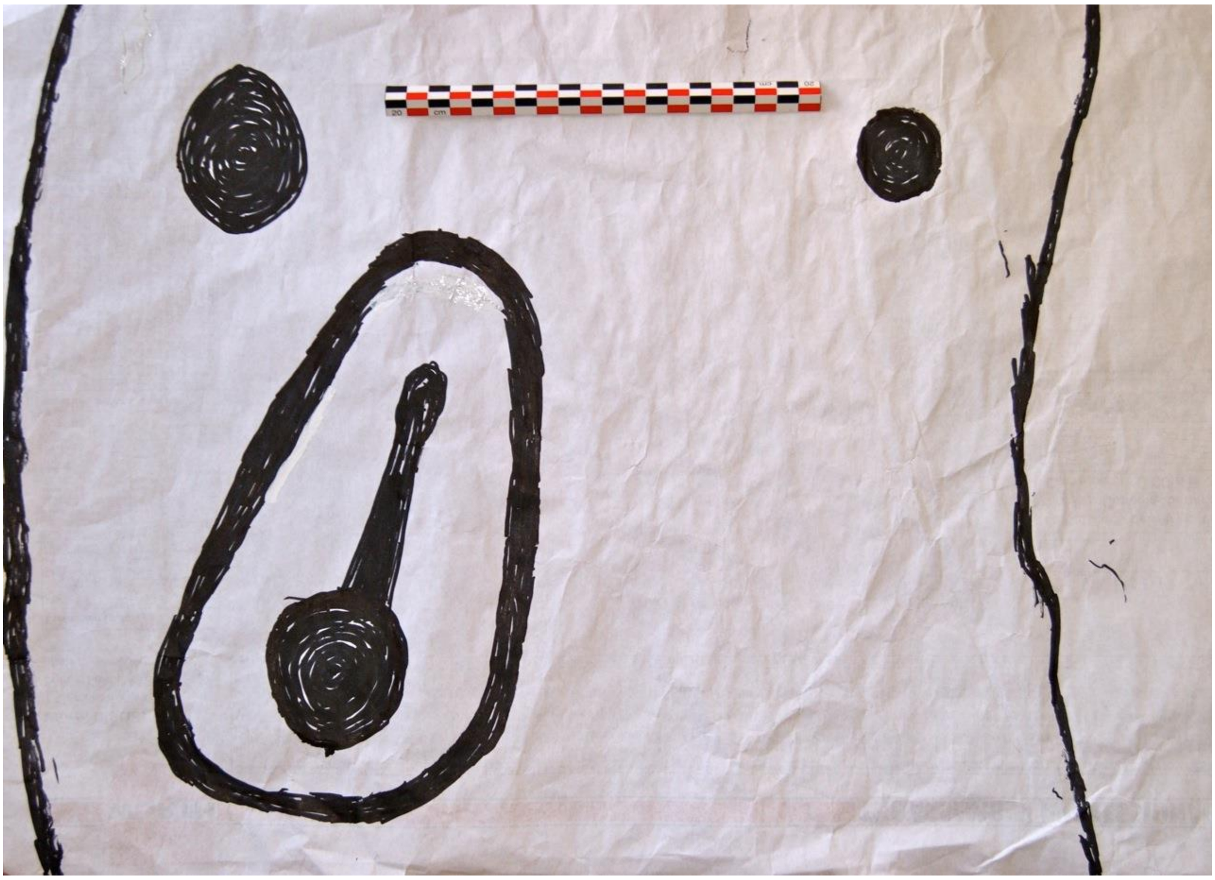


Figure 5. Ink-on-paper tracing of carvings on the upper surface of Stone 9 - with a 20 cm rule for scale.

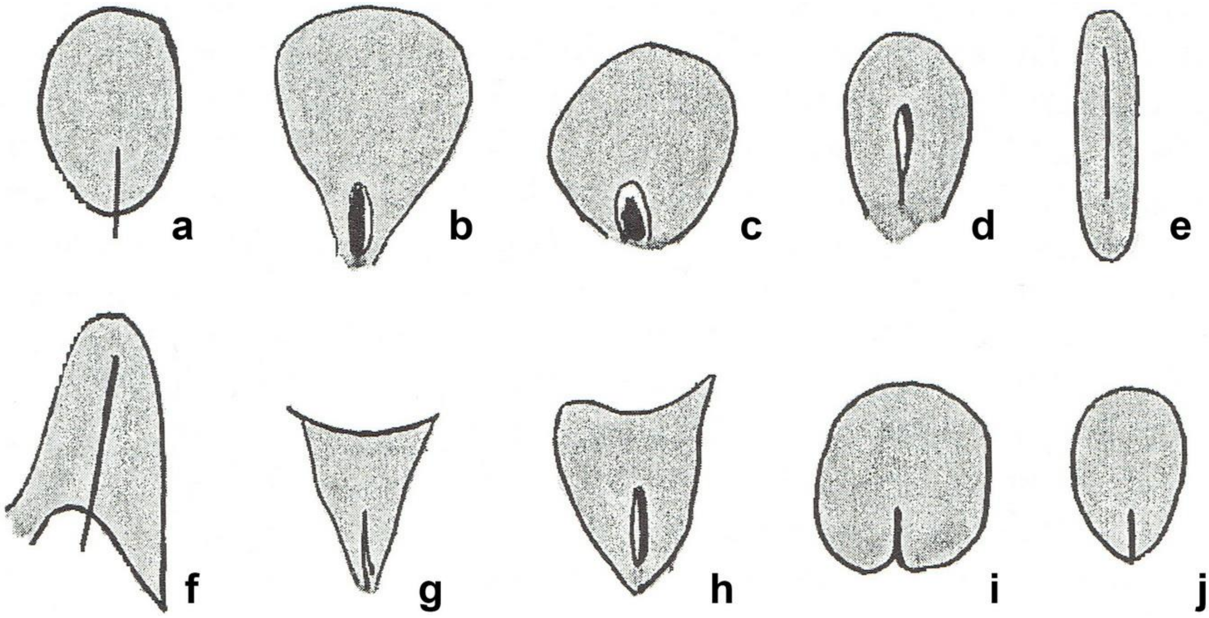


Figure 6. Carved vulvas: L'Abri Blanchard (a, b. c), La Ferrassie, Dordogne (d, e, h), El Castillo (f), Pergouset (g), Laussel (i), and Lalinde (j).

Additionally, there are two arcs of unknown meaning pecked towards the south-eastern end of the stone. All features were pecked by secondary percussion.

3.2. Portal Stone 1

Portal Stone 1 has undulating geomorphic features on its north-eastern outer side that are not artificial. This may imply that the planners favoured the stone if they had discerned in this a possibly anthropomorphic image (Figure 7a) which they perhaps interpreted through mythology. The form is not dissimilar to the outline of the back of a human image (Figure 7b) located, as it were, partly inside the stone and yet as if emerging from it. This is the only stone that bears any natural image, so perhaps it was set at this location because of perceived anthropomorphism and because this position on the circle's perimeter had some other aspect that was considered significant. Whatever else, this exterior side of Portal Stone 1 is turned to the local midsummer sunrise, while its opposite side - the internal side - faces the recumbent Stone 9 and midwinter sunset.

The other portal stone - similarly tall and narrow - bears an ithyphallic image (Figure 8).

3.3. The lozenge-shaped megalith

Stone 14 is a three-tonne boulder, lozenge shaped, standing on a point (Figure 9). One edge has been artificially improved. Fahy (1959: 5) writes that the stone is "a large, lozenge-shaped boulder rather flat on its inner face but heavily bulbous on its outer or northern face. Three sides of the lozenge appeared to be natural edges but the upper right hand side had been produced by breaking the boulder along a joint plane".

Keiller and Piggott (1936: 420), Smith (1965: 19; 7, 251), Gimbutas (1989; 1991) and Meaden (1999: 3-6; 2008: 13-15) explain why traditionally the lozenge shape suggests femininity. Drombeg excavator Fahy (1959: 20-21) writes thus: "Lozenge shaped stones associated with pillar stones have been recognized at Avebury (citing Childe (1952: 102) who says "they are clearly male and female symbols") and are taken to represent or to be symbolical of the male and female sexes and to be connected with a fertility cult." Smith (1965: 251) writes similarly with regard to Avebury saying that if the stones "do indeed represent male and female symbols, the implication must be that the monuments were dedicated to a fertility cult."

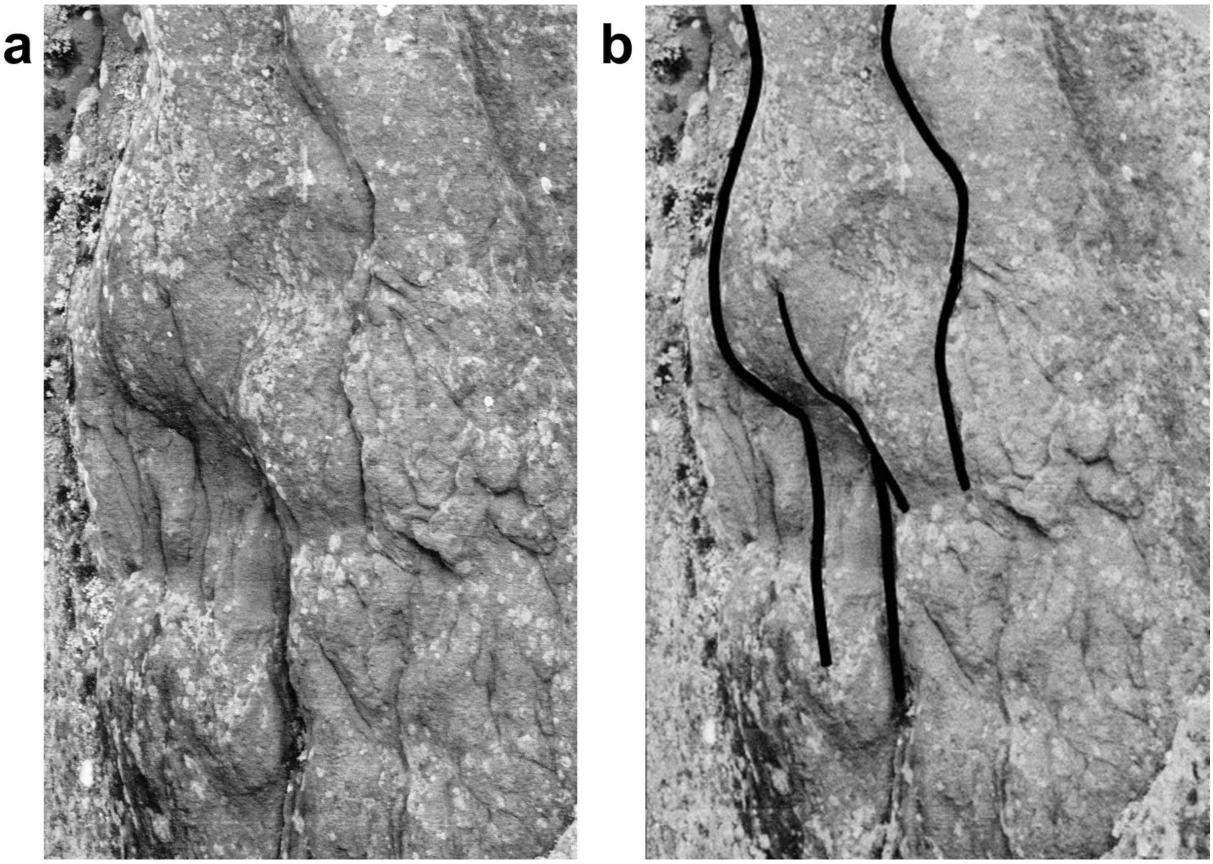
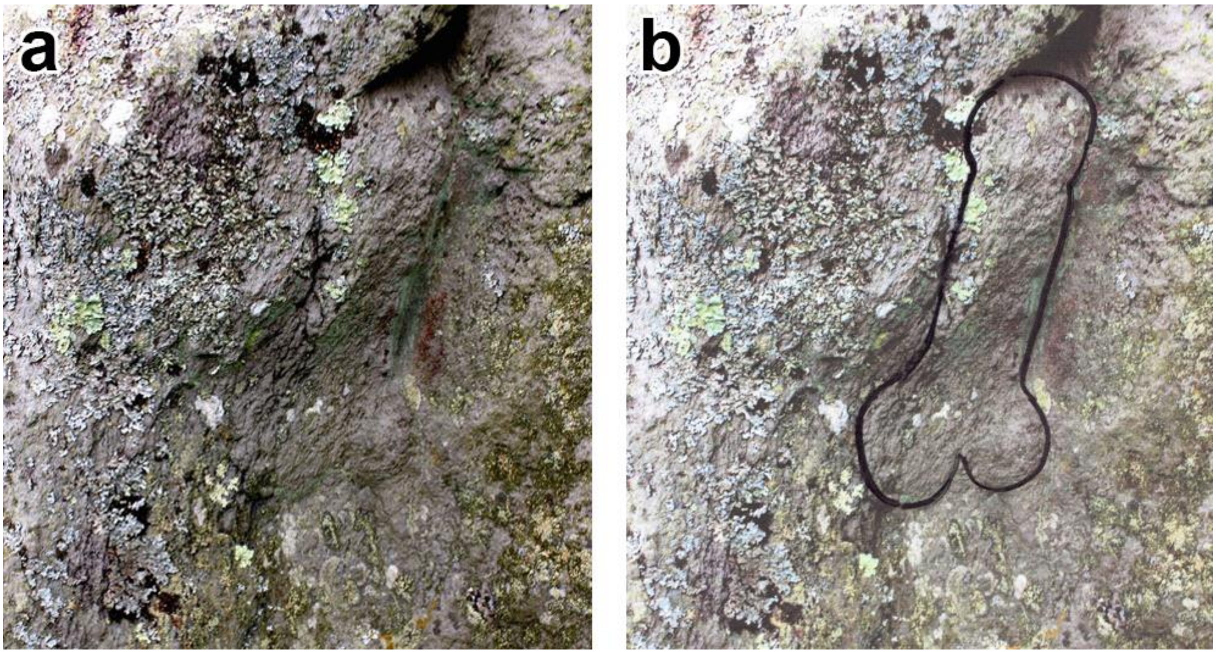


Figure 7. a. Stone 1 with natural contours that could be viewed as an anthropomorphic image. Author's photograph. b. The shape of the image is here emphasised in a manner that could have been done in prehistoric times using charcoal, chalk or red ochre (the latter is known for prehistoric Scandinavia). The image gives the impression of a human form within the stone as if emerging from it. Author's photograph.



Figures 8a and 8b. An ithyphallic image on portal stone 17. The shadow of this tall male stone falls upon the female lozenge stone 14 at the quasi-equinoxes. Author's photographs.

Figure 9. Stones 14 and 15. The pillar stone is offset with respect to the regular perimeter of the circle, contrast with the plan in Figure 3. By deliberately choosing shaped rocks, improved with sculptural help, they illustrate female and male imagery. Photographed early morning 25 June 2012 by the author.

3.4. The pillar megalith

Adjacent to the lozenge megalith is the short narrow Stone 15 (Figure 9). It is 1.10 m high, 48 cm wide and 25 cm thick. Total weight is no more than 400 kg. Fahy (1959: 5) writes that it “differs from all surviving stones in the circle and though no tool marks are visible on its surface or angles its rather phallic outline can hardly have been an accidental occurrence”. Fahy (1959: 20) further writes that Stone 15 “seems to have been fashioned into its present shape in antiquity”.

In contrast to its neighbours Stone 15 is oddly located in a forward position relative to Stones 14 and 16. Compare by referring to the plan in Figure 3. This ensured that at the equinoxes (as explained below) the rising sun would shine through the gap between Stones 16 and 17 and illuminate the eastern side of Stone 15, throwing its shadow on to Lozenge Stone 14.

4. Results

Firstly, it is demonstrated how at the five agricultural festival dates of the summer months from the spring equinox to the autumn equinox all the stones from Stone 1 to Stone 5 at sunrise cast shadows in turn upon *the recumbent stone* (Sections 4.1 to 4.3).

This is followed by considering the run of five agricultural festival dates of the winter period from autumn equinox to spring equinox including the winter solstice in which three different stones throw sunrise shadows upon *the lozenge megalith* (Sections 4.4 to 4.7).

It is then demonstrated how at Knowth and Newgrange shadows are similarly cast at the relevant seasons upon appropriate stones (Sections 4.8 to 4.9).

4.1. Drombeg light and shade effects at the summer solstice sunrise: Showing how the shadow of Portal Stone 1 is cast upon the symbols on the recumbent stone

Significantly, portal Stone 1 and the central part of the recumbent megalith (Stone 9) are aligned on midsummer sunrise (Figures 10 and 11), immediately after which the sun casts a weak shadow of the portal stone upon the recumbent. Note that there is a time delay approaching seven minutes as regards the time of the local summer solstice sunrise due to the roof of a single-storey twentieth-century house and vegetation in that direction.

Figure 10. This shows the disposition of the standing stones as seen from the recumbent stone. The time was a few minutes before sunrise on 19 June 2012 with steady rain falling. Author's photograph.

Figures 12 and 13 show the subsequent progress of the shadow as it gains strength while moving along the recumbent stone.

The last photograph (Figure 14) shows the position of the shadow still later when the carvings are illuminated.

In the absence of cloud the sun first gleams over the house roof on the horizon at about 0557. Also, compared with modern times, because of the precession of the equinoxes, the sun would have risen in prehistoric times one degree (equivalent to two solar diameters) farther north along the horizon - and the shadow just after sunrise would have covered still more of the recumbent stone than it does today.

The shadow of the portal stone moves northwards as the sun moves south. The illuminated area of the recumbent stone advances too, eventually reaching the carvings (Figure 14). This last photograph and the next (Figure 15) taken at 0615 show the carvings fully illuminated and the shadow of portal Stone 1 nearer to leaving the recumbent stone.

The plans in Figure 16 explain the situation for 21 June. The days three or four days earlier or later are scarcely different.

Figure 11. This shows where the sun rises at the summer solstice as seen from the recumbent stone. Compare with the stone positions in Figure 10. The emerging sun aligns with the south-eastern edge of portal Stone 1 and a point to the south of the middle of the recumbent stone. In contrast with the prehistoric situation, the sun's arrival is delayed by a few minutes because of an intervening house roof and vegetation. On 19 June 2012 the top of the orb began to appear at about 0557 Irish Summer Time but sunlight was then blocked as rain clouds reached the horizon. Author's photograph.

Figure 12. Photograph looking south-west. On 17 June 2013 distant cloud in the north-east initially blocked the local sunrise, but a little later at about 0600 the sun appeared and the shadow of Portal Stone 1 lay, as shown, across the right half (*i.e.* the north-western part) of the recumbent Stone 9 (unfortunately a small spurious shadow is present too. Contrast with Figure 13) while the shadow of Stone 2 straddles Stones 8 and 9. Note that the carvings on the recumbent stone remain engulfed in the shade of the portal stone. All the while, the sunlit section between the shadows of Stones 1 and 2 shifts steadily northwards (*i.e.* to the right). Author's photograph.

Figure 13. A little later the shadow of the portal stone has moved farther northwards allowing sunlight to start illuminating the carvings on the recumbent stone. (The spurious extra shadow on the latter is still a nuisance although it is not detrimental to the explanation). Author's photograph.

Figure 14. A few minutes later the pecked carvings are completely illuminated - and the sun is brighter and the shadows sharper.

Figure 15. This later picture was taken by the author at 0615.

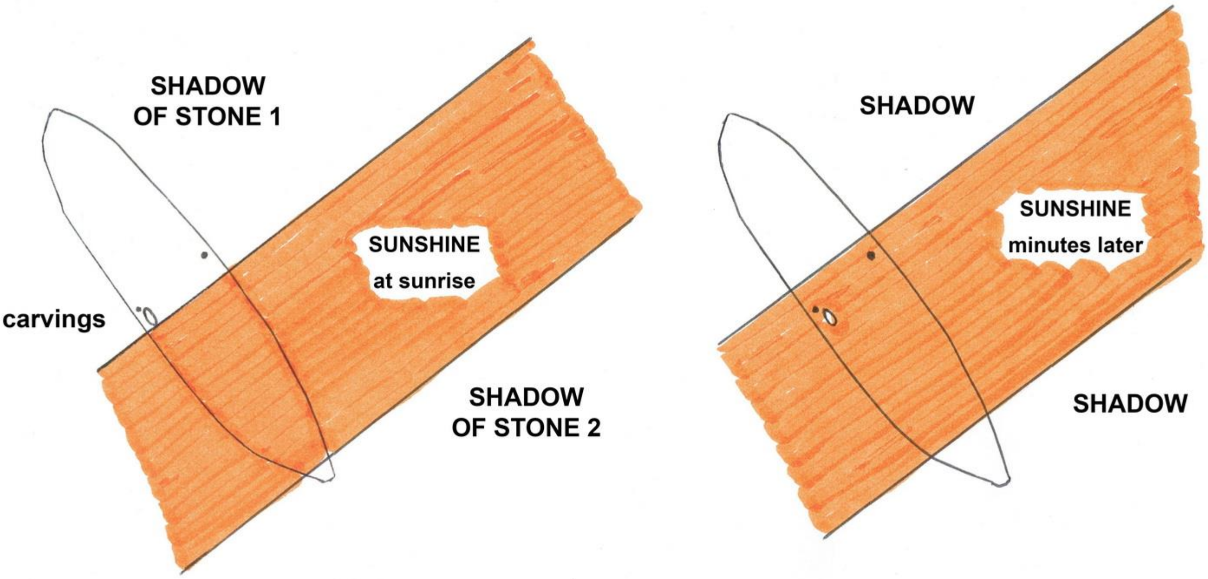


Figure 16. Initially, just after sunrise about a third of the recumbent stone is in sunshine (as in the photograph of Figure 12). The carvings are then wholly in the shadow of the portal stone. Gradually, the sunshine nears the carvings as indicated in the first plan (at left). A little later (second plan) the golden light of the sun reaches and illuminates the carvings. In these plans shadows are shown white.

A possibility that is discussed later (in Section 5) is that this may represent a calendrical fertility union between a male stone and female recumbent. This may have been interpreted as a union between Sun and Earth (the latter represented by the recumbent stone and its principal carving) implying a ‘marriage’ between Sky Father and Earth Mother, in the sense of the *hieros gamos,* so long glorified by the classical Greeks (Burkert 1985). No references to an

Irish or British Neolithic or Bronze Age *hieros gamos* can be cited because these early communities were not literate and left nothing in writing, but the myth is known elsewhere in the world from later ages and up to modern times - including, for instance, tribal stories recounted to anthropologists in India (Das 2014: 31-34) and North America (Krupp 1997; Bender 2017).

4.2. Drombeg sunrise light and shade effects at the equinoxes relative to the recumbent stone: Showing how Stones 4 and 5 jointly cast shadows upon it.

Figure 17 shows Stones 4 and 5 viewed from near the circle centre, and Figure 18 the same stones when observed from the recumbent Stone 9. The angled view in Figure 18 was deliberately arranged by the planners, and provides a lithic V-notch and a vertical crevice in line with the sun rising at or close to the equinoxes.

Figure 19 shows the sun rising through the V-notch.

Figure 20 is a photograph taken a few minutes later when the sun is brighter, having cleared the trees. The vertical shaft of light is still upon the recumbent Stone 9, while the light passing the V-notch is visible *upon* the upper surface of the flat stone close to the carvings. Without the delay caused by trees, the main carving on the recumbent stone would have commenced wholly in shadow before becoming illuminated by the light of the sun.

Figure 17. Stones 4 and 5 as viewed from near the circle centre. Author’s photograph.

Figure 18. The angled view of Stones 4 and 5 when seen from the recumbent Stone 9. Notice the V-notch and vertical gap between the stones through which sunlight passes at the equinoctial sunrises. Author's photograph.

Figure 19. Autumn equinox, 21 September 2012: The sun is seen in the lithic V-notch, rising from behind trees on the horizon in the east. At the same time the sun is shining through the narrow vertical space between these stones. Author's photograph.

Figure 20. Looking west a few minutes after sunrise, the narrow shaft of light from between Stones 4 and 5 falls upon the recumbent stone. Author’s photograph.

4.3. Drombeg sunrise light and shade effects at the May and August festivals of the agricultural year: Showing how Stones 2 and 3 cast shadows upon the recumbent stone

The date on the reconstructed Neolithic-Bronze Age calendar for the end of spring and the start of summer is 6 May (Section 2.2 of this paper). It is Day 137, midway between the spring equinox (22 March, Day 92) and midsummer solstice (21 June, Day 183).

Solar azimuths are the same for 6 August as for 6 May, so it is the same for the Beltane festivities (*i.e.* prehistoric May Day) as for prehistoric Lughnasadh on 6 August.

The principle behind the positioning of Stones 2 and 3 is shown by the plans in Figures 3 and 21, and explains how at sunrise on the indicated dates the principal carving on the recumbent stone begins in shadow (Figure 22) from whose darkness it is released a few minutes later (Figure 23). Note that in prehistoric times, because of the precession of the equinoxes, the sun would have risen rather further north so the shadow of Stone 2 would have fallen on to Stone 9 a little further south.

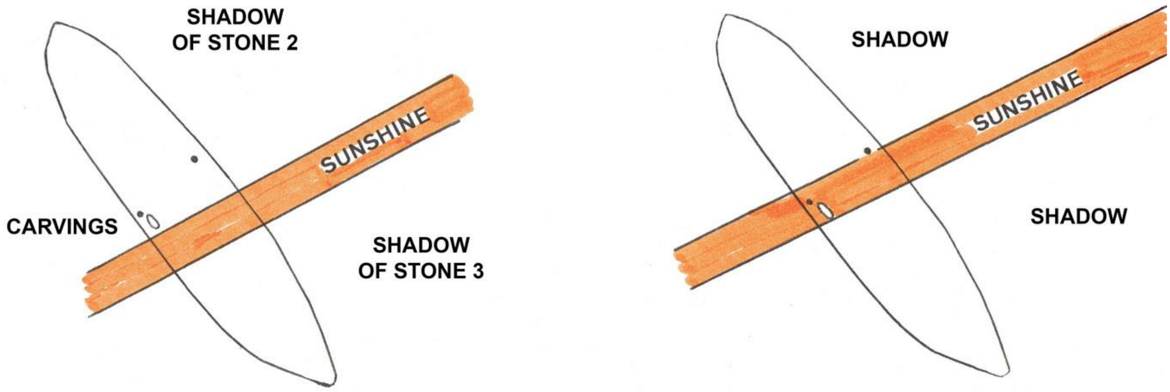


Figure 21. (Left) At Beltane sunrise on 6 May, as on 6 August, the shadow of Stone 2 crucially covers the carvings on the recumbent stone (compare with the plan in Figure 3). (Right) A few minutes later, a golden shaft of light from the moving sun illuminates the carvings. In these plans shadows are shown white.

Figure 22. The shadow of Stone 2 initially engulfed the carvings on the right half of Stone 9 but in moving away to the right it began to allow the sunlight to arrive. The time was shortly after sunrise on 3 August 2013. Author's photograph.

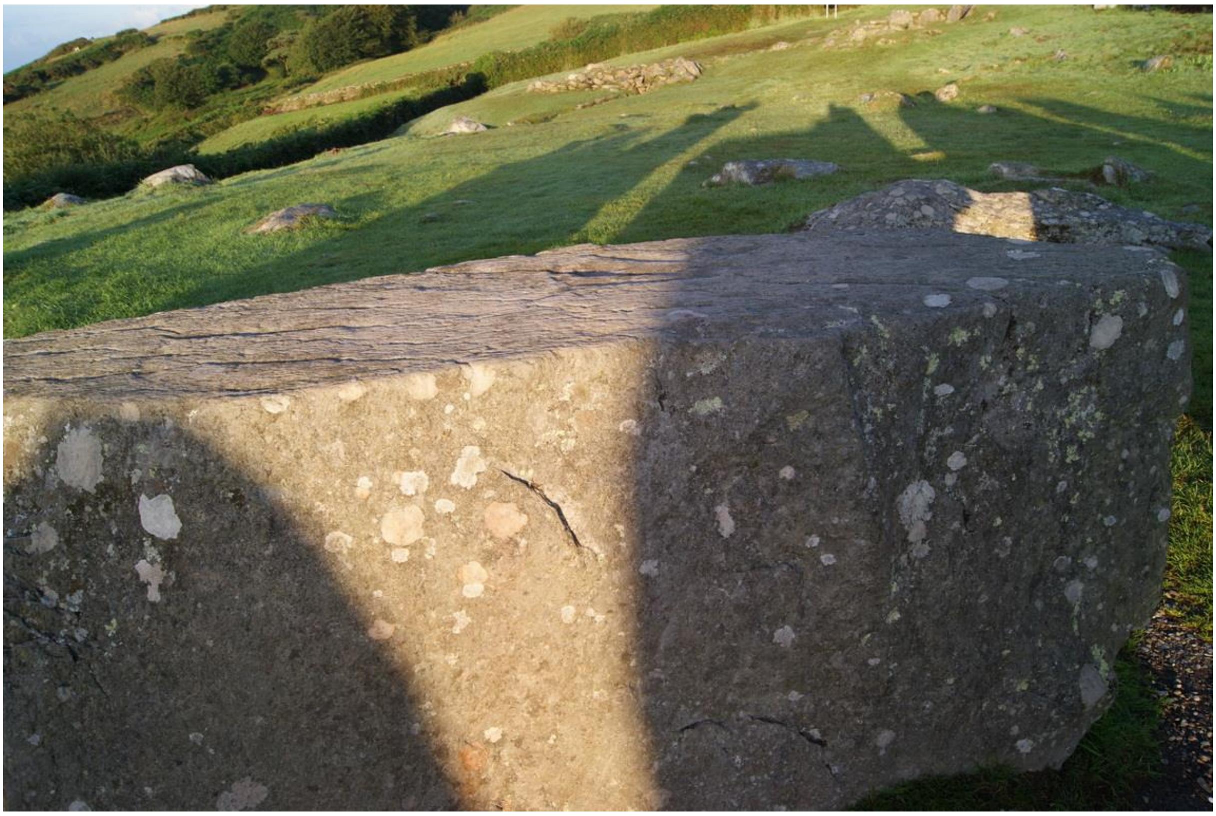


Figure 23. This photograph by the author shows that at 0649 the Stone 2 shadow (at right of picture) has almost cleared the feminine symbol on Stone 9 after which the latter is fully illuminated by the sun.

Figure 23, taken on 3 August, indicates how much the shadow has moved in the several minutes since sunrise. Figures 23 and 24 show the top surface of the recumbent stone at the moment when the shadow is clearing the northern end of the longitudinal carving at 0649.

Figure 24. Another photograph of the same image on Stone 9, also taken at 0649. Author’s photograph.

4.4. Drombeg sunrise light and shade effects at the equinoxes relative to the lozenge Stone 14: Showing how the pillar Stone 15 casts a shadow upon the former.

At each equinox two displays take place simultaneously involving iconic union by shadow and then light. One was described in Section 4.2 (namely, when Stones 4 and 5 jointly cast shadows upon the recumbent stone).

The second is a pairing that repeats, via artistic shadow imagery, the linking of potentially male and female stones in a manner that emphasizes the proposed gender interpretation. This is again a result of deliberate lithic selection as explained in Sections 3.3 and 3.4 following the comments about Drombeg initiated by the excavator Fahy (1959).

At the September equinox (the autumn third quarter day, 21 September) the union heralds the importance of the lozenge stone for the forthcoming winter six months of the year. At the March equinox (the spring first quarter day, 22 March) the union serves to terminate the winter half of the year.

It was explained in Section 2.2 that 21 September is Day 275, being midway between the summer solstice Day 183 (21 June) and the winter solstice Day 1. Day 92 is 22 March because it is midway between the winter solstice Day 1 and the summer solstice Day 183.

Compare the photographs of Figure 25 with the photograph of the same stones (14 and 15) in Figure 9. This shadow effect happens only at the equinoxes. It arises from the special positioning of Stones 14,15, 16 and 17 (refer to the plan in Figure 3) by which the builders contrived to allow the passage of sunlight through a narrow gap created between Stones 16 and 17, to fall upon the offset pillar stone whose shadow unites it with the centre of the lozenge stone. Fahy (1959, 20-21) suspected that the shapes of these stones may indicate a fertility cult in some manner (Section 3.3), and here one can possibly see why.

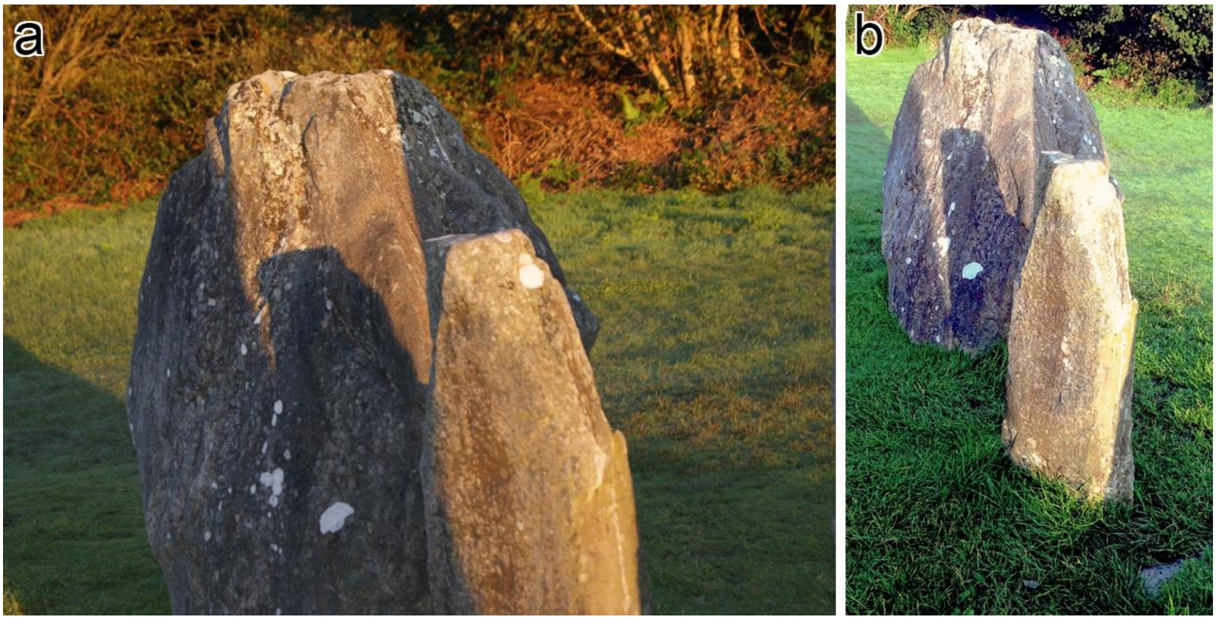


Figure 25. a. Medial union of the sunlit pillar Stone 15 with the lozenge Stone 14 by shadow at sunrise on 21 September 2012. The light of the rising sun passes through the prepared lithic gap between Stones 16 and 17, to reach the offset pillar stone in order that its shadow meets the centre of the lozenge stone. b. Similarly.

Furthermore, as this shadow moves away, the bigger shadow of the tall straight-sided portal Stone 17 replaces it in a central position on the lozenge stone. This portal stone has the ithyphallic carving on it (Figure 8).

4.5. Drombeg sunrise light and shade effects at the February and November festivals of the agricultural year: Showing how Stones 2 and 3 cast shadows upon the lozenge Stone 14

On 5 November 2012 - Day 320 which is midway between autumn equinox (Day 275, 21 September) and Day 1 (the winter solstice) of the 365-day calendar - sunrise photographs were taken. Figure 26 was taken seven minutes after sunrise when the lozenge stone was still almost completely covered by the shadow of Stone 2. A few minutes earlier (as per Figure 27) the lozenge had been completely in shadow.

It would be the same for the Imbolc festival, Day 47, which we know as 5 February - the date midway between the winter solstice (Day 1) and the first quarter day, Day 92 on 22 March.

4.6. Drombeg sunrise action at the winter solstice involving shadows and the lozenge stone

At the winter solstice the sun rises over the sea instead of from behind hills which it does for the seven other festival dates of the year previously discussed.

As regards the action of sun and shadow at the great lozenge stone, prehistoric circumstances differed from the current situation because a major stone is missing from the Drombeg monument. Because this stone was described and measured by Franklin (1903, 23-24), we call it the Franklin Stone. Six years later Somerville (1909) found it to be missing. In 2012 the present author sought to trace it, and found a likely stone only 500 metres away at Drombeg House where it had stood for over a century (Figure 28). Franklin records it, explaining that in the stone circle, "there is a central stone, rather round, 3 feet high and 22 inches wide". These measurements accord with the stone that the author found.

Figure 26. 5 November 2012. This photograph of the lozenge stone was taken by the author standing between Stones 5 and 6 at 0743, seven minutes after sunrise. It is the shadow of Stone 2 that covers the lozenge stone.

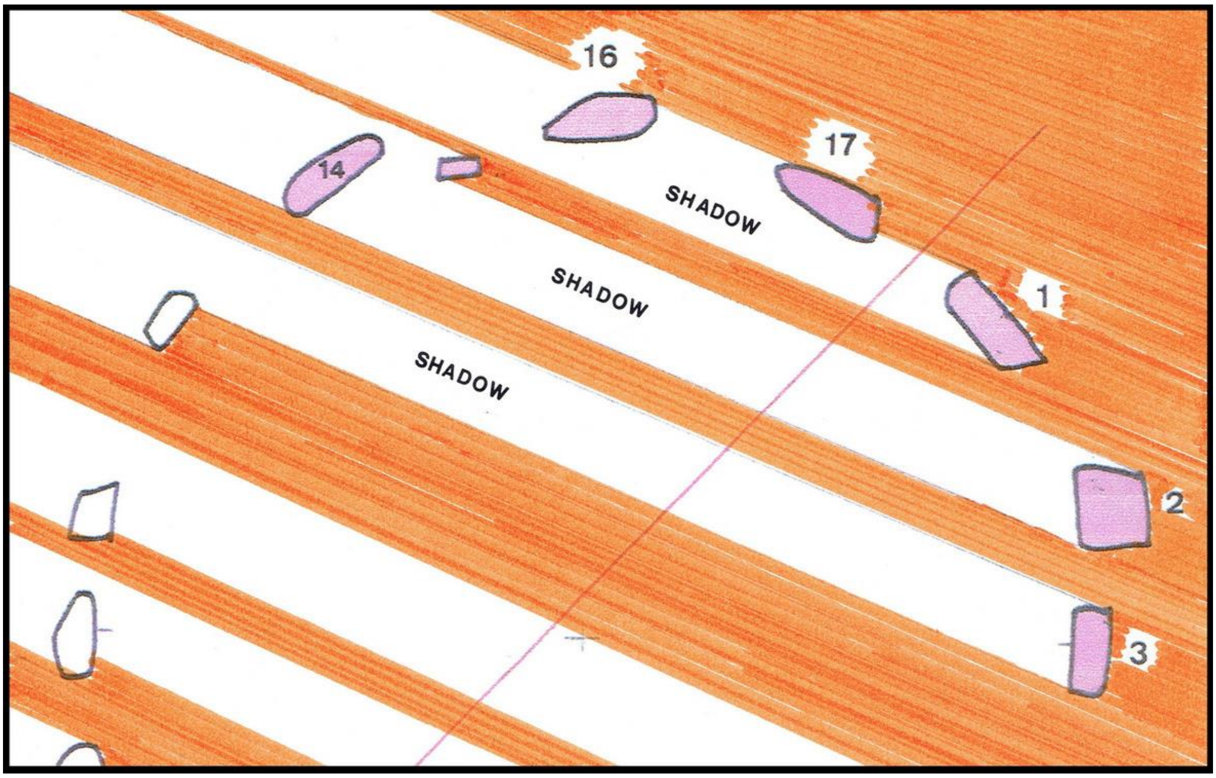


Figure 27. Showing how at sunrise the shadow of Stone 2 initially covers the lozenge stone until a few minutes later when golden sunlight starts to illuminate the latter. In this plan shadows are shown white.

Figure 28. This stone is unusual. It is a black slatey, fine-grained sandstone whose biggest surfaces are colourfully mottled with patches of yellow, orange, red and grey. The colouring is from limonite iron hydroxide (specialist information from geologist Peter Bruck).

This allowed the author to construct a replica and position it for photography at the winter solstice (Figures 29 and 30). From the plan and the photographs one can tell that in midwinter week the shadow of the Franklin Stone encountered the middle of the lozenge stone (Figure 31). Full details are reported in a monograph to be published in 2017.

4.7. Drombeg summary for the eight festival dates of the agricultural year

For the agricultural festivals of the summer months the principal carving on the recumbent Stone 9 receives shadows from a sequence of standing stones.

For the festivals of the winter half of the year it is the turn of the lozenge megalith, Stone 14, to accept shadows. Figure 32 summarizes. Note that at the equinoxes both the recumbent stone and the lozenge stone take part simultaneously. In all cases the critical times of day are the minutes beginning with sunrise.

Inter-stone shadow play is proven for all eight festivals of the ancient calendar. This shows that the 8-festival calendar as known from Celtic times had been in use two millennia earlier. Meaden (2009) had already proved this independently through research on 60 long barrows of Neolithic Wessex.

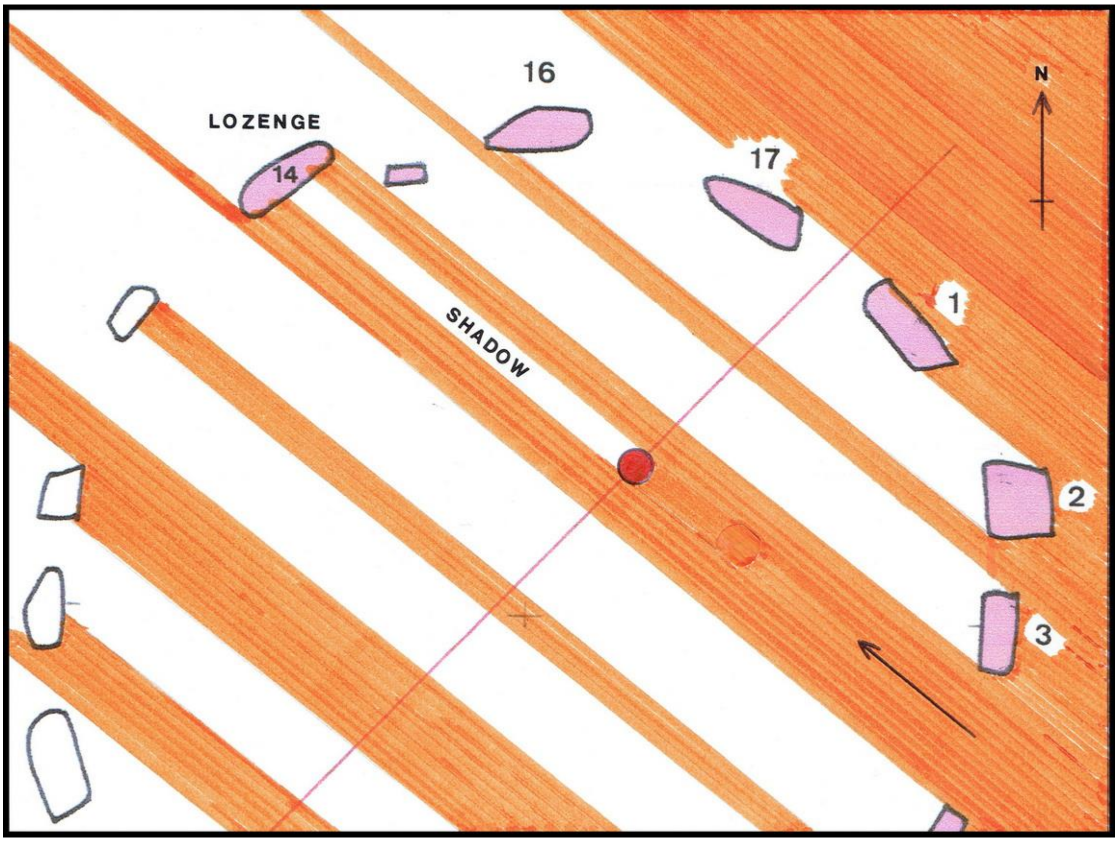


Figure 29. Plan of Drombeg in the light of the rising sun at the winter solstice (in this plan shadows are shown white). The shadows of Stones 3 and 4 both miss the lozenge stone while allowing the sun to shine upon the Franklin Stone (round spot) such that its full shadow arrives in the middle of the lozenge. The Franklin Stone is on the known winter-solstice sunrise line at the point where it crosses the diameter that bisects the recumbent stone and the gap between portal Stones 17 and 1.

Figure 30. A few minutes after sunrise on 17 December 2013 the shadow of the replica of the Franklin Stone falls centrally upon the lozenge stone. Author's photograph.

Figure 31. Sunrise in the week of the winter solstice - one of several test reconstructions made on 17 December 2013. Author's photograph.

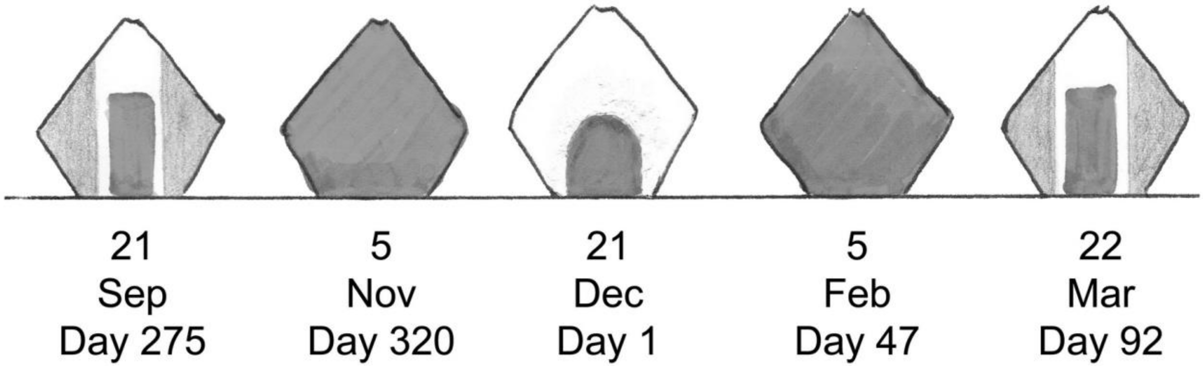


Figure 32. How shadows fall upon the lozenge stone at the festival dates of the winter half of the year.

The precision of the shadow casting shows how exact the dates were intended to be. Thus Imbolc is 5 February (Day 47), not 1 or 2 February. The first day of summer (later called Beltane or May Day) used to be Day 137, 6 May (not the current 1 May). Lughnasadh (Lammas) used to be Day 229, 6 August (not 1 August), and Samhain was formerly Day 320, 5 November (not 31 October or 1 November). The dates for the spring first quarter day (day 92) and the autumn third quarter day (Day 275) were 22 March and 21 September respectively. Celebrations likely often began on the eves of the shadow-casting festival dates.

Sunrise shadows similarly feature at other Neolithic and Bronze Age sites including Knowth, Newgrange, Stonehenge and Avebury. Knowth and Newgrange are treated next, and the others follow in the accompanying paper (Meaden 2016).

It is notable that Knowth supports effects of shadow casting at or close to the spring first quarter and autumn third quarter sunsets as well as sunrises.

4.8. Knowth at and near the equinoxes

The magnificent mound at Knowth covers two stone-lined passages whose directions approximate to, but do not match, the sunrises and sunsets at the spring and summer equinoxes.

A ring of carved recumbent kerbstones surrounds the monument. One fine kerbstone is positioned at each entrance.

Astronomical cosmic knowledge was neatly summarized and stored by what may be termed pictorial intelligence. The author suggests that images and symbols were pecked into stones as a means of safeguarding aspects of basic knowledge that would prove helpful when teaching new generations of aspirants.

In respecting solar behaviour at the approximate equinoxes, passages were built whose directions internally were nearly but not exactly those of equinoctial sunrises and sunsets. In the absence of clocks, lengths of night and day could not be determined with precision. Instead - and because the eight agricultural festivals of the year recur at 45 to 46 day intervals - day-counting would lead to the required March and September dates by tally-stick notching (Section 2.2). Therefore, as regards the approximate equinoxes, what mattered to the planners and worshippers at Knowth were the pre-arranged aspects of the relationship between each entrance recumbent kerbstone and the straight-sided pillar stone standing outside.

4.8.1. Sunsets and sunrises at Knowth

Consider the entrance to the western passage of Knowth (Figure 33). It has been observed (*e.g.*, on 16 September 1980 (Brennan 1983: 101); and by author's friends on 20 September 2013 (private communication)) that towards the equinoxes the light of the setting sun casts a shadow of the pillar stone upon the recumbent stone. As the moments of sunset approach the shadow moves along the recumbent stone towards the vertical medial line inscribed on it.

Figure 33. Western side of the great monument at Knowth with its entrance and passageway. On the optimum dates in spring and autumn the setting sun casts a shadow of the pillar stone on the recumbent kerbstone, its target apparently the medial vertical line carved on the latter. Author's photograph.

It is the same for the eastern facing passage (Figure 34) where there is a recumbent stone with medial vertical line and a narrow straight-sided standing stone that creates union by shadow at the optimum sunrise (Brennan 1983: 103). The sunset-days that mattered to the Knowth community were the days on the 365-day calendar when potentially male-to-female stone-to-stone union was achieved by interactive shadow *at the passage entrances.*

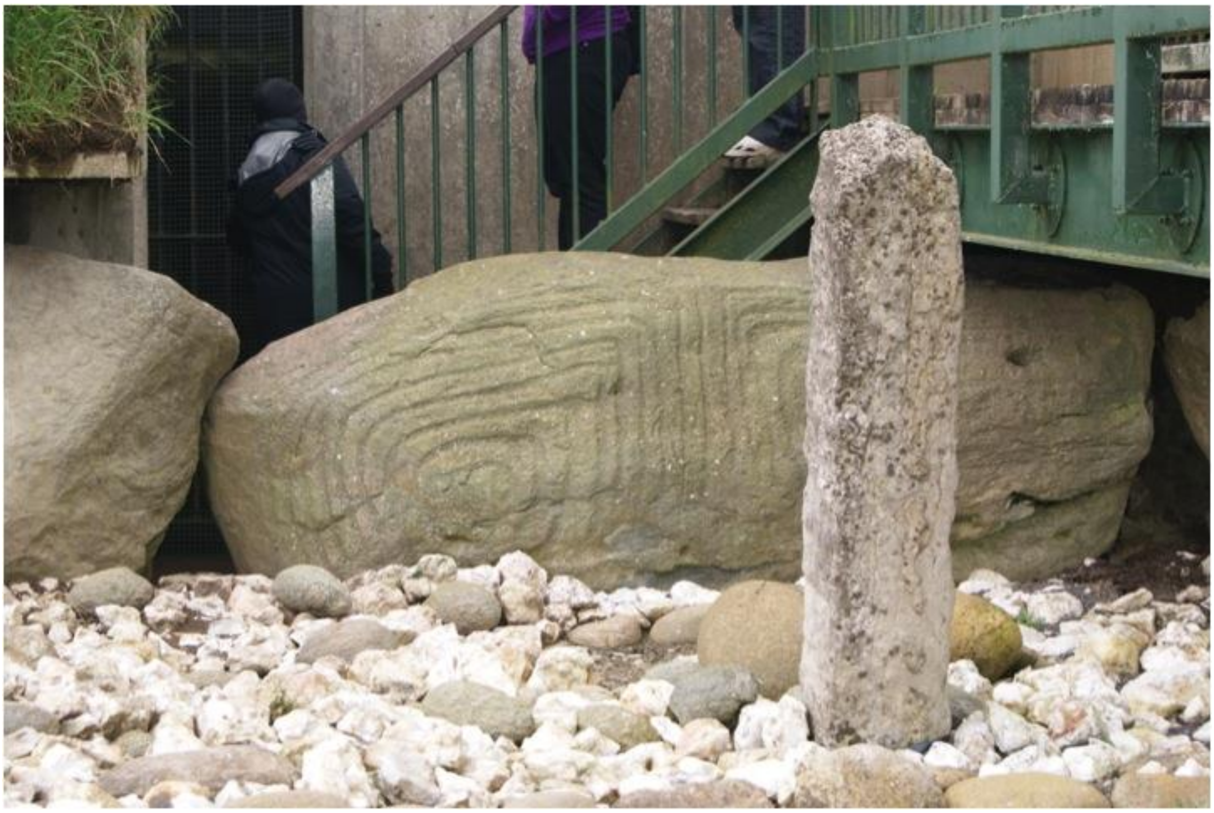


Figure 34. In front of the eastern passage entrance at Knowth lies a kerbstone whose vertical medial line is the target for the shadow of the pillar stone at sunrise on the optimum spring or autumn day planned for it. Author's photograph.

The fact that the passages inside the monument do not duplicate the directions of the equinoctial rising or setting sun is a different matter, and has been addressed by Kate Prendergast (2017).

4.9. Newgrange winter solstice sunrise alignment

Newgrange, too, has a finely carved stone positioned in front of its stone-lined passage (Figure 35). The alignment is to the winter solstice sunrise.

The prehistoric community arranged for a stone, GC1, of the great circle (Figure 36) to stand outside the entrance such that its shadow would fall upon the kerbstone K1 at the entrance. It is well known that in midwinter week the light of the rising sun shines through the roof-box above the entrance and reaches the end chamber (O'Kelly 1982). Optimum is the morning of the solstice. It is possible that an additional aim planned for the first minutes after sunrise was that the shadow of the external stone GC1 would meet and cover lozenges engraved on the entrance stone (at the left in the illustration, Figure 35) and, skirting the edge of the triple spirals, move towards the carved vertical line before leaving the bottom of the stone beneath the carved vertical line. That is what it does now, and perhaps did better in the Neolithic and Early Bronze Age. It is interesting that at Drombeg it was the lozenge megalith that received shadows in the winter half of the year (Figure 32) while at Newgrange carved lozenges come into play again. Note that at Newgrange ground levels may have changed a little since the site was abandoned. In photographs of a century ago the entrance stone is seen lying slightly angled to the horizontal, so some readjustment has since been done.

Figure 35. Newgrange, like Knowth, has a splendid carved recumbent kerbstone awaiting a midwinter shadow from the standing stone GC1 of the great circle. At the solsticial sunrise the shadow of GC1 commences by striking the southern end of the recumbent stone K1 for which calculations suggest that, when in prehistoric use, it covered some of the engraved lozenges at the left and the edges of the triple spirals (author's sketch).

Prendergast (1991) examined shadow play at Newgrange by computer simulation for three stones of the great circle using the date of 2015 BCE obtained by Sweetman's 1984 excavation at GC-2 (Sweetman *et al.* 1985). The results are significant. The shadow casting stones were GC1, GC-1, and GC-2 and the entrance stone, K1, was the receptor. The shadow from GC-2 to the K1 southern-end lozenges is equinoctial, while that from GC-1 corresponds to the midway intercalary dates near the start of November and February. In this way all five agricultural calendar dates for the winter half of the year are accounted for. Possibly at the other side of the great cairn of Newgrange the dates for the festivals of the summer months were similarly acknowledged with respect to stone K52 at sunset.

Kerbstone K52 with its array of lozenges is a fine carved megalith facing sunset at the summer solstice (Figure 37). The suggestion is that in this region there may have been one or more external stones of the great circle whose purpose was to cast a shadow upon the megalith at the summer solstice sunset and maybe on other dates too. Excavation will tell.

Figure 36. Stone GC1, part of the great circle GC, standing outside kerbstone K1 and the entrance passage to the Newgrange monument (author’s photograph).

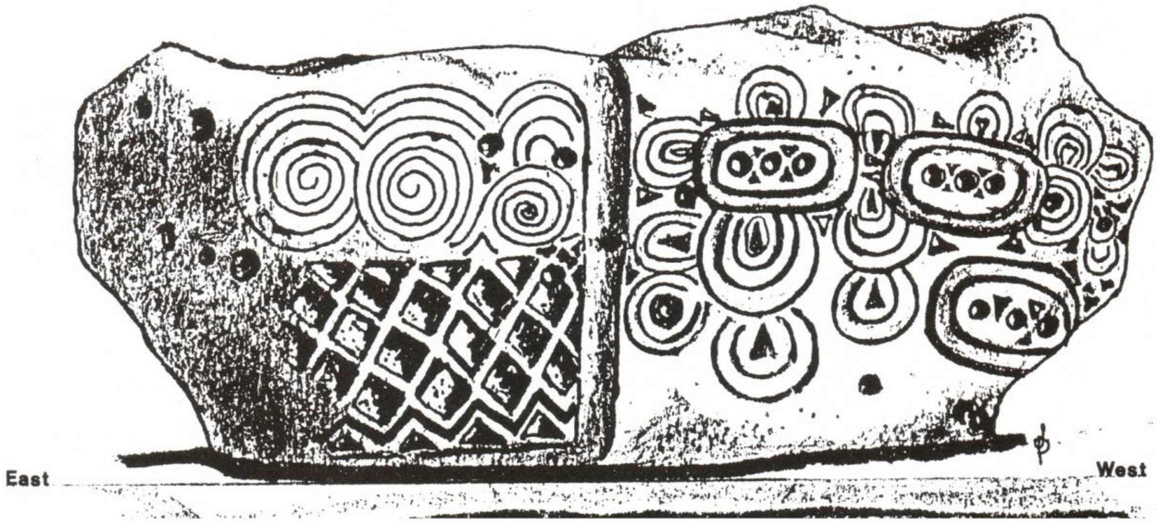


Figure 37. Kerbstone K52 at Newgrange faces the summer solstice sunset. The stone has a line pecked vertically in the middle. This marks the principal axis passing through the monument that follows the line of both the winter solstice sunrise and the summer solstice sunset (author’s sketch).

4.10. North-south lithic union at Templebryan Stone Circle, Ireland

At the recumbent stone circle at Templebryan near Clonakilty which is 17 km from Drombeg, a variation on union by shadow takes place annually at midday on the winter solstice. Figure 38 shows how at noon the shadow from the straight-sided southernmost megalith reaches the quartz stone to its north. The latter is positioned off-centre, much as at Drombeg, in the central region of the circle. For most of the rest of the year this midday contact by shadow does not occur because the noontime shadow is too short.

Figure 38. Templebryan Stone Circle: the southerly stone nearest to the camera is tall and straight-sided. At the left is the broad recumbent stone. At noon on 22 December 2013 the shadow of the southerly stone makes contact with the short squat quartz stone in the central area (author's photograph).

Olwyn Pritchard (2016) has recently reported similar research involving pairs of standing stones in West Wales.

At Templebryan because only five perimeter stones remain, and four or more are missing including at least one portal stone, sunrise analysis has not been attempted.

5. Conclusions

The facts of this research are that the stones of Drombeg were carefully arranged such that at sunrises on eight key dates of the year - spaced at intervals of 45 or 46 days measured from the solstices - the rising sun would cast shadows of preselected standing stones on to one or other of two particular megaliths. One shadow-casting stone, as recorded and measured in 1903 by Denham Franklin, Justice of the Peace and secretary of the Cork Historical and Archaeological Society, was in 1909 reported to be missing when Captain Boyle Somerville visited. It is suggested that the flat-bottomed standing stone found in 2012 near Drombeg House half-a-kilometre away is the missing stone.

In the first minutes after sunrise as the sun moves, the shadows move, and each target of interest - depending on the chosen date for each particular shadow-covered stone - progressively gets illuminated by sunshine of increasing strength.

Examination suggests that two fundamental measures using lithic symbology, either static or dynamic, had been prepared at Drombeg in order to make the impact dramatic and meaningful. One made use of familiar well-loved symbols and shapes, the dynamic one involved cosmic drama.

The first explores the use of lithic images including symbolic outlines and engravings to transmit meanings understood by devoted communities. The symbols are lozenge-shaped stones and pillar-type forms, besides also engraved symbols and natural geological lithic forms. The result is instinctive indications of the feminine and the masculine as Drombeg excavator Edward Fahy (1959: 21, 23, 25) had foreseen. This understanding helps to introduce explanations when it comes to interpreting underlying aspects of the intentions for the stone circle at Drombeg, and the external stones and major kerbstones at Knowth and Newgrange.

For Drombeg, citing Fahy (1959: 21), "Stone 15, whether by design or by accident, presents a curiously phallic outline which, taken in conjunction with the lozenge shaped boulder, and the Avebury analogy, … tends to suggest that at Drombeg we are dealing with another instance of symbolism which by its nature ought to be connected with a fertility cult".

He further emphasizes (Fahy 1958: 25) that “the axial orientation of the circle confirms that the midwinter sunset played a major role in the religious practices of its builders who, if we admit the proffered interpretation of Stones 15 and 14 as male and female symbols, would appear to have practised a fertility cult”.

The present study, beginning in 2012, also considered the watchable dramas that can still be witnessed at Drombeg today, in which solar movement at preselected optimal sunrise dates creates shadows that cross the surface of a carefully positioned lozenge-shaped standing stone and the recumbent stone. Such action is another means by which non-literate societies could express their spirituality.

A few earlier studies have been made that examined effects of sunlight and shade caused by standing stones. In October 1985 the author began the present research on the concept of shadow casting at Stonehenge that would occur at the summer solstice. His first research photographs of shadow casting by the Heel Stone at Stonehenge in the week of the summer solstice were taken in 1986, and the first published solstice-week photographs, dated 1987 and 1989, followed later (Meaden 1992: plates 13, 14 and 15; and Meaden 1997). Meanwhile, unknown to the author until 2015, Prendergast (1991: fig. 5) reported his thesis research study of shadow casting at Newgrange for the five dates that are the winter solstice, the equinoxes and the intercalary dates between. Bradley (1989), rather differently, discussed matters of darkness and shade in the interiors of megalithic-chambered tombs using examples from the south of Brittany. Pasztor *et al.* (2000: 111-113) and Pasztor (2011) also considered aspects of light, brightness and shade in the middle of Stonehenge.

Examined in detail in the present paper are questions arising from the sophisticated design of the Drombeg Stone Circle. Dramatic enchantment proceeds from the shadow motion produced by the light of the moving sun in the minutes after its rising. This follows from the deliberately irregular yet intentional positioning of circumferential stones related to specific calendar dates when a series of shadows at sunrise - cast by straight-sided stones - fall upon one or other of two particular megaliths. This succeeds to perfection on the eight festival dates known from the traditional agricultural calendar. It explains how these calendar dates were encoded into the monument, and are here decoded by the present research.

The story of moving sun and phallic shade unfolds like the drama of a silent movie expressed in wordless mime. By linking stones that represent the sexes, it is proposed that interpretation was through the concept and desire for fertility - an understandable core feature of life for farming communities. The vision would have been unmistakable and heartening for hard-working peoples who toiled the land and suffered the vicissitudes of changing fortune that came with the arrival of seasonal and unseasonal weather.

The results of this research accord with Irish archaeological judgment. Thus Prof. Ronald Hicks (1985: 72-73) writing of astronomical traditions of ancient Ireland and Britain: “In early monuments ... there are tales that associate stone circles and henges with the old cross-quarter days and the solstices, some of these associations being in the form of place names, like the proposal by Ó Ríordáin and Daniel (1964: 16) that the name Newgrange is an anglicization of *An Uamh Gréine*, meaning the cave of the sun.”

Hicks (1985: 79) concluded “this strongly suggests that it was an attempt to symbolize the midwinter sun impregnating the earth so that it would again bring forth food for the people.” As a consequence, and for other reasons involving local mythology, he determined “it is hard to resist the suspicion that the agricultural cycle, and thus the year, the seasons, and astronomy are intimately involved in it.”

Perceptions of a lost spirituality are being rediscovered in the art and religion of the British and Irish Neolithic and Early Bronze Age. The role of the sky and sun in archaeology - archaeoastronomy - has developed increasingly learned rigour recently and provides insights into beliefs and practices of prehistoric cultures as, for instance, in the volume edited by Silva and Campion (2015). It turns out that the Drombeg explanation may lie with the classic cosmological fertility drama which is the *hieros gamos*. Thus, Edward Fahy (1959: 20-21) could be right (Section 3.3) in proposing a connection with a fertility cult. For example, the ancient Irish in creating a situation in which solar energy replaces the initial shadow may have been contemplating "Sun and Earth" as primary divinities much as in India where there is a "three-day fecundity festival celebrated by the Hindus in East India known as Ambabuchi occurring on, or a day later to, the summer solstice". In fact, these festivalgoers hold that "the sunrays are believed to fertilize the Mother Earth" (Das 2014: 31). In another example of surviving age-old festivals Das (2014: 31) relates that there is the annual Sarhul fertility festival of proto-Australoid tribals in Jharkhand that "celebrates the marriage between the mother earth and the father sky" and of "the earth becoming fertile … which is signalled by the blossoming of the Sal tree (*Shorea robusta*)".

What had been intelligently built into Irish and British monuments long ago using symbolic artistry and cosmic motion is being deciphered in the twenty-first century and clarified at various sites through interdisciplinary analyses.

In another paper related findings are presented for Avebury and Stonehenge (Meaden 2017a). A monograph giving more detail about the Drombeg discoveries is awaiting publication (Meaden 2017b). The research continues, in a continual refining of the sunrise observations for the optimum dates of the calendar.

Acknowledgments

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Stonehenge and Avebury: Megalithic shadow casting at the solstices at sunrise

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Abstract:

The paper examines how specific megaliths at Stonehenge and Avebury were positioned relative to others and to particular sunrises such as to produce watchable effects arising from solar movement and resulting lithic shadows. At Stonehenge and environs numerous research expeditions (exceeding 120 that started in 1981) combined with accurate compass analysis, photography and studies of the best plans of the sarsen-stone and bluestone phases have led to explanations for apparent anomalies of stone positioning that have not been clarified before.

Firstly, at the summer solstice in the Late Neolithic the Altar Stone was illuminated by sunshine for the first three or four minutes of the day, following which the shadow of the round-topped Heel Stone was cast into the middle of Stonehenge to reach the Altar Stone. This circumstance continues to be witnessed today. It is a consequence of the Heel Stone being deliberately offset from the Stonehenge axis of symmetry. Again, there is the offset positioning of the anomalous half-height, half-width, Stone 11 that disrupts the otherwise regular arc of the lintelled sarsen circle. It is also a fact that the Altar Stone, although on the midsummer sunrise axis and bisected by it, does not lie perpendicular to the monument's axis but is instead angled lengthways in the direction of the winter solstice sunrise. The same is true of the orientation of the Great Trilithon (as recently discussed by T. Daw). This suggests that the Altar Stone and the Great Trilithon were deliberately positioned this way in order to respect and emphasise an older arrangement in which a midwinter sunrise megalithic setting had been important. Such an arrangement involving the winter solstice sunrise still exists because the shadow of the short round-topped Stone 11 at sunrise appears aimed at the rhyolite ignimbrite Bluestones 40 and 38 - both of which are damaged, fallen and possibly parts of a single original**.** In similar manner the site of Hole G could indicate the former position of an ancestral stone with regard to equinoctial sunrises. Thus, these shadow-casting experiences for sunrise at Stonehenge may have affinities with the proven stone-to-stone casting of shadows for the same significant calendar dates at the carefully examined Drombeg Stone Circle. At Avebury the stones of the Cove in the northern circle together with Avebury's Stone F harmonize likewise at the summer solstice sunrise. Two surviving megaliths in Avebury's southern circle behave similarly. It is discussed whether an explanation in terms of the ancient worldview of the *hieros gamos* between Sky and Earth may be appropriate for Stonehenge and Avebury as it could also be at Drombeg.

Keywords: altar stone; Avebury; Heel Stone; *hieros gamos*; shadow casting; Stonehenge; summer solstice sunrise; winter solstice sunrise; winter solstice sunset

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1. Introduction

Stonehenge in southern England is one of the world's most remarkable and puzzling monuments from the Neolithic and Bronze Age, and is all the more attractive because of its mysteries.

It is a masterpiece of planning and engineering achievement that dates from British Neolithic prehistory and for which the detailed design reasoning is unknown since the loss of the knowledge of the people who built and used it.

In the present research it is the period beginning with the era of the shaped sarsen stones - about 2550 BCE - that attracts initial attention. The biggest stones, in the central area of the re-planned monument, were raised first, and the outer ring of standing stones with lintels followed. In its sarsen form Stonehenge continued in use for about a thousand years before abandonment, after which, in disuse, it suffered from a total lack of maintenance. Stones fell, and visitors wreaked damage by striking off pieces for souvenirs or for what they were led to believe were medicinal or healing purposes (Chippindale 1983: 44, 159; Darvill & Wainwright 2009). And now Stonehenge - which is only minimally repaired - instead attracts the attention of the world for its tumbled beauty and continuing enigma.

What then did it mean, the plan of the 26th century BCE that was devised by a visionary architect of unknown name? This is where the secrets of Stonehenge lie - in the design plan and its relation to the positioning of specific stones surviving from an earlier era of the monument. In assessing these problems it is shown how helpful the research undertaken at Drombeg proves to be, at which stone circle so many perimeter stones survive unharmed that sunrise shadow casting is readily tested on site for all eight traditional agricultural festival days (Meaden 2017).

Only a few studies have earlier examined effects of sunlight and shade caused by standing stones. In October 1985 the author began the present Stonehenge research on the concept of shadow casting at the summer solstice. The first research photographs of a shadow cast by the Heel Stone at Stonehenge in the week of the summer solstice were taken in 1986, and the first published solstice-week photographs (dated 1987 and 1989) followed in 1992 (Meaden 1992: plates 13, 14,15; Meaden 1997).

Meanwhile, unknown to the author, Prendergast (1991: fig. 5) reported his M.Sc. study of winter solstice shadow-casting at Newgrange. Bradley (1989), rather differently, discussed matters of darkness and shade in the interiors of megalithic-chambered tombs using examples from the south of Brittany. Pásztor (2000) and Pásztor *et al.* (2011) considered aspects of light and shade within Stonehenge at the summer solstice. Pritchard (2016) has discovered examples of shadow casting in Wales involving stone pairs between one standing stone and the base of its neighbour. The principal reported events involve the winter or summer solstices or the equinoxes.

As with Ruggles (1997) when writing of Stonehenge, Pásztor *et al.* (2011: 6) remark that attempts to explain the orientation towards the midsummer sunrise is often done from the point of view of observers inside the monument looking outwards along the axis, and yet the small space in the interior allows few observers to participate in this. Pásztor then approached the problem differently "through the experiential act of virtual reality reconstructions of the materiality of a prehistoric monument in its terrestrial and celestial location". Results were interesting as to the spatially changing effects of brightness due to sunlight across the entire interior during the subsequent hour or so. The present author's approach differs by considering what watchers would see from outside when facing the monument and standing in the region of the Heel Stone as the sun rose. By the nature of the Heel Stone's huge shadow moving across the ground with its point penetrating the monument to reach the Altar Stone and then withdrawing and shortening, many dozens of people, if not hundreds, could see this happening. It would be an experience and celebration for an entire community - not just for a few priests standing near the Altar Stone.

Neolithic Avebury, also in Wiltshire, is considered too in a joint effort of trying to learn something of the intentions of the planners of both monuments

2. Methodology

For Stonehenge the most useful survey plans are those in Cleal *et al.* (1995: 28, 234, 344 and loose insert plans). For Avebury the plan that serves best was published by Smith (1965: 205, fig. 70) because it makes use of Alexander Keiller's surveys and excavations. In the preceding paper of the present volume (Meaden 2017) the stone circle at Drombeg in Ireland was analyzed in such detail that the principles of the basic discoveries (shadow casting and stone-to-stone positioning) can now be tested with respect to the Wiltshire monuments.

Attention is directed to features of Stonehenge that appear anomalous insofar as certain stones appear out of alignment, but for which there would have been good reason at the time of planning in the third millennium.

For instance, (1) the huge stone standing outside the monument - the Heel Stone - is slightly off line as regards the rising point of the sun at the summer solstice relative to the symmetry of the main monument. (2) There is the Slaughter Stone in which the puzzle relates to the reason for its positioning before it fell or was felled. (3) Thirdly, why is a stone of the main sarsen circle - Stone 11 - much shorter and less wide than the others, being also round topped and never intended to be lintel-bearing, while standing awkwardly just off the circumference of the linteled sarsen circle? (4) Fourthly, at the focus of the monument, was the Altar Stone standing or did it lie recumbent?

At Avebury similar questions as to the precision of stone positioning arise too.

The answers presented here have reference to the choice of stones by shape and positioning. They result from consulting the best plans, and making many site visits checking the positions of crucial stones in combination with high accuracy compass measurements.

For the latter a military compass marked at one-degree intervals that can be read through its prismatic viewfinder to the nearest half-degree was used. Finally, quality photography was undertaken, initially with a Minolta single lens reflex AF 7000 film camera and latterly by a digital SLR Sony Alpha 290 at numerous sunrises that include the summer and winter solstices and sunset at the winter solstice.

3. Results for sunrise light and shade effects at Stonehenge at the summer solstice

Important stones at Stonehenge are the externally located Heel Stone (Figure 1) and the internally positioned focal stone called the Altar Stone.

Other key stones are the pairs numbered as Stones 1 and 30 that together with the midpoint of the Altar Stone define the axis of the monument. At the same time the Stonehenge axis is the bisector of the nearest section of the long ditch-and-bank avenue. Both the axis and the Avenue correspond with the azimuth of midsummer sunrise as it was 4500 years ago. Figure 2 is a map of the monument.

On the mornings of the week of Neolithic summer solstice, solar phenomena begin when the light of the rising sun streams past the externally located Heel Stone to enter the central portals (Figure 2) and reach the Altar Stone which, as now in the final arrangement of the stones of Stonehenge, lay recumbent. After a few minutes the moving sun - as viewed from the centre of the monument - becomes eclipsed by the standing Heel Stone (Figure 3).

During the eclipse period (3 to 4 minutes long) the moving sun throws the phallic shadow of the Heel Stone into the Stonehenge monument (Figure 4). There, on the ground at the focus of the monument, the shadow encounters the recumbent Altar Stone (or in a still earlier age a possibly standing Altar Stone) (Meaden 1997; 2012a: 76). This union between rising sun and recumbent Altar Stone is an event timed for midsummer week, and in clear sky conditions has taken place every year of the last 4500 years. Note how this compares with events taking place at the summer solstice in Drombeg (Meaden 2017). It was similar at Avebury (compare with Sections 4.5 and 4.6 below).

Figure 1. The Heel Stone stands outside the monument beyond the henge ditch and bank. (Photograph by the author.)

The Altar Stone, being a rich mica-filled megalith, would sparkle in the sunshine if freshly scraped or wetted. Midsummer week is the supreme time of year when the light of the rising sun can reach it. By contrast, in the week of midwinter at sunset only a narrow beam of sunlight can reach a small part of the *back* of the Altar Stone, having passed between perimeter Stones 15 and 16 and the narrow gap between the stones of the Great Trilithon 55 and 56 (Figure 2).

Note that Atkinson (1979: 211-212) reported that one end of the Altar Stone had been obliquely bevelled. This suggests that, although now lying flat (Cleal *et al.* 1995: 29; Daw

2015) and therefore not in need of a stone-hole if it was expressly positioned to be prone, then in some period of the monument's history earlier than the final phase, the stone may have stood upright (Atkinson 1979: 211-212). Cleal *et al.* 1995: 188) consider a possible stone hole for it.

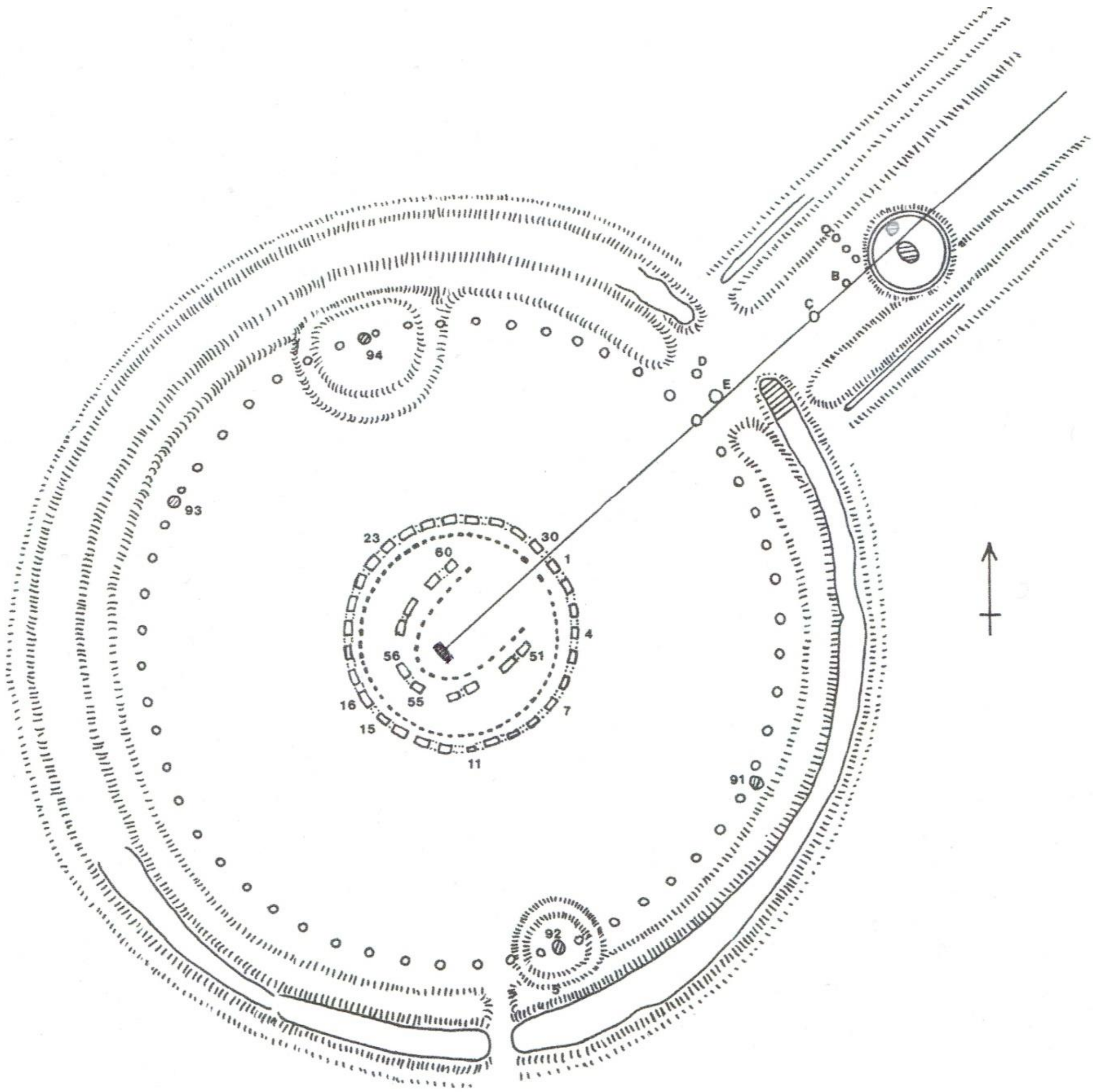

Figure 2. Plan of Stonehenge as it may have been in its final phase if construction had been fully completed. Note how the stone pair numbered 30 and 1 together with the midpoint of the recumbent Altar Stone define the axis of the monument - as does the bisector of the Avenue on the final approach to Stonehenge. Yet, the Heel Stone which is 80 metres from the centre of the monument is slightly offset from the Stonehenge axis. Also note that the Heel Stone has a ring ditch around it that cuts an earlier, therefore older, stone hole (Pitts 1981: fig. 1; Cleal *et al.* 1995: fig. 79) which is *farther from* the monument than is the Heel Stone. This older stone hole (attributed to a missing Stone 97) is sketched lightly on this plan on the inside edge of the Heel Stone circle. (Author's drawing based on published plans including Stone (1924: plate 3), excavator Hawley (1928: plate 23), Atkinson (1956: fig. 8, facing p. 204) and Pitts (1982: 77)).

Also note that 4500 years ago, because of subsequent changes in Earth's ecliptic due to the precession of the equinoxes, the sun rose farther north than it does now by the width of two solar diameters, or one degree of arc. Figure 3 partly reflects this.

Figure 3. Reconstruction of how the Neolithic rising sun appeared when observed from ground level on the Stonehenge axis in the middle of the monument. The Heel Stone stands 4.7 metres high in its present leaning state. If restored to the vertical, it would stand nearer 5.2 m high (Atkinson 1978: 51-52). Photograph by the author.

Figure 4. Schematic illustration of how Stonehenge was intended to function in its final phase. The Heel Stone shadow reaches the recumbent Altar Stone - as it still does every midsummer week in clear sunrise conditions. Note, too, that both the Great Trilithon and the Altar Stone are skewed slightly through 10 degrees because that is how the Altar Stone and the standing Great Trilithon Stone 56 are now (see Section 4.1). (Painted by Maureen Oliver with publishing permission.)

The view that the expectant community had, waiting outside the monument under conditions of a bright rising sun, is demonstrated by Figure 5. Many dozens of spectators could witness and appreciate the phenomenon even if weakened by veiled sunshine.

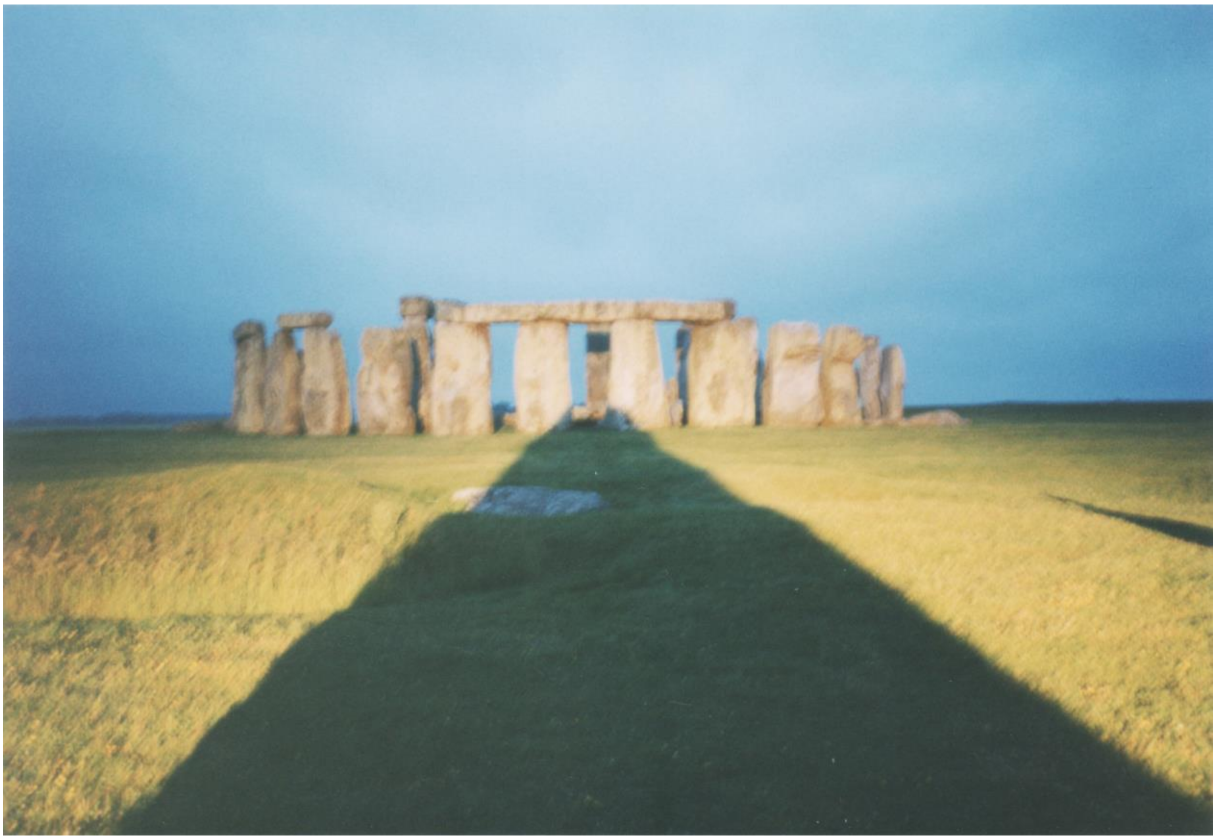

Figure 5. The ingenuity of the ancients: In midsummer week the sunrise shadow of the phallic-shaped Heel Stone enters the Stonehenge monument and reaches the focal stone called the Altar Stone. This is a reconstruction photographed by the author sitting with his back against the Heel Stone.

On many occasions the shadow cast by the full orb at sunrise can be feeble at first. For there to be a strong shadow from the start there must be no clouds on the north-eastern horizon, no mist or fog, and preferably a dust-free atmosphere as may happen following a period of rain. Usually, eyewitnesses watch a rather weak shadow entering the monument (even if too feeble for good photography) but *any* shadow would have been good enough for the ancient British devotees.

As the sun rises, the shadow darkens as it gains strength. Figure 6 gives an example in which the shadow, having penetrated the monument minutes earlier, is on its way out.

From the Heel Stone the author has seen the shadow fully enter the monument even when it was too weak to photograph well. Other witnesses have been inside the monument and watched the shadow reaching the Altar Stone. Snailum (1985) wrote, “We saw that the tremendously long shadow cast by the Heel Stone and passing through the central trilithon just, but only just, finished exactly upon the altar where we were sitting”.

Simon Banton (English Heritage) viewing from inside Stonehenge reported (private communication), “I’ve observed the shadow penetrating the circle (in 2013) and I’ve calculated that it would reach the Altar Stone under perfect conditions.” Two friends of the author in solstice week 2015 actually filmed the shadow when its tip was fully inside the monument (video film to be published).

Note how this compares with events at the summer solstice at Drombeg in Ireland (Meaden 2017: fig. 12, 16) and the Avebury Cove (this paper, Section 4.5).

Figure 6. This photograph was taken a few minutes after sunrise on 19 June 1989 by the author standing on the Stonehenge axis. Shortly before this, the entire peak of the shadow was inside the monument between portal Stones 1 and 30. A little later as detumescence progresses and the shadow, now darker, moves to the right and is on its way out, a part is still inside while a part falls upon portal Stone 30.

The stone known as the Slaughter Stone lies prone inside the circular bank on the Stonehenge axis (refer to Figure 2 where its position is close to and just south of Hole E). In lying flat this stone has no relevance to the functioning of the present Stonehenge monument as the stones are now. The stone's function was probably purposeful in an earlier period of Stonehenge's prehistory. This matter is discussed in Section 4.4.

4. Results for sunrise phenomena at Stonehenge at the winter solstice

There are compelling reasons to suggest that at an earlier period in the story of Stonehenge there had been a deliberate arrangement that recognized the observation of the winter solstice sunrise in relation to lithic selection and the positioning of certain stones.

4.1. Inbuilt alignments at Stonehenge to the winter solstice sunrise

Firstly, the Altar Stone lies prone and in alignment with the direction of midwinter sunrise. Its position is not at right angles to the Stonehenge axis as might have been expected. Because also the axis of the summer solstice sunrise bisects the recumbent Altar Stone, it suggests that the stone was deliberately set like this - at least in the final phase of use of the monument. This has been explained independently by Daw (2015). The fall of Stones 55 and 156 that now lie upon the Altar Stone did not knock it from a standing position. Instead they fell upon where the slightly-angled Altar Stone was already lying flat in the turf where it is now (Figure 7).

Secondly, the still-standing Great Trilithon Stone 56 appears to be set parallel to the recumbent Altar Stone (Daw 2015).

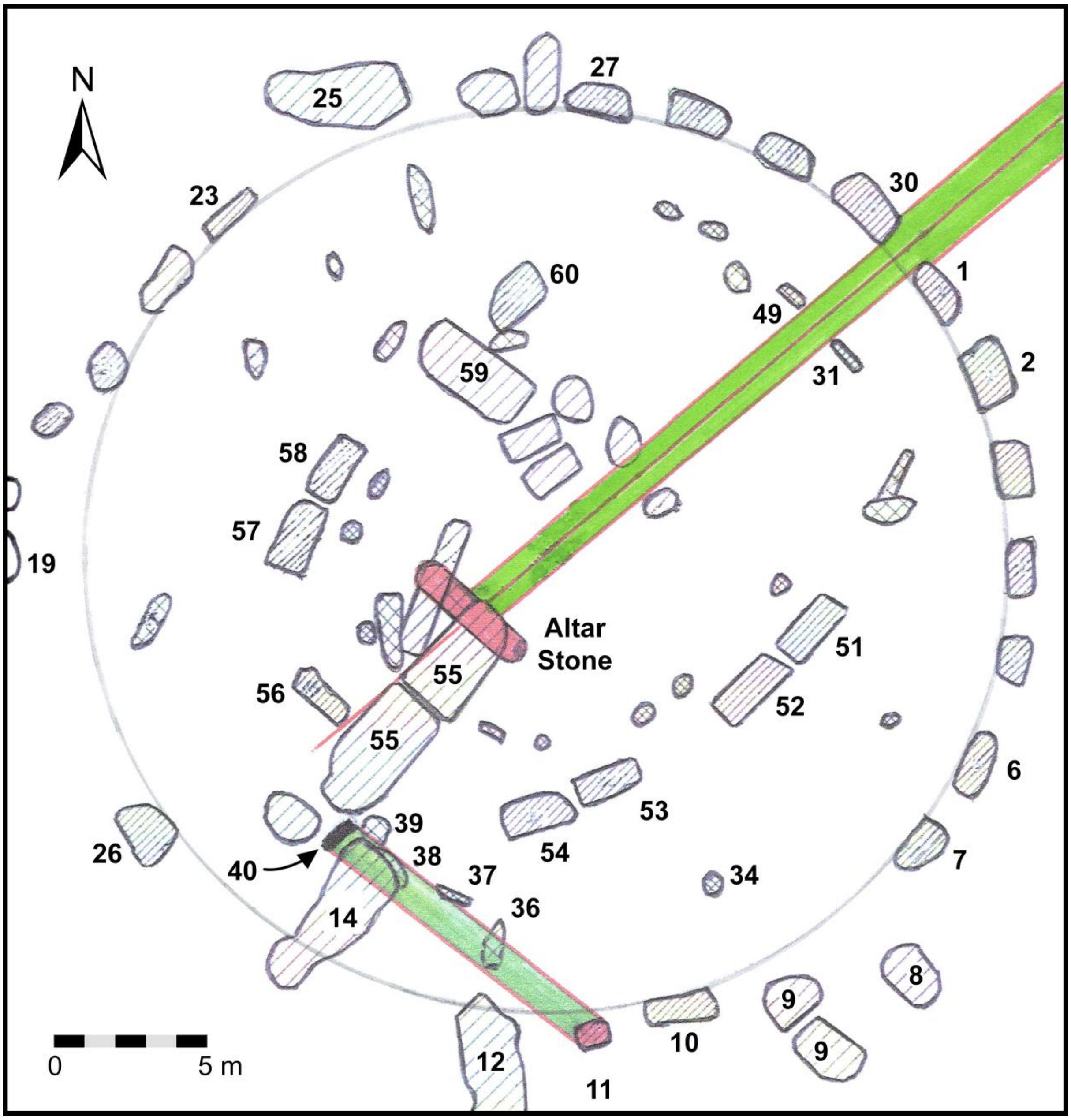

Figure 7. Two shadow casting situations are suggested in this figure. (1) The shadow from the Heel Stone that reaches the recumbent Altar Stone at midsummer sunrise; (2) the shadow from the short squat Stone 11 (at the south in this plan) with its winter solstice sunrise alignment to a stone at or near the present position of broken Bluestone 40 (shown black). Notice that the long recumbent Altar Stone is parallel to the latter line, and not at right angles to the midsummer sunrise axis of Stonehenge. The same applies to the Great Trilithon Stone 56. (Author's diagram, after Cleal *et al.* 1995: 27) with the discussed shadows introduced).

Thirdly, there is another alignment between Trilithon Stones 57 and 58 (Figure 8) that just misses Stone 53 and Stone 8 such that at the midwinter sunrise sunlight passes through prearranged gaps (Freeman & Freeman 2001) as seen in the photograph taken on 27 December 2014 and follows a line that is close to and parallel to the recumbent Altar Stone. Simon Banton (2012), who told the author about this, took similar photographs in 2011 and 2012.

Fourthly, there is the major circumstance that involves the enigmatic half-size, half-width Stone 11 whose purpose has never been explained.

Figure 8. In the week of the winter solstice the rising sun shines through prepared gaps between the sarsens in a direction that is close to and parallel to the recumbent Altar Stone. (Photograph by the author, 27 December 2014.)

4.2. Reasons for proposing that the half-size Stone 11 is a survivor from an earlier stone arrangement

At the place where a tall sarsen orthostat - flat-topped with tenons - should stand on the main 30-stone outer ring, there is instead a round-topped sarsen at half the height expected for stones of the linteled sarsen ring. It is also half the width and less thick. This dwarf is numbered Stone 11 (Figures 9 and 10). Its round top is not so different from that of the familiar Heel Stone when regarded along the Stonehenge axis in the direction of midsummer sunrise, as in Figure 3. Hence, it is suggested that Stone 11 may have functioned similarly to the Heel Stone but with respect to a winter solstice alignment if the stone is a survivor from earlier times.

The 30-stone ring of orthostats with 30 lintels could never have been completed in the presence of the short Stone 11 if the latter was already present for being ancestral from an earlier stone arrangement (to which Hole G and the Slaughter Stone may also belong, see Section 4.4). This can explain why the later-built arc of the perimeter of the main sarsen circle is offset relative to the position of Stone 11 (Figure 7). It recalls the singular situation known for Drombeg in which the positions of a pillar stone and a lozenge-shaped stone are both intentionally staggered (and Drombeg's circumferential Stone 16 also subtly shifted) in order to allow a sunrise shadow of the pillar stone to fall upon the lozenge stone at the equinoxes (refer to Meaden 2017: Sections 3.3, 3.4).

Hence the major question is whether the Stonehenge builders set up an additional stone such that the shadow of the round-topped Stone 11 would fall upon it at or soon after the winter solstice sunrise. If so, has such a special stone survived the turmoil of later millennia?

Study of the plan in Figure 7 combined with the line of the photographed shadow of Stone 11 taken near the winter solstice of 2014 (Figure 11) suggests possibilities.

Figure 9. The short rounded Stone 11 (next to the bigger Stone 10) stands slightly offset from the true perimeter of the outer ring of tall standing sarsen stones (compare with the plan in Figure 7) and is only half their height and half their width. (Photograph by the author an hour after sunrise on 31 August 1996.)

Interior to the ring of sarsen stones (Stones 1 to 30) is a bluestone ring (Stones 31 to 49). Bluestone 40 - but now damaged - is at right angles to the circumference of the bluestone circle, while also being aligned to Stone 11 as regards the winter solstice sunrise. This ensures that the shadow of Stone 11 would make union with the waiting bluestone (an intention inferably initiated in an earlier phase of Stonehenge) (Figure 6).

The bulk of the shadow of Stone 11 misses the pointed base of the bluestone circle's fallen Stone 36 and standing Stone 37 to arrive at a place where badly damaged bluestones 38, 39 and 40 lie crowded awkwardly together. Why so close (Figure 7)? Bluestone 38 lies flat beneath the weight of the huge fallen sarsen Stone 14, and almost touching Bluestones 40 and 39. Bluestone 39 is spotted dolerite. Bluestones 38 and 40 are rhyolite ignimbrite, the only examples known for standing stones at Stonehenge (Cleal *et al.* 1995: 28; John 2011), so it may be that they are parts of a single ignimbrite stone broken by the fall of sarsen Stone 14. A tentative proposal is that in earlier times a single bluestone stood alone at this place in order to function solsticially with the shadow of sarsen Stone 11, and that later when the stones of the outer bluestone circle were introduced it was left in position while ensuring that the later Bluestones 36, 37 and 39 would not obstruct the shadow line from Stone 11. Its former standing position may be beneath the fallen sarsen where Bluestone 38 now lies. Hence, just as a particularly special rock type (a micaceous greenish sandstone) was chosen for the mineral to serve as the Altar Stone at the summer solstice, so might this rhyolite ignimbrite tuff have been selected to do duty at the winter solstice.

Figure 10. The enigmatic Stone 11 (leaning, at left of the picture) stands next to Stone 10 which is a normal stone of the outer sarsen circle. This emphasizes its anomalous shortness and rounded top. The nearest orthostats at the right are Stones 6 and 7. Lying battered and broken on the ground between standing Stones 7 and 10 are sarsen Stones 8 and 9 having fallen outwards. (Photograph by the author, 25 August 1997)

Figure 11. After a reddish sunrise on 27 December 2014, the shadow of the round-topped Stone 11 (the foreground stone) falls in the direction where part of Bluestone 40 lies just beyond the prone sarsen Stone 14 that has toppled inwards on top of the broken Bluestone 38. The latter and Bluestone 40 may be parts of what used to be a single stone. Compare with Figure 12. (Photograph by the author.)

Excavations are warranted because none have been done in this part of the monument that embraces the settings of sarsen Stones 10, 11, 14, 15, and Bluestones 37, 38, 39 and 40 (Cleal *et al.* 1995: 194-195, 197, 220-221). It could have been partly out of respect for an ancestral situation that Stone 11 was left in place while the ring of linteled sarsen stones was being raised so that an ancient winter solstice bonding by shadow would continue until the last moment. But the linteled ring of sarsen stones was never completed, so the short round-topped stone remained.

The photographs of Figures 11 and 12 taken shortly after sunrise a few days after the solstice in 2014 show the shadow of the round-topped Stone 11 crossing the fallen Bluestone 36 and part of the fallen sarsen Stone 14. However, if Stone 14 had not fallen, the said shadow could instead have directly met a rhyolite ignimbrite bluestone standing at or near this place.

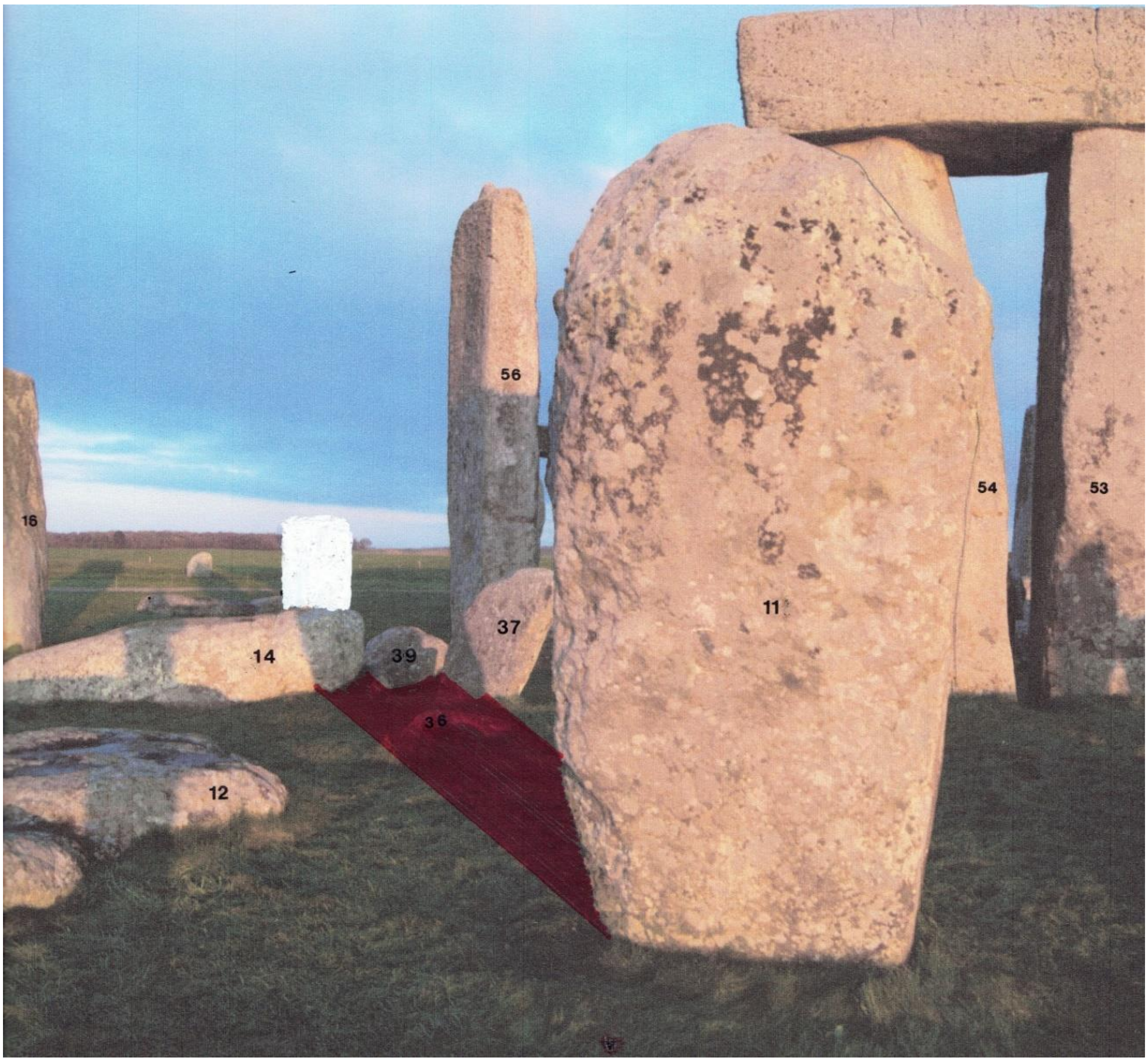

Figure 12. To help understand Figure 11 the photographed sunrise shadow of sarsen Stone 11 has been darkened and the position of a standing stone inserted at the place where Bluestone 40 is in the ground. It is shown white for emphasis and clarity. The big sarsen Stone 14 has fallen from the left and lies across Bluestone 38 which may itself be part of a once-single bluestone because both 38 and 40 are rhyolite ignimbrite, the only examples known at Stonehenge. The shadow of Stone 11 crosses the fallen Bluestone 36, grazes the upright Bluestone 37, and then crosses the broken Bluestone 38 (most of which is beneath Stone 14) and the fragment numbered Bluestone 39. Bluestone 36 lies prone has fallen from the right (compare with the plan in Figure 7 and the photograph of Figure 11). Note that this photograph was taken six days after the solstice and a few minutes later than sunrise, so this situation roughly corresponds to the position of shadows for 21 December just after the solstice sunrise. (Author’s photograph).

Compare this photograph with the plan in Figure 7 and the explanation in Figure 12. Shown white in Figure 12 for clarity of expression is a standing stone such as could be a receptor for a winter solstice shadow cast by the round-topped anomalous Stone 11 which, as explained, is not a member of the great linteled sarsen circle. In the picture the ignimbrite stone (38 plus 40) is pictured as if standing at the current position of fallen Bluestone 40 and yet, as explained above, its original stonehole may lie beneath the fallen sarsen Stone 14 close to the position of fallen Bluestone 38. These tentative suggestions can only be tested by excavation.

4.3. Results for solar phenomena at Stonehenge at the winter solstice sunset

In midwinter week the sun sets in the opposite direction to that of sunrise at midsummer. Observers today when standing on the Stonehenge axis outside Stonehenge at the north-east can watch the sun setting as demonstrated by the photograph in Figure 13, where nowadays the sun comes into sight just before the tallest stone, Stone 56, is reached. However, 4500 years ago the companion trilithon stone, number 55, was also standing. The sun could not then be seen until the last minute of sunset when it appeared briefly between the pair of vertical megaliths 55 and 56.

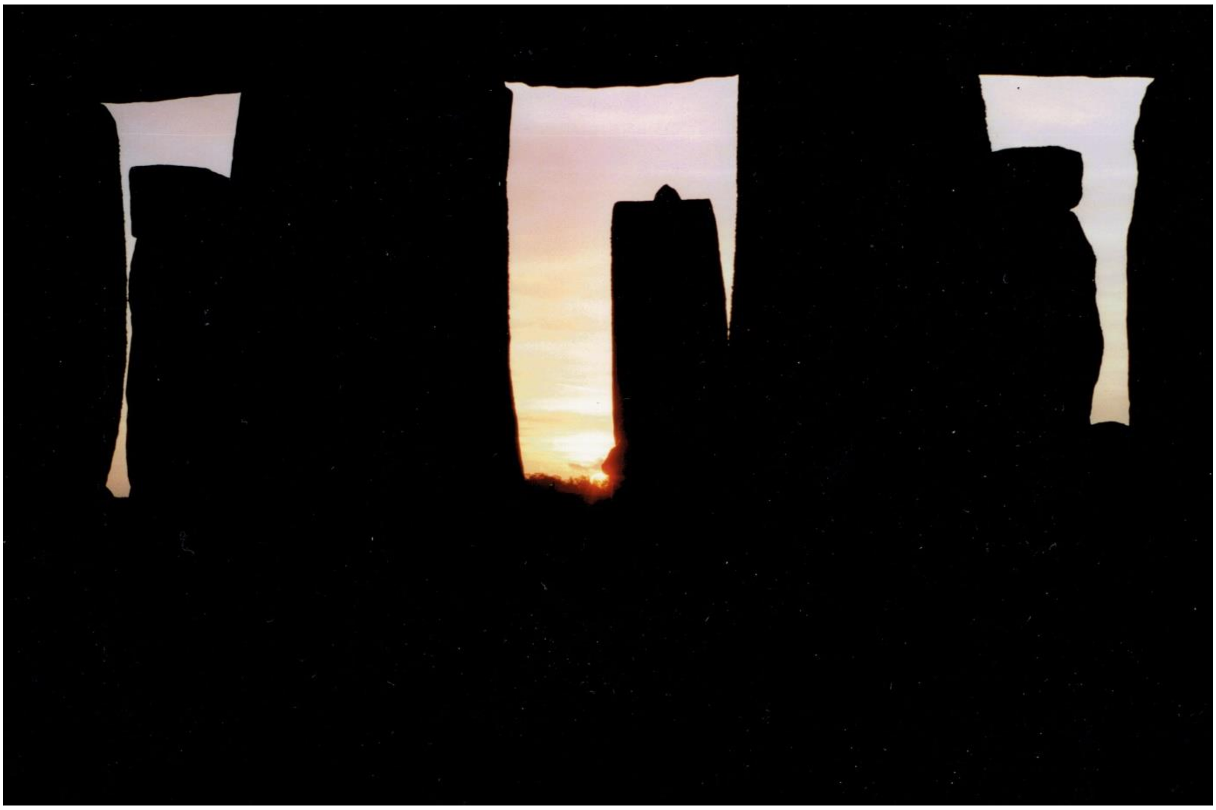

Figure 13. View from the Heel Stone of the sun setting between Stone 56 and the now prone companion Stone 55. (Photograph by the author.)

4.4. Further results for solar phenomena at midsummer sunrise: a possible meaning for the Slaughter Stone

The fallen stone known as the Slaughter Stone (Stone S in Figure 14) lies prone alongside and south of Stonehole E (Figure 2) within the perimeter of the grand circular ditch and on a line from the Heel Stone to the Altar Stone. Cleal *et al.* (1995: 284-287), in considering the situation resulting from Hawley's excavation in this area, concluded (Cleal *et* *al.*: 287), “We do not know the exact location of the Slaughter Stone’s original hole beneath its present site”.

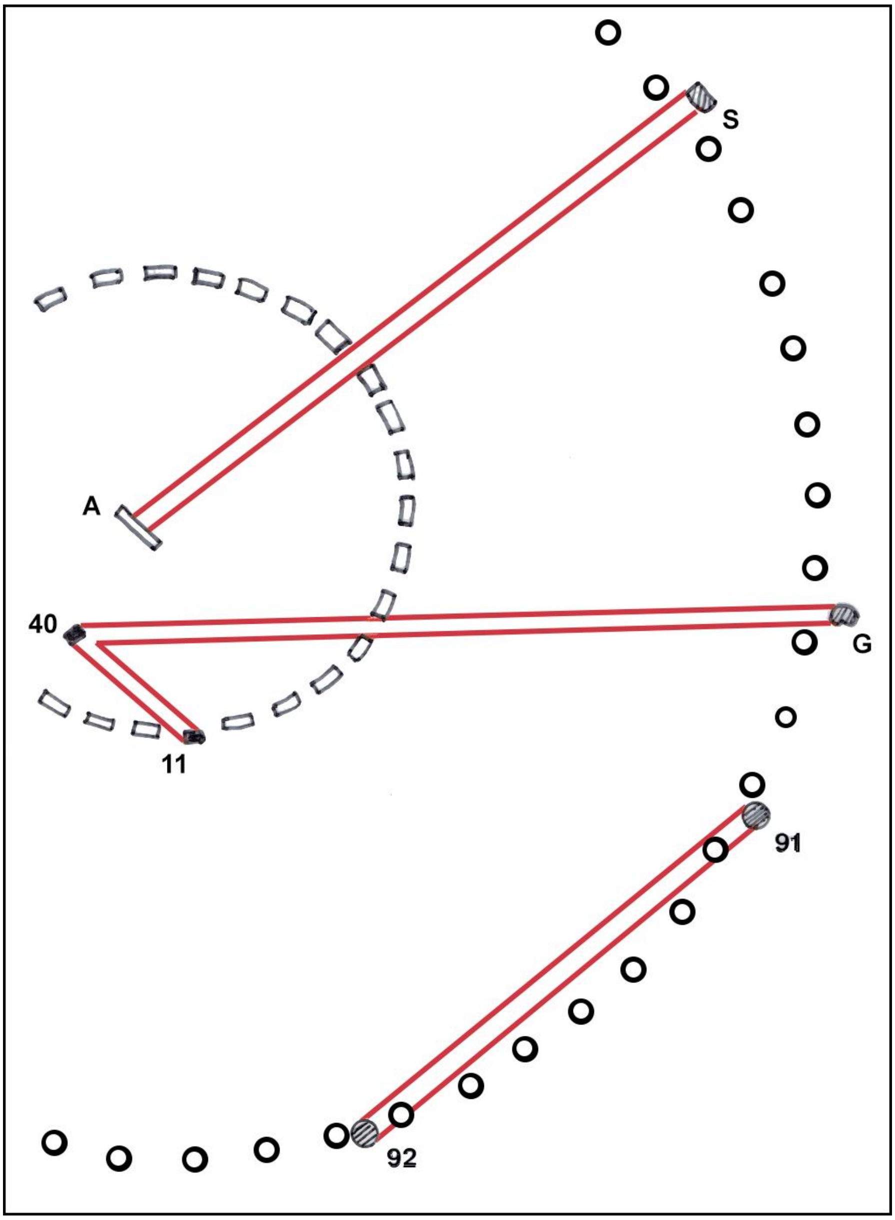

Figure 14. The plan shows the positions of seven stones or stone-holes and arcs of the Aubrey Hole circle and sarsen circle. The long axis of the Altar Stone A is towards the winter solstice sunrise, and is not, as explained in Section 4.2, exactly perpendicular to the Avenue and the summer solstice sunrise. Included is the line of shadow cast by Slaughter Stone S when standing. Additionally, the plan shows how a shadow from the short round-topped Stone 11 would fall upon the ignimbrite Stone 40/38 at midwinter sunrise and how a shadow from a stone at Hole G would cast an equinoctial shadow upon the same stone (refer to text in Section 4.2). The two Station Stones, 91 and 92, that relate to the direction of the winter solstice sunset and midsummer sunrise are included too. The same would apply to Station Stones 93 and 94 (not shown). (Drawn by the author).

The Slaughter Stone has no relevance to the working of the present-day Stonehenge monument, but one may suggest that it could have been positioned at some stage in the history of the monument to function as a midsummer sunrise shadow maker if a decision had been made that on too many occasions at solstice sunrise the shadow from a pre-existing Heel Stone was disappointingly weak.

As for the Heel Stone, Cleal *et al.* (1995: 274) discuss Bronze Age Beaker sherds found at the side of its stone hole. This leads Cleal *et al.* (1995: 467, 578) to propose a date for the Heel Stone as possibly belonging to Phase 3a (which is a date range of a century or so starting from 2550 BCE) while nonetheless allowing that its date could be earlier. Indeed, the potsherds only provide a *terminus ante quem* for the hole of the Heel Stone.

The length of the Slaughter Stone is 6.2 m but if its hole lies beneath the prone stone the hole's depth is unknown. The depth will not necessarily be similar to that of nearby Stonehole E which is 2.0 m (Hawley 1921: 36).

The distance of the Slaughter Stone (Stone S, Figure 14) to the Altar Stone is 45 m. This is much less than the distance of 80 m for the 5.2 m-high Heel Stone (for its height refer to the caption of Figure 3). Hence, standing upright in its hole the Slaughter Stone would cast a stronger shadow into the monument at summer solstice sunrise than would the Heel Stone.

A further suggestion is that if in antiquity it had come to pass that the Slaughter Stone, Stone S, was no longer needed for this purpose and that instead it should be preserved by partial burial in a shallow longitudinal pit in the chalk, then it was left visible possibly out of respect for its earlier significance.

However, it may be more likely that it was still standing in the late sixteenth century. Burl (1994: 77-89) deliberates the matter on the basis of Elizabethan-age engravings and watercolours, and reproduces the engraving from Camden's *Britannica* of 1610. Bakker (1979: 107-11, illustration in Plate 10) discusses a watercolour by Lucas de Heere ("drawn on the spot") and suggests that it dates from 1568-69. Chippindale (1983: 34-36 and facing p 48) also discusses the artistry, and includes pictures by William Smith (1588) and 'R.F.'

There is an image of Stone S in the R.F. print of an imperfect Stonehenge (dated 1575) that shows Stone S as a rounded boulder lying prone. In an otherwise reckless copy made for Camden's *Britannia* of 1610 Stone S appears upright. Many similarities, including the repetition of gross errors between these various illustrations, prove that they are descendant engravings modified by artistic licence from a lost original that was likely drawn by Joris Hofnagel in 1568-69 (Bakker 1979: 109). Neither de Heere's known watercolour of 1568-69 (Bakker 1979: Plate 10) nor William Smith's watercolour of 1588 (reproduced by Chippindale (1983: facing p. 48) show any stones at the axial entrance, but those of R.F. and Camden do (Burl 1994: 88).

In short, one must consider that Stone S was perhaps still upright in the sixteenth century. Importantly, it happens that from the point of view of the present research and analysis, it does not matter whether Stone S was standing or not at that time. *Either way, in antiquity, a solstice sunrise shadow will have penetrated the monument whether it was thrown directly by the Heel Stone or by Stone S because they have the same alignment.*

Finally, there is Hole G - meaning there is a possible missing Stone G to consider (Cleal *et al.* 1995: 288). An equinoctial possibility at Stonehenge is prompted by the nature of the research undertaken at Drombeg (Meaden 2017). Hole G is 1.2 m deep near the circle of Aubrey Holes in the east (Figure 13). If Hole G formerly held a stone, then as with the Slaughter Stone S it is in the right position to cast a shadow into the monument - this time at the equinoxes. A target stone for a shadow from a stone at G could be the rhyolite ignimbrite bluestone discussed in Section 4.2.

4.5. Results for shadow phenomena at the Avebury Cove at the summer solstice sunrise

The Cove Stones at Avebury centre a 99-metre diameter ring of stones called the North Circle which according to Keiller & Smith numbered 27 stones (Smith 1965: 205). A plan is provided in Figure 15.

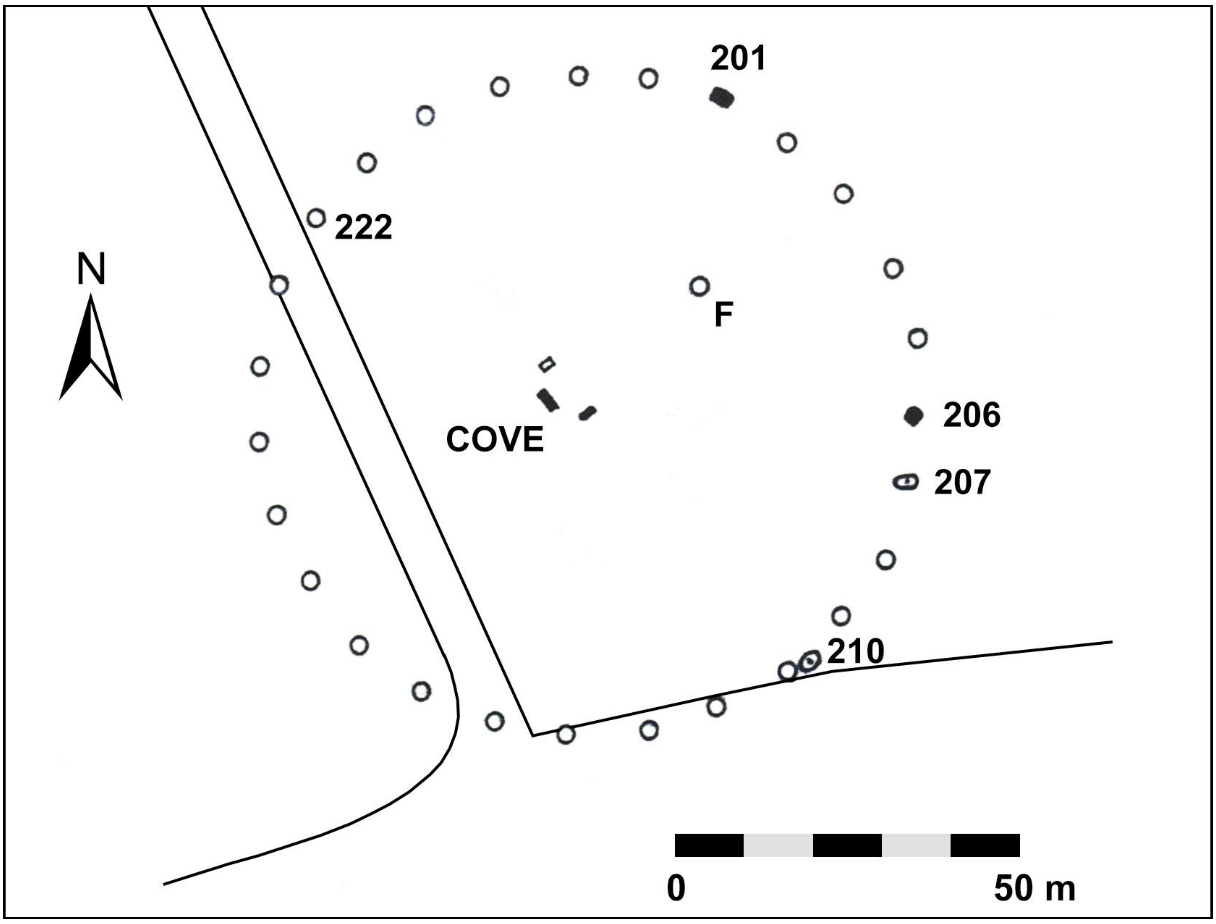

Figure 15. Plan of the North Circle at Avebury centred by the Cove. Note the position of Stone F that functions at Avebury in the same manner as the Heel Stone at Stonehenge and portal Stone 1 at Drombeg. Drawn by the author after Smith (1965: 205, fig. 70).

Nowadays at Avebury the sun rises at 51.5 degrees east of north, being delayed from the time and direction applicable to a low flat horizon by the presence of the hill known as Totterdown, a part of Hackpen. 4900 years ago in the Late Neolithic the direction of midsummer sunrise would have been about one degree less than 51.5 because of changes in the inclination of the ecliptic that occur at a rate of about 0.2 degree per thousand years, giving an azimuth of 50.5 degrees east of north. The axial orientation of the Avebury Cove is close to this figure.

In addition, a fourth standing stone (known as Stone F) - which operated as if part of the Cove - was some 25 metres distant and almost exactly on the same alignment (Smith 1965; 2015: fig. 70; Meaden 2012b). It is this stone, now missing but its position known that could have functioned at Avebury with regard to the midsummer sunrise as does the Heel Stone at Stonehenge and as does portal Stone 1 at Drombeg (Meaden 2017: fig. 12, 16).

The photograph in Figure 16 shows the current midsummer sunrise in the absence of Stone F - destroyed in the nineteenth century. This stone is critical to the proper functioning of the Cove. The watercolour painted by J. Browne in 1825 shows that Stone F was by then seriously damaged (Gray 1935: 108) (Figure 17).

The midsummer sun having risen over Totterdown Hill shines on Stone F whose shadow pairs with the waiting Cove stone. This is illustrated by Figure 18 drawn on the basis of Stukeley’s 1723 sketch of the Cove relative to Stone F, to which the summer solstice shadow of Stone F has been added. Only at midsummer could this happen at the Cove. The arrangement was well planned and executed, as at Stonehenge and Drombeg.

Figure 16. At the Avebury Cove looking north-east at the time of sunrise in midsummer week 1991. (Photograph by the author.)

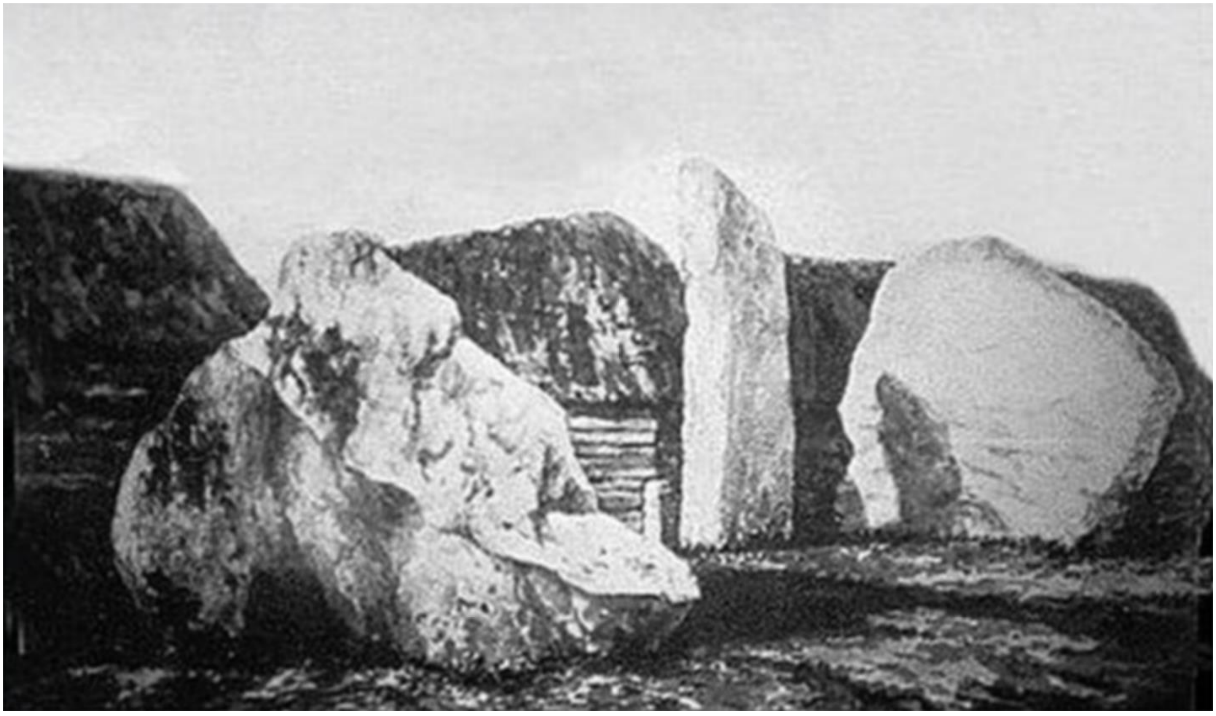

Figure 17. A watercolour of the damaged Stone F at the Avebury Cove, 1825, by J. Browne (H. St. G. Gray 1935: 208).

4.6. Results for shadow phenomena at Avebury's South Circle at particular sunrises

Avebury's Stones 105 and 106 of the South Circle also function in relation to a positioned stone and the sun rising over the eastern hills at the summer solstice and Beltane respectively. The 6.5 m long Obelisk (measured in 1723 by Stukeley (1743: Plate 16) as 21 feet long) that centred the South Circle is the stone that cast shadows at sunrise for the dates of the early May start-of-summer festival (Beltane) and the summer solstice (Figure 19). This pillar-like stone was destroyed in the 18th century, but Alexander Keiller found its stonehole and in 1939 marked its position with a concrete post (Smith 1965: 198, 200, 205). This allows alignments to the surviving Stones 105 and 106 to be determined, as explained by the plan in Figure 20. See Figures 21 and 22 for photographs of these stones.

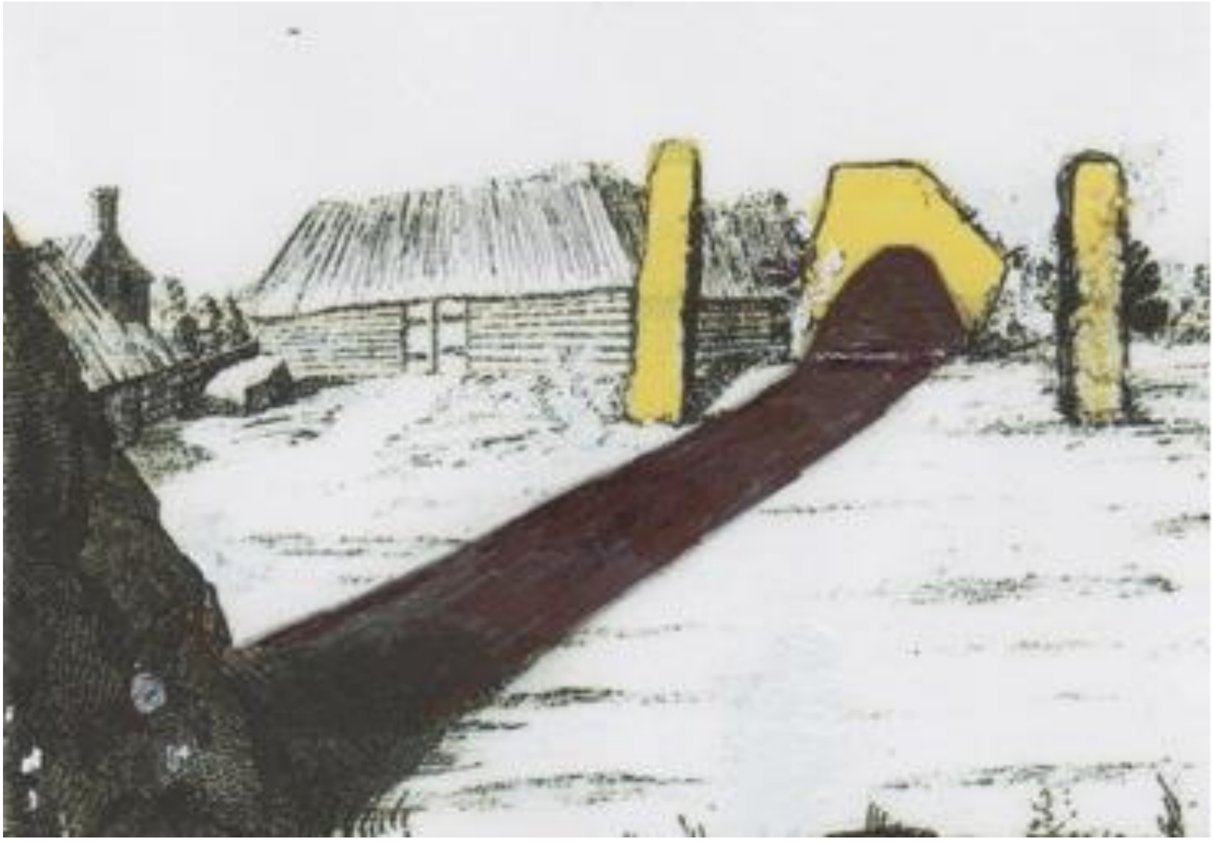

Figure 18. The four megaliths of the Cove are in this sketch redrawn by the author after William Stukeley's 1723 sketch in order to include the missing tall narrow Cove stone at the extreme right. Stone F is at the left. Soon after sunrise at the summer solstice its shadow falls on the middle Cove stone (after Stukeley 1743: facing page 25).

Figure 19. William Stukeley's sketch of the Obelisk which he measured in 1723 as 21 feet in length. (Stukeley 1743: plate 16, facing p. 30).

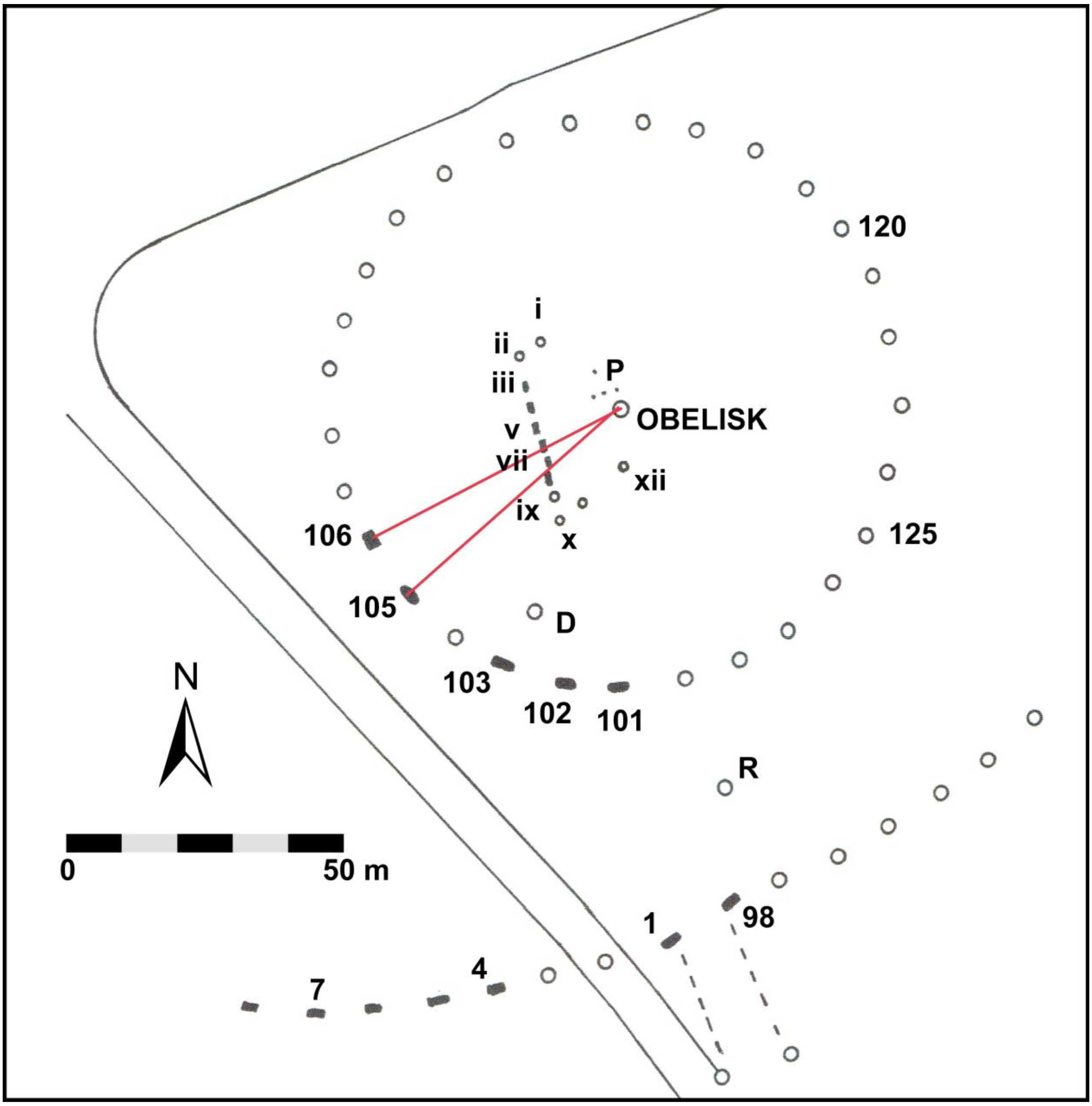

Figure 20. Plan of the South Circle at Avebury showing the relationships of Stones 106 and 105 with the directions of the Obelisk and Beltane at the summer solstice sunrises (drawn by the author after Smith 1965: 205).

Significant may be a related finding of another stone on the same sunrise alignment that terminates at Avebury's Obelisk and Stone 106. The additional stone lies prone on the false crest of the eastern hills where the Beltane sun rises at 62.5 degrees east of north. It has a symmetrical five-sided shape with a groove pecked medially (Figure 23). The man-made groove is coloured red by the presence of algae *haematococcus pluviatus*. The stone is placed to denote the sunrise position as seen from Avebury.

This concept of a horizon marker is repeated for the line from the horizon that ends with the Obelisk and Stone 105, because it too has a marker stone on Totterdown. Among five other placed stones on the false crest of the eastern hills that relate to stone positions of Avebury's South Circle there is another five-sided stone with an artificially pecked groove that relates to the sunrises at Imbolc and Samhain. It is suspected that the shadow phenomena at Avebury worked for all eight traditional festival dates of the farming year as has been demonstrated for Drombeg (Meaden 1999; 2016).

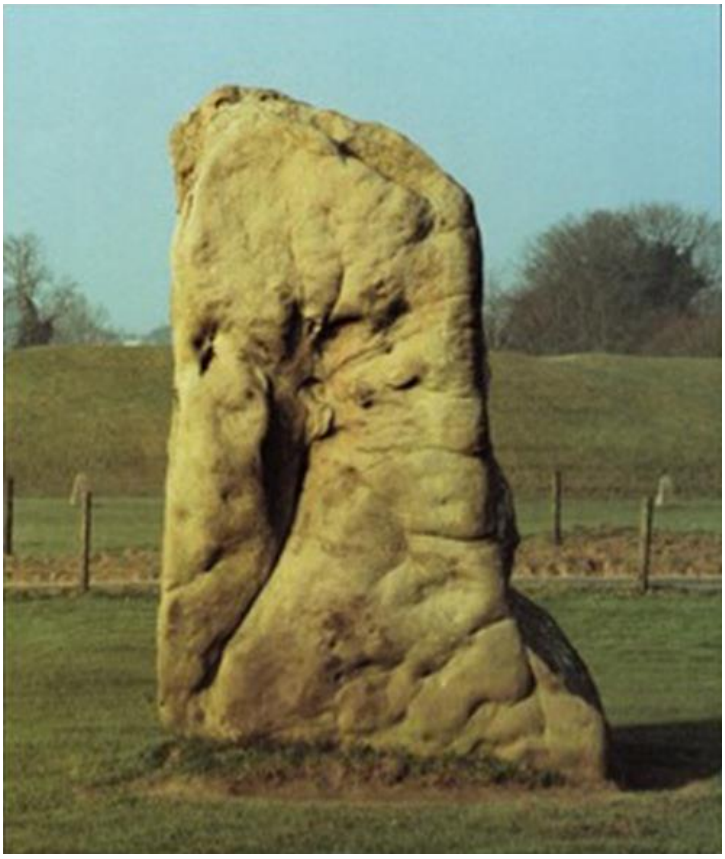

Figure 21. Stone 106 of the South Circle at Avebury was set to align with the Obelisk such that at Beltane sunrise the shadow of the Obelisk would fall upon it (compare with the plan in Figure 20). (Author's photograph)

Figure 22. The roundish Stone 105 of the South Circle at Avebury was set to align with the Obelisk such that at the summer solstice sunrise the Obelisk shadow would fall upon it (compare with the plan in Figure 20). (Author's photograph)

Figure 23. This shaped stone with medially pecked groove is on the hills east of Avebury. It marks the false crest near the Ridgeway where the sun rises at Beltane as seen by watchers at the South Circle. (Author's photograph)

5. Conclusions

This research investigated how at Stonehenge and Avebury positioned stones of particular shape or outline are able to transmit watchable meanings arising from solar movement by the creation and displacement of shadows. The purposeful engagement of shadows between particular stones was arranged to take place at sunrise, and the optimal occasions were special dates of the agricultural calendar year, above all the solstices. In a companion paper similar effects involving sun and moving shadow were announced for the stone circle at Drombeg in County Cork, Ireland (Meaden 2017).

Demonstrated first was how at Stonehenge it was arranged that in midsummer week the light of the rising sun would shine along the Stonehenge axis and enter the portal gateway to illuminate the Altar Stone. The shadow of the round-topped Heel Stone followed soon after. Today, 4500 years after the idea was first staged, eyewitnesses testify as to how the shadow continues to return every midsummer week to reach the micaceous Altar Stone - the only week of the year when it can do so. The diminutive round-topped sarsen Stone 11 behaves similarly with respect to the ignimbrite rhyolite bluestone 38 and/or 40 at the winter solstice sunrise. Later in the day the midwinter sun sets along the axis of the monument.

The concept is similar for Avebury's North Circle in which the light of the rising midsummer sun shines on the principal feature, the great Cove Stone, soon followed by the shadow of an intermediary stone (Stone F, destroyed in the 19th century). At Avebury's South Circle similar effects took place annually until the villagers destroyed its centrepiece, the pillar-like Obelisk, in the 18th century.

Hawley (1928: 176), summing up his years of excavation at Stonehenge 1920 to 1926, added that it "was no doubt first and foremost a temple and secondly a place of assembly where priests and military nobles dispensed justice and promulgated laws. It would be a well-known landmark, a centre for trade, and a nodal point."

It is timely to enquire how far an understanding of the meaning of such monuments can be interpreted by 21st-century scholarship. Recently, Silva and Campion (2015) treated the role and importance of the sky in archaeology. Citing Campion (2015), "recent scholarship, emerging from new disciplines such as archaeoastronomy and cultural astronomy, has argued that a complete understanding of the human environment and culture must include the sky as well as land and sea/water".

For Stonehenge and Avebury no research as to the effect of shadows cast by specific standing stones has been done hitherto. Regarding Newgrange and the effect of shadows cast by individual stones Prendergast (1991) examined surviving standing stones of the Great Circle for solar calendrical functions (further treated by Meaden 2017). The former demonstrated meaningful shadow phenomena for sunrises at the winter solstice, the equinoxes and the intercalary dates between - altogether five calendar dates of the winter half of the year (Prendergast 1991: 14, fig. 5). In turn, three different stones at Newgrange cast shadows on the waiting recipient which is the entrance kerbstone. Depending on which occasion Prendergast showed how the moving shadows either skirt the edges of the deeply carved triple spirals or largely cover them. Pursuing this proposal Prendergast (1991: 18) concludes, "this suggests that part of the Great Circle may have been used as an eight point calendar". The present author, unaware of Prendergast's research, studied this in 2014 for the winter solstice sunrise noting how a lithic shadow covered the south-western carved lozenges on the Newgrange entrance stone and continued by skimming the edges of the triple spirals (Meaden 2017). The effects of shadow-casting at Avebury's South and North Circles were studied too (Meaden 1999: 20-29, 66-75) besides the aforesaid work at Drombeg (Meaden 2017).

Pásztor (2000) and Pásztor *et al.* (2011) considered the effect of midsummer sunrises at Stonehenge from the point of view of a strong brightness that arises inside the monument due to direct light and reflected light coupled with shade. Pritchard (2016) has researched the casting of shadows between pairs of standing stones in West Wales.

Bradley (1989) rather differently discussed matters of darkness and shade in the interiors of megalithic-chambered tombs using examples from the south of Brittany.

The author's research at Stonehenge began in 1981, and into megalith shadow casting in 1985. Heel Stone photographs were taken in the week of the summer solstice in many years from 1986 to 2014. The first photographs published were taken in 1987 and 1989 (Meaden 1992: plates 13, 14, 15).

The Irish archaeologist Professor Ronald Hicks (1985: 72-73) in considering astronomical traditions of ancient Ireland and Britain wrote, "In early monuments ... there are tales that associate stone circles and henges with the old cross-quarter days and the solstices, some of these associations being in the form of place names, like the proposal by Ó Ríordáin & Daniel (1964: 16) that the name Newgrange is an anglicization of *An Uamh Gréine*, meaning the cave of the sun." The same author concluded (Hicks 1985: 79), "This strongly suggests that it was an attempt to symbolize the midwinter sun impregnating the earth so that it would again bring forth food for the people." For various reasons involving local mythology he declared "it is hard to resist the suspicion that the agricultural cycle, and thus the year, the seasons, and astronomy are intimately involved in it." Grinsell (1976) compiled much on the matter of folklore linked to British ancient monuments.

Fahy (1959: 21) in his excavation paper about Drombeg Stone Circle when discussing the positions of specified shaped stones (Stones 14 and 15 as being lozenge and phallic shaped) said that the situation "… tends to suggest that at Drombeg we are dealing with another instance of symbolism which by its nature ought to be connected with a fertility cult". He further emphasized (Fahy 1958: 25) that "the axial orientation of the circle confirms that the midwinter sunset played a major role in the religious practices of its builders who, if we admit the proffered interpretation of Stones 15 and 14 as male and female symbols, would appear to have practised a fertility cult".

Agricultural societies worldwide knew that successful fertility of grain, animal stock and women were paramount for the security of their farming livelihood in addition to uncertain and fickle prospects from hunting. Most Neolithic societies held diverse but generic beliefs concerning mortuary practices that expressed considerable interest and deep respect for their ancestors. Fowler (2010) and Smith & Brickley (2009) discuss such matters for Britain and Ireland. More specifically as to what concerns prehistoric ritual and religion there is the multi-author volume edited by Gibson and Simpson (1998) which centres on what can be learnt from monuments and their remains. Additionally helpful in prehistoric contexts are the studies by archaeologists Merrifield (1987), Edmonds (1999), Cooney (2000), and Bradley (2007). As for Mother Earth concepts they were likely widespread long before the arrival of the great patriarchal religions and their very different belief systems (Das 2014; Gimbutas 1989; 1991; Meaden 2012a). In fact, a Divine Mother figure seems to have been prevalent in continents worldwide as prehistory gave way to recorded history (personal communication with Ronald Hutton on 29 May 1998). The concept of a divine mother and divine father was then not only a universal worldview (Eliade 1958: 38-123, 239-264) but it still is for some tribes living today (*e.g.*, Das 2014). Partly this may be a consequence of fundamental images present as psychological archetypes. Eliade (1958: 216-238) helpfully discusses examples of how early mankind viewed epiphanies, signs and forms in stones held to be sacred. To this day in parts of tribal India - as with the proto-Australoid Kolarian Mundari tribes of Jharkhand and elsewhere - the practice of raising megaliths persists, together with associated ideas of Mother Earth, of Sacred Marriage belief complete with festivals, and of fertility settings in stone. Das (2014: 31-34) provides *contemporary* examples.

One is the Sarhul fertility festival: "Sarhul celebrates the marriage between the Mother Earth and the Father Sky. The festival also celebrates the earth becoming fertile … which is signalled by the blossoming of the Sal tree (*Shorea robusta*). The blooming signifies that Mother Earth is all set to produce as she is fertile now, hence farming can commence … For the tribals Sarhul also beckons the beginning of the New Year." Das (2014: 31) adds, "A similar three day fecundity festival is celebrated by the Hindus in East India known as Ambabuchi occurring on or a day later to the Summer Solstice." He further says, "Among several tribes in North-East India where megalith erection after death continues uninterruptedly, many monuments are dedicated to Mother Earth." It is reassuring that tribes still exist in Asia and the Americas whereby anthropologists and archaeologists can continue to obtain explanations like these from living communities. For the native Indians of North America Krupp (1997: 97-125) is among those who have studied similar aspects of indigenous traditions that today continue to demonstrate beliefs as to time-honoured views of an Earth Mother and Sky Father.

If for the British and Irish megalithic ages the primary fertility deity was female, one may ask to what extent cooperation with a solar sky god may have been thought to provide farmers with fertility success - such as rich soils, fecund livestock, fertile women, and appropriate seasonal weather (Eliade 1958: 239-242, 256-262, 331-341, 354-366). The concept proposed in this paper implies hierogamy - a spiritual worldview between deities known as Sacred Marriage. Such an understanding has long been known for classical literary times in countries of the Mediterranean, the Near East and Middle East, besides widely across the primitive tribal world of the continents and Pacific Ocean islands (*passim* in Burkert 1985: 108-109, 132-134; Campbell 1974; Eliade 1958; Frazer 1957). The rite of Sacred Marriage was a well-loved practice of agricultural communities. Kramer (1969) goes into detail and summarises by writing that the idea of "Sacred Marriage" was "joyously and rapturously" celebrated in the ancient eastern Mediterranean for more than two thousand years (Kramer 1969: 49). Cook

(1940: 1025-1065) has detailed at length the *hieros gamos* that was so long cherished and celebrated in classical Greece, its origins dating from prehistory.

In the present paper about Neolithic and Bronze Age Britain the proposal is that beginning in the Neolithic there may have been a legendary belief in male-female episodic mating of the divine that was interpreted via shadow interaction between stones. This would predate the known historical accounts of the Eurasian perspective and practice of Sacred Marriage. The suggestion is that the stones of Stonehenge and Avebury were perhaps arranged for the enactment of a visual spectacle observable by big numbers of people at the solstices and at other dates of the agricultural calendar. The additional Stonehenge mystery regarding the purpose of the anomalous short phallic-like Stone 11 in the outer ring of otherwise lintelled sarsen stones could be interpreted in this context too, as similarly the equinoctial sunrises and sunsets at Knowth involving pillar stones, the winter solstice sunrise at Newgrange, and all eight agricultural festival dates at Drombeg as explained by Meaden (2017).

Stonehenge was likely an influential multifunctional centre for business, trade, and exchange particularly at the time of agricultural festivals, besides serving as a religious centre and ancillary cemetery (Parker Pearson & Ramilisonina 1998a; 1998b). It has been argued that one such business may have centred on the idea - advocated by Darvill and Wainwright (2009) - that Stonehenge could have served as a centre for healing, partly on account of supposed medicinal benefits arising from the properties of the Welsh bluestones, because this too could explain the enduring Stonehenge folktale on this matter that was recorded in Medieval times (Atkinson 1979: 190-191; Chippindale 1983: 44, 159). Darvill (2006: 141-146) suggests possible links to divinities for Stonehenge, and summarizes some of the known solar and lunar features, the idea of a cult centre, and the oracular suggestion by Curnow (2004: 1-8) of a "possibility that Stonehenge was an oracle, a place to which people made pilgrimages in order to contact the supernatural, the gods or the dead, possibly at specific times of the year..." (Darvill 2004: 146).

Whatever the original intentions of the planners, it is here proposed that dramatic art accomplished by moving shadow between chosen stones was intelligently combined with religion in a manifestly moving spectacle - a play without words, a masterwork achieved through intentional lithic planning to provide reassurance to hardworking devoted farming communities.

Acknowledgments

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Knowth passage-grave in Ireland: An instrument of precision astronomy?

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Abstract

Knowth is one of three large monuments at the Neolithic complex in the bend of the River Boyne in County Meath, Ireland. The others are Newgrange and Dowth. All three have obvious solar alignments but whereas the alignment to the winter solstice sunrise at Newgrange has been extensively researched and interpreted, little has been attempted regarding the way that astronomy functions at Knowth and Dowth. This paper treats the evidence for solar and lunar alignments at Knowth.

Knowth has two internal passages with entrances at the east and west. The paper draws on new surveys as well as interpretations of the evidence at Knowth that includes rock art engraved on kerbstones around the circumference. Particular engravings on kerbstone K52 are interpreted as depicting astronomical cycles. It is argued that, while Knowth's passages function in relation to the equinoxes, they are not internally orientated to match exactly the equinoctial directions. Rather, it seems that they may have been constructed and used to facilitate the harmonisation of the solar and lunar cycles - much in the same way as does the equinoctial Judeo-Christian festival of Easter. The paper concludes by suggesting that like Newgrange, Knowth may be an astronomical instrument that enabled its builders and users to construct accurate calendars and counting systems, which in turn facilitated calculated planning and was a fundamental structuring principle for their ritual lives and cosmological beliefs.

Keywords: astronomy; counting; Dowth; equinox; Knowth; moon; Newgrange

1. Introduction

The three large Neolithic monuments at the prehistoric complex on the banks of the river Boyne in County Meath, Ireland, are called Newgrange, Knowth and Dowth. Astronomical alignments comprise a central function of these monuments (see for example, O' Kelly 1982; Moroney 1999; Ruggles 1999). Astronomy at Newgrange has been extensively researched and interpreted, but less work has been done on the way that astronomy functions at Knowth and Dowth. This paper focuses on the evidence for astronomical alignments at Knowth, and on interpretations of this evidence.

Whereas at Newgrange there is a single passage facing south-east, at Knowth there are two passages. One faces approximately east and the other approximately west. For many

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years it was said without proof that these are equinoctial solar alignments, aligned on the rising and setting sun at the vernal (spring) and autumn equinoxes respectively, hence directly complementing the winter solstice rising sun alignment at Newgrange. This paper considers new surveys at Knowth, and a synopsis of this evidence is presented and reviewed in the context of the megalithic rock art at the site, of which some prominent examples can be interpreted as depicting astronomical cycles.

Furthermore, whereas Knowth's passages do function in relation to the equinoxes, precise survey and other evidence shows that internally they are not direct equinoctial alignments. Instead, it is suggested that the intention may have been to facilitate the harmonisation of the solar and lunar cycles.

Before exploring the evidence at Knowth in detail, we need a brief explanation of what we mean by 'precision astronomy' when discussing astronomy at the Boyne valley sites, and what is being defined and communicated by and through the use of this term.

Ruggles (2005: 348) has suggested that 'precision astronomy' refers to the fine-grained detail or nature of measurements, so a frequent topic of discussion in prehistoric astronomy is whether it was as 'precise' as with current astronomy. There is, rightly, a focus on questions such as what a solstice is, how it is measured, and whether the people of prehistory could measure a true 'solstice'. As we discover and document more evidence that our Neolithic ancestors understood such 'precise' astronomical concepts and events, this in turn reveals that 'precision' so defined may not be the critical issue. Rather, there needs to be a greater focus on what the people wanted this information and knowledge *for*. In other words, to what purposes was such astronomical knowledge put, whether or not it was truly 'precise'?

It is unlikely that we can definitively answer this question. Nonetheless, as we continue to reconstruct the levels of astronomical knowledge understood and recorded by our Neolithic ancestors, we can make the connection between this and other abundant evidence for their rich artistic and ritual lives - and suggest the many ways in which they were intrinsically linked.

2. Evidence for astronomy at the Boyne valley monuments: Knowth in context

I have argued elsewhere that the three large passage-graves at the Boyne valley should be seen as a single monumental complex - and that this evidence is critical for understanding the role of astronomy at each individual monument and as an inter-related group (Prendergast 2004). The inter-relatedness of the three great monuments is demonstrated through a focus on four aspects of their sequences: (1) the similarities in their structural and decorative features, (2) the common chronological horizon for their construction and use, (3) the inter-visibility of the three mounds, and (4) their central focus within the site as a whole (2004: 13-15).

It is the similarities in the structural and decorative features and common chronological horizon of all three monuments that may offer the best evidence that astronomy functions as a common, interrelated, feature across all three monuments. These major passage-graves are built to a common design. Each is a grand cairn over an acre in area, approximately 10m high, covering passages and chambers constructed with orthostats, lintels and capstones. All three cairns have kerbs of massive contiguous slabs laid on their edges surrounding the external base of the mound. The kerbstones, the passage and chamber orthostats, lintels and capstones at all three sites are profusely decorated with elaborate rock art. The dominant motifs are spirals, wavy lines, concentric circles, dots, zigzags and chevrons (Eogan 1986: 44-65).

Finds from the three passage-graves also appear to indicate a shared set of material culture. At Newgrange and Knowth identical stone basins, pendants, pins and beads were found, as well as human skeletal and cremated remains (O'Kelly 1982: 104-7; Eogan 1986: 39-43).

Available radiocarbon dates indicate that the building of the three main passage-graves occurred on a common chronological horizon ca. 3200-3000 BCE (Grogan 1991; Smyth 2009).

This shared design, based on enclosed and aligned passages, with related megalithic art, would appear to have been employed to facilitate astronomical measurements and impart astronomical information at all three monuments. This would support and contextualise the unique evidence for astronomical alignments at Knowth. Moreover, a common set of associated finds and a shared chronological horizon strongly indicate that the three sites - barely a mile apart - were built to function together, and their individual astronomical properties should be understood in this context.

2.1. Astronomy at Newgrange

Of the three passage-graves, there is no doubt that Newgrange has received the most attention. It was the first to be re-discovered in 1699, by landowner Charles Campbell. It has been excavated several times, most recently and notably by Prof. Michael O'Kelly, who also undertook an ambitious reconstruction programme of the monument. Stories about an astronomical alignment at Newgrange were popular for hundreds of years. Indeed, oral traditions regarding astronomical alignments at the Boyne valley sites were faithfully passed on throughout the medieval period during which time the monuments were abandoned, and continued into the modern phase of the monument's history. O'Kelly finally ended the speculation when his team directly witnessed the winter solstice sunrise alignment at Newgrange on 21 December 1972 (O'Kelly 1982: 124).

O'Kelly's reconstruction of Newgrange has preserved its original alignment. Today, one can fully partake of the experience of the sun entering the 'roof box' above the entrance at Newgrange on the morning of the winter solstice, and for around 11 days before and after the solstice. At the same time, excavation has allowed systematic testing of this eyewitness experience. It is now proven that the alignment at Newgrange is a 'precision alignment'.

Jon Patrick has proved that the winter solstice orientation was operative when Newgrange was constructed, and therefore is an original, central and permanent feature of the monument (Patrick 1974). Tim O'Brien has shown that the chamber and passage are sophisticated complex constructions, designed to maximise the accuracy and length of the beam of light entering the chamber (O'Brien 1988). On the basis of his research, O' Brien argues that at the time of construction, the beam of light entering the passage at Newgrange was so precisely framed by the roof-box that it could be used to calculate the exact day of the solstice itself (1988: 55-9).

This has meant we have, in turn, been able to build on this evidence and suggest how and why astronomy may have functioned in relation to the architecture, the rock art, and ritual practices at the site. This includes speculation about the role of the winter solstice as a key point that structured many aspects of social and economic life, including ritual, as the major astronomical moment so clearly identified and venerated at Newgrange (Prendergast 2012; Hensey 2015).

3. Astronomy at Knowth: Alignment of the passages

If the evidence at Newgrange has been so painstakingly reconstructed, what about Knowth?

Limited excavations took place at Knowth in 1941, which established the existence of decorated kerbstones and its contemporaneity with the other Neolithic cairns. However, Knowth remained largely silted over and nothing was known of its passages. In 1962 it remained the largest unopened mound in Ireland. Prof. George Eogan began excavations at

Knowth and the surrounding landscape in 1963 (Eogan 1986). These undertakings were completed around 40 years later, together with a (somewhat controversial) reconstruction of the mound, its passages, kerbstones and surrounding features.

At Knowth Tomb 1, two passages were discovered within the main mound, running approximately east and west (Figure 1).

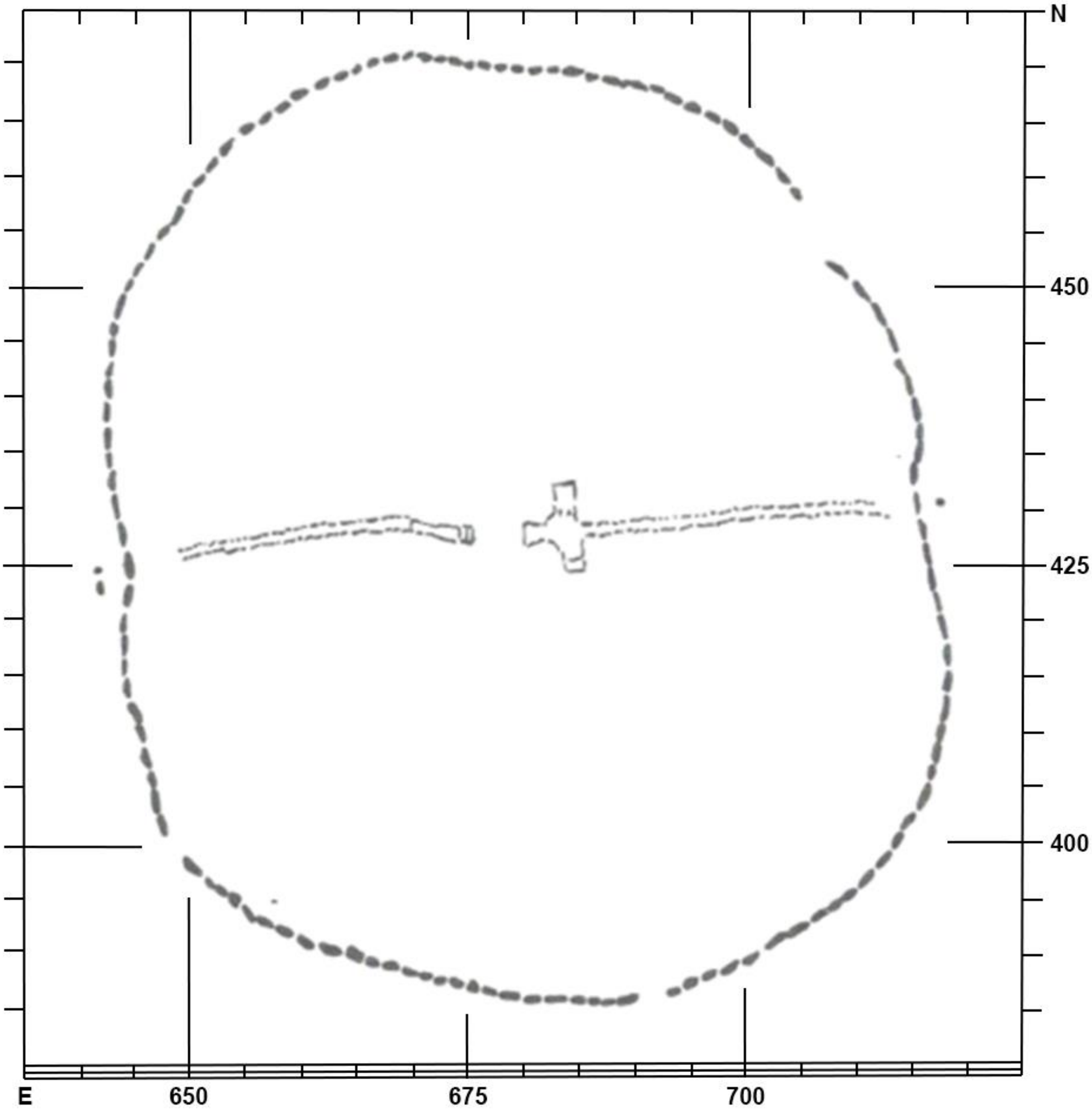

Figure 1. Plan of Knowth showing the two passages and the standing stones outside their entrances. The kerbstone positions are located after Eogan (1986: 31) but the map has been reset on the Irish Ordnance Survey grid, while noting that true north is 1 degree 13' west of grid north (see also Prendergast & Ray 2015). Each northing is to be preceded by 273, thus N 273400, and each easting by 299, thus E 299700).

The eastern passage is 40.4m long (Figure 2), and the western passage is 34.2m long. Both lead to recessed chambers. The eastern chamber is a complex cruciform structure, similar in construction to the chamber at Newgrange.

The most obvious astronomical alignments suggested by the approximate east and west alignments at Knowth are to the rising and setting sun on the autumn and vernal equinoxes. Equinoctial alignments at Knowth have been suggested by Eogan (1986: 178) and appear to be verified by eyewitness observations of the orientation of Knowth West by independent researcher Martin Brennan (1983).

Figure 2. Eastern Passage, Knowth, County Meath, Ireland. (Photo by P. Sakradja 2005).

Brennan and colleagues were able to document and photograph the setting sun entering the west passage at Knowth around the autumnal equinox in 1980. He at first entered the west passage at Knowth at sunset on 13 September 1980, around nine days before the equinox, and found clear evidence for the penetration of direct sunlight into the passage (Brennan 1983: 57-8).

On 16 September, the team, with a photographer, returned to Knowth at sunset, and again recorded the movement of light and shadow from both inside the western passage and outside, on the entrance stones. The observations appeared to confirm that as equinox approached, the shadow of the standing stone moved closer to the vertical line on the entrance stone, and the beam of light penetrated further into the chamber.

Brennan and his team recorded their eyewitness accounts but were unable to survey the passage alignment at Knowth West. This work has since been undertaken by Frank Prendergast and Tom Ray and their findings provide the level of precision needed to analyse possible alignments. They argue that: “The findings indicate that contrary to earlier suggestions, the eastern passage and the western passage (inner and outer) are not aligned towards sunrise and sunset respectively at the period of the vernal and autumnal equinoxes.” (2015: ii).

Their survey of the passage and entrance indicates that the sun most deeply penetrates the passage of Knowth West at sunset, not on the equinoxes but just over two weeks after the autumnal equinox or equivalently just over two weeks before the vernal equinox (2015: 6). In other words, while Brennan's eye-witness observations appeared to show the sun moving closer to the standing stone and the vertical line on the entrance kerbstone as the autumn equinox approached, survey data indicates the full alignment at Knowth West does not occur until two weeks after the autumn equinox has passed.

The same survey data indicate that at Knowth East, the rising sun enters the passage some six days before the equinoctial rising sun in the autumn and around six days after the rising sun at vernal equinox (2015: 11).

3.1. Precision alignments at Knowth

As we have seen, O'Brien has argued that the winter solstice alignment at Newgrange was so accurate it could predict the day of the solstice. Do the alignments at Knowth reveal a similar level of precision? In this context it is worth noting that the solstice - which is the shortest day - can vary by a day or so each year in the Gregorian calendar. So while simple day-counts from solstice to equinox to solstice can establish the approximate day of the equinox, it will not identify the exact day as to when the sun shines along either passage when near the equinoxes.

As Brennan has noted, an instrument like an aligned passage in a monument that accurately measures real-time phenomena can do this far more effectively (1983: 41-5). Aligned passages are more accurate versions of a sun-dial or gnomon. Instead of casting a shadow, the passage narrows a beam of light as it is projected into the chamber. This is not only a particularly accurate form of solar measurement; it also gives warnings of forthcoming solar events. Given the minimal shifts in the obliquity of the ecliptic over millennia, a passage is also a permanent structure, which does not need re-alignment and will continue to provide accurate observations once it is constructed.

Whereas solstice means 'standstill' - because the sun moves so slowly on the horizon during this time - at equinox the sun is moving fast on the horizon - by nearly as much as a solar disc a day during the equinox itself. This has led Ruggles (1997) to argue that defining and measuring the equinox precisely is more difficult than for the solstice - and thus to question whether prehistoric peoples would have known what the equinox was or had any interest in it at all.

Other archaeo-astronomers, including Antony Murphy and Richard Moore, point to the range of evidence available at Knowth's two passage alignments to argue that far from being misinterpreted as equinox alignments, the passages at Knowth may perform an even more complex function (Murphy & Moore 2006: 189-92). Murphy and Moore argue they may have been designed and used to calibrate the harmonization of the solar and lunar cycles, using the moon at the equinox to count one cycle in the context of another - in much the same way as does the Jewish festival of Passover and its Christian counterpart, Easter.

If the passages at Knowth can be interpreted as facilitating observations that integrate the lunar and solar cycles, this would make it an instrument designed to measure a 'moveable feast', in contrast to Newgrange that is designed to measure a fixed point. The main reason for this is because the lunar cycle does not *a priori* harmonise with the solar cycle, made up of points like the solstice. There are up to 13 synodic lunations of 29 days in every synodic or tropical solar cycle or year of 365.24 days (the time it takes for the earth to do a full circle of the sun). Over time, a count based on the lunar cycle alone would drift in relation to the seasons. So, in order to properly align the solar year with the lunar cycle, astronomers measure a fixed point like the solstice and the movements of the moon in relation to such solar points. It is possible, therefore, that just as Newgrange enables precision measurement of the winter solstice, Knowth may facilitate observation of the moon in relation to the sun at equinox, in order to establish a system for aligning the two cycles.

Gillies MacBain (2006) has suggested a specific counting system that may be facilitated by these alignments. MacBain argues that Knowth East (vernal equinox plus 6 days) marks three synodic lunar months (of 29 days) before the summer solstice, six synodic lunar months before the autumn equinox and nine synodic lunar months before the winter solstice. Knowth West, MacBain (2006) argues, marks thirteen synodic lunar months before the following vernal equinox.

This evidence would need further exploration and verification before it is proven, but it certainly raises some very interesting possibilities about the more complex ways that solar and lunar alignments may work at Knowth. Moreover, this may be supported by other evidence that we have for an interest in the moon at Knowth.

Terence Meaden (2017) introduces the additional point that, although the sun does not shine along the passages to its fullest extent at the equinoxes at Knowth, the shadow of an outer standing stone does achieve union with the vertical line engraved on the kerbstones in front each passage at the equinoxes as determined by means of day-counting.

3.2. Rock art at Knowth: Representing harmonisation of the solar and lunar cycles?

Stone K52 (on Eogan's numbering scheme, 1986: 132) (Figure 3) is one of the kerbstones at Knowth, and is also known as the Calendar Stone. As many researchers have argued, it may be a representation of the moon's monthly cycle, or the synodic month (see for example, Brennan 1983: 144).

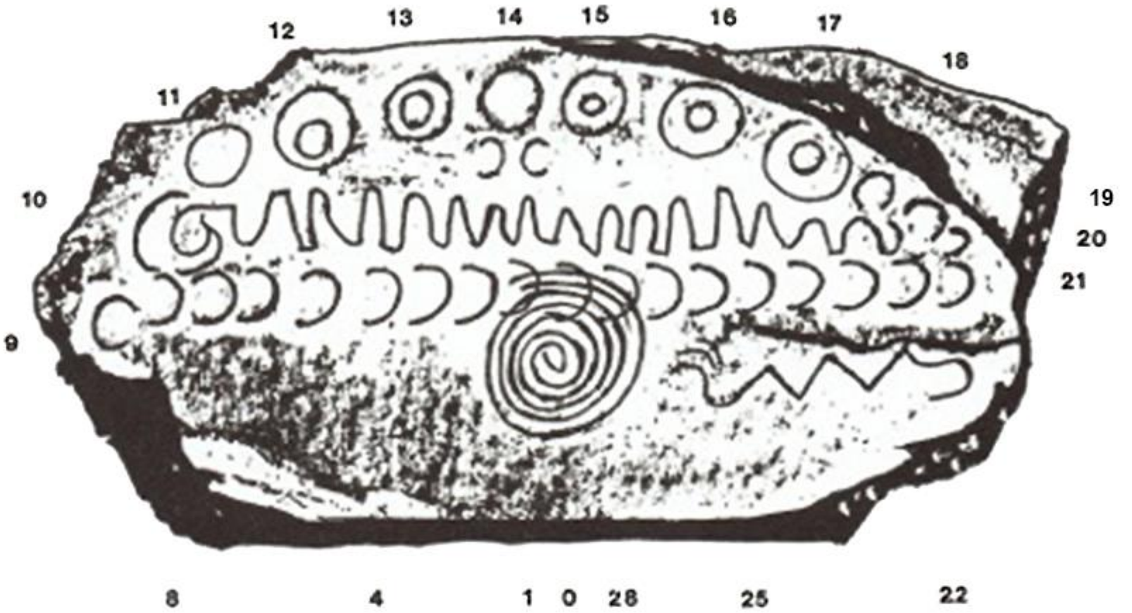

Figure 3. Calendar stone K52 at Knowth (figure from Meaden 1991: 125).

Twenty-nine circles and crescents are carved around the long wavy line in the middle of the stone. These appear to represent the monthly cycle of the moon. Counting clockwise, the new moon is the first crescent to emerge from the spiral. Crescents become circles through the moon's waxing phase until it reaches full moon - the circle at the top of the stone. Circles become crescents again through the moon's waning phase. The nights of dark moon (the three nights of the month when the moon is not visible) are represented by the three crescents in the spiral. The new moon emerges from the spiral and the monthly cycle is repeated.

Moreover, it has been claimed that the lunar counting system on K52 is even more complex. It can be used to calculate the harmonisation of the lunar and solar cycles over five solar years (Brennan 1983: 144). 12 lunar months are just over 354 days, but a solar year is just over 365 days. Hence, every five solar years, there will be two 'extra' - or 62 - lunar months. The wavy line in the middle of the stone counts out 31. Each turn represents the lunar month depicted in crescents and circles around it. The line reverses, to count to 62 which is the number of lunar months in five solar years. The reversal of the line at 31 harmonises the lunar count with the equinoxes as there is one extra lunar month every two and half years.

Murphy and Moore have claimed that the Calendar Stone can be used to map even more complex astronomical cycles, including the 'Metonic Cycle', named after an Athenian astronomer called Meton (2006: 196). In the Metonic Cycle, the sun and moon harmonise over 19 solar years, which equals 235 synodic months. At the bottom-right hand corner of K52 there is a wavy line that counts out seven. Seven multiplied by 31 - the count of the wavy line in the middle of the stone - equals 217. Half way along the wavy line there are two small crescents, where the wavy line count stops at 18. Add 18 to 217 and one has 235: the number of lunar months in a 19-year solar cycle.

Murphy and Moore (2006: 197) have further argued for a similar interpretation of kerbstone K53 - also known as the 'Lunar Stone' - at Knowth, viz. that its profusion of circles, crescents, waves, spirals and lines also can be used to count the sidereal and synodic lunar months. Both are critical for measuring the Metonic Cycle.

Comprehensive surveys of the rock art in the region have been undertaken by several researchers, including those that suggest a consistent and wide ranging inter-relationship between the rock art and astronomy (See for example, Van Hock 1987, 1988). One further example at Knowth includes kerbstone K15 - also known as the 'sundial stone' (Figure 4).

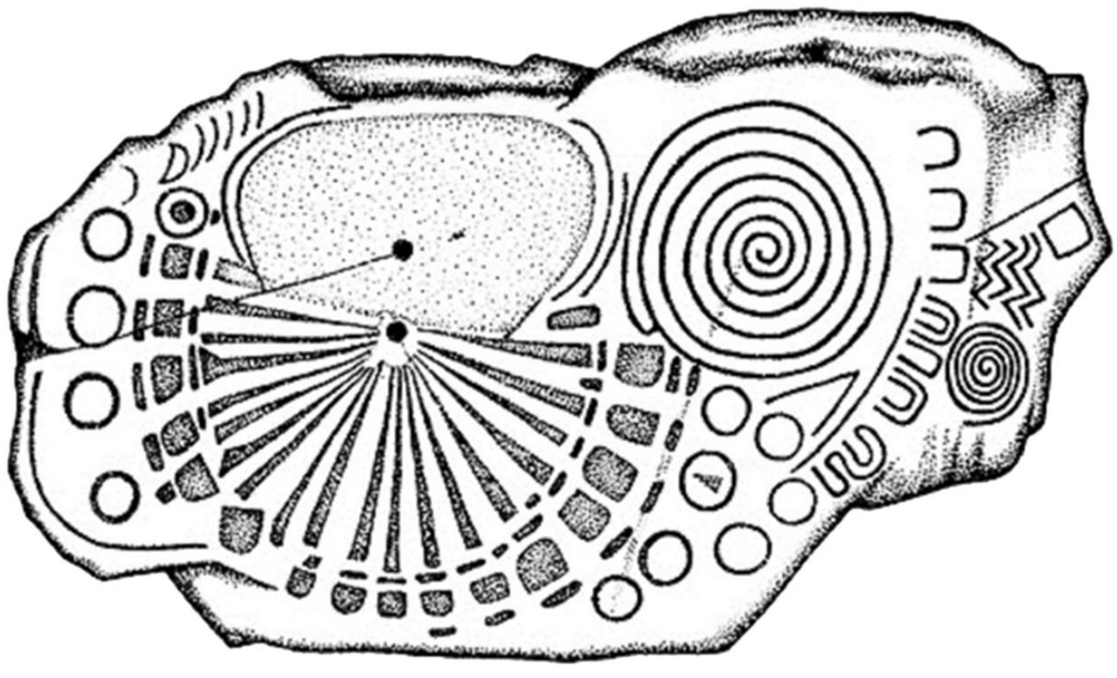

Figure 4 Kerbstone K15 at Knowth - the 'sundial stone'.

The central image on this stone has been interpreted as a depiction of a sundial, with the extreme positions reached by the sun on the horizon - the summer and winter solstices - marked at the extreme radial shadows or 'spokes' thrown from the central gnomon, with the equinox marked as equidistant between these two extreme points (Brennan 1983: 190-1). An interest in the lunar cycle is also suggested by the presence of crescents and circles on each side of the stone - in turn indicating, and adding to the evidence for a combined interest in the solar and lunar cycles at Knowth (Wun 2008: 15). Euan Mackie (2009; 2013) has corroborated such interpretations by arguing K15 should be interpreted as "an exact representation on stone of the sixteen-month solar calendar" (2009: 26) - the so-called prehistoric calendar as first suggested by Alexander Thom, former Professor of Engineering Science at the University of Oxford.

4. Conclusion

If the survey of the passages and the rock art evidence at Knowth both point to an interest in, and emphasis on, the alignment of solar and lunar cycles, how might we interpret this evidence from a cultural perspective? First, it suggests a comparable interest in precision astronomy at Knowth demonstrated at Newgrange. The alignment of the Knowth passages, and associated rock art, may not display an interest in basic alignments but in sophisticated calculations, possibly designed to both identify the equinoxes and facilitate the counting of the moon's cycles in relation to the sun. If so, this evidence would strengthen the case for precision astronomy at the Boyne valley sites as a whole. Moreover, it further suggests that the alignments at Knowth work with the alignments at Newgrange. The builders of Newgrange chose to measure the winter solstice. The builders of Knowth chose to measure the equinoxes in relation to the moon. If we note evidence for further alignments at other sites in the Boyne valley (and beyond) that complement those at Newgrange and Knowth, we can begin to see that Neolithic astronomers may have been able to map the cycles of the planets and stars at a sophisticated level - pointing to a society with a level of knowledge that could be embedded into permanent instruments in the landscape.

This in turn enabled that knowledge to be passed on to future generations - including our own. It is therefore vital that we preserve and continue to analyse and interpret these astronomical megalithic instruments, so that we too can be part of this great endeavour to understand and pass on this precious knowledge to the people of the future.

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The Star-Beings and stones: Petroforms and the reflection of Native American cosmology, myth and stellar traditions

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Abstract:

Native American myths, legends and oral traditions are rich with stories of giant beings existing in ancient times. They all talk of giant Thunderers or Thunder-beings, giant snakes and great Thunderbirds. Even the first humans were said to be giants, some half man, half animal. The Tsistsistas (Cheyenne) have a name for the giant beings that their ancestors encountered during the early migration to the grasslands of the Great Plains. They called them haztova hotoxceo or "two-faced star people". Other Plains tribes such as the Black Feet, Gros Ventres and Lakota have similar stories.

These old stories may have real world counterparts. Discovered in a prehistoric effigy-mound group (the Kolterman Mounds) in south-eastern Wisconsin (U.S.A.) is a human-like petroform or lithic effigy with a serpentine body and wing-like arms known as the 'Star-being'. Configured in stone, it is approximately 20 metres in length with a red coloured, bison-shaped headstone aligned to face the summer solstice sunrise. However, it is not a lone or singular occurrence. The 'Star-being' is but one of two human-like petroform effigies discovered in south-eastern Wisconsin. There is another of almost the same size called the Starman which also has a red coloured, bison-shaped headstone aligned to face the summer solstice sunrise. Both the Starman and Star-Being lithic complexes are codified by the State Historical Society of Wisconsin as archaeological sites of Archaic age.

Each giant lithic effigy appears to be a reflection of certain constellations and stars. The 'Star-being' is a mirror-image of the (western) constellations of Scorpius and Libra (with Sagittarius); the Starman is an almost exact representation of Taurus and the Pleiades. Both giant effigies are estimated to be 3500-6000 years old, embodiments of ancient legends and traditions writ large in stone and connected to 'The People' through ceremony and acts of cosmic renewal.

Keywords: headstone; Massaum; petroform; Star-Being; Wisconsin

1. Introduction

To find the origin of many Plains Indians traditions, one needs to look to the east whence they came. The 'text book' Plains Indians, generally the macro Sioux, Cheyenne, Arapaho, Assiniboine, Crow and other related tribes migrated west to the Plains area from the upper Great Lakes area. Some were woodland-adapted, others lived on the prairie and woodland border areas of southern Wisconsin and Minnesota. No matter the later tribal affiliation, all

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had been settled in the northern and western Great Lakes area for untold generations. They were either proto-Algonquin or proto-Siouan speaking people who, living close to each other for generations, developed a similar lifestyle and common culture despite the differing language core (Bender 2004: 14; Hewes 1948; Powers 1977: 18; Waldman 1985: 39-40, 67-68).

When they migrated west, ‘the people’ as most called themselves did what others have done during their migrations or journey of nations; they took their beliefs and traditions with them. Because of this, many ancient traditions, beliefs and ceremonies practiced on the Plains retained ties to their earlier origins in the east (Powell 1969: 26; Schlesier 1987: 50-51; Taylor & Sturtevant 1996: 136-139).

Retained in the (transported) traditions are stories related to the stars. It is these ancient stories that form a foundation for the Plains Indian cosmologies. How the cosmologies developed and then established through ceremony was timed to natural and celestial events. Some or parts of the Plains Indian cosmological view linking ‘the people’ to the universe may well be found in two petroform sites in south eastern Wisconsin. Petroforms (or lithiforms) are best described as geometric or effigy forms constructed with large rocks or small boulders and used for ritual purpose (Behm *et al.* 1989; Bender 1992; Steinbring 1970a; Steinbring *et al.* 1995; Steinbring *et al.* 2003).

Together with petroglyphs and pictographs, petroforms are considered a form of rock art (Steinbring 1999; Steinbring & Buchner 1997: 73-84). To create most such forms, individual rocks were intentionally placed on the land surface to form an outline or particular shape, *e.g.* a circle or turtle, but in some cases selective removal of rocks laid down by random (glacial) scatter may have been employed, thus achieving the desired shape. Both the Starman and Star-Being were made by careful positioning of rocks on the land surface.

Petroforms were first mapped and examined in North Dakota, South Dakota, Minnesota and Iowa by T.H. Lewis (1886, 1889, 1890 and 1891). Lewis recognized the antiquity of the forms by how deeply the individual rocks composing the petroform were embedded in the prairie soil. Cyrus Thomas (1894: 35) noted that the "boulder" [petroform] sites were "found upon the highest lands of the Missouri and James rivers and their tributaries" linking their occurrence to prominences and rivers. Few reports followed. It was almost a century before attention to petroform once again entered the mainstream of rock art research with the rediscovery of the Tie Creek Site in southeastern Manitoba, Canada (Steinbring 1970a, Steinbring *et al.* 2003: 111-112; Sutton 1965).

A few years later at the Big Horn (Wyoming) and Moose Mountain (Saskatchewan) 'medicine wheels' (Brumley 1988), both large petroform sites, field investigations were conducted to test proposed solstice and stellar alignments of these stone monuments (Eddy 1974; 1977). Moose Mountain was dated as early as 500 BCE based on Eddy’s heliacal star rise calculations, a date later supported by carbon dating (Kehoe & Kehoe 1977: 86).

Then in 1986, the Krug-Senn petroform site was discovered in the Kettle Moraine landscape of southeastern Wisconsin (Behm *et al.* 1989). A complex site with three distinct loci, it included the easternmost, solstice and equinox-aligned 'medicine wheel' known in North America, effigy and geometric shape boulder arrangements, standing stones, earthen mounds and more. Because there was little to no available literature or experience on how to scientifically investigate a complex petroform site with suspected astronomical alignments and, associated with it, an environmental interaction sphere containing late Archaic age (3000-1000 BCE) hilltop shrines with attributes of mutual visibility over distance (Steinbring *et al.* 1995: 22-23), a new paradigm and methodologies beyond excavation had to literally be invented.

Furthermore, all needed to be relevant to the geologic history, climate and Native American astronomy traditions and cosmologies indigenous to the upper Midwest and northern grasslands of the North American mid-continent, not the American desert southwest or meso-America (Bender 2007).

2. Practical Factors and Methodology

During the six years spent investigating the Krug-Senn petroform and archaeoastronomy site (1986-1992), the methods needed to objectively assess whether ancient Native American astronomical attributes and observations were a primary function of a petroform site were eventually developed (Bender 2008a). These methods were further developed with the discovery and investigations of both the Starman and Star-being petroform sites and their apparent stellar attributes (Bender 2004; 2008b; 2011a). Logically, if astronomical alignments are suspected or detected, a practical working knowledge of astronomy basics is essential.

The basic astronomical skills brought to an investigation should include, but are not limited to, a knowledge or familiarity with: (1) the night-sky realm including constellation and individual bright star and planet recognition or identification together with their seasonal movements over time; (2) stellar colours and magnitude values as indicated by the Hertzsprung-Russel diagram (Abel 1984: 288, A.38); (3) celestial coordinate systems (Abel 1984: 57-61); (4) solar and lunar cycles apparent from Earth and their seasonal movement against the background of stars, i.e. the concept of the Zodiac (Cornelius 1997); (5) astronomical algorithms and their mathematical base (Meeus 1991; 1997); (6) astronomical terms and nomenclature (Abel 1984: A.5-A.26), and (7) familiarity with star charts, maps and ephemerides.

Furthermore, years of observational experience working within the limits of unaided or naked-eye astronomy is of critical importance and, perhaps, the best experience that one can possess when working in the field of archaeoastronomy, a field of study inherently within the limits of unaided eye observations (Bender 2008b; 2011a).

Because Wisconsin is part of the heavily glaciated North American mid-continent which is a relatively recently formed late Ice Age landscape (Clayton *et al.* 1991; LaBerge 1994: 249-299; Syverson & Colgan 2011: 537), geological factors should include but are not limited to: (1) knowledge of late Pleistocene geology, glaciation and local glacial dynamics; (2) knowledge of lithic identification, sources and ice transport; (3) Bowen’s reaction series and how when applied to differential weathering profiles (Bloom 1978: 120; Ehlers & Blatt 1982: 147-157, 270-272), and (4) Holocene climate, vegetation and megafauna shifts over time (Bender 2007).

Cultural factors should include but are not limited to knowledge of (1) both ancient and resident indigenous populations (Quimby 1960); (2) prehistoric and historic era settlement patterns (Waldman 1985: 39-40); (3) tribal migration histories (Taylor & Sturtevant 1996: 136-139); (4) macro-language group core areas and oral traditions (Powell 1969: 26; Schlesier 1987: 50-51; Waldman 1985: 67-68); (5) oral traditions, stories and beliefs based on generations of observation of the natural world, especially those with astronomical events or direct links to celestial observations and the development of a cosmology (Bender 2011a; 2011b; Goodman 1992; Schlesier 1987).

On the physical landscape, field research in the Kettle Moraine and former prairie areas coupled with an intensive field survey (Bender 1995a; Steinbring 1997; Steinbring *et al.* 1995) had clearly demonstrated the development and placement of ‘trail shrines’ (Bender 1995a; Blakeslee & Blasing 1988). These shrines were located along the trails or footpaths connecting river headwaters, drainage divides and springs at the base of prominent hills. The hills exhibited not only prominence, a phenomenal attribute (Steinbring 1992), but *aspects of mutual visibility* one to another (Bender 1995a; 2008a; 2011b; Steinbring 1992; 1997; Steinbring *et al.* 1995). Both the spring areas at the base of the hills and the tops of the hills became favored locations for rock art, petroform or boulder effigies, Manitou or standing stones, bison-effigy rocks, and cairns. Many of these 'trail shrines' apparently date from the mid to late Archaic, ca. 3000 to 1000 BCE with some likely older (Bender 1995a; 2008a; Steinbring 1997; Steinbring *et al*. 1995; Steinbring & Buchner 1997).

In addition to the trail, an intensive survey had clearly demonstrated that potential existed for the discovery of what we had labelled "heritage phenomena" (Bender 1995a; Steinbring *et al.* 1995). Heritage phenomena can include but are not limited to prehistoric cultural remains (such as artifacts, petroform, mounds, etc.); a historic and ethnic presence; aboriginal environmental 'interaction areas' which include springs, hilltops, vistas, astro-archaeological sight-lines and the general quality of horizontal aesthetics viewed from hilltops plus other intangible rather than physical remains (Bender 1995a; 2008a; 2011b; Steinbring 1992; Steinbring *et al.* 1995).

Included in the heritage phenomena was the recognition of an Archaic-age lithic artifact association and the select locations for shrine sites indicating a 'definite Archaic presence' imprinted on the cultural landscape of the Kettle Moraine (Bender 1995a; 2008a; 2011b; Steinbring 1997).

Development and utilization of the parameters and methodology inherent in the cultural landscape model represented a distinct paradigm shift on how to approach the investigation of sites on the cultural landscape. Furthermore, because of the proven association of trails with springs, prominence, river headwaters and drainage divides, there was a predictive component within the model if these factors came together in one area. They did in eastern Fond du Lac County and set the stage for the discovery of the Starman site.

Prior to my first field visit after being invited to assess some suspected standing stones on a nearby property, topographic map analysis and archival research were employed. Through an interview with one local landowner and his neighbours, many of them farmers who had lived in the area since before World War II, information was relayed that a trail or footpath did indeed skirt the marsh on the east base of a 'target' hill that I had previously determined would be 'of interest'. This hill was of interest because springs at its base fed the headwaters of both the Sheboygan and Milwaukee rivers forming part of a drainage divide. Along with the trail, prominence, springs, river headwaters and the divide were important criteria in the parameters of the field model's predictive qualities. If the hill was found to be uncultivated never having been cleared for agricultural purposes, the possibility of discovering an intact, prehistoric trail shrine at its base or on its summit existed.

However, the initial plan was to go there to survey and ascertain whether or not it held promise of containing 'petroform' and to confirm whether any remnants of a pre-settlement 'Indian' trail or footpath were still visible. It was on the morning of my first visit that, with field books and compass in hand, I walked into and discovered what would later be named the 'Starman' site.

3. The Starman and site description

The Starman, which is a petroform and archaeoastronomy site complex, is located in eastern Fond du Lac County (Figure 1). The Starman petroform (from which the site takes its name) is a very masculine, approximate 17 metres (55 feet) long, stickman-shaped effigy bearing an atlatl (Figure 2).

The complex occupies a small hill which affords a 360° panoramic view from the hilltop (Figures 3 and 4). Some vistas are now partially obscured by trees and brush, but during the time of the much warmer and drier Climatic Optimum approximately 7000-3000 years ago, the area was far more open with few trees (Bender 2007: 7; Goldstein 1983: 39; Goldstein &

Kind 1983; King 1981), a prairie landscape with oak openings which persisted on for millennia (Denevan 1992).

Remnant vestiges of a more open landscape with widespread prairie and interspersed oak savannah were recorded in the 1830s by the Government Land Office surveyors (Figure 1).

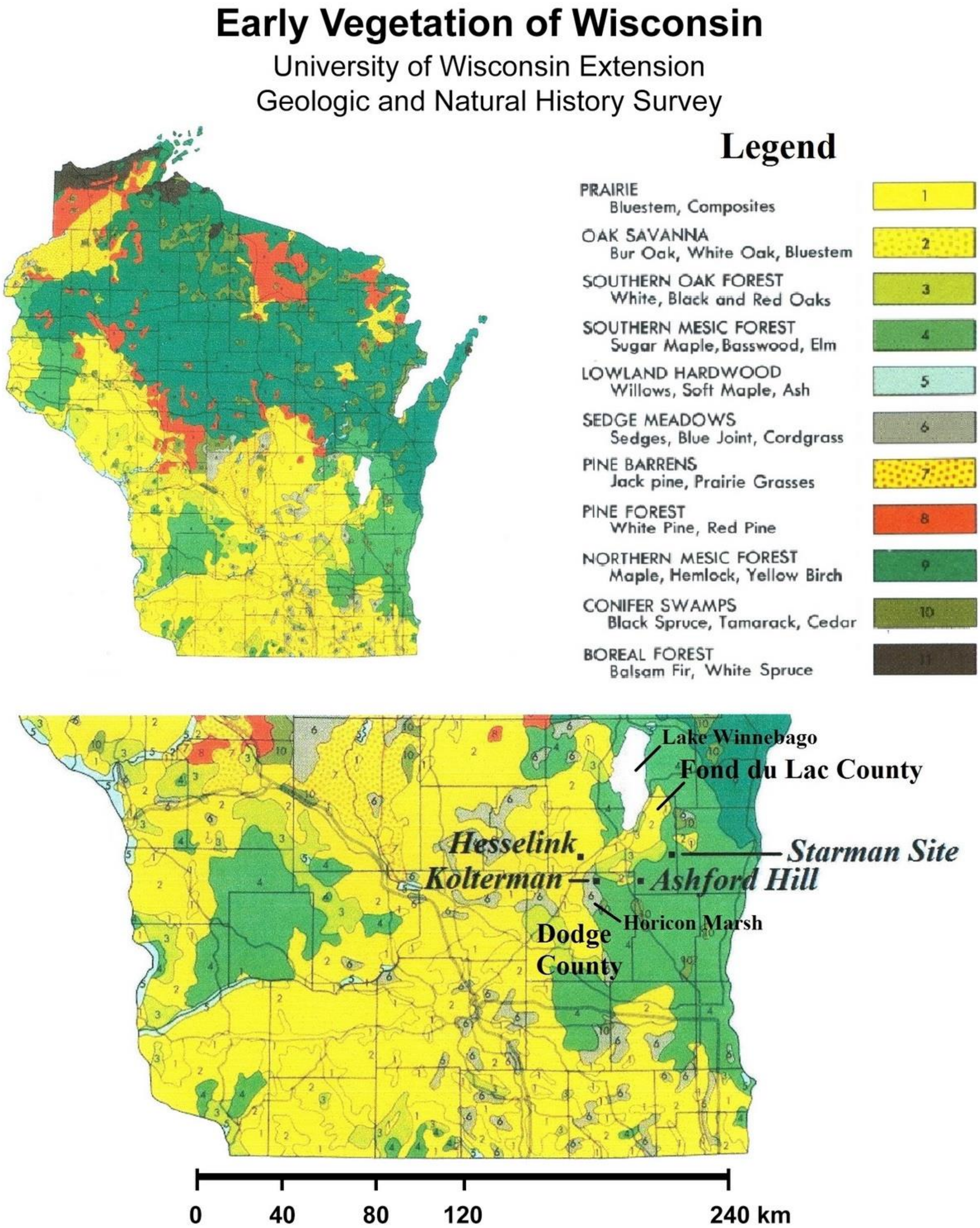

Figure 1. Pre-settlement vegetation map of southern Wisconsin with the locations of important bison effigy and petroform sites. Fond du Lac and Dodge Counties are marked. Note that the areas coloured yellow (Nos. 1 & 2) in the southern part of Wisconsin are prairie and oak savanna, both open grassland landscapes.

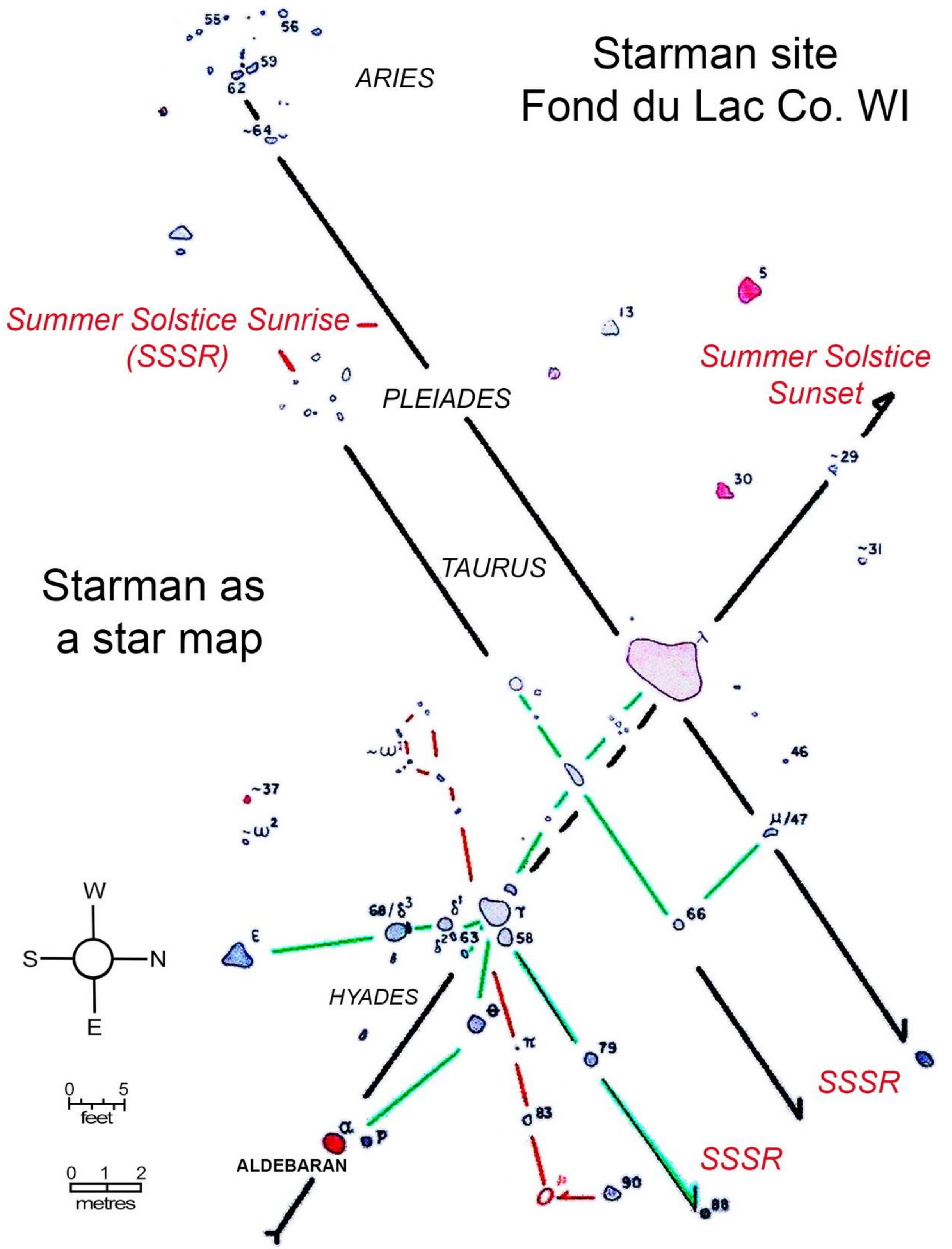

Figure 2. Partial map of the Starman site as a star map illustrating its astronomical attributes. Note the red-coloured, summer solstice sunrise aligned, bison-shaped headstone (see Figure 9), the parallel, multiple summer solstice sunrise alignments, and the rock-for-star designations of the individual rocks directly compared to a star chart. A red coloured rock was strategically placed to indicate the red star Aldebaran. The rock in the 'pelvis' of the Starman is a recumbent Bison Stone also aligned to face the summer solstice sunrise (Figure 10). All the proposed solstice alignments have been observed and photographically confirmed. Each exhibits the full solar disk shift consistent with 3500-4000 years of the shift of the obliquity of the ecliptic.

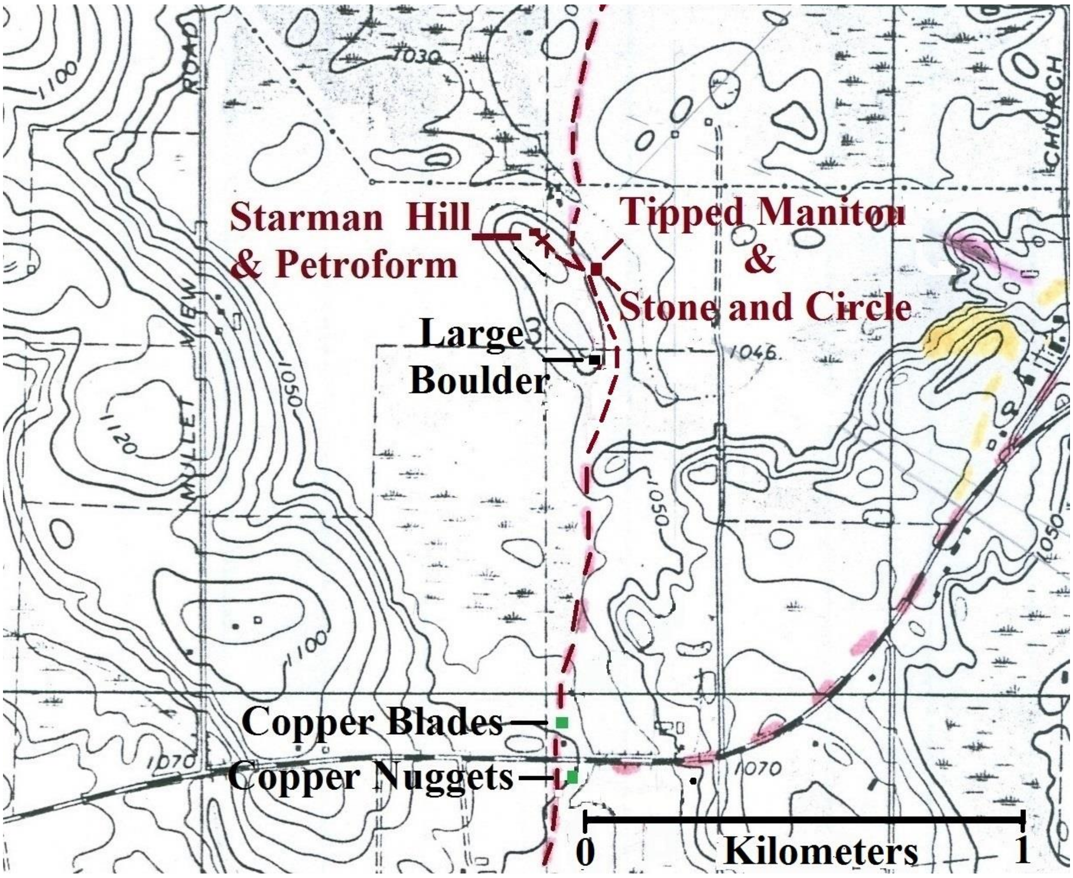

Figure 3. Portion of a United States Department of the Interior Geologic Survey, Dundee Quadrangle, Wisconsin, 7.5 Minute Series (Topographic) map showing the Starman hill, trail (dashed line), tipped Manitou stone and where refined copper nuggets and a copper blade were found. Contour lines are at 10 foot intervals.

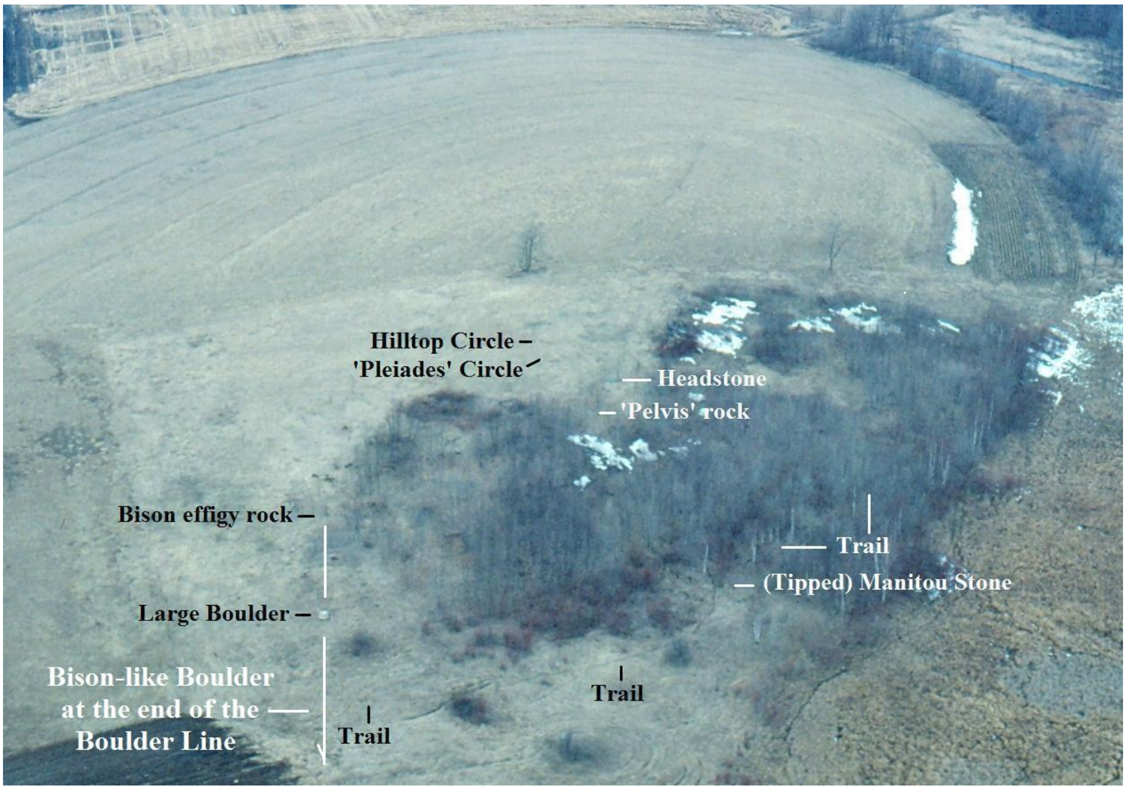

Figure 4. Aerial photograph of the Starman hill with the hilltop circle, the 'Pleiades' circle, the Starman headstone, pelvis rocks and other site features identified (Figure 2). View is looking approximate north.

3.1. Description of principal stones

On the morning of the first visit, I discovered what appeared to be a vestige of the trail and, looking north, saw a large boulder near the edge of a plowed field on the south slope of the 'target' hill (Figures 3, 4 and 5).

Figure 5. The large granite boulder, a glacial erratic resting on the southern end of the ‘target’ hill. It has been rolled out of place, the pit where it rested for millennia to the immediate west of the boulder. The highly weathered top is now at the bottom. View in photograph is looking west.

Once at the base of the ‘target’ hill slope, the trail was easily noticeable as a concave depression again running north between the hill’s east slope and the broad marsh to the east (Figures 3 and 4). This trail was almost certainly the one the local inhabitants and farmers had informed me was there. It had been used by cows at one time, the rut produced by the cows within the edges of the wider trail. Following the trail north a bit farther, my pace quickened when I saw a large, red-rhyolite boulder lying on its side just ahead (north) of me (Figures 3, 4 and 6). The boulder, triangular in shape and about a meter high, was obviously tipped over and lying where it had once likely stood for millennia on what appeared to be an earthen mound surrounded by a circle of smaller boulders (Figure 6 and 7).

Here, by a spring opposite the now tipped standing stone, the trail split with a spur running up the hill's east slope. Following the trail and nearing the top of the hill, two prominent rocks were seen sticking up out of the grass. The largest rocks on the Starman site hilltop, both are bison-effigy rocks that were incorporated into the lithic outline of the Starman and aligned to face the summer solstice sunrise (Figures 2, 8, 9 and 10). Of glacial origin, they are highly weathered and deeply embedded in the soil as is the reddish-cast rock that was strategically placed to represent the red star Aldebaran (Figures 2 and 11). Aldebaran is one of the 20 brightest stars (0.87 visual magnitude), a K5III-M2V Class red giant (Abel 1984: A.38).

Figure 6. The metre or waist high, triangular-shaped, red rhyolite porphyry rock (now tipped) which once stood on an earthen mound surrounded by a circle of rocks partially visible in the photo.

Figure 7. Photo showing the remarkable difference between the still smooth, flat base and highly weathered sides which, unlike the base, have been exposed to the long term weathering in the atmosphere.

Figure 8. Photograph of the Starman petroform bison-shaped 'pelvis' rock (at left) and headstone (at right) in the tall grass (see Figures 2 and 4). View is looking approximately north.

Figure 9. The Starman bison-shaped headstone aligned to face the summer solstice sunrise (see Figure 2). It has been worked to achieve the bison profile including the hump, head and straight, flat back end (Figure 2). It is over 2m long and 1.7m high to the tip of the hump. Extremely weathered red granite, the rock would have been bright red in colour when first positioned.

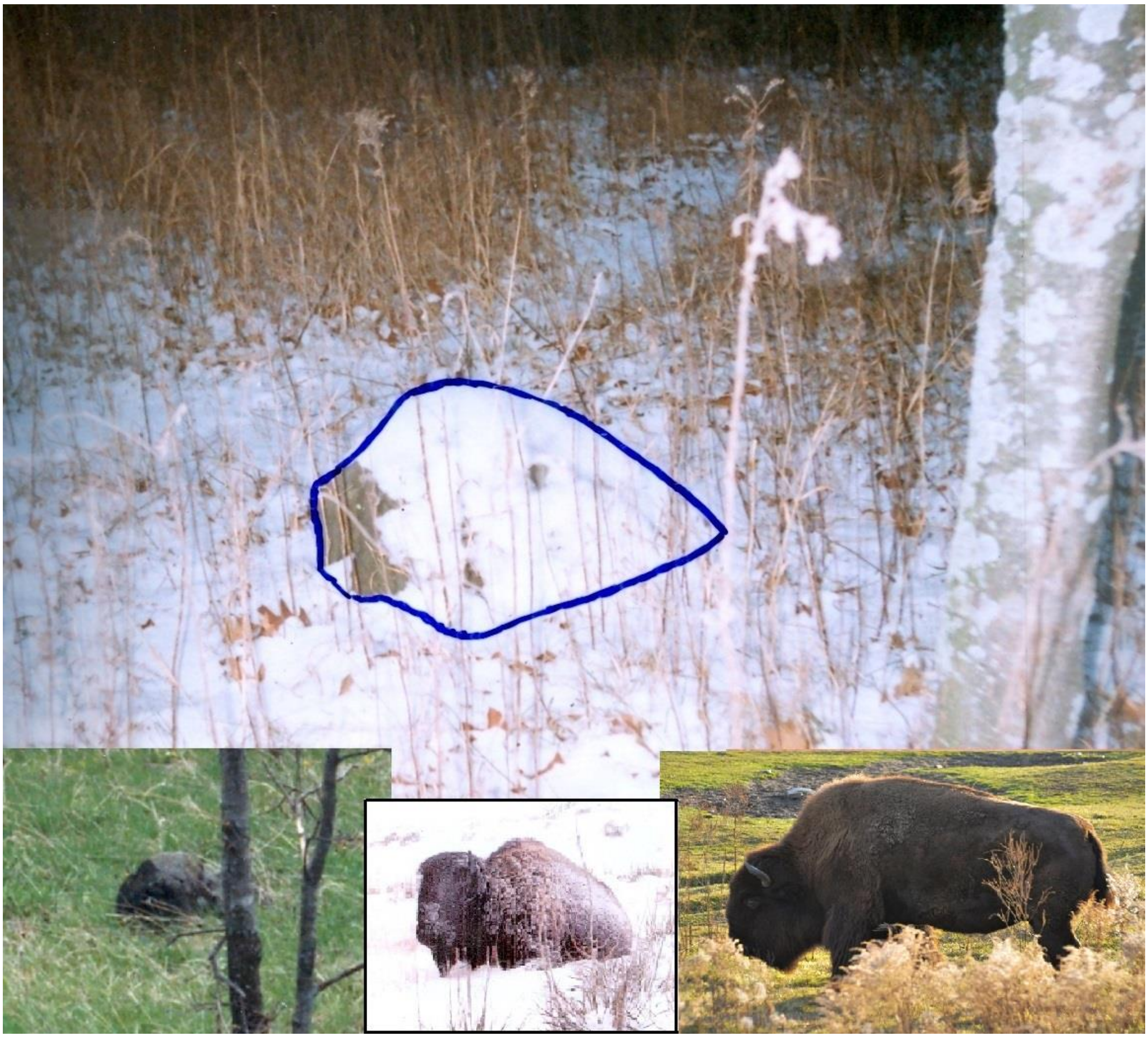

Figure 10. The Starman 'pelvis' rock covered in snow and in the tall grass (photo inset at lower left). It is a recumbent bison (photo inset bottom center) effigy aligned to face the summer solstice sunrise (Figure 2). Note the pronounced hump, flat face and head down posture reminiscent of a real bison (photo inset at lower right). It is almost a metre long. View is looking southeast.

Not a part of the Starman petroform, one other prominent bison effigy rock rests slightly below the south side of the hill summit (Figure 4). Facing east, it has been worked, the hump enhanced by pecking a circular base and the rear or back end squared off like that of a real bison in profile. At one time it likely had facial features, but if pecked, the process may have weakened the rock as the head is now exfoliated (Figure 12). An intermittent spring flows a slight distant to the west of the rock.

Located on the south-east hill slope, the largest boulder on the site (Figures 4 and 5) was utilized as the terminal point of an alignment of spaced rocks over which the winter solstice sunrise was observed from the hilltop circle (Figures 13 and 14). As mentioned, this rock was rolled and now rests on its highly weathered top next to (east) of the pit where it had originally rested.

Figure 11. Photo of the extremely weathered and deeply embedded, reddish cast (granodiorite) rock placed to represent the bright, red star Aldebaran (Figure 2).

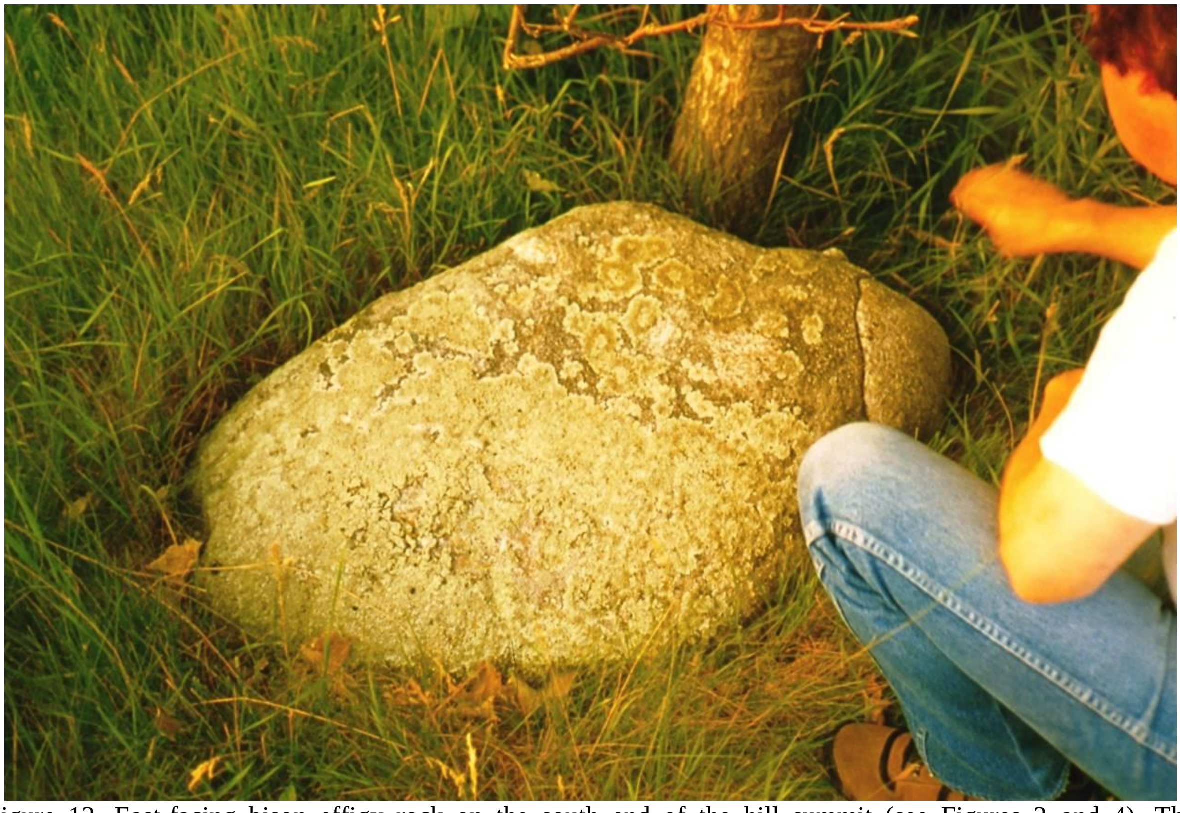

Figure 12. East-facing bison effigy rock on the south end of the hill summit (see Figures 2 and 4). The pronounced hump was enhanced by pecking about its base. The slight knob on the right or top of the head may have represented the horns in profile. The face portion of the rock is now exfoliated, a consequence of time and exposure to the elements.

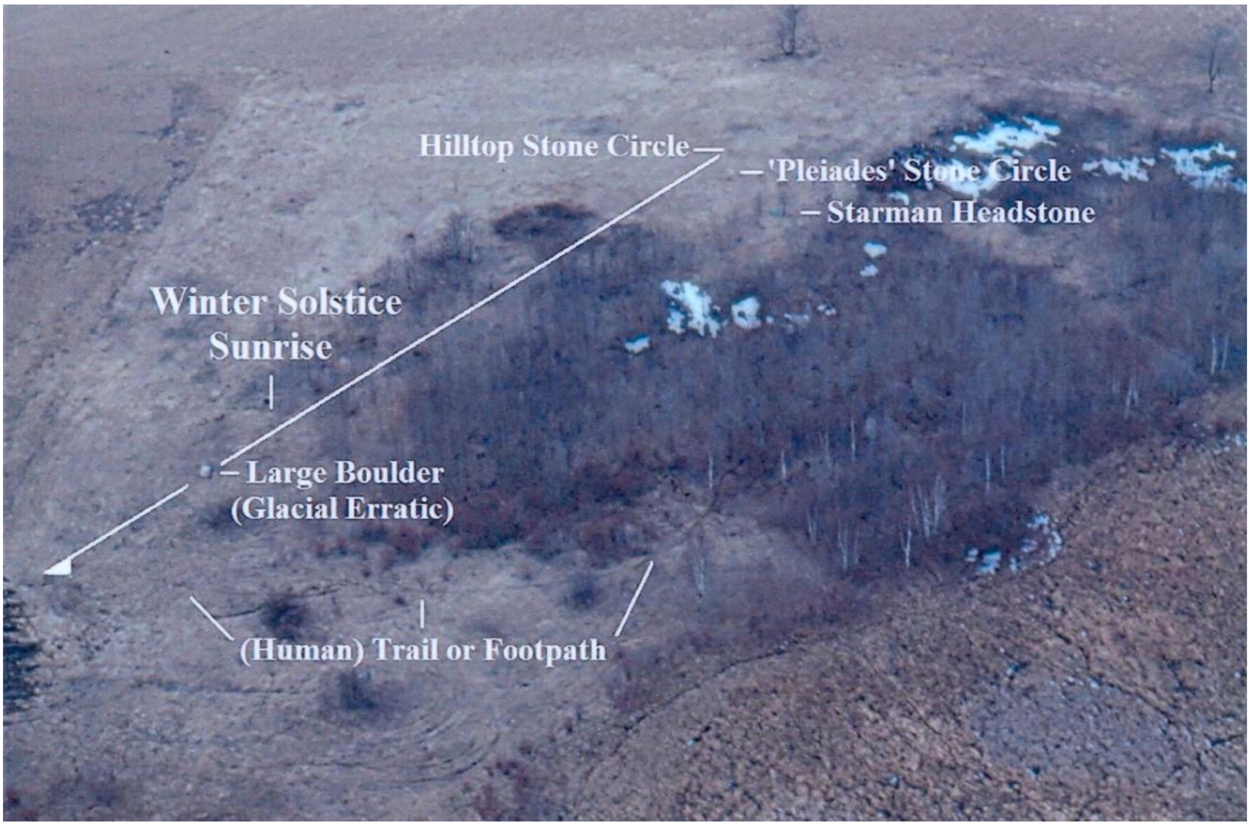

Figure 13. Aerial photo showing the winter solstice sunrise alignment overlooking the large erratic on the south end of the hill. The hilltop and Pleiades circles and Starman headstone locations are also indicated.

3.2. Dating the Starman

Dating sites like the Starman in an archeological context can be difficult. When excavated, petroform sites proper almost universally lacked any dateable artefacts or other cultural debris (Buchner 1980; Garvie 1991; Kehoe 1965: 15; Steinbring 1970a: 238, Steinbring & Steinbring 1999: 10). They were, archaeologically speaking, non-productive and therefore problematic, i.e. not really conducive to accepted archaeological excavation methodology, paradigms or peer review looking for artefact data only. However, at the Starman site, four indirect dating methods were eventually employed. All indicated the same time period indicating a ‘best fit’ date of epoch 1500 BCE.

One of the dating methods, the observed degree of the *shift of the obliquity of the ecliptic* (Aveni 1972; Meeus 1991: 135-136) was anticipated and then confirmed by observation and photographically (Figures 15 and 16). A second dating method, the apparent degree of stellar *precession of the equinoxes* (Gribbin 1996: 322-323; Meeus 1991: 123-130), *i.e.* the apparent shift of stellar rise azimuths over time for the proposed individual star rise alignments, is based on the azimuths of spaced rock alignments and heliacal star rises for the epoch (Figure 17 and Table 1).

At the Starman site, the epoch of probable use had been determined by the realization that the lone red rock placed in the 'foot' of the petroform unambiguously correlated to the red star Aldebaran in the Hyades (Figures 2 and 17) and the degree of shift in its rise azimuth over the millennia (Bender 1994a). It was a most critical step in the site investigation. Over the next two years using an off-the-shelf precession program (Sky Map 1.3), the spaced rock alignments were consistently seen to align with the center of a one degree high by one and half degree wide ‘target box’ approximately two degrees above the horizon for the helical rise of eight separate bright stars and the Pleiades 3500 years ago (Figure 17).

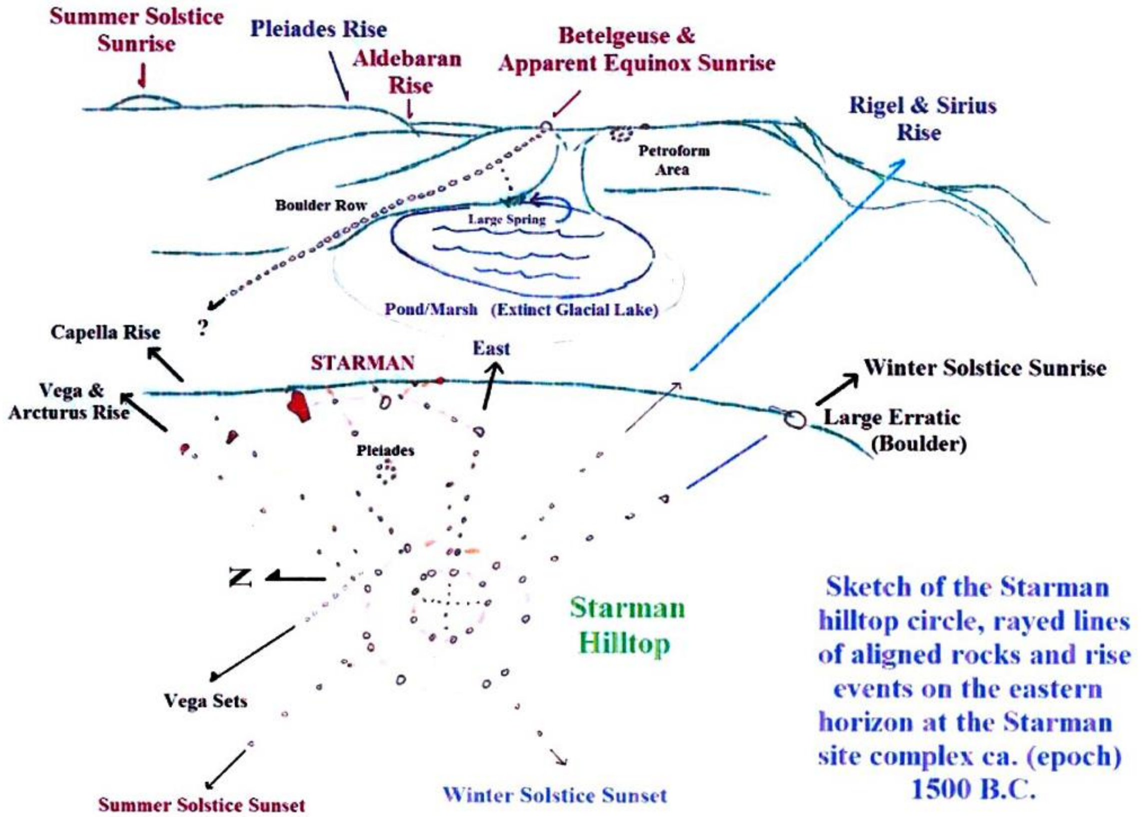

Figure 14. Sketch map of the Starman site showing the cross-in-circle hilltop circle and alignments of spaced rocks radiating toward the eastern horizon where star and solstice sunrises and sunsets were observed. Note also the large erratic boulder on the winter solstice sunrise alignment or azimuth (Figure 13). According to long term land owners whose properties have been in the same families for generations, cairns were located on distant hilltops in-line with the proposed stellar alignments before being destroyed by post-World War 2 agricultural land clearing.

Figure 15. The winter solstice sunrise (full disk between the parallel vertical white lines) viewed from the hilltop circle. Note that the disk of the sun shifted a minimum of one full sun disk north (left) of the camera centre (and arrow) pointed along the alignment of spaced rocks and toward the large boulder (Figures 13 and 14). The effect is due to the shift of the obliquity of the ecliptic or change in the earth's tilt over 3500-5000 years.

Figure 16. Photograph of the summer solstice sunrise viewed from the Starman site hilltop circle. Note the sun (between the two parallel vertical lines) and its extreme shift south (right) of the centre of the hill marked by a tower and white line. Three parallel summer solstice alignments at the Starman site point at the direct centre of the hill which is approximately 3 km distant across the marsh (Figures 2 and 7).

Table 1: Stellar rise azimuths about 1500 BCE at 43.75° N. latitude. (Rise azimuths calculated at approximately 1.5 - 2.5° elevation unless noted). Current and precession stellar rise values calculated from *SkyMap Pro Version 8* (Marriott 2001).

	Azimuths	
	Epoch 1500 BCE	**Epoch 2000 CE**
Vega	~ 29°	~ 32°
Vega	~ 32° (elevation 3°+)	Vega -- little changed over the epochs
Arcturus	~ 30°	~ 64.5°
	~ 33° (elevation 3°+)	
Deneb	~ 35°(+)	~ 15°
Capella	~ 41°	~ 12°
Castor	~ 47°	~ 45°
Pollux	~ 51°	~ 51°
Pleiades	~ 81°	~ 57°
Procyon	~ 81.5°	~ 84°
Aldebaran	~ 86°	~ 68°
Betelgeuse	~ 91°	~ 81°
Sirius	~ 117°(+)	~ 116°
Rigel	~ 118°	~ 103°

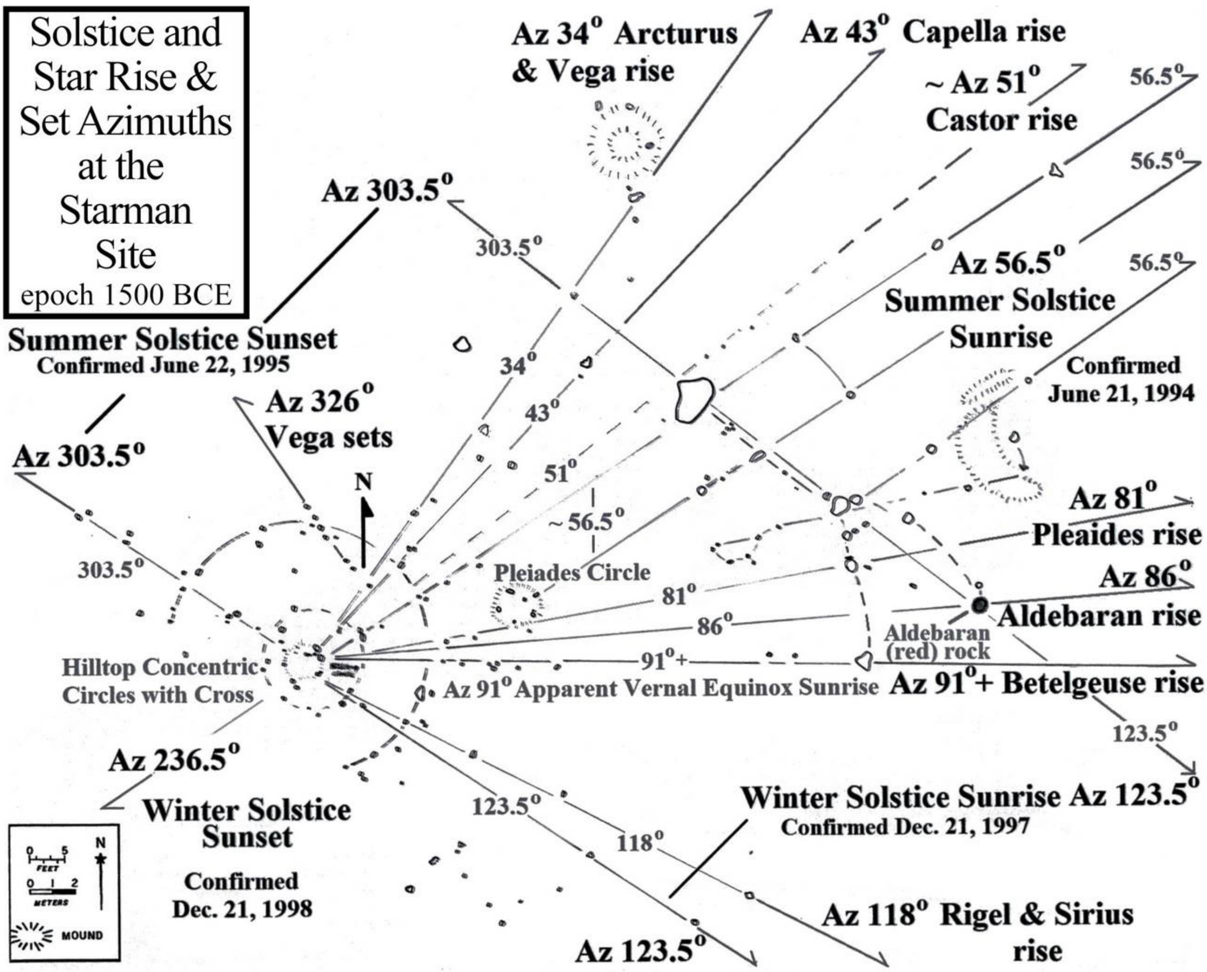

Figure 17. Map of the Starman site showing all the rocks mapped on the site (see Figures 2 and 14) together with the alignments of spaced rock identified for the solstice rise and set azimuths and the stellar heliacal rise azimuths observed from the hilltop circle ca. 1500 BCE.

A third method of dating the time of prehistoric habitation when the Starman site was likely laid out and utilized is through examination of the proximal area land owners' artifacts collected over the past hundred and seventy years. A comprehensive analysis of artifact collections gathered by area landowners was conducted early in the investigation. Dated by their style, shape and workmanship (Figure 18), artifacts in all the collections that were examined are overwhelmingly pre-ceramic in date or age dating from the middle to late Archaic period circa 3000-1500 BCE (Goldstein & Osborn 1988; Stoltman 1986).

Collections included two distinctive and diagnostic Old Copper Culture tanged-base spear points (Figure 18) approximately 4000 years old (Steinbring 1997; Stoltman 1986: 217-226).

Rock art studies were also employed. By examining the Archaic age petroglyphs at the Jeffers Petroglyph Site on the Minnesota-South Dakota border (Lothson 1976; Steinbring 1999), temporal and stylistic links were established through comparison to the pecked images of bison, tanged copper spear points, and stickman figures bearing atlatls in a pose identical to the Starman (Figure 20). Some atlatl symbols at Jeffers and that of the loop-handled atlatl bearing Starman are a close match with similar symbols found at Indian Knoll in Kentucky which have been dated to 3000-1000 BCE (Lothson 1976: 29-30; Callahan 2004: 60, 63), dates coeval with the proposed date for the Starman petroform.

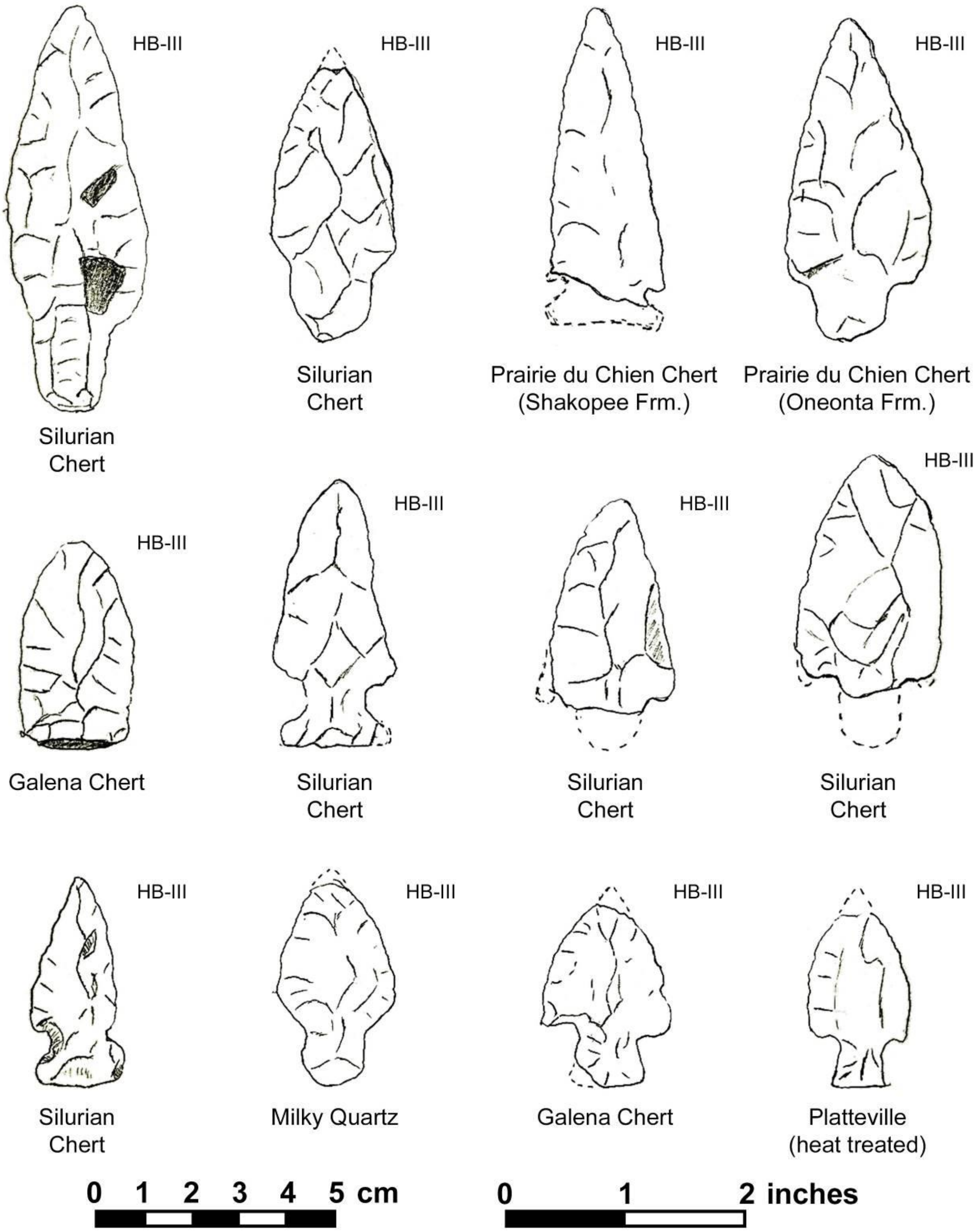

Figure 18. Sketches of artefacts from an area land owner's personal collection of lithic points found approximately 1.5 kilometers north of the Starman site. All are mid to late Archaic period in age (3000-1000 BCE) and made from cherts typical to southeastern Wisconsin. Well over 200 points from two private collections were examined with over 95% dating pre-1500 BCE.

Another clue to the age at Jeffers comes from the projectile point carvings which show numerous 'rat-tailed' stemmed and tanged projectile points (Lothson 1976: 17, 25, 45). The only material in use at the time malleable enough to produce long, thin-tailed points is copper (Figure 19), and indicates Old Copper Culture age technology serving as another horizon marker for the late Archaic period date of the Starman petroform site (Lothson 1976: 31;

Steinbring 1970b: 61). This is also consistent with the date and arc of copper point distribution spread west and north from southeastern Wisconsin to the grasslands of Manitoba in lower Canada (Steinbring 1970b: 69). Of interest, bison hunting scenes using atlatls abound at Jeffers, perhaps not unexpected, and bison effigy rocks also occur as a part of the cultural landscape associated with the geographic arc and time line (Bender 2013).

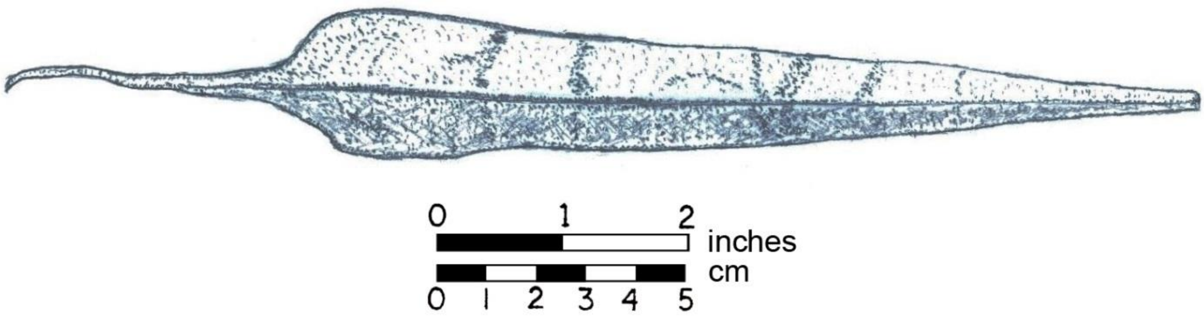

Figure 19. Field sketch of Old Copper Culture tanged or 'rat-tail' spear point found on the trail directly south of the Starman site where refined copper nuggets were also recovered (see Figure 3). Another almost identical spear point was found there in the 1930's or earlier. The large size (approximately 30cm) indicates a purely ceremonial use. A number of other rat-tail and tanged-base Old Copper Culture spear points were found just to the east and south of the Starman site area (Steinbring et al 1995, Steinbring 1997).

Figure 20. Petroglyphs of stickmen bearing atlatls with an erection at the Jeffers Petroglyph site in the same pose as the Starman petroform (at right) with a massive erection and bearing a loop-handled atlatl. The pecked image at left is approximately 0.8m long, the middle figure approximately 0.5m.

3.3. Cheyenne cosmology, stars and the Wolves of Heaven

The indigenous purpose for creating petroform sites like the Starman is difficult to ascertain. A major reason for the uncertainty is the difference between a function, i.e. how the site is physically connected to the landscape and sometimes the sky, versus the purpose of why it was constructed and how it functioned in a spiritual sense (Bender 2008b). At the Starman site, the discovery of solstice alignments and then a later revelation of stellar alignments keyed to the landscape could be confirmed by careful mapping and computer driven astronomical precession programs. These alignments represented site function, i.e. a physical if not tangible connection to the landscape and sky interface, but could not explain the purpose of why they were established. This was to change in the summer of 1995 after an article published in a local newspaper about the preliminary Starman site investigation came to the attention of representatives of visiting Cheyenne Indian Nation delegation.

Within a month, a traditional Northern Cheyenne elder and healer and member, Mr. Ralph Redfox of Boise, Idaho, contacted me and asked for permission to visit the site in

September. Upon meeting for the first time, rather than inquiring about the possibility of visiting the site, he explained that he came “seeking centre.” He instead asked if I had the “sunrise on the longest day” or the summer solstice sunrise and “certain stars” at the Starman. The stars Mr. Redfox asked about were the Pleiades, the “red wolf named Aldebaran”, the “white wolf” the “blue kit fox [star]” and the “black star in the northeast,” later in the conversation identified as Vega. The “white wolf” and “blue kit fox” stars were still unnamed. It had already been determined that the lone red rock in the Starman petroform represented the red-star Aldebaran in the Hyades (Bender 1994a: fig. 2). In addition, the summer solstice sunrise alignment had already been verified (Figures 2, 16 and 17). Furthermore, rocks placed to represent the Pleiades had been mapped along with alignments of spaced stone that we would shortly learn indicated the azimuths for the heliacal rise slightly above the horizon of Aldebaran, the Pleiades, Capella, Vega and Betelgeuse. Utilizing a computer precession program, the azimuths for all of them indicated that they were likely observed rising in the predawn sky ca. 1500 BCE (Bender 1994b; 1995).

After further communication from Mr. Redfox and members of the Cheyenne Wolf Lodge in March 1996, it became evident why he had asked about the “red wolf” Aldebaran, the “white wolf” that we call the star Sirius, and the “blue kit fox” [star], i.e. the blue-white star Rigel. Mr. Redfox had suggested we look at the most detailed description of the Massaum ceremony or "Crazy Animal Dance" described by Karl Schlesier (1987: 77-109) in the book of Cheyenne cosmology, *The Wolves of Heaven*. The Massaum, a world renewal ceremony and ritual bison hunt originated with the Cheyenne cultural hero Motseyoef, better known as Sweet Medicine (Grinnell 1972: 285-336; Hoebel 1960: 7, 16-17; Powell 1969: 26; Schlesier 1987: 78). Ancient by all accounts, Mails (1973: 26) stated that the rituals for the Massaum were given to the Cheyenne by Sweet Medicine in about 1000 BCE (a date which closely supports the corroborating astronomical, artefact and rock art dates).

The primary spirits or *maiyun* Sweet Medicine and a companion met in the Wolf Lodge where the Massaum ceremony originated were Nonoma and his wife Esceheman. Nonoma is “Thunder” and the "red wolf" represented by the red star Aldebaran (although in more ancient times, the red wolf star may have been Betelgeuse). Esceheman, “Our Grandmother”, is the deep earth represented by the "white wolf" and bright star Sirius (Schlesier 1987: 8, 15, 84). Nonoma and Esceheman had a daughter, Ehyophstah or “Yellow-haired woman” who is a buffalo spirit in human form and was given as wife to the companion of Sweet Medicine (Schlesier 1987: 78). This giving was the origin of the Massaum, the Cheyenne renewal ceremony which is a giving of the earth in all four directions and the establishing of a sacred relationship with animals (Schlesier 1987: 78). Ehyophstah represented Voh’kis the ‘blue kit fox’ in the Massaum (Schlesier 1987: 84), known to us as the blue-white star Rigel.

To the Tsistsistas as the Cheyenne call themselves, the Massaum consisted of 56 days and incorporated the anticipated heliacal rise of the bright stars Aldebaran, Rigel and Sirius on timed, 28-day intervals beginning on the summer solstice (Schlesier 1987: 83-84). The incremental 28-day timing of events was a core element of the Massaum (Hoebel 1960: 16-17). The number 28 is a significant and sacred number to most Plains Indian groups, the number of ribs in a bison, days "the moon lives" and a woman's menses (Powers 1977: 50-51). It is the product of two other sacred numbers, four and seven (Kehoe 1992: 212, Nabokov 1967: 24, 27; Powers 1997: 4). Schlesier (1987: 87, 91) sees the Big Horn Medicine Wheel with its 28 spokes as a flattened version of a Massaum wolf lodge built on a 28 pole frame.

After learning of the “white wolf” and “blue kit fox” and keeping their function in mind, the shared alignment used to anticipate the heliacal rise for both Sirius and Rigel was discovered at the 118° azimuth where the precession program indicated it would have been ca. 1500 BCE (Bender 1996). By 1998 the Starman site mapping of all solstice and stellar alignments for epoch 1500 BCE was complete with all of the rocks, no matter how small, mapped (Figure 17, Table 1). Using the stellar precession program and looking only at first magnitude or brighter stars important in Plains Indian cosmologies, the sequential timing for heliacal star rise azimuths that would have occurred on approximate 28 day intervals before and after the summer solstice, observed in-line with the alignments of spaced rocks, was completed (Figure 17).

At the Starman site, the 'best fit' timing strongly suggests that the stellar incremental day count leading up to the Massaum began approximately 84 days (28 days X 3) before the summer solstice (sunrise) with the heliacal rise of Capella. It was then followed by the Pleiades which rose at the half-way point 42 days later (28 days x 1.5). Aldebaran rose heliacally 14 days (28 days X 0.5) after the Pleiades. Then, 28 days later, Betelgeuse (the “red wolf” at the time) rose helically in the dawn sky the day of the summer solstice sunrise, signaling the start of the Massaum ceremony and ritual hunt. Rigel (the “blue kit fox”) rose 28 days after the summer solstice sunrise followed 28 days later by Sirius (the “white wolf”), signaling the end of the ritual hunt. The 28-day intervals starting with heliacal rise of the red stars Aldebaran and Betelgeuse, the blue star Rigel and the white star Sirius timed before, one the day of and after the summer solstice are important not only for the number symbolism, but the color attributes preserved in the Cheyenne Massaum ceremony as the *maiyuns*. It would not be until a thousand years later and as a consequence of the *precession of the equinoxes* that the red star Aldebaran first rose heliacally with the summer solstice sunrise ca. 100-500 C.E. (Eddy 1974; 1977; Schlesier 1987: 85). It became the “red wolf” star of the Massaum, likely replacing Betelgeuse whose time had long passed.

Through knowledge of the ancient stories and ceremonies, the Starman lithic complex has gone beyond the determination of an astronomical function to, as the Cheyenne saw it, the original purpose for its construction. Utilizing the input from the Cheyenne and ancient Tsistsistas tradition, it is likely the first time that a petroform or megalith site’s purpose may be linked to an ancient Plains Indian ceremony, one with a genesis or origin in the east whence the people migrated. Furthermore, its discovery had been anticipated by the Cheyenne becoming, according to Cheyenne elders, a fulfillment of prophecy to return to their origin.

4. The Star-Being

Discovering one giant human-like petroform, the Starman, determined to be a star map in the Native sense was unexpected, to say the least, and considered by some, if real, the “holy grail” in archaeoastronomy (personal communication with Ed Krupp, December, 1994). But to first discover and then identify a second star-based petroform, the Kolterman Star-Being, was fortuitous and lent credence if not credibility to both. As mentioned previously, a comprehensive description of the (Kolterman) Star-Being has already been published (Bender 2004). However, a review of its salient features together with more recent mappings of an additional petroform together with personal conjecture formed since then are not only timely, but considered appropriate. Furthermore, a report on features mapped at the Star-Being site since the 2004 publication was authored will help to define the cosmological significance of additional petroform and two bison-effigy stones that were likely utilized in conjunction with the Star-Being.

The Star-Being lithic outline or petroform is an approximate 20m long, stickman-like lithic effigy with a serpentine body ending with up-turned ‘tail’, wing-like arms and a bison-shaped headstone. There is a partial diamond-shape or obtuse triangle of stones shaped above the Star-Being headstone (Figure 21).

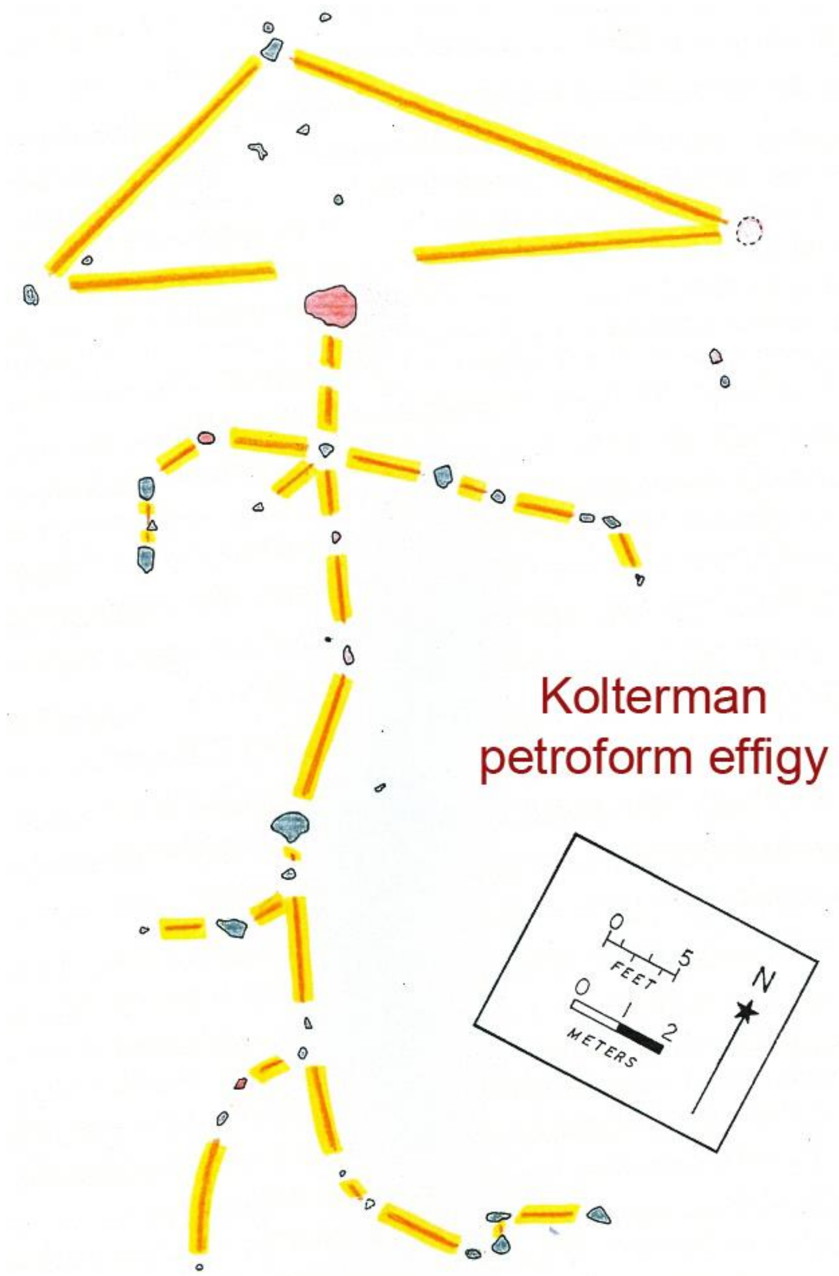

Figure 21. Map of the Kolterman Star-Being, a male, human-like lithic effigy with a serpentine body and red-coloured, bison-shaped headstone.

The Star-Being is located on a small hill on the east side of the Horicon marsh (Figure 22). From it the entire (north to south) length of the Horicon Marsh basin to the west can be viewed. Save for some trees to the west which have grown up in the past 100 years, the north to south vista presents a continuous view with a near 0° elevation toward the entire western horizon. Over the years, the western portion of the site has been destroyed mainly by road construction and partly by agricultural cultivation. The land containing the remaining mound group has never been cultivated, only pastured.

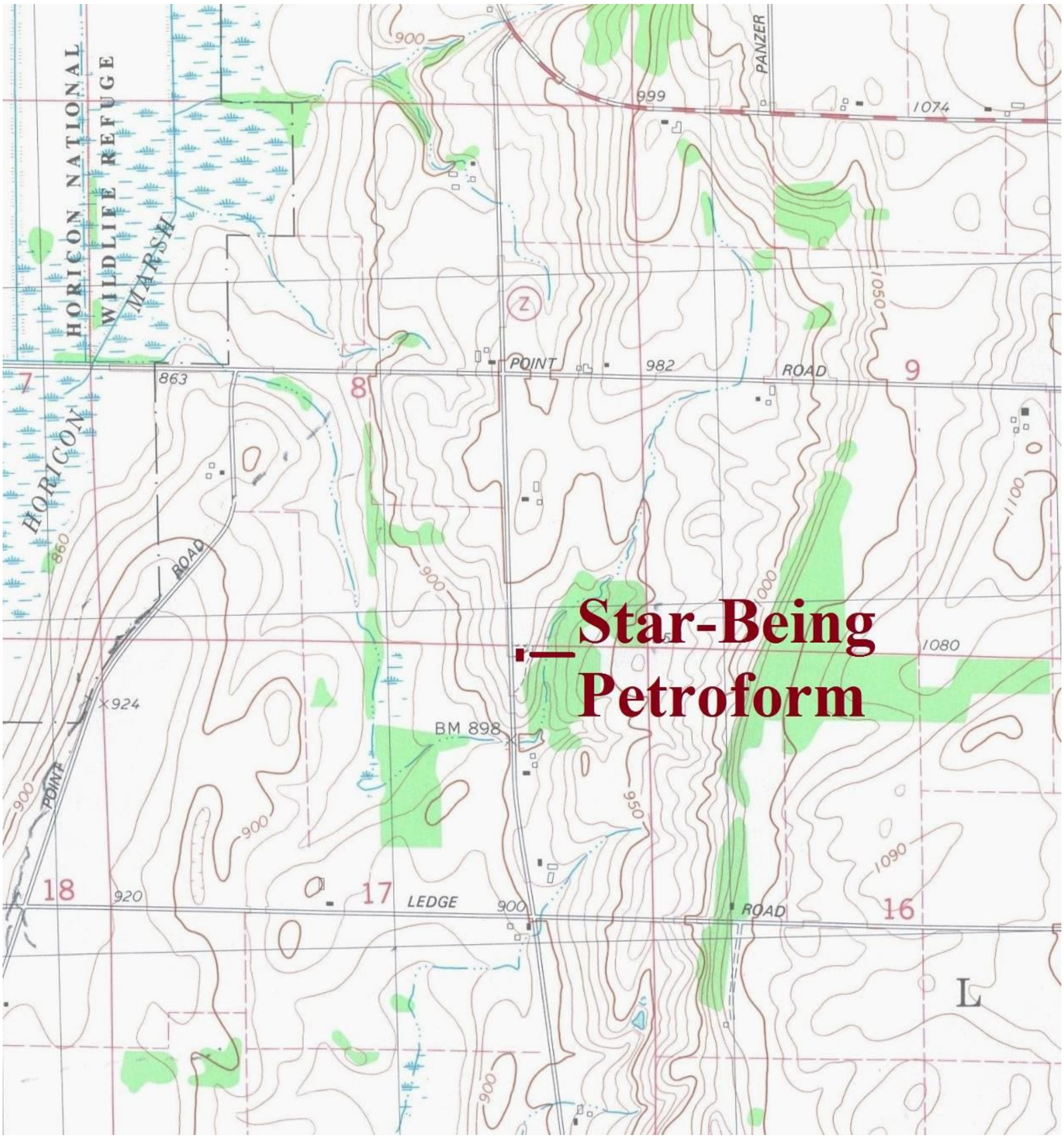

Figure 22. Portion of a United States Department of the Interior Geologic Survey, Mayville North Quadrangle, Wisconsin, 7.5 Minute Series (Topographic) map showing the location of the Star-Being petroform hill on the east side of the Horicon Marsh. Contour lines are at 10 foot intervals.

4.1. Star-Being headstone description and solstice alignments

The Star-Being headstone (Figures 21 and 23), like the Starman headstone (Figures 2 and 9), is a deeply weathered, red-coloured (red rhyolite porphyry) bison-shaped rock with a cleaved, flat back end, aligned to face the summer solstice sunrise (Figures 23, 24 and 25). It is considered to be two-headed (Figure 25), to the Cheyenne, *haztova hotoxceo* or “two-faced [star people]” and to the Lakota, *Anukkite* or “face on both sides (Powers 1977: 197; Schlesier 1987: 79).

Figure 23. Photo (top) of the highly weathered, Star-being bison-shaped headstone. In the grazing light of the late Fall and early Winter the eye detail and what may have been a horn are apparent. Note the cleaved flat, straight and perpendicular back (west) end and dip like that on buffalo in viewed in full profile (bottom photo). When fresh, the red rhyolite porphyry headstone was a deep red color.

Figure 24. A direct, overhead view of the Star-Being headstone showing its dual humps and flat, cleaved straight rear end.

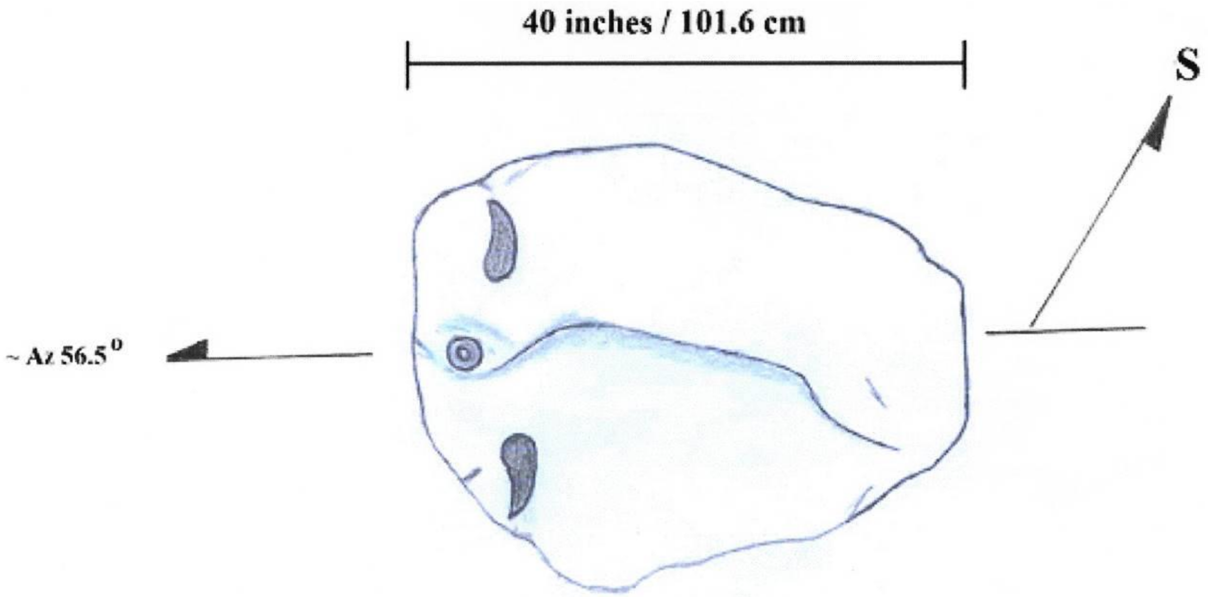

Figure 25. Outline drawing the two-headed bison effigy rock with horns and eye added to suggest the dual bison profile viewed from either the north or south. At the latitude of Kolterman, the azimuth 56.5° is near the 0° elevation of the first flash of the summer solstice sunrise.

Because the summer solstice sunrise is now blocked by vegetation, the reverse azimuth, i.e. the winter solstice sunset, was utilized in order to confirm the accuracy of the alignments (Figures 26 and 27).

Viewed across the Horicon Marsh, the sun is seen to set on the horizon at 0° elevation. This is another likely reason why the location was chosen for the site.

Figure 26. Aerial view of the Star-Being lithic outline or petroform with 'helper lines' and the direction of the winter solstice sunset viewed overlooking the aligned, bison-shaped headstone and an aligned rock (see Figure 27). Road construction likely destroyed others in the alignment.

When mapping the lithic outline or petroform, the upper body bending north-west from a lower body south-to-north alignment, the 'hooked' leg terminating with the large rock 'stingers', a 'tail' stone, a triangle of stones surrounding the headstone and the sinuous body shape are all highly diagnostic features for someone with a background in astronomy. It is a very recognizable pattern which can be found in the night sky. The 'stickman' effigy on the ground at Kolterman can be seen as a star or rock mirror-image of the constellations that we call Scorpius and Libra (Figure 28).

4.2. Thunderbird traditions

A natural question is why would people create a mirror image of these particular stars or stellar pattern? The answer may lie within the thunderbird traditions and stories of the Plains and other American Indian together with the seasonal rising and setting of the stars in Libra and Scorpius relative to the sun during ancient times.

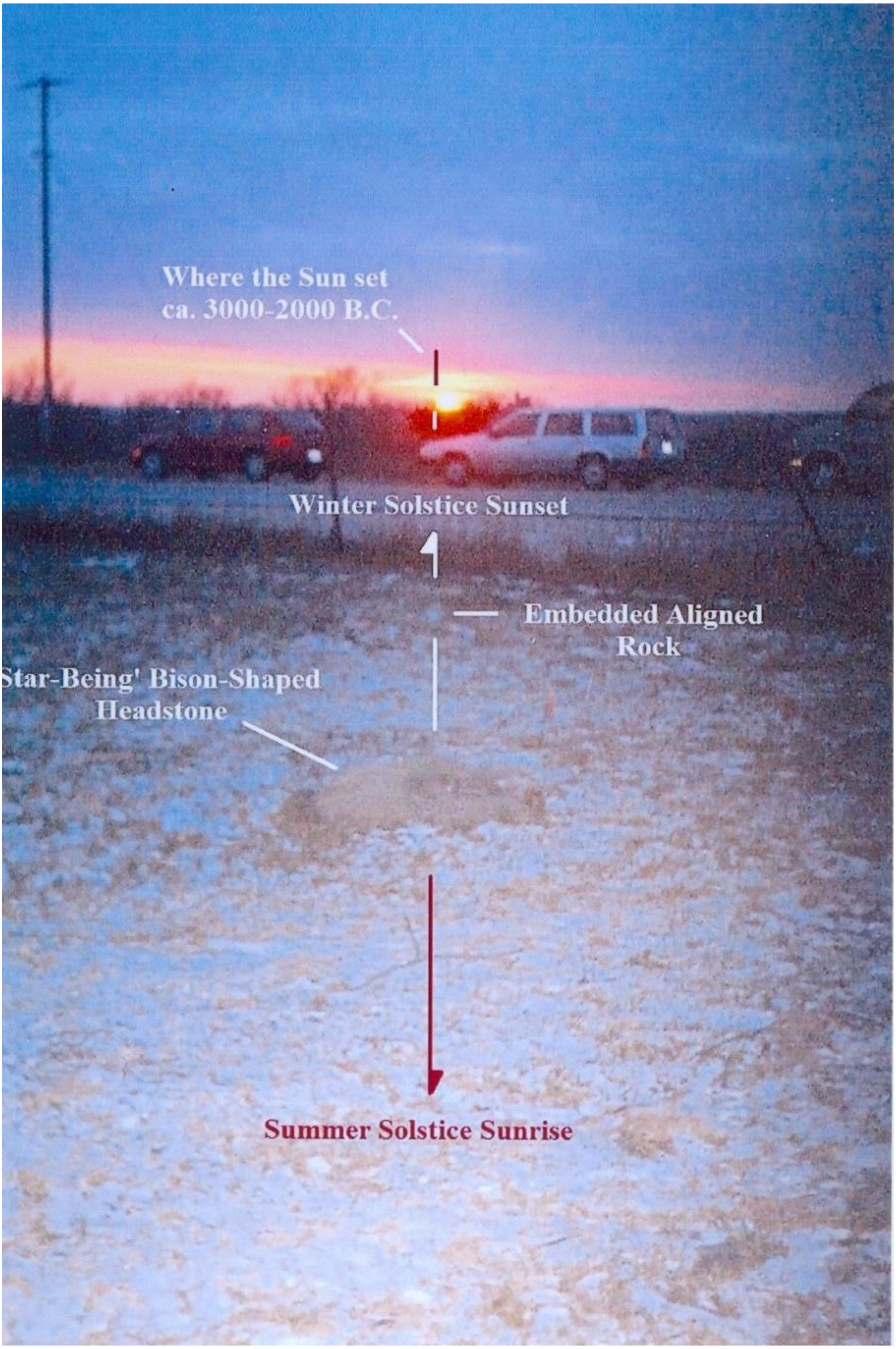

Figure 27. The winter solstice sunset overlooking the Star-Being headstone and aligned rock (Figure 26). Note the full solar diameter shift to the right or north of the alignment, which is the effect of 4000 years of the *shift of obliquity of the ecliptic.*

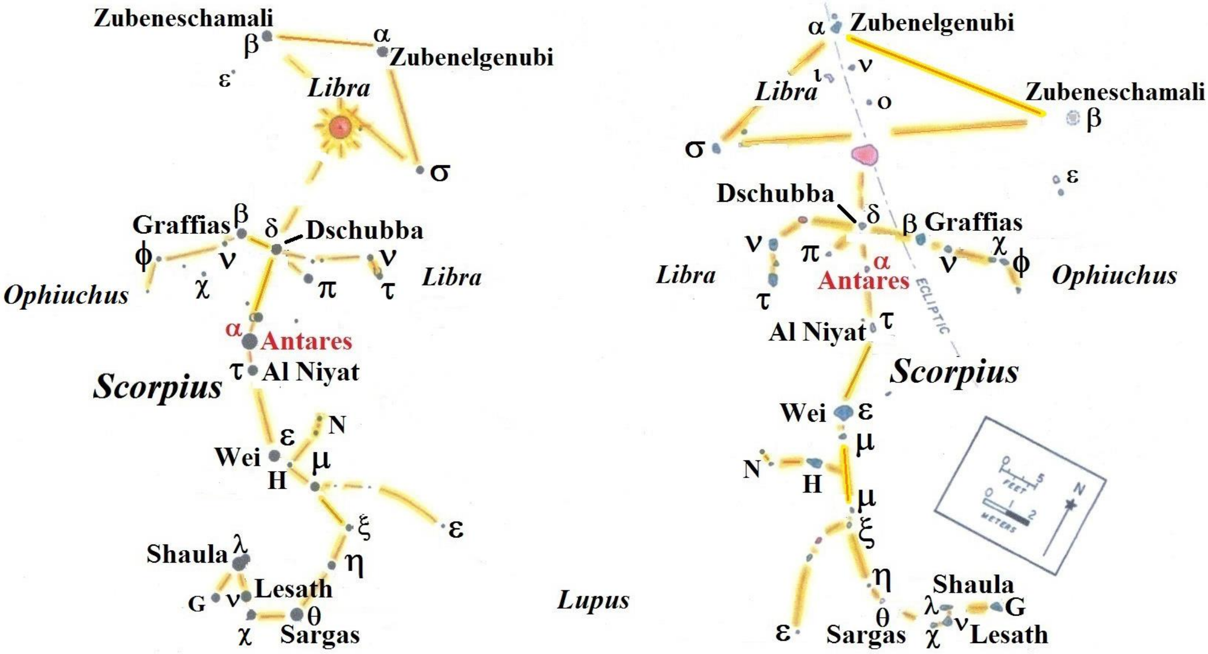

Figure 28. Illustration showing the Kolterman Star-Being (at right) as a mirror image of the western constellations Scorpius and Libra. Note that the individual stones in the lithic form can be annotated 'rock for star' when compared to the mirrored star map. The Star-Being's red-coloured, bison-shaped headstone is in the same location in the stones making up the constellation that we call Libra as was the Sun during the autumnal equinox sunrise about 4000-2000 BCE.

One of the most ancient and widespread traditions amongst Native American people is the thunderbird tradition (Grant 2000: 311; Owusu 1997: 132-133, 178-179, 187-188). Thunderbird stories are part of almost every tribal mythology. They are especially prevalent in the Midwest and Great Plains where severe thunderstorms occur on a seasonal basis. Thunderbirds are said to arrive in the spring of the year, their coming announced by the seasonal weather changes that produce thunderstorms. Their return brought the rain each spring to herald the growing grass, blossoming flowers and to make the berries large and sweet (Cooper 1975: 9-10; Grinnell 1972: 95-96; Mails 1972: 93). Lightning is said to flash from their eyes, many times depicted in a zigzag shape which can also represent a serpent motif, while thunder is said to be the noise of the battle between the thunderbird and giant serpents who live under water. Like the thunderstorms that subside in the autumn, it is the season when the thunderbird is also said to depart, going south (Cooper 1970: 9-10, 146, 193; Grinnell 1972: 95-97; Taylor & Sturtevant 1996: 46-47, 477-478). For the Native American people there were strong ceremonial associations between the thunderbird; the number four; the four seasons that quarter the year; animal migrations; and the Sun dance (Cooper 1975: 184, 191-197; Grinnell 1972: 262- 263; Powers 1977: 97; Williamson 1989: 234).

Not surprisingly, Thunderbird traditions and rock art representations in the upper Midwest and north-eastern United States are very similar if not identical to those on the Great Plains with some greatly resembling the Star-Being. Like those attributed to the Starman, the reason for the similarities is that many of the Algonquin and Siouan people, including the Lakota and Cheyenne, migrated to the Plains from the upper Midwest taking their traditions with them (Powell 1969: 26; Schlesier 1987: 50-51). Three reoccurring archetypical elements linked to the thunderbird abound in American Indian mythologies and traditions. They are the thunderbird or Thunderers, giant serpents and a cultural hero who may be half human and half animal, and, many times, a 'Star-Being' who is also a cultural hero. T.E. Mails (1972: 92) remarked that "Many tribes regarded certain bright stars as men ..." and Father Florimund J.

Bonduel said in 1855, “They [the Indians] look to the stars which they worship as guardian gods” (Rosholt & Gehl 1976: 226). All three elements are incorporated into the Star-Being.

Lewis Spence (1994: 152-159,172-173,201-203) recites many stories of people marrying or being abducted by ‘star-people‘. These unions often times produced offspring who possessed powers or traits beyond those of ordinary humans. In Lakota cosmologies and traditions, stories of the cultural hero Fallen Star linking him to prominent landmarks and the sky prevailed (Bender 2011c: 168-170, Goodman 1992: 3). In one story Fallen Star (whose father was a star and mother human) had to recover the Chief’s arm lost to the “The Thunderers” or *Wakinyans* (Goodman 1992: 217-220). Fallen Star recovers the arm from “The Thunderers” in the Spring of the year. The Chief’s arm was seen in select stars in the constellation of Orion which is seasonally ’opposite’ the constellation of Scorpius. In the Spring, Orion sets early in the evening with Scorpius rising early in the morning. Therefore, the Chief’s arm story is an allegory for earth renewal and fertility timed to seasonal rising and setting of the stars. The Greek myth of Orion and his nemesis, the Scorpion was born of this same seasonal and stellar sky division (Krupp 1991: 136-137). But rather than seeing Orion and Scorpius rising and setting, Indian people saw other shapes and invented other stories, i.e. the Chief’s arm and “Thunderers”.

Another Plains Indian cultural hero, Clot-of- Blood, was also recognized in the stars. Clot-of- Blood, a buffalo fetus born of man, was a half man-half bison hero acting on behalf of man. He was identified with the Great Nebula in Orion’s ’sword’ (Kehoe 1992: 207-214). Serpents, thunderbirds and the number four are main elements in the Clot-of-Blood stories. In Gros Ventres stories where he is known as “Blood Clot”, Clot-of-Blood slays four evil foes including a giant serpent but cannot completely overcome a thunderbird with whom he strikes a truce. The thunderbird is Bha’a, the giver to the Gros Ventres of the Feathered Pipe during a severe thunderstorm. The Feathered Pipe is a sacred relic used in renewal ceremonies (Cooper 1975: 482-487). Again, the parallels to Orion and likely Scorpius as Bha’a, a thunderbird (bringing storms) not being able to overcome one another and thus separated are remarkable.

Many Native American myths and stories about the stars and constellations are likely as old as those of Orion and Scorpius. According to Schlesier (1987: 15), the Tsistsistas (Cheyenne) retain dim memories and knowledge of “stars and all their different groups ... gradually [being] forgotten” and that “... star constellations provided signals at certain times for Tsistsistas actions ... and some star clusters are considered Tsistsistas spirits, relatives in the sky”. As Ralph Redfox first remarked after viewing the ‘star-being’ petroform, the site and then the maps, “There are old stories I heard about this as a boy. I can’t remember them exactly, but they were about star people and what is here, this Thunder being” (personal communication, April, 1998).

The “old stories” that Ralph Redfox mentioned are Cheyenne stories of the origin of their cultural hero Motseyoef or “Sweet Medicine” (Hoebel 1960: 7; Powell 1969: 26; Schlesier 1987: 78). Sweet Medicine origin stories resonate with the same archetypal elements common to the Fallen Star and Clot-of-Blood stories. Sweet Medicine met, then was instructed and given his ‘medicine’ by Nonoma, represented by the red star Aldebaran, and his wife Esceheman, represented by the white star Sirius. Their daughter was Ehyophstah, represented by the blue-white star Rigel. Before meeting Nonoma and Esceheman, Sweet Medicine and a companion were rescued from a giant serpent called an *axxea* that had severely injured his companion. The rescuer, Nonoma, killed the *axxea* and his wife Esceheman butchered it. The companion was then taken to their (Wolf) lodge where he was healed or ‘renewed‘. While in the Wolf Lodge, both Sweet Medicine and the companion were give white flint knives and ate from very white stone bowls (Schlesier 1987: 77). On a related note, the Blackfoot, another northern Plains tribe, identify Clot-of-Blood's white flint knife with Orion's nebula (Kehoe 1992: 212).

Once again there is a symbolic relationship with the stars in or near Orion as slayers who vanquish a giant serpent (Scorpius?) and then hold renewal ceremonies for human beings. Furthermore, in yet another story, Sweet Medicine uses his ‘medicine’ to vanquish giant beings called *haztova hotoxceo,* in which *haztova* is translated as “both sides of the head” and *hotoxceo* as “star” or “two face star people” (Schlesier 1987: 79), reminiscent of the two-headed bison effigy headstone of the Star-Being (Figures 21 and 25).

The parallels of the archetypal elements in the cultural hero stories to the Kolterman Star-Being are almost overwhelming. The Star-Being may represent the perpetual transformation of metaphor (serpent) on metaphor (thunderbird) on metaphor (half human and half bison); a Thunderer configured in stone linked and timed to the perpetual movement of the stars. If so, it is based on as ancient a Native American tradition as can be found and their reverence for a natural object’s ability to transform and change.

4.3. Dating the Star-Being

Dating of the Kolterman Star Being is also based on associations, not absolute dating techniques. Like the Starman form, all of the individual rocks placed on the original land surface are now deeply embedded with only the top of the rocks exposed. They are also highly weathered from exposure to the atmosphere and differential weathering, the surfaces not exposed still smooth and retaining the rocks texture and colour.

The ‘dual bison headstone’ location may provide another valuable clue as to possible origins and age of the Star Being. Between 4000 and 1000 BCE, the autumnal equinox sun rose into the background of stars we now call Libra (Figure 29) although, at the time, Libra was still part of Scorpius (Allen 1963: 366; Cornelius 1997: 105; Sesti 1991: 440). People who possessed astronomical knowledge of knowing where the sun rose relative to the background of stars from season to season were available, and accomplishing the feat is not that difficult (Goodman 1992: 48-49; Krupp 1991: 132-134; Schlesier 1987: 71-72).

From the historic record and precession data, the best-fit date for where the Star-Being effigy headstone (as the sun) is located relative to its body and ‘Libra-like’ triangle of stars is between 4000 and 1000 BCE (Figure 28). The half-degree of *shift of the obliquity of the ecliptic* (one full sun diameter to the north) observed for the winter solstice sunset (Figure 27) also supports the precession date of the autumnal equinox sunrise for the proposed date of 2000 BCE (Aveni 1972; Meeus 1991: 135-136).

Based on these factors and others, a late Archaic age is proposed for the Star Being, coeval with the Starman’s early date of 2000 BCE.

The Star Being could, however, be older. This is based on the extreme differential weathering surfaces of some of the rocks (especially seen in the headstone), observed *shift of the obliquity of the ecliptic*, and on the precession dates for the autumnal equinox against the background of stars that the Star Being is proposed to mirror (Figures 28 and 29).

Over the past 175 years, thousands of prehistoric artifacts have been discovered in the greater Horicon Marsh area. Like those recovered from the proximal habitation sites near the Starman site, the vast majority date from the Archaic period (Steinbring *et al.* 1995), dated by their style, shape and workmanship.

Typical of the artifacts are those from a family member’s collection found on the family farm over the past 100 years in fields to the west of the Star-Being site (Figures 30 and 31). Dating from the mid to late Archaic time period circa 6000-1500 BCE (Goldstein & Osborn 1988; Stoltman 1986), the collection also includes full-grooved stone axes, which is a hallmark of the Archaic period (Quimby 1960: 43-44).

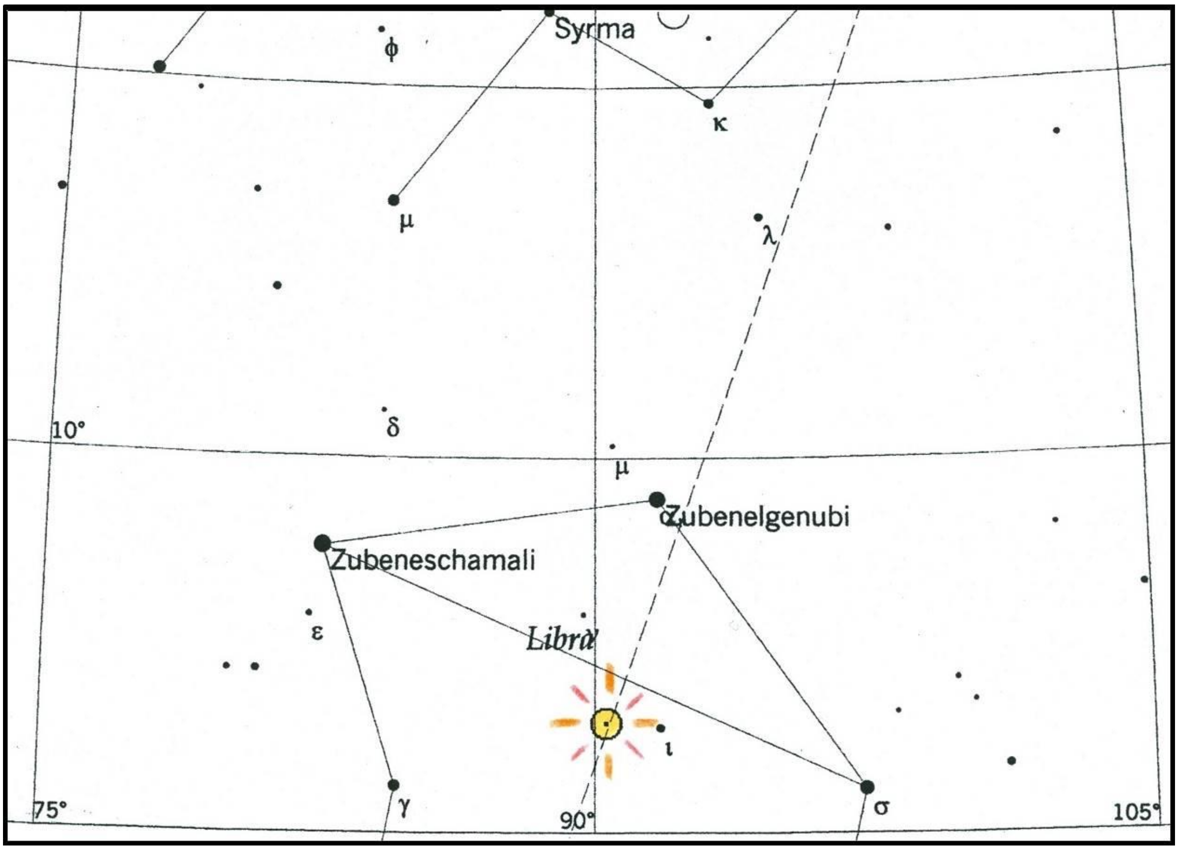

Figure 29. The Autumnal equinox sunrise in the constellation of Libra in 2000 BCE.

Figure 30. Middle to late Archaic spear points and knives from a private collection gathered by family members on the Star-Being farm and property. Made from local cherts, they date between 4000-1500 BCE.

Figure 31. Archaic period spear points, knives and small axe from a private collection gathered by family members on the Star-Being farm and property. The axe is made of gabbro, the points from local cherts. The two blades at right are early Archaic dating approximately 6000 BCE. All others including the axe date between 3000-1000 BCE.

There is, however, one other corroborating date supported by stellar precession. Since 2004, continuing field work, the mapping of all the rocks on the north end of the site, and further examination of Plains Indian stellar traditions with their attendant cosmologies have produced a larger, if not more complex, picture of what may be reflected in 'the above.' Located a short distance to the south of the Star-Being are two bison-effigy rocks (Figure 32). One, named "Bruder's rock" is a large, north-facing bison-effigy rock. The other is a smaller although still large rock that is aligned east-west.

Both bison effigy rocks are exactly located and spaced in relationship to the Star-Being petroform mirror-image of Scorpius when the bright stars Rigel Kent (alpha Centauri) and Hadar (beta Centaurus) culminated during the vernal equinox ca. 2000-4000 BCE No longer visible at the latitude of the site (43.5° N. Latitude), both bright stars were highly visible riding low above the horizon in the night sky prior to 1200 BCE (Figure 33).

Lakota informants say that the two bison effigy rocks are lithic representations of the White Buffalo Calf woman with a calf (Dinah Crow Dog and Leola One Feather, personal communication). Both are coming from the south as bright, white stars—white being the Lakota sacred colour for the direction south (Powers 1977: 49). Moreover, the north-south and the east-west alignments of the bison effigy stones quarter-divide space, in keeping with a cosmic compact representing the universe. They are a strong female counterpart to the very masculine Star Being (Powers 1977: 49-50; Sundstrom 2004: 81-87). If so, like the Thunderbird, the southern stars may represent the buffalo that the White Buffalo Calf Woman changes into (Powers 1977: 196-197), coming back from the south in the spring of the year along with the Thunderbird, the rain and the greening of the grass—all indicative of the world being reborn.

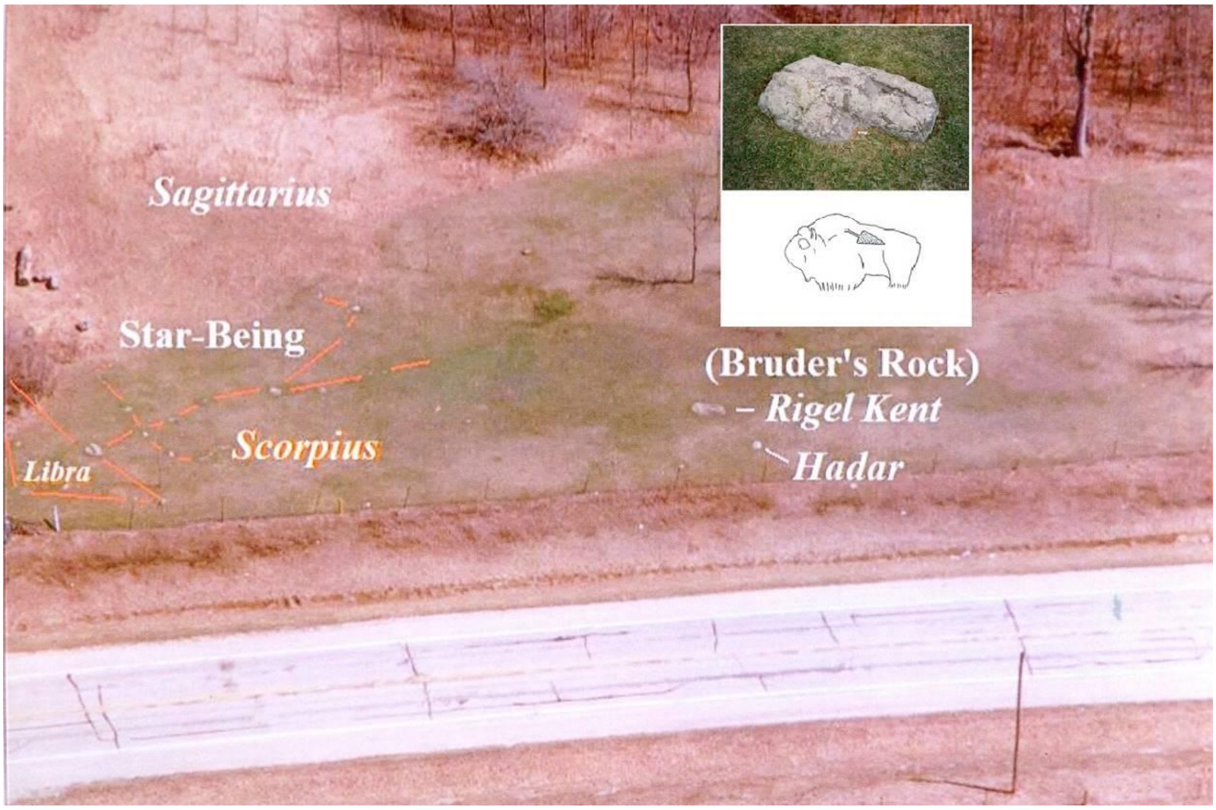

Figure 32. Aerial photograph of the Star-Being as a reflection of Scorpius and Libra with the two bison effigy rocks. Bruder's rock (see inset) is identified as the bright star Rigel Kent (*alpha Centauri*), the smaller one to the south-west of it identified as the star Hadar (*beta Centauri*). The constellation Centaurus is no longer visible at the northern latitude of the Star-Being site, a consequence of precession of the equinoxes. View is looking east with north to the left.

4.4. As above, so below

In 2007 a small but fortuitous grass fire exposed more fully the tops of the deeply embedded rocks to the immediate east of the Star-Being lithic outline. Because of their location on the ground relative to the Star-Being and the stars in the night sky east of Scorpius (Figure 34), it was conjectured that the rocks may represent the stars of the constellation that we call Sagittarius. After all the rocks were compiled into a map (Figure 35), it became apparent that the somewhat elliptical shape could be interpreted and configured as a mirror-image of the stars in the area of the constellation Sagittarius. When keyed into the overall Star-Being map, the picture that emerged was one with the long axis of the 'ellipse' aligned to the summer solstice sunset as viewed overlooking the Star-Being headstone. The alignment and the event were confirmed the same year.

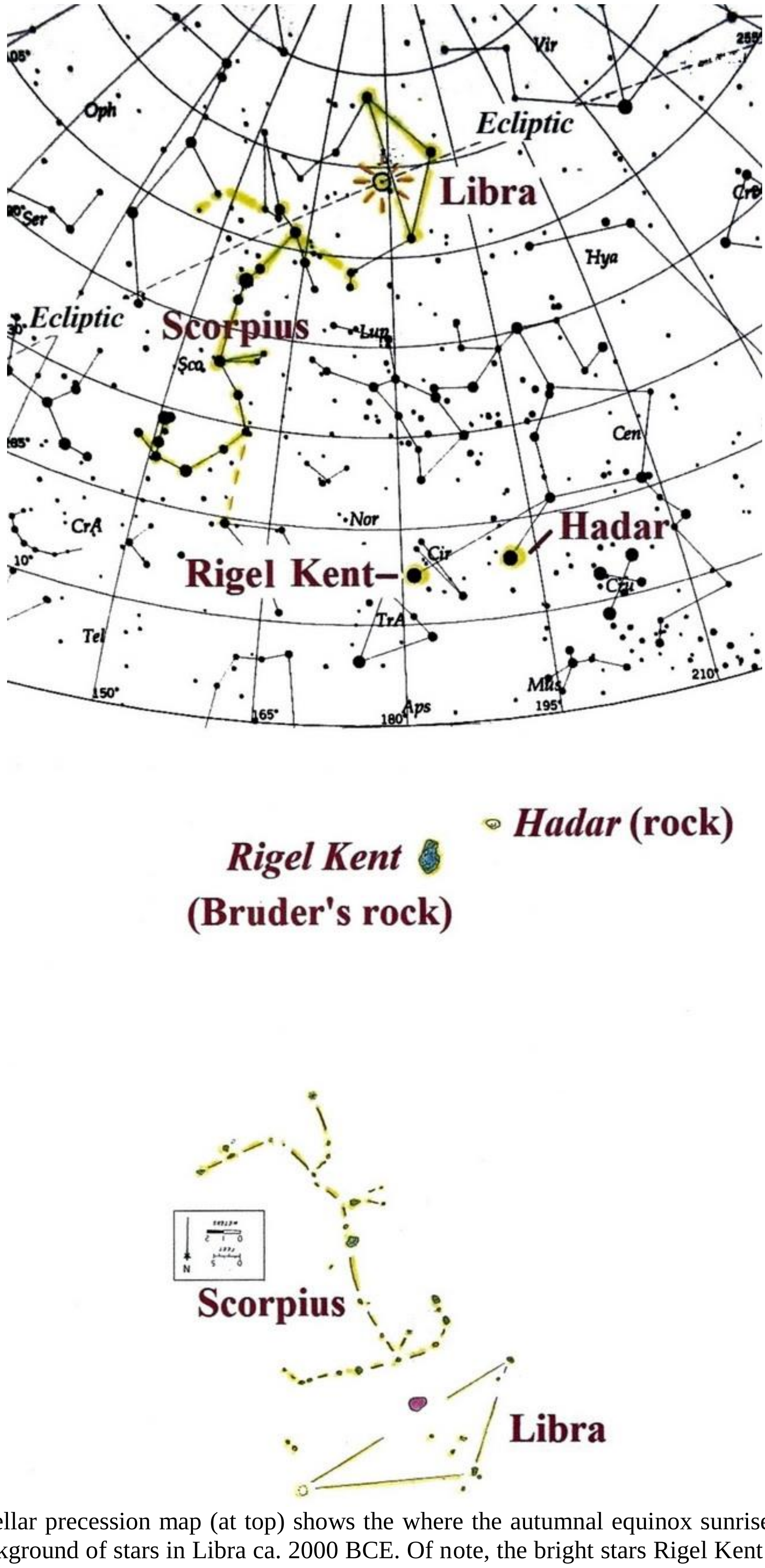

Figure 33. The stellar precession map (at top) shows the where the autumnal equinox sunrise would have been relative to the background of stars in Libra ca. 2000 BCE. Of note, the bright stars Rigel Kent and Hadar were at or near culmination near midnight during the time of the vernal equinox ca. 2000 BCE. The illustration (at bottom) is a map of the Star-Being with the two bison effigy rocks including Bruder's Rock (see Figure 32). Both effigy rocks and the Star-Being are in an almost exactly mirrored or reflected location relative to Rigel Kent, Hadar and Scorpius in the night sky. The location of the Star-Being headstone likely indicates where the sun rose into Libra at the time of the autumnal equinox between 4000-2000 BCE, the proposed date of origin of the Star-Being and other petroforms found at the site (Bender 2004).

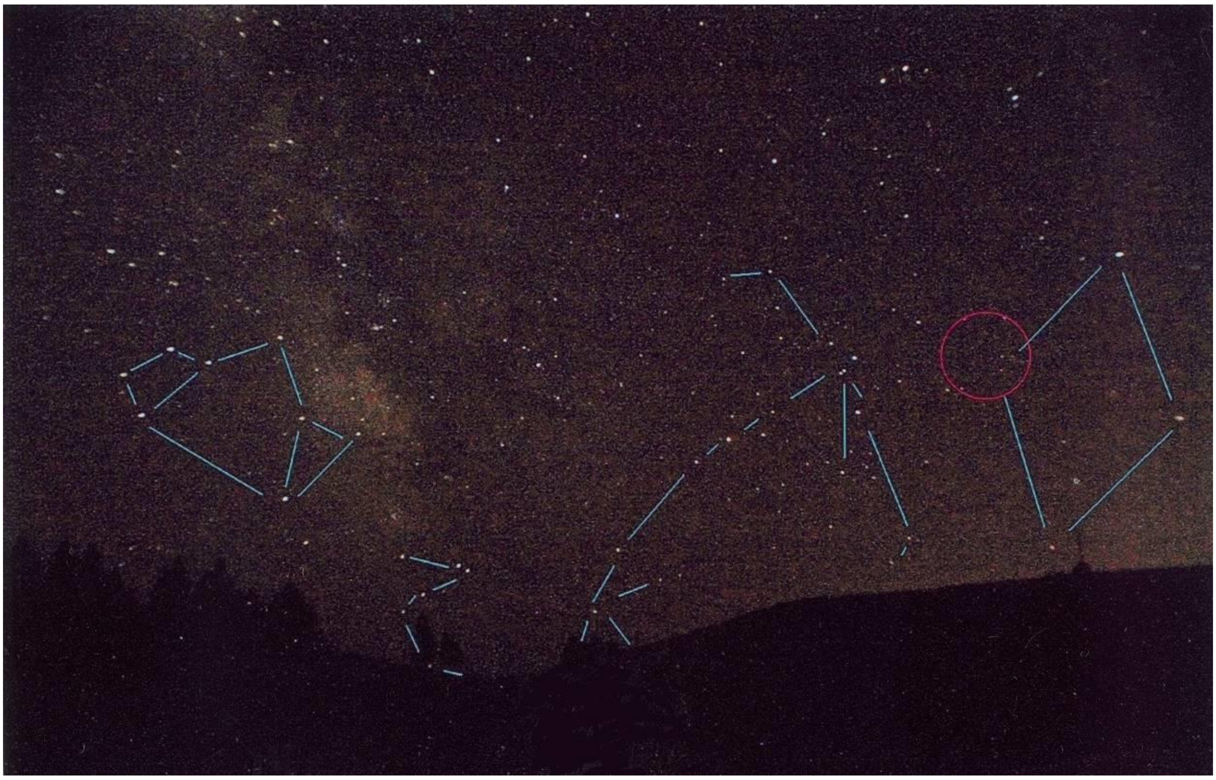

Figure 34. Photo of the southern night sky from the dark skies of the Pine Ridge reservation in South Dakota. The 'helper lines' show the constellations of Sagittarius, sometimes known as the 'teapot' (at left), with the Milky Way the 'puff of steam' coming from the spout and the stars in Scorpius configured as the Star Being (at center). The diamond shape at right is Libra. The red circle shows where the Autumnal equinox rose in the background of stars ca. 4000 BCE (see Figures 29 and 33).

The mapping of the lithic form that we call Sagittarius as an archer or 'the teapot' does not conform to Plains Indian astronomical convention, but perhaps could represent a humped animal, *e.g.* a bison (Leola One Feather and Iegor Reznikoff, personal communications).

This conjecture may not be unreasonable when Lakota and Plains Indian cosmologies are factored into the discussion. It is in the night sky directly above the 'spout' of the 'teapot' where the richest part of the Milky Way streams upward (Figure 34).

In the ancient bison culture and associated cosmologies, the Milky Way was perceived as the visible breath or spirit of bison (Sundstrom 2004: 81-87). The Lakota say the stars are *wakan*, "the Holy Breath of the Great Spirit" and like the Milky Way or bison's breath, considered sacred (Goodman 1992: 1, 21, 23, 56). Because of these provocative features and others mapped on this site over the past 20 years, the rocks so carefully placed on the ground so long ago may well express the most complete indigenous 'map' of the cosmos laid out in stone known to exist.

5. Discussion and Conclusions

In the heavily glaciated south-eastern corner of Wisconsin, glacial erratic rocks and boulders were utilized to create petroform sites, i.e. with forms outlined lithically. At two sites, the Starman and Kolterman Star-Being, rocks were incorporated into giant human-like forms. The individual colour and form of chosen rocks were a vital part of the design. Both sites are a reflection of a select part of the night sky where *the people* 'anticipated' certain and predictable events timed to the seasonal rise of the sun and stars. Although they may have reflected stars in the night sky in the physical sense, each was a physical embodiment of cosmologies that had originated in the upper mid-west of the United States transported to the Great Plains millennia later.

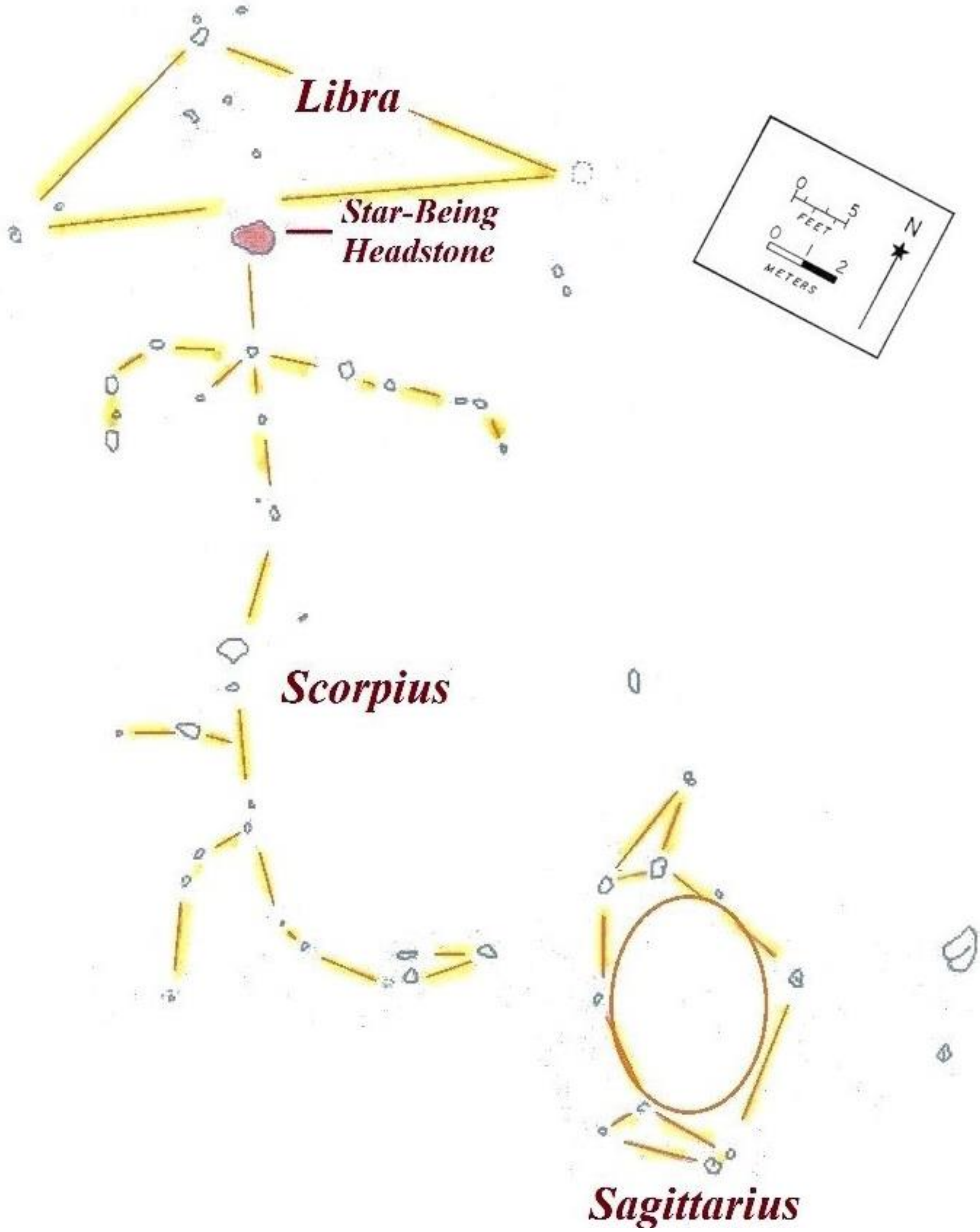

Figure 35. Compiled map of the deeply embedded rocks showing the 'ellipse' as Sagittarius with 'helper lines' added and the Star-Being petroform designated as Scorpius and Libra (see Figure 34).

Now perceived by visiting delegations of Cheyenne and Lakota as a place of 'origins', it is likely that the iconic Great Plains buffalo culture may have originated thousands of years earlier in the former prairie and open grasslands of southern Wisconsin. If true, 'the people' gathered at these places to seek blessings by enacting rituals timed to the seasonal movements of the sun and stars in order to ensure a successful hunt, fecundity and cosmic order. That order was set in stone.

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GIS-based landscape analysis of megalithic graves in the Island of Sardinia (Italy)

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Abstract:

One of the most important megalithic groups in Western Europe in terms of number and characteristics is the group of over 200 monuments of various types in Sardinia. It now seems to be confirmed that the rise of the megalithic phenomenon was during the culture of San Michele of Ozieri (Late Neolithic, 4000-3300 B.C.E.). The Sardinian dolmen graves, however, had a maximum distribution during the Chalcolithic, as evidenced by most of the finds from excavations. The phenomenon also shows a close relationship beyond Sardinia and especially with the monuments of Catalonia, Pyrenees, non-coastal departments of French-midi, Corsica and Puglia.

About 90 dolmen graves of various types have been investigated, namely the simple type, “corridor” type, “*allée couverte*” type, and others of uncertain attribution, located in central-western Sardinia, and particularly in a significant area of ca. 3500 km^2 coinciding with the historical regions of Marghine-Planargia, Middle Valley of Tirso and Montiferru. This includes some 40% of all Sardinian dolmens. Locational trends and relationships with regard to landscape elements were studied with the aid of GIS methodologies such as viewshed and cost surface analysis. This allowed an evaluation of the role of visual dominance on the surroundings in relation to waterways and natural access routes.

These dolmens enjoy an isolated positional character, being found more often in high plateaus, but also on low plateaus and hills. Although different concentrations are found in dolmenic graves, these do not seem to have any direct relationship among them, but their influence is apparently directed towards travel routes and sensitive elements of the landscape that have capabilities of territorial demarcation.

The particular location emphasizes the significance of these monuments as territorial markers for segmentary societies. It seems that a dolmen was constructed according to the territory immediately surrounding it. This reinforces the hypothesis of there being a secondary task, in addition to that of burial, to symbolize a message or landmark for those who moved towards "another" territory: a sign of belonging.

Keywords: dolmen; GIS; landscape; Neolithic; Sardinia

Sommario:

Uno dei più importanti gruppi megalitici dell'Europa occidentale in termini di numero e caratteristiche è quello presente in Sardegna, che consta di oltre 200 dolmens. Sembra essere

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confermato che la genesi del fenomeno sia avvenuta durante la cultura di San Michele di Ozieri (Tardo Neolitico: 4000-3300 B.C.E.). I dolmen sardi, però, hanno avuto la loro massima diffusione durante il Calcolitico, come evidenziato dalla maggior parte dei reperti provenienti dagli scavi. Il fenomeno dolmenico sardo mostra anche strette relazioni con aree extra-insulari, soprattutto con i dolmens della Catalogna, dei Pirenei, con quelli delle province non-costiere del sud della Francia continentale, con la Corsica e la Puglia, nell'Italia meridionale.

Sono stati analizzati in questa sede circa 90 dolmens di varie tipologie: di tipo semplice, a "corridoio", ad '*allée couverte*' e altri di attribuzione incerta, situati nella Sardegna centro-occidentale, e in particolare in una zona significativa di circa 3500 km^2, coincidente con le regioni storiche del Marghine-Planargia, della Media Valle del Tirso e del Montiferru. Il campione indagato comprende così il 40% circa di tutti i dolmens sardi. Sono state studiate le tendenze ubicazionali e le relazioni con gli elementi del paesaggio con l'ausilio di metodologie GIS come la viewshed analysis e la least-cost path analysis.

I dolmens analizzati si trovano più spesso presso altipiani, ma anche su colline basse. Sono prevalentemente isolati, ma in rari casi sono raggruppati in necropoli. Sebbene in alcune aree siano stati individuati dei raggruppamenti di questi monumenti, essi non sembrano però avere rapporto diretto tra loro, ma la loro ubicazione è probabilmente legata a vie di percorrenza e ad elementi sensibili del paesaggio, così da suggerire un ruolo di marker territoriale.

La particolare posizione sottolinea il ruolo di questi monumenti come marcatori territoriali per società segmentarie. Sembra che i dolmens siano stati edificati in relazione col territorio immediatamente circostante. Questo dato rafforza l'ipotesi che i dolmens, oltre che la funzione primaria di sepoltura, svolgessero anche un compito secondario, con l'obbiettivo di simboleggiare un messaggio o rappresentare un punto di riferimento per coloro che avevano la necessità di muoversi verso territori pertinenti a diversi gruppi umani: un segno di appartenenza.

Parole chiave: dolmen; sistema informativo territoriale; archeologia del paesaggio; Neolitico; Sardegna

1. Introduction

In Sardinia archaeologists have shown an important megalithic phenomenon, consisting of over 200 dolmens, situated for the most part in the central-northern area of the island. Currently, we know of at least 221 dolmen monuments. As regards typology, the dolmens belong to five main categories: simple type, "corridor" type, "side entrance" type, "mixed" type (i.e. monuments partly excavated in the rock and partly built with orthostats and dolmenic coverage) and '*allées couvertes*'. The majority of the dolmenic burials belong to the simple class, followed by the *allées couvertes*, while only few tombs are of other kinds.

From the point of view of chronology, there are no radiocarbon dates. The data from recent stratigraphical investigations, the archaeological materials sporadically recovered in some dolmens, the structural and cultural relationships among the Sardinian dolmens and other prehistoric monuments of the island, typological comparisons with similar dolmenic monuments of various extra-insular areas, allow however to report that the dolmens of Sardinia belong to a time period ranging from the late Neolithic to the Eneolithic (from the end of the fourth to the beginning of the second millennium B.C.E.), perhaps with a degree of reuse in the Bronze age.

Recent research has highlighted tight structural and cultural relationships between the megalithic monuments of Sardinia with some extra-insular regions, as in Iberia, France and especially Corsica.

In the present work we want to analyze systematically the relationship among the megalithic graves and the surrounding environment. We believe that the lithology and especially the geomorphology are extremely important factors in order to better understand the dolmen phenomenon and the locational modalities of these burial structures.

To achieve the proposed objective, it was decided to study the dolmens present in a sample area of west-central Sardinia, characterized by a high concentration and, regarding the geomorphological aspect, especially by a plateau environment, that constitutes the preferred morphological landscape for the building of dolmens across the whole island (Figure 1).

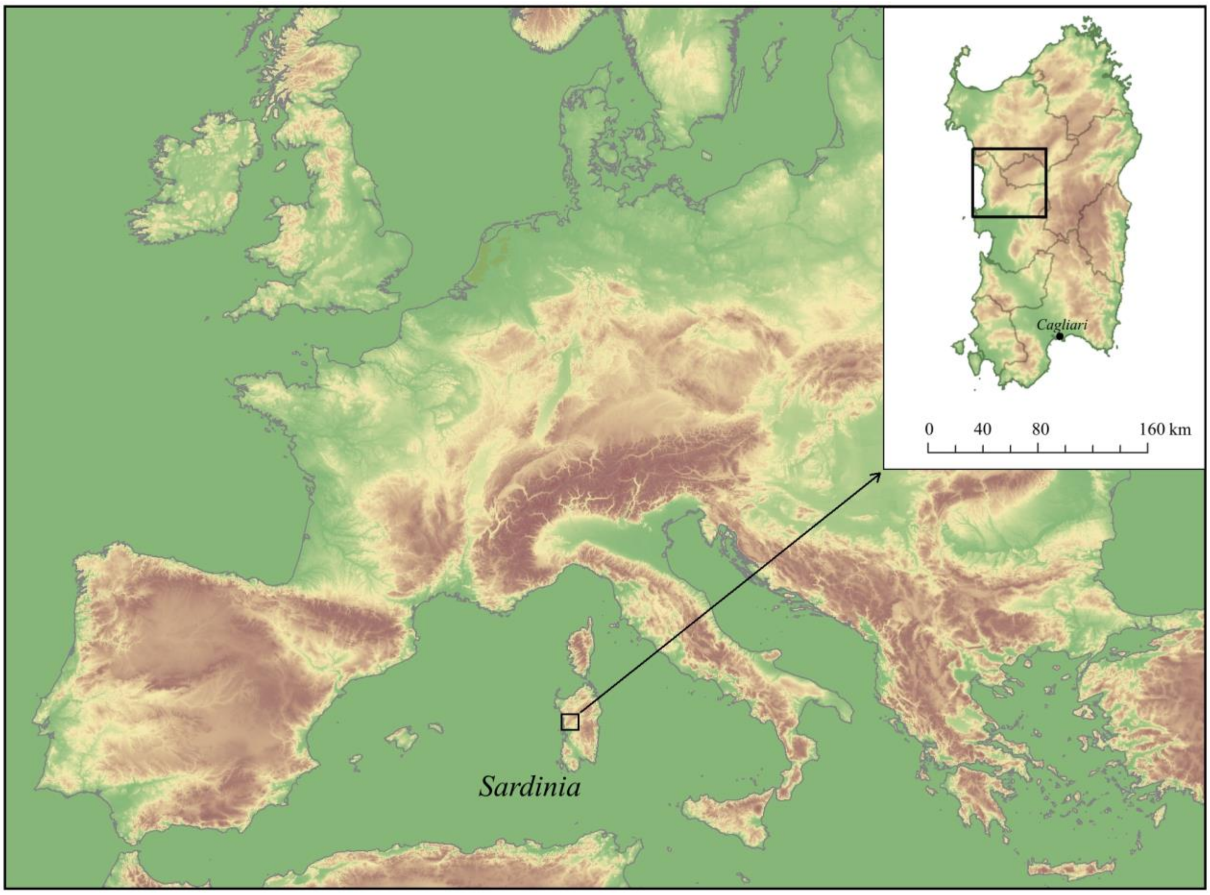

Figure 1. Sardinia and the study area (Elaboration of the Authors on the basis of a raster map of the European Environment Agency).

1.1. The territory

The geographical zone under consideration includes an area of about 1790 km^2; it consists of three areas characterized by geomorphological forms typical of the plateau, known as the highlands of Abbasanta, Campeda and Planargia (Figure 2), and two mountain ranges, Montiferru and Marghine, that form an arc from southwest to northeast. The largest area is the basaltic plateau of Abbasanta, whose surface is slightly inclined from north-west to south-east: it is not very rugged, the valleys are few and hardly visible, and average altitude varies from 300 to 400 m. a.s.l. (Mori 1975).

The formation of the plateau took place during the Middle-Upper Pliocene, when in Sardinia the tectonic graben of the Campidano began to descend and volcanic activity awoke, particularly in the Monte Arci and in Montiferru: the copious basaltic emissions gave rise to the vast basaltic plateaus characteristic of the central and northern parts of the island. It was the same origin for the Campeda plateau which extends to the north of Abbasanta plateau. It is separated from the Marghine near the mountain formations included in today's territories of Lei, Silanus, Bolotana, Bortigali and Macomer. At the western border of Campeda there is the Planargia region which, as the name suggests, indicates a small zone mainly flat and set on two levels: the upper one (average altitude 340m) is a basaltic plateau, the lower one with hillside peculiarity slopes down to the mouth of the river Temo and the region of Villanova, which marks the north-west border.

Figure 2. Dolmen Terra Tenera-Macomer. In the background is the plateau of Campeda (photo by R. Cicilloni).

The Planargia is limited to the west by the sea and to the south by the Riu Mannu that separates it from the Montiferru. In the north-east the area is bordered by the Marghine. Finally mountainous areas delineate the areas of plateau. The Montiferru is the largest of the ancient Sardinian volcanic systems, consisting of a set of trachytic and basaltic rocks that extend for about 700 km^2, reaching the highest elevation with Monte Urtigu (1050 m a.s.l.).

The whole is a complex that appears like a big flattened cone with simple and regular shapes but strongly affected by valleys that descend from all sides except the north-east, where the mountain connects with Marghine and Campeda. The central backbone of the massif is composed of trachytic lavas, while the sides of higher slope comprise basaltic flows younger than the central lavas. The basalts that expanded on the sides of this ancient volcano constitute today a large crown of plateaus that characterizes the environment of our study. As just mentioned, in the north-east of Montiferru there is the Marghine massif characterized to the south by steep slopes and much more rugged shapes. In another way we can say that the two environments are closely related: in fact the Marghine constitutes the hem of Campeda, which further east, towards the Tirso valley, occurs with steep forms and imposing fronts at the territory of Bortigali. Among the highest peaks of Marghine are Monte Santu Padre (1030 m), Punta Iammeddari (1118 m), and the highest peak Punta Palai (1200 m above sea level). The Campeda plateau instead has an average altitude of 650 meters.

1.2. Previous research

The presence of megalithic graves in Sardinia was known since the beginning of last century. The first scientific work that concerns a Sardinian dolmen was, the article published by the archaeologist Taramelli (1906), who reported the existence of the dolmen Sa Perda 'e

S'Altare in the territory of Macomer, the first monument of this type discovered in Sardinia. Subsequently, Taramelli (1916; 1919) and other scholars took up the argument, among them Mackenzie (1910; 1913), Davies (1939), Lilliu (1968; 1988), Atzeni (1968; 1982; 1988), Santoni (1973), and Moravetti (1998a). Finally, there is a book by Cicilloni (2009) about all known Sardinian dolmens.

However, none of the cited studies treated specifically the relationship between dolmens and the landscape. They merely note that the morphological environment in which these burial buildings most often rise is the plateau, followed by low tablelands and hilly areas (Cicilloni 2009: 136), with all environments linked in the past and the present to a pastoral economy (Lilliu 1988: 197).

As regards the area under examination, besides information provided by the researchers mentioned above, there are only signalings of single dolmenic monuments: for example, in the works on the historic regions of Marghine and Planargia (Moravetti 1998b; 2000) and on the areas of Cuglieri (Pes 2009), Sedilo and Aidomaggiore (Tanda 1996; 1997; 1998), Abbasanta and Norbello (Cicilloni 1997; Usai 1999), Narbolia (Usai 2005), Neoneli (Loi 2012), and Bonarcado-Seneghe (Maisola 2012).

However, there are no studies and reflections on the dolmen megalithism of the area in general, except for the observation of some authors on specific zones of the sample area: for example the analysis of Moravetti (2000: 36-38) on Marghine-Planargia and the accurate exposure of Paschina (2000: 428-434) on the dolmen phenomenon in the territory of Macomer.

In Sardinia no GIS-based territorial analysis has ever been done regarding the dolmens. The GIS methodology for the study of the archaeological landscape has been applied till now only on sites and monuments of protohistoric age (see for example, Puggioni 2009; Angius *et al.* 2010, 2012; de Montis & Caschili 2012; Fenu *et al.* 2012; Sanna 2012; Vanzetti *et al.* 2013; Cicilloni & Cabras 2014).

1.3. Dolmen graves in the sample area

In the examined area there are 90 megalithic tombs. The largest concentration (71% of total) is localized at the plateaus of Abbasanta (64%) and Campeda in the North of Macomer (7%). (Figure 3).

This area of concentration, located in the South of the Marghine, sees the presence of the vast majority of the monuments subjected to this analysis. The other areas of concentration of dolmens, again in a plateau environment, are those of Suni and Sindia (12%), lowland areas in the countryside of Cuglieri sloping down to the high sea coasts between Torre Foghe (mouth of the Riu Mannu) to the north and Santa Caterina di Pittinurri (mouth of Riu Santa Caterina) to the south, and the foothills of Montiferru near Narbolia (3%). Their locations in rugged areas have lower rates (14% of the monuments). 83% then are located in plateau, some crowning the edges and corners with a large view of the land below or the canyons that penetrate these volcanic formations. Others, such as the dolmen Baccarzos of Noragugume, are located at lower altitudes, at entrances to canyons that from lower territories rise to the top of the highlands. However, most of the analyzed dolmens are located at the centre of the highlands, away from these positions listed above with a scattered distribution across the territory which tends to his massive occupation.

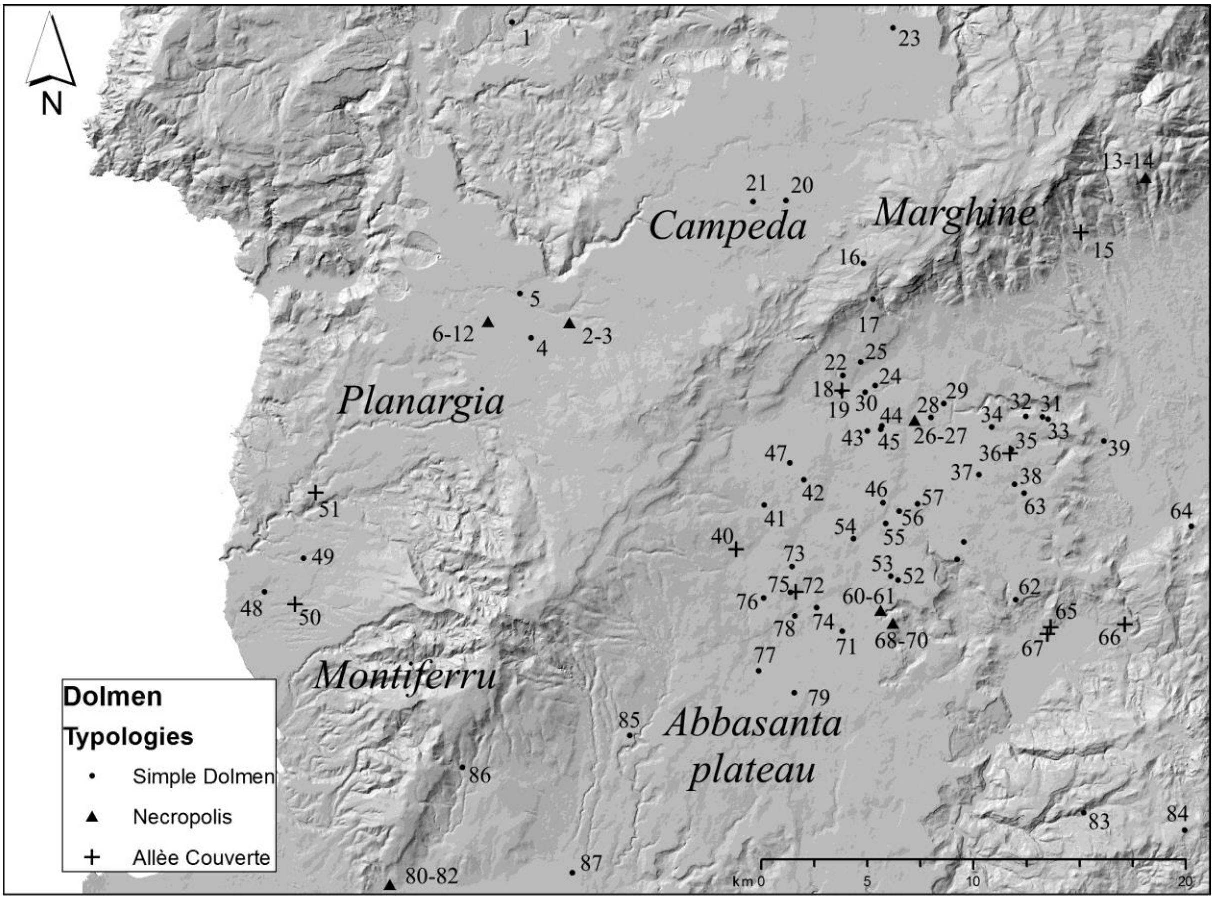

Figure 3. Map of distribution of the examined dolmens: 1. San Sebastiano-Padria; 2. Nela I-Sindia; 3. Nela II-Sindia; 4. Serrese-Sindia; 5. Furrighesu-Sindia; 6. Matta Larentu I-Suni; 7. Matta Larentu II-Suni; 8. Matta Larentu III-Suni; 9. Matta Larentu IV-Suni; 10. Matta Larentu V-Suni; 11. Matta Larentu VI-Suni; 12. Matta Larentu VII-Suni; 13. Tanca Noa A-Bolotana; 14. Tanca Noa B-Bolotana; 15. S. Basilio-Lei; 16. Tuide-Bortigali; 17. Carrarzu Iddia-Bortigali; 18. Sa Perda 'e S'Altare-Macomer; 19. Tanca Sa Marchesa-Macomer; 20. Su Edrosu-Macomer; 21. Terra Tenera-Macomer; 22. Bidui-Macomer; 23. Aeddo-Macomer; 24. Sa Tanca Sar Bogadas-Birori; 25. Noazza-Birori; 26. Arbu I-Birori; 27. Arbu II-Birori; 28. Corrizzola-Birori; 29. Mura Pranosa-Birori; 30. Pradu Lassia-Birori; 31. Sa Fronte Uda-Dualchi; 32. Mazzarighe A-Dualchi; 33. Mazzarighe B-Dualchi; 34. Lughe-Dualchi; 35. Badde Ide-Dualchi; 36. Brancatzu-Dualchi; 37. Paule Rues-Dualchi; 38. Baratta-Dualchi; 39. Baccarzos-Noragugume; 40. Pedra in Cuccuru-Borore; 41. Giuanne Pedraghe-Borore; 42. Muttianu-Borore; 43. Sa Matta e sa Ide-Borore; 44. Serbine A-Borore; 45. Serbine B-Borore; 46. Arghentu-Borore; 47. Su Narbanu-Borore; 48. Monte Lacana-Cuglieri; 49. Su Livrandu-Cuglieri; 50. Su Lizu-Cuglieri; 51. Sa Cobelcada-Sennariolo; 52. Succhiau-Aidomaggiore; 53. Mura Fratta-Aidomaggiore; 54. Tuvamene-Aidomaggiore; 55. Nucrastala-Aidomaggiore; 56. Meddaris-Aidomaggiore; 57. Su Nuradorzu-Aidomaggiore; 58. Scarallotza-Aidomaggiore; 59. Crobecada-Aidomaggiore; 60. S'Aspru I-Aidomaggiore; 61. S'Aspru II-Aidomaggiore; 62. Iloi-Sedilo; 63. Lure-Sedilo; 64. Filigorri-Sedilo; 65. Monte Trigu-Sedilo; 66. Torozzula-Sedilo; 67. Monte Paza-Sedilo; 68. Nurarchei A-Norbello; 69. Nurarchei B-Norbello; 70. Nurarchei C-Norbello; 71. Abbamuru-Norbello; 72. Sa Perda Piccada-Norbello; 73. Sa Codina 'e S'Ispreddosu-Norbello; 74. Mura 'e Iscovas-Norbello; 75. S'Angrone-Abbasanta; 76. Mesu Enas-Abbasanta; 77. Cannigheddu 'e S'Ena-Abbasanta; 78. Mura 'e Putzu-Abbasanta; 79. Su Nuratzolu-Abbasanta; 80. Carrazzu I-Narbolia; 81. Carrazzu II-Narbolia; 82. Carrazzu III-Narbolia; 83. S. Maria di Olisai-Neoneli; 84. Nole-Neoneli; 85. Serra Crastula-Bonarcado; 86. Serra Passa-Seneghe; 87. Su Conzau de Is Froris Grogus-Milis (Elaboration of the Authors).

We note that these dolmens are rarely grouped in necropoli (except for Matta Larentu-Suni, with at least seven, Nurarchei–Norbello and Carrazzu-Narbolia, with three dolmens), but are usually located in isolated places or, when there are several in the same area, at a good distance from each other, almost as if delimiting in some way a piece of territory.

The megalithic tombs of this area are mostly simple dolmens (71%) (Figure 4), but also *allées couvertes* (15%) (Figure 5). Among the simple dolmens, their plans are mainly quadrangular (68%), but also circular (32%). So are of uncertain typological attribution.

Figure 4. Dolmen Matta Larentu I, Suni (simple type) (photo by R. Cicilloni).

The building material most often used is basalt (73%), being locally the more diffused type of rock having regard to the geological structure of the area. Also used was trachyte, granite and limestone.

The orientation of the entrances of the dolmens is interesting (Hoskin 2001). In Sardinia we know the orientation of only 52 dolmens (60% of the total). We cannot determine the orientation of the others because they are destroyed or undetectable. There are orientations toward all the points of the compass, but 52% of those considered are oriented towards south-east, 13% to east, 11% to south-west and 8% to south, while other directions have lower percentages. These data can be compared with those of the other dolmen tombs of Sardinia, where most of them are orientated to south-east (41%) (Cicilloni 2009: 151-153). However, this preference is often found in the dolmen monuments of Western Europe: *i.e.* orientation towards the arc that goes from east to south in dolmens of the Atlantic coasts, from Brittany to the Basque country (Chevalier 1984), in Catalonia (Esteva Cruañas 1970), in some departments of central-southern France (Chevalier 1984) and in Corsica (Cesari 2001). We cannot determine with certainty the reasons for the orientation of the dolmens, but we believe that it is probably connected to magical-sacral motives, so the builders of these monuments chose an orientation related to certain points of the horizon, for example, where the sun rises or sets at certain times of the year (Cicilloni 2009: 152).

Figure 5. *Allée couverte* Pedra in Cuccuru, Borore (photo by R. Cicilloni).

The dolmens of Serrese-Sindia and Monte-Paza Sedilo, which are decorated on the upper surface of the coverage slab, stand out in importance.

In the first monument, on the upper surface and on the edges of the slab there are narrow incisions which form, on each of the sides, except the entrance, some figures. Two of them, on the north and west sides, might be anthropomorphic. The figure on the south side is a rectangle, divided into four parts, connected to the figure of the west side. On the south-west and north-east corners there are engraved irregular semicircles. The engravings extend also across the thickness of the slab, and they are cut by a further line which, along the thickness, runs horizontally all around the table (Figure 6).

There are no precise comparisons with other examples of megalithic art in Western Europe, but only very general similarities with "U" motifs and crossed lines engraved on orthostats of French and English dolmens (Shee Twohig 1981).

Engravings are also present on a trachytic slab found in Monte-Paza Sedilo, presumably pertinent to a passage tomb. There is a schematic decoration with shells, concentric circles with a single radial line, and a schematic anthropomorphic female figure (Melis 1996) (Figure 7).

The motifs of concentric circles with a single radial line have close comparisons with the engravings present on some standing stones of the territory of Mamoiada, and in particular on the monumental Stele of Boeli (Fadda 1997; Atzeni 1998; Manca & Zirottu 1999). Outside of Sardinia, these figurative motifs are found in megalithic monuments of the Irish, for example in the megalithic necropolis of Loughcrew (Co. Meath) (Shee Twohig 1981: 202-220) and on the monumental standing stone of Ardmore (Co. Donegal) (McNally 2006: 98).

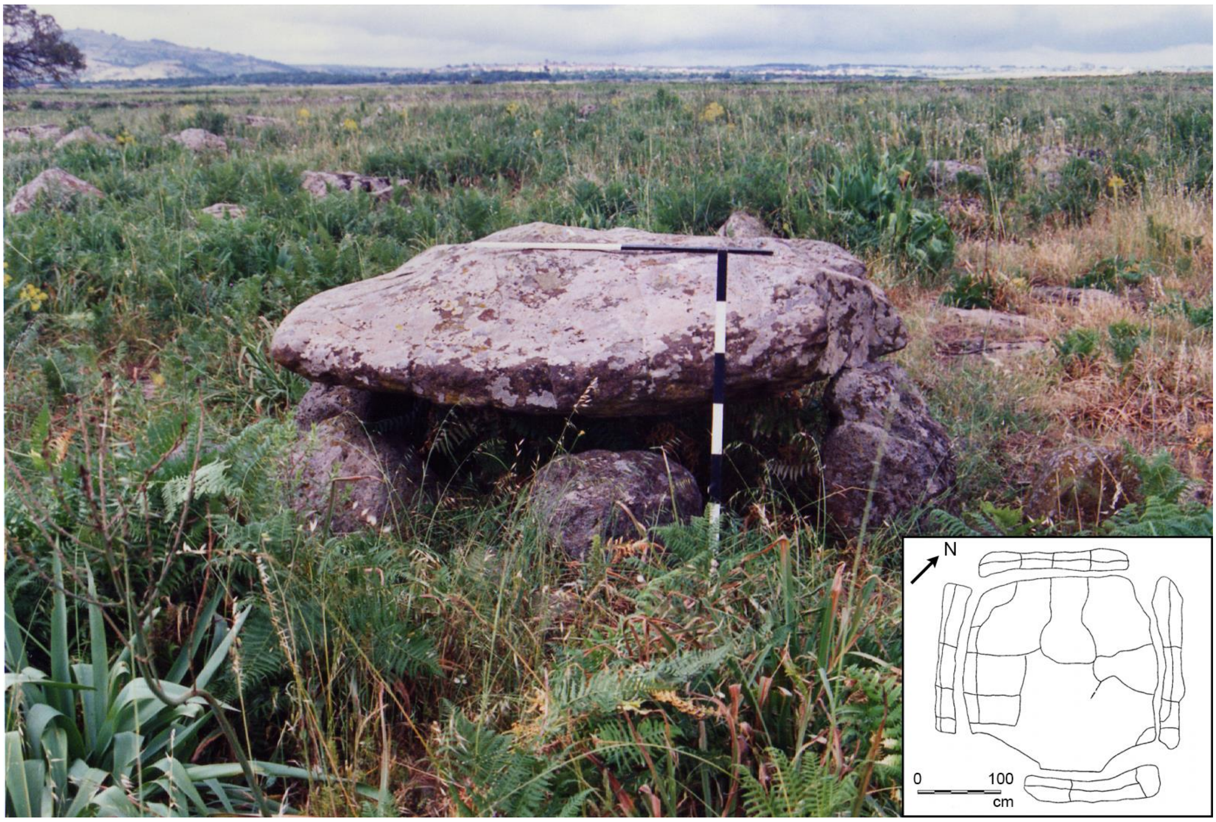

Figure 6. Dolmen Serrese, Sindia (simple type), with petroglyphs on the coverage slab (photo by R. Cicilloni).

Figure 7. Megalithic monument of Monte Paza-Sedilo (*allée couverte* type), with petroglyphs on a slab (adapted by Melis 1996).

2. Methods

2.1. Objectives

In recent years, the analysis of settlement characteristics of dolmen burials led to an interpretation of this major monumental display - so well diffused across much of Europe - being approached as having the role of territorial marker (Chapman 1981; Jarman *et al.* 1982; Renfrew 1983; Criado Boado 1989; Patton 1992; Barnatt 1998; Thomas 1998; Parker Pearson 1999; Cámara Serrano 2001; Depalmas 2001; Scarre 2007; García Sanjuán 2011). The dolmen assumed a certain symbolic value for those who were to walk the areas in their vicinity and could be compared to the role of contemporary menhirs (Lilliu 1988: 87; Soula 2012: 579) that in many cases are located in proximity of dolmens (Cicilloni 2009: 164-165).

In Sardinia, menhirs associated with dolmens were found at S. Lorenzo, Mesu Serra I, Berre, S. Stefano, Monte Cuccu I-II, Malghesi, Arcone, Montiju Coronas, Oronitta, Monte Sa Rughe I, Monte Mannu, S. Lisei, Sa Pirichedda I, II e III, S. Basilio, Lussurgiu, Sa 'Onca 'e sa 'emina, Minde Puzzu, Sa Corte Noa e San Basilio (Cicilloni 2009: 164-165). The dolmen burials should have a "monumental" connotation as testified by the presence of peristaliths, whose remains are often observed around the central core of the dolmens (Giot 1976: 204-205; Cesari 2001: 12; Cicilloni 2009: 21, 150-151). The peristalith is found in the dolmens of Mesu Serra I, Doli Fichima II, Sa Janna de su Laccu, Elcomis, Pubusattile, Su Coveccu, Tespile, Su Urreddu, Nela I, Matta Larentu, Matta Larentu III, Matta Larentu IV, Matta Larentu V, Matta Larentu VI, Tanca Noa A, S. Basilio, Sinne, Motorra, Cucchè-Zia Arvara, Tuide, Sa Perda 'e S'Altare, Tanca Sa Marchesa, Su Edrosu, Terra Tenera, Bidui, Sa Tanca Sar Bogadas, Noazza, Arbu I, Arbu II, Corrizzola, Pradu Lassia, Sculacacca, Sa 'Onca 'e sa 'emina, Badde Ide, Paule Rues, Giuanne Pedraghe, Sa Matta Ide, Serbine A, Arghentu, Monte Lacana, Su Lizu, Sa Cobelcada, Nucrastala, Meddaris, Su Nuradorzu, Scarallotza, Iloi, Lure, Filigorri, Perda Longa, Carazzu, and Sa Corte Noa (Cicilloni 2009: 150-151).

We are in presence of a form of worship linked to the land because there was a contact with it, as also demonstrated by contemporary *Domus de Janas* (Tanda 2009: 67). Also, the building characteristics of the dolmens reflect undoubtedly the willingness to appear and to visually communicate, that combine well with locational conditions of good visual domain on the surrounding landscape, at the edges of plateaus or in their vicinity, near steep slopes that overlook areas of lower elevation. As regards the nature of these events, some researchers have suggested that they could be related to paths of transhumance (Tanda 2009: 68), within a contrast pattern, traditionally prevalent in the archaeological Sardinian literature, among farming communities, whose funerary aspect manifested itself in the so-called *Domus de Janas* caves, and pastoral communities, who buried in dolmens (Lilliu 1988: 197).

Without tackling in detail the complex issue of transhumance in Sardinia this aspect can be outlined, at least for Sardinia, in its general features. It is usual, unfortunately, that there is no direct evidence for the final phases of the Late Neolithic and the Copper Age - the chronological range in which are dated the Sardinian dolmens (Cicilloni 2009: 182-183). It is important, however, to clarify the issue.

The territorial object of our analysis is not an area normally affected by historical long-range transhumances known and documented in Sardinia from the Middle Age onwards: those who moved from the areas of Gennargentu, Barbagia, Mandrolisai and Ogliastra towards the regions of Campidano and Sulcis-Iglesiente, Gerrei and Sarrabus, Baronia, Nurra (Ortu 1988: 821), with distances covered between 30-60 and 50-120km, probably by retracing earlier roads. It must be noted that transhumance, in traditionally known continental manifestations, involves moving livestock during hot weather to areas more suitable, in terms of climate, for grazing. The Sardinian phenomenon had though, historically, its opposites in direction and timing. In the island there is a spatial and seasonal different approach by the pastor to transhumance, with the aim of spending the cold season, instead of the summer, in places with a warmer climate (Ortu 1988: 822).

In this regard, although it is not possible to treat in detail every local circumstance, literary sources mention the *mudas* phenomenon, a transhumance of small scale limited to the municipalities or micro-regions of Sardinia (Ortu 1988: 822-823). Transhumance of least distance ("*practica de trasterminancia*") has been suggested, on the basis of the growing number of farm animals encountered in the archaeological record, for the Copper Age in Seville (Andalucía – Spain) (Murrieta Flores *et al.* 2011: 214). As Ortu (1988: 824) says, transhumance is "a passage of borders", and it is here that we find the links to some parts of our investigation, with the aspect of boundary marker and at the same time of communication of a message to the outside already advanced by other scholars for several areas of the island (Spanedda & Cámara 2009: 155), relating to a membership of a group to a territorial entity manifested through megalithic tombs (Afonso Marrero *et al*. 2010; Spanedda 2010). The claim: "If this step is not legitimate, authorized or agreed, it becomes a 'trespassing' and it is a source of conflict" (Ortu 1988: 823), referred to transhumance, might suggest a vision of the landscape as a palimpsest in which also the people of Sardinian prehistory were closely related with alternate issues of ownership and territorial relationships. Contact areas between groups/people or zones of strategic interest were probably enshrined in monumental form, with single monuments or even as necropoli, witnessed for example at Matta Larentu-Suni (Moravetti 2000: 320-324), Caratzu-Narbolia (Maisola 2012: 53-55) or in an external case to our study area at Su Sordanu-Nughedu San Nicolò (Basoli 1998: 151; Basoli 2001: 107).

It is clear that this parallelism leads us to compare phenomena very distant in time, and it is also clear that the lack of comprehensive stratigraphic data makes more difficult the reconstruction of archaeological context. However, the area of central-western Sardinia - the object of our analysis - offers us a large monumental sample that includes about 40% of the islanders finds. Having noticed the typical locational choice of the dolmenic burials, we tried to investigate the characters that may have affected movement in these territories. We have tried, thus, to simulate a series of paths that, through the ages, have been able to have a relationship with the dolmens.

At a time when a shepherd designs and reasons about hypothetical shifts functional to relationships that he engages with the territory and its resources, the mobility through the space around it is based and structured according to a set of routes that probably, if they were in direct connection with the activities of subsistence, tended to avoid the most inaccessible areas or difficult journeys, thus making a selection between difficult and easier routes (except when a hard road was required by other reasons, for example for worship). This factor may reflect a stratified knowledge of the area that allowed pastors to trace paths as best functional for the saving of time, manpower, exposure of livestock to the transit, local events - all those situations, in short, of different entities that have happened and still happen in the rural life of the island. To quote F. Cambi,

> *"It is always the story that produces landscapes, operating on natural environmental frameworks through the actions of man. These, in different ways, and with different complexity, overlap the natural substrate and are part of a historical legacy that is progressively enriched with a process comparable to the unstoppable transformation of an individual's genetic heritage, which continue, even after his death, in subsequent generations"* (Cambi 2003: 12).

2.2. The GIS methodology

For the analysis, we used the potentialities offered by GIS -- Geographic Information System applications. The software allowed us, first, to store the resulting data from the field survey conducted during these years of research and to geo-reference 87 dolmens (about 40% of the total number known for Sardinia). The dolmens were referenced following a review and update aimed for a more precise clarification of the status of findings that led to adding new monuments compared to the status of research of 2009 (Cicilloni 2009). The production of an updated and accurate map of dolmens of the study area and an accurate geo-referencing were made through field surveys but also thanks to the published research on bibliographic and cartographic heritage, and the webGIS database made available by R.A.S - *Regione Autonoma della Sardegna*, through its geo-portal.

With GIS it was possible to perform a series of analyses because the georeference data and shapes of the relief were able to be handled in three-dimensional form using a DEM - Digital Elevation Model (Wheatley & Gillings 2002: 95, 96; Conolly & Lake 2006: 90-111). This is a powerful tool for interpreting physical characteristics of the territorial context. It was also possible to assess, by creating a Cost Surface Model (Wheatley & Gillings, 2002: 137-141; Conolly & Lake, 2006: 214-215, 221-224, 233), the main trends related to travel routes in relation to the geomorphological characteristics of the environment in which it is configured and the settlement pattern examined (Figure 8).

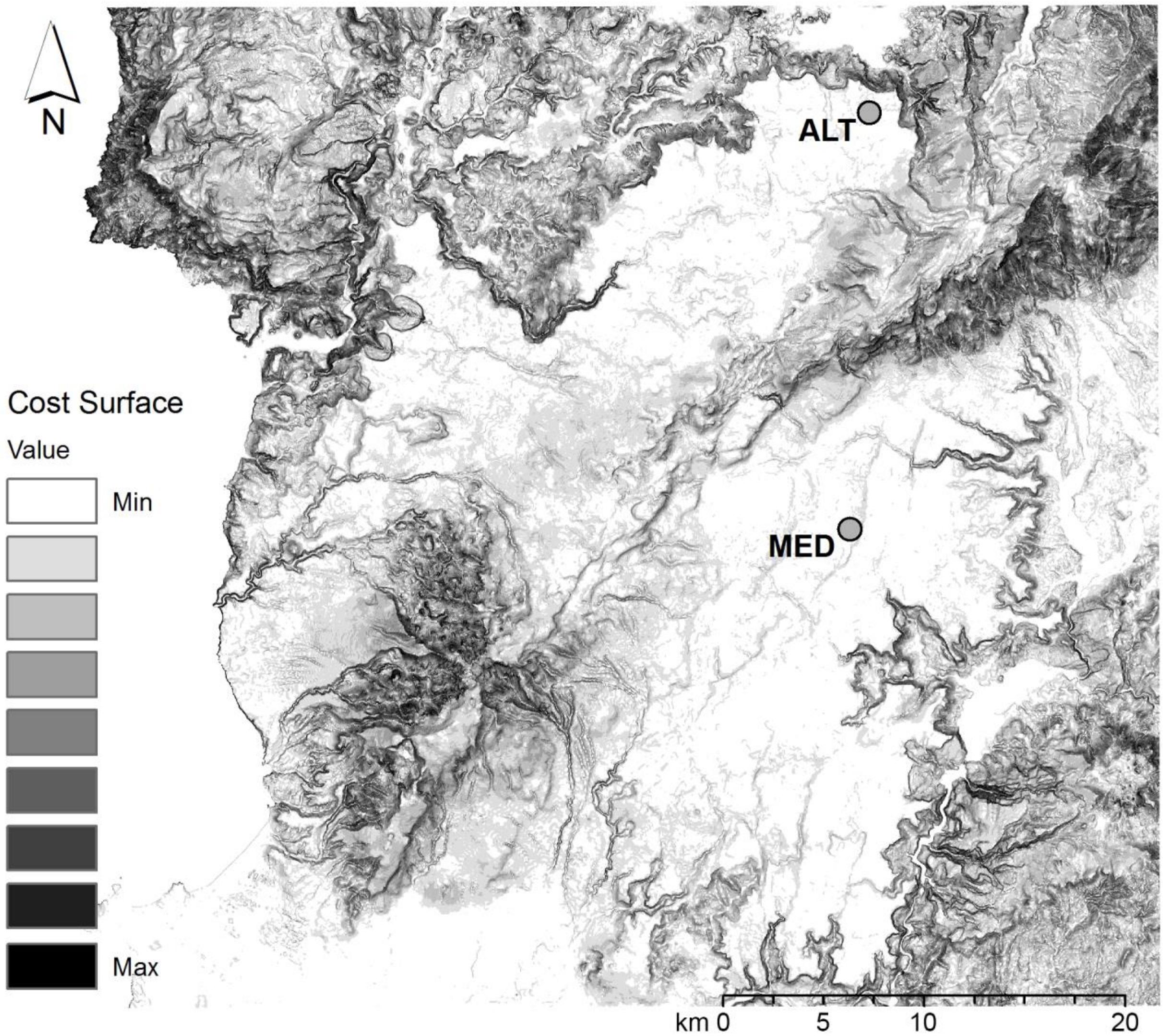

Figure 8.The Cost surface model obtained from a map algebra among the hydrography shapefile and the reclassified slope derived by DTM (Elaboration of M. Cabras).

Seasonal movement tasks related to pastoralism, therefore, were to take place on paths more or less annually repeated near areas in close relationship, for proximity or intervisibility, with many dolmens. We then calculated the Least Cost Path Analysis (LCPA) (Wheatley & Gillings, 2002: 142-143; Conolly & Lake, 2006: 217, 252-255, 262, 294), based on the Cost Surface Model created and calibrated through Reclass and Map Algebra procedures (Wheatley & Gillings 2002: 84, 92; Conolly & Lake, 2006: 187-207), taking into account the degree of slope of the terrain and the presence of wet areas and rivers (for some examples of Cost Surface Model calibration, see Pecere 2006: 185-188; Gherdevich 2009: 56-63; Casarotto *et al.* 2009: 294-300; Camerieri & Mattioli 2013: 334-337).

Identifying the areas with the lowest cost of traveling on the basis of digital cartography was made possible by a process of interpolation between the layers contours and spot elevations of CTR (Technical Regional Map) with 1.10,000 scale. The simulation of the paths often showed close proximity or coincidence with various types of today's roads. The DTM with 10-metre definition can be downloaded from the geo-portal of the *Regione Autonoma della Sardegna*. These applications provide a geographic information tool that contains more information than traditional cartography in proposing a 3-D representation of the shapes of the relief and numerical maps on which to base analyses. So we used a tool that allow us to reproduce conditions hard to quantify in a field survey due to the state of preservation of buildings and a lack of perception on the field of ancient landscape conditions covered by the subsequent human actions.

3. Results

3.1. The analysis towards the median point

By a geo-processing procedure we calculated the median point (Spatial Statistics Tools in ArcGIS) concerning the geographical distribution of dolmens examined. With LCPA we simulated paths that join the dolmens located on the borders of our study area with the geographic median point of the analyzed area. These dolmens are listed in the first column of the Table 1. We operated through this procedure in order to evaluate the spatial relationships of these Least Cost Paths with other non-peripheral dolmens joined on the path towards the median point located on Borore plateau at about 390m above sea level near the Arghentu dolmen. For many of these paths analysis showed that several dolmens, not located in peripheral areas of the global distribution, are located at varying distances to the paths traced by LCPA, often very close.

The Viewshed Analysis (Wheatley & Gillings, 2002: 179-192; Conolly & Lake, 2006: 225-232) calculated with a radius of 2.5 km to a neighborhood of 360° from one observer placed 2m high above ground level in correspondence of each grave has highlighted a complex relationship of the intervisibility of dolmens with several of these Least Cost Paths. This corroborated in our view the relationship of these with important hubs functional to movement within the territory (Figure 9).

3.2. The relationship between dolmens at different altitudes

A second analysis was then performed that simulates links within a sample area, chosen by the authors for elevation between 700 and 800 m above sea level (near the dolmen of Aeddo-Macomer, one of dolmens located at higher altitude), with dolmens located at lower altitudes in order to simulate the activity of transhumance which included shifts towards milder territories during the winter season (Table 2). This analysis also highlighted the results described in Section 3.1.

Table 1. Distances between Least-Cost Paths from peripheral dolmen towards median point.

Dolmen where LCP begins	**Dolmens found along the path and distances** (in metres; accurate to the nearest round figure)
San Sebastiano	Furrighesu 1250, Muttianu 1070
Cannighedda 'e S'Ena	S'Angrone 750, Mura 'e Iscovas 660, Abba Muru 1000, Tuvamene 400, Nucrastala 530, Arghentu 285
Serrese	Nela 500, Muttianu 1070
Aeddo	Edrosu 790, Muttianu 1070
Pedra in Cuccuru	S'Ispreddosu 500, Tuvamene 1300, Arghentu 1000
Mura 'e Putzu	S'Ispreddosu 185
S'Angrone	Sa Perda Piccada 315, Mura 'e Putzu 500, Mura 'e Iscovas 880, Tuvamene 570, Arghentu 530
Mesu Enas	S'Ispreddosu 185
San Basilio	Mura Pranosa 860, Corrizzola 840, Arbu 160, Serbine A 780
Tanca Noa	Edrosu 780
Nurazzolu	Arghentu 270, Nucrastala 530, Meddaris 1100, Tuvamene 415, Mura Fratta 1500, Mura 'e Iscovas 660, Abba Muru 960, S'Angrone 1130.
Abba Muru	Mura 'e Iscovas 1200, Mura Fratta 1550, Tuvamene 410, Nucrastala 540, Arghentu 270
Nurarchei	Arghentu 274, Nucrastala 540, Mura Fratta 1000
Monte Paza	Monte Trigu 350, Iloi 870, Crobecada 62, Nuradorzu 200
Torozzula	Iloi 1400, Crobecada 62, Nuradorzu 196
Filigorri	Nuradorzu 350, Paule Rues 1060, Baratta 450, Lure 0
Monte Lacana	Su Lizzu 470, Su Livrandu 20, Giuanne Pedraghe 410, Muttianu 40, Sa Cobelcada 1000
Mazzarighe A	Lughe 110, Sa Fronte Uda 390, Mazzarighe B 210
Baccarzos	Brancatzu 500, Badde Ide 570, Baratta 530, Paule Rues 310
Noazza	Pradu Lassia 115, Sarbogadas 360, Serbine A 74, Serbine B 170
Carrarzu Iddia	Sa Matta 'e Sa Ide 43, Serbine B 660, Serbine A 770, Perda 'e S'Altare 190, Bidui 50, Noazza 900
Tuide	Muttianu 1060
Nole	Monte Paza 600, Monte Trigu 750, Crobecada 65, Sa Tanca ‘e S’Ozzastru 830, Nuradorzu 200, Meddaris 950, Arghentu 920, Aeddo 820, Edrosu 800

However, in totality, dolmens show an elevation relationship that is not much heterogeneous. It is correct to keep in mind that many monuments are considerably distant from the paths traced by LCPA although sometimes they retain a relationship of intervisibility.

The anomaly, if there is one, may be in the parameters (certainly implementable) that we entered into the software in order to calibrate the Cost Surface Model (Figure 9). Also, we may be in the presence of groups of dolmens that do not have strategic characters but probably other tasks within the territorial organization, perhaps with “symbolic” meanings.

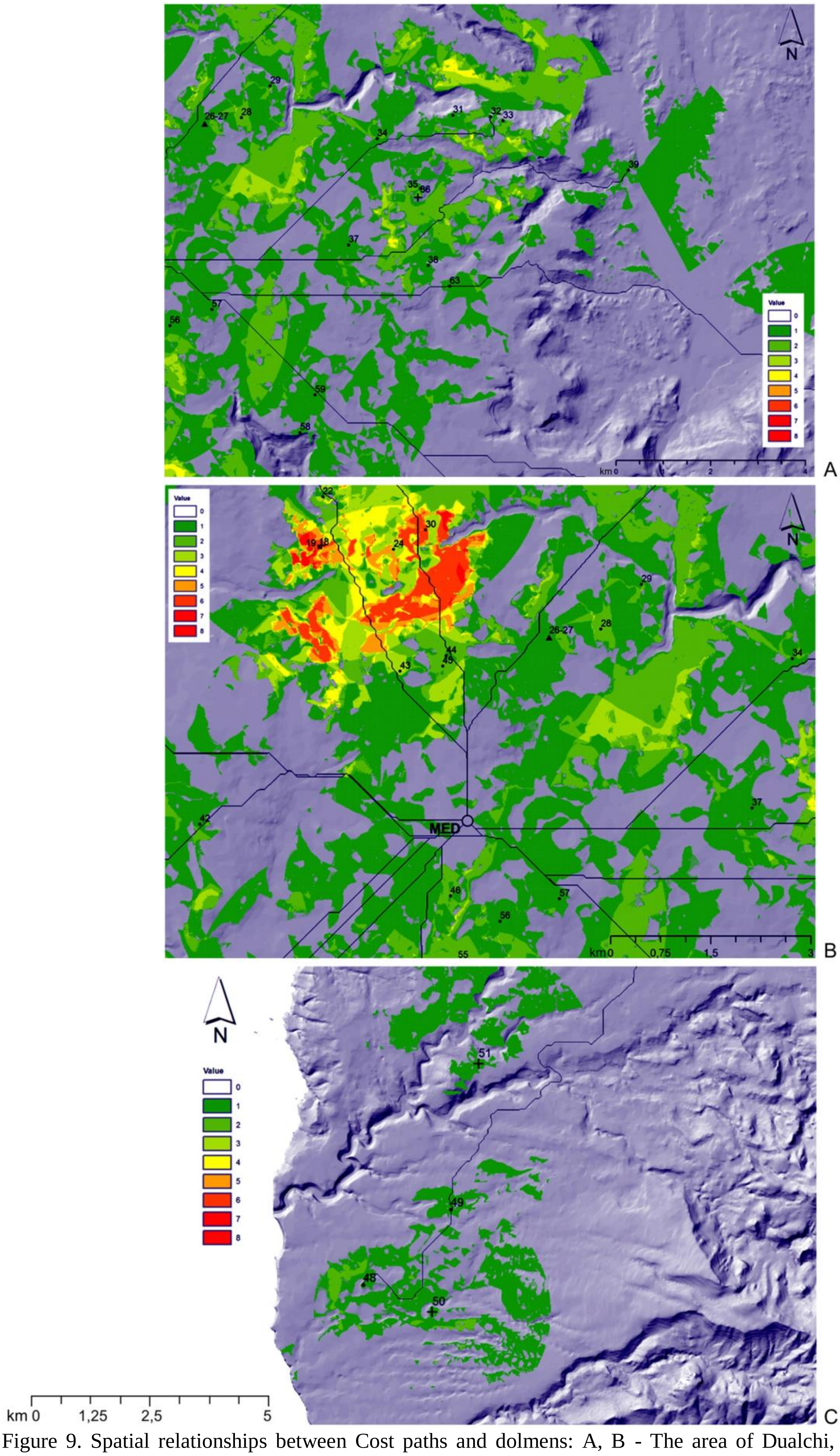

Figure 9. Spatial relationships between Cost paths and dolmens: A, B - The area of Dualchi, Aidomaggiore, Birori, Macomer, Borore, Noragugume; C - The coastal area near Cuglieri (Elaboration of M. Cabras).

Table 2. Least-Cost Path Analysis from the sample area towards dolmen located at lower altitudes. (Distances in metres; accurate to the nearest round figure.)

Arrival dolmen	Dolmens found along the path and distances
Caratzu	Cannighedda 'e S'Ena 1600, Mesu Enas 1080, Pedra in Cuccuru 620, Giuanne Pedraghe 480, Edrosu 800
Cannighedda 'e S'Ena	Mesu Enas 540, Mura 'e Putzu 750, Sa Perda Piccada 1000, S'Angrone 670, S'Ispreddosu 770, Giuanne Pedraghe 440, Edrosu 800
Nurazzolu	Cannighedda 'e S'Ena 1040, S'Angrone 650, Mesu Enas 540, Mura 'e Putzu 750, Sa Perda Piccada 1000, S'Ispreddosu 770, Giuanne Pedraghe 440, Edrosu 800
Mura 'e Iscovas	Sa Perda Piccada 650, Mura 'e Putzu 940, S'Ispreddosu 25, Giuanne Pedraghe 440, Edrosu 800
Torozzula	Iloi 1400, Tanca 'e S'Ozzastru 850, Crobecada 60, Nuradorzu 200, Edrosu 800
San Basilio	Pradu Lassia 160, Sarbogadas 230, Perda 'e S'Altare 1050, Edrosu 800
Mazzarighe B	Mazzarighe A 240, Sa Fronte Uda 390, Lughe 123, Corrizzola 610, Arbu 15, Edrosu 800
Monte Trigu	Iloi 870, Crobecada 60, Nuradorzu 200, Edrosu 800
Succhiau	Mura Fratta 70, Tuvamene 250, Muttianu 230, Edrosu 800
Carrarzu Iddia	Tuide 430
Sa Perda 'e S'Altare	Bidui 700, Edrosu 800
Noazza	Bidui 820, Pradu Lassia 625, Sarbogadas 470, Perda 'e S'Altare 370, Edrosu 800
Baccarzos	Badde Ide 470, Brancatzu 670, Sa Fronte Uda 900, Mazzarighe B 970, Lughe 570, Corrizzola 610, Arbu 10, Edrosu 800
Filigorri	Lure 0, Baratta 450, Paule Rues 1050, Nuradorzu 650, Meddaris 950, Edrosu 800
Monte Lacana	Su Livrandu 20, Serrese 1300, Furrighesu 520, Terra Tenera 2000, Aeddo 900, Nela 1550
Nurarchei	Abba Muru 1340, Succhiau 1850, Mura Fratta 1500,Tuvamene 820, Muttianu 230, Edrosu 800

4. Discussion and conclusions

The study of the location of Sardinian dolmens was carried out taking into account the geomorphology of the environment. The analysis, through precise geo-referencing of each monument and with the application of GIS tools, seems to confirm what has already been highlighted in previous studies with the macroscopic analysis of the phenomenon.

But there are problems: the analysis was carried out taking into account the actual landscape, which, however, in a land almost untouched like Sardinia, with very little human intervention, should not deviate too much from that of the Neolithic and Copper Age. Clearly, landscape changes, not easily appraisable, have occurred, for example in the vegetation coverage of the area and probably in the hydrography of the area. These features of the territory have certainly conditioned the locational choices of human groups. It is also necessary to excavate dolmen burials to find new data, pertinent to the stratigraphic context both palaeobotanical and palaeoenvironmental.

The researches have highlighted some features that recur with a certain constancy. First, many of the dolmens considered are very close to nature trails, sometimes coinciding with canyons or valleys (Figure 9). Moreover, these monuments, as compared with natural ways and, in general, to the surrounding area, are highly visible, although the number of these dolmens is not so great in this area. The data resulting from the analysis however, have not given precise and unequivocal answers, as might be expected, about any connection between dolmens and routes of transhumance. In any case, the study highlighted the strategic nature of the areas interested by the dolmen phenomenon.

Next, it is confirmed that the distribution of the dolmens is scattered over the whole area: in fact, these monuments are rarely grouped in necropoli, but are usually isolated.

To these elements can be added the data constituted by the coexistence, in the same territories such as the plateau of Campeda, of dolmens and the more numerous rock-cut tombs (denominated in local language “Domus de Janas” - fairy houses). The latter are datable to the Late Neolithic and Copper Age, in use at the same time as the dolmens.

All of this leads us to believe that the Sardinian dolmens, as opposed to artificial caves called “domus de janas” (spaces essentially funerary and ritual), should have not just a funerary function, but also some "political" purpose. In fact, these monuments could be interpreted as “signs of territorial demarcation of segmentary societies”, agreeing with the hypothesis proposed by Renfrew (1976), with functions of control and organization of the territory.

During the Late Neolithic (characterized by the Ozieri culture), and the later Copper Age, small groups of farmers and shepherds, who lived locally and were not part of a centralized society of chiefs, in some areas may have felt the need of a first territorial organization: the possession of the territory could be well testified by the presence of megalithic tombs, perhaps pertinent to burials of ancestors, leaders or heroes of the various communities. The scattered distribution of dolmens in this territory and the remoteness of some sites by real and potential paths, highlighted by LCPA, could suggest a kind of "hierarchical structure" of the landscape as regards the funeral area, perhaps following a process of progressive ‘gemmation’ from primary burial phenomena.

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