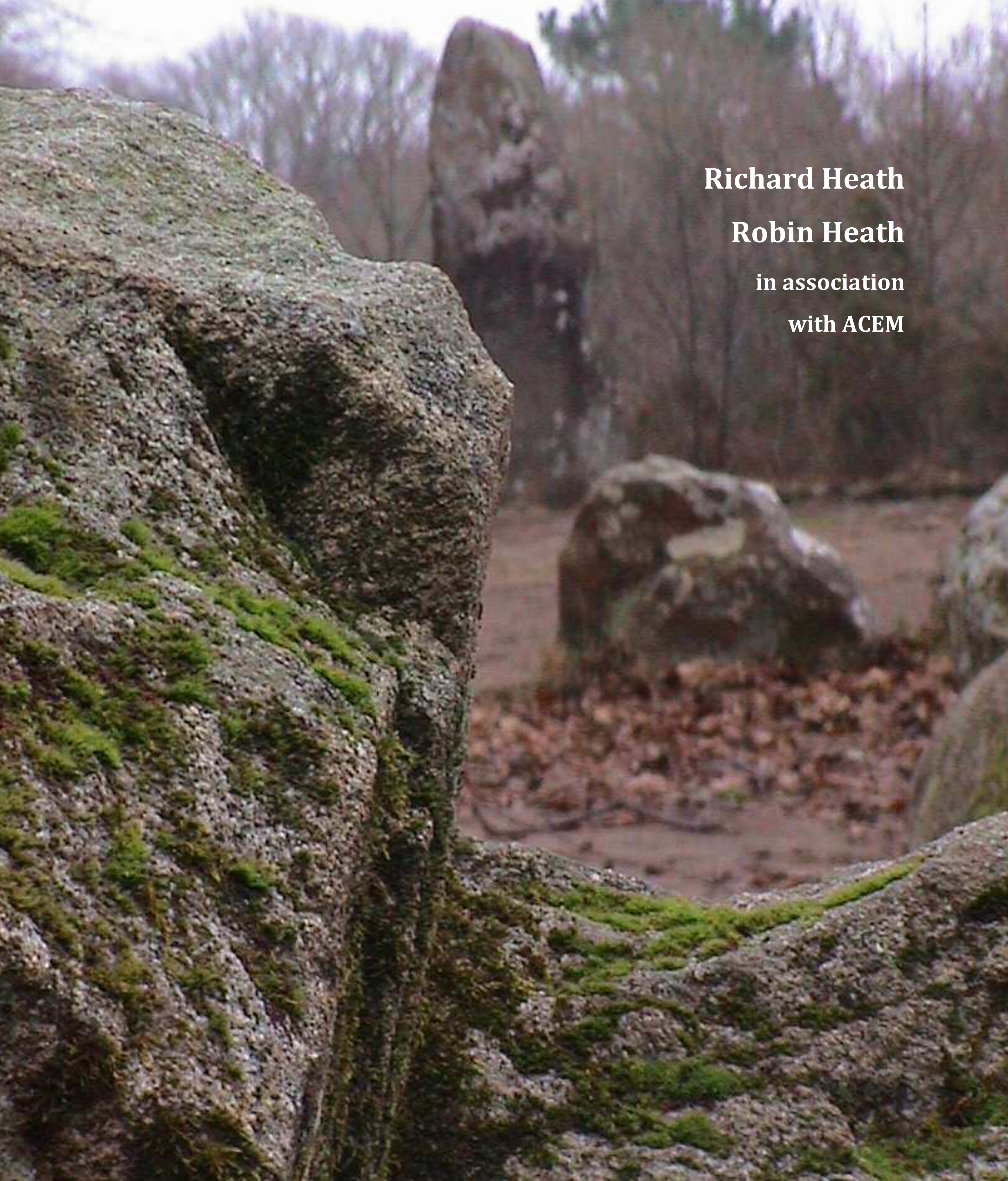
THE ORIGINS OF MEGALITHIC ASTRONOMY AS FOUND AT LE MANIO

Based on a Theodolite Survey of Le Manio, Carnac, Brittany, 22nd to 25th March 2010



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ABSTRACT

This paper presents the theory that in the Megalithic period, around 4500-4000 BCE, astronomical time periods were counted as one day to one inch to form primitive metrological lengths that could then be compared, to reveal the fundamental ratios between the solar year, lunar year, and lunar month and hence define a solar-lunar calendar. The means for comparison used was to place lengths as the longer sides of right angled triangles, leading to a unique slope angle. Our March 2010 survey of Le Manio supports this theory.

Following the discovery of such a triangle at Le Manio near Carnac, Brittany, the authors conducted a theodolite survey to accurately establish that both three and four solar year counts had been made in day-inches along the azimuth associated with the midsummer sunrise at that latitude, an angle itself generated between the longer sides of a 3:4:5 triangle (the simplest Pythagorean triangle). The difference in day-inches between three solar years and three lunar years was confirmed as being a megalithic yard of 32.7 inches within the monument, showing that the megalithic yard emerges naturally from day-inch counting the sun and moon over three years.

The invariant proportion of this soli-lunar triangle can be seen at Le Manio as that formed by the diagonal between four squares of equal side length and this generates a natural reading of metres since the modern metre is 4/3 the day-inch count for a lunar month. Finally, the angle of the Quadrilateral is revealed as adapted to the right angled of the three year triangle towards the East of its southern kerb.

It can be inferred that later metrology was derived from such a starting point since the inch and an "English" foot of twelve inches are commensurate with the metrological units of the historical period.

ACKNOWLEDGEMENTS AND BACKGROUND

The survey visit was facilitated by Howard Crowhurst who has helped us make visits between 2004-20010, showing us many little known aspects of local monuments and first drawing our attention to Le Manio in 2007. Our thanks also to *L'* Association pour le Connaiss*ance et l'E*tude des Megalithes of which we are now members. It was ACEM's survey of Le Manio helped establish the potential of the site. The Pythagorean geometry underlying Le Manio (adapted as figure 1-9) was developed by Howard Crowhurst from the work of AAK (Association Archeologique Kergal), established in the 1970s.

This document, prepared by Richard Heath and co-edited by Robin Heath, is based on a survey detailed in Appendix 1 and conducted by Robin and Richard Heath. All theodolite measurements, the survey data and a new Le Manio Quadrilateral plan were undertaken by Robin Heath.

Thom's plan of Le Manio was reported in Megalithic Remains in Britain and Brittany, Clarendon Press, Oxford, 1978 and figure 9.11 on page 112 used beneath diagrams in the main body, "The enclosure and menhir at Le Manio…"

Figure 1-2 is adapted from The Roots of Civilisation by Alexander Marshak, Weidenfield and Nicolson 1972.

DAY-INCH COUNTING AND THE MEGALITHIC YARD

The effect of the seasons, sun, moon and the periodicities of the planets, as these are experienced on earth, give celestial time a definite pattern. This could be studied by counting elapsed time between celestial events. We propose it was this step that led uniquely to the cultural advance called the Megalithic. It evolved an approach to measuring and calculating that is unfamiliar to our present science and mathematics and these methods have lain unrecognized in megalithic stone monuments until now. These monumental complexes were however required to measure the numerical properties of celestial time periods before the development of notational mathematics. The megalithic technology combined counting and geometry to achieve sophisticated insights into celestial dynamics and this activity probably led to the subsequent development of mathematics around the Fertile Crescent.

Figure 1-1 One of many Alignments at Carnac, Brittany, where many rows of stones travel at about 23 degrees east-north-east through the landscape for unknown reasons

The Development of the Day-Inch

The primary unit of time employed was the day itself. Counting days allowed significant achievements: For example, by good fortune the lunar month can be counted over two whole periods to total 59 days. At 29.53 days, the lunar month is nearly 29 ½ days and this means that two months are 59 days long, to nearly one part in a thousand.

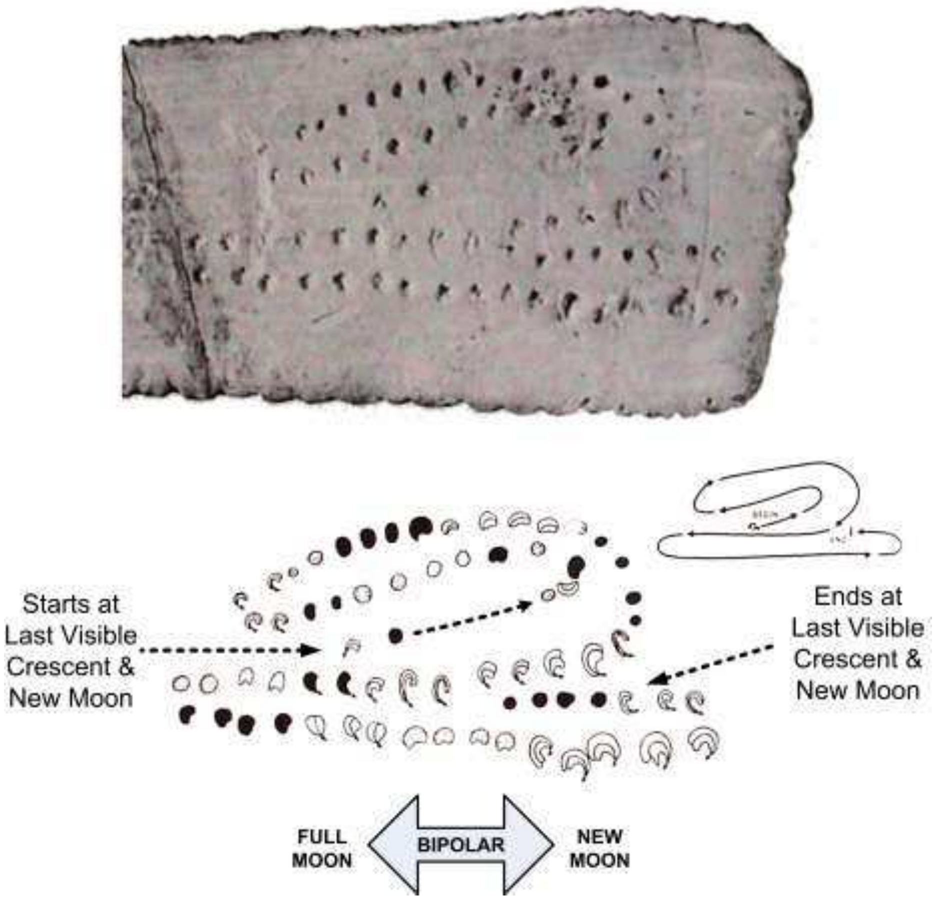


Figure 1-2 Engraved and shaped bone plaque from the rock shelter site of Blanchard (Dordogne) from Aurignacian period about 35,000 years ago. This was one of many bones interpreted by Alexander Marshack as being based upon the phases of lunar months, in his book; The Roots of Civilisation.

Such counts are found in the Stone Age as sets of notches or other marks scored on bone[1]. We will demonstrate that these marks later came to be made using equally spaced marks, using a size similar to our present inch length, a

[1] See The Roots of Civilisation by Alexander Marshak, Weidenfeld & Nicolson, London, 1972

digit related to the width of a finger or thumb. An inch measure has many uses, being conveniently small, while larger numbers of them, used in a longer count, generate lengths large enough to construct geometrical structures from which time periods could be compared as ratios. The adoption of a constant length for each day also allowed fractions of a day to be detectable when these counts were employed geometrically; one eighth of an inch would be visible as three of our hours. The resulting system of metrology allowed the cosmic time ratios of the Sun and Moon (within the year) to be extensively studied. This activity appears to have been the precursor for the system of metrology – a system based on ratio - that was inherited as the historical or ‘classical’ measures used throughout the world, rationally based by that time on a foot of twelve inches.

Four year counting, between identical sunrises on an horizon mark, generates 1461 day-inches, and the division of this by four (by folding a marked rope twice) gives a 365 ¼ day-inch year. Such a direct use of measure contrasts with our present methods where measurements are abstracted from equipment measuring angles and time as numbers using a numerical notation. Megalithic astronomers were instead maintaining a direct connection between their apparatus and each measurement through the use of direct geometrical techniques.

This approach unexpectedly enables calculations of a powerful kind via the type of these geometries found within the organization of megalithic sites. These frequently employ right-angled triangles, which enable day counts to be compared without using modern trigonometrical methods - the difference between the two longer sides of a right-angled triangle naturally presenting ratios as unique slope angles. A metrology arose within these triangles because the day was being counted in inches to produce various lengths - of time.

Studying the Lunar and Solar Year

After quantifying the solar year as a length in day-inches, the most obvious time proportion to study is the difference between the 12 lunar months of a lunar year (354.367 days) and the solar year (365.2422 days), which is about $1/3^{rd}$ of a lunar month longer. Day-inch counts can, as stated above, give reasonable results for the length of the solar year and lunar month, at least as good as 365 ¼ day-inches and 29 ½ day-inches respectively. The lunar year is then 12 times 29 ½ days or 354 day-inches long. However, a longer count of three lunar years (36 lunar months) yields an extra whole day to the count, at 1063 days. This is accurate to almost one part in ten thousand and is only 2 ½ hours short of the correct time for 36 lunar months (1063 $1/10^{th}$ days), giving a lunar month of similar accuracy at 29.528 days.

Brittany is one of the oldest megalithic regions in Europe and the region around Carnac contains many complex monuments already known to be aligned to the Sun and Moon. At the latitude of Carnac, the angle of the Sun's rising and setting points at winter and summer solstices have the unique geometrical property of forming the first Pythagorean triangle (with side lengths 3 by 4 by 5 units long) relative to the east-west axis. Many such triangles were built into the monuments around Carnac so as to define the position of the Sun at sunrise or sunset during both solstices, the summer sunrise sun then being opposite where the winter sunset would occur and visa versa.

The wealth of megalith construction near the latitude of Carnac, at which this most simple of all the whole number triangles could be used, indicates (a) the geometrical roots of their methodology and (b) a choice of the specific latitude of Carnac. This conscious relationship between megalithic monuments and latitude is also to be found elsewhere[2].

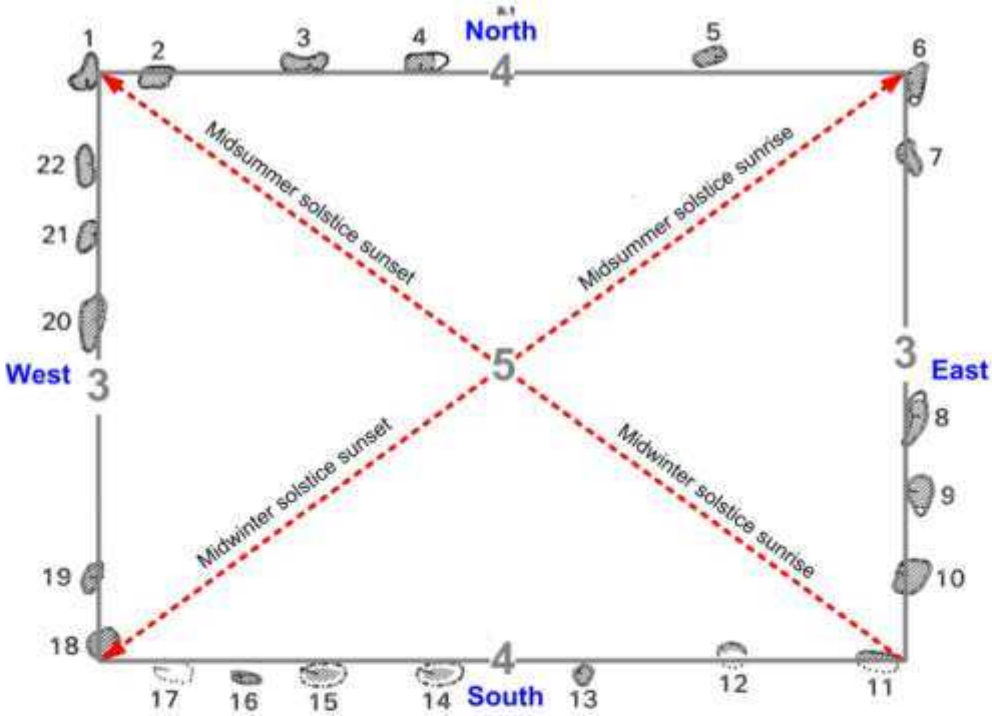


Figure 1-3 The usefulness of 3,4,5 triangles at Carnac in aligning to solstice sunrises and sunsets at Carnac. One of the clearest examples of this geometry can be found within the Crucuno rectangle. *Alexander Thom's 1973 survey of this* region demonstrated that 3,4,5 triangles were regularly incorporated in megalithic structures around Carnac.

Such a triangle can be constructed using a rod of any length to mark out three sides of length 3, 4 and 5. In fact such whole number triangles are best constructed on the ground using ropes where the right angle is automatically formed during the process when manipulating a regularly knotted loop of rope. Inch-day counting lengths can be compared using such a right angled triangle, a pegged rope ensuring an accurate right angle, as shown in Fig 1-4.

It is only through the adoption of day-inch counting that the lengths within such geometries become meaningful, for then these can be compared with each other. It is necessary to understand what inch-counting can deliver in terms of its astronomical applications and this led to the composition of an itinerary in

[2] At Bryn Celli Dhu, on Anglesey, 3-4-5 geometry gives the midsummer sunrise angle. In Britain, horizon elevations are often used to achieve extreme moon and sun rises/sets which define a right angle. Avebury employs a 3-4-5 triangle in this way, as does Stonehenge but using 5-12-13 instead.

which earlier steps in inch counting would lead naturally to later and more sophisticated possibilities[3]. These have been found to explain what the megalithic people actually built at Le Manio, a site near Carnac that is unique in its design.

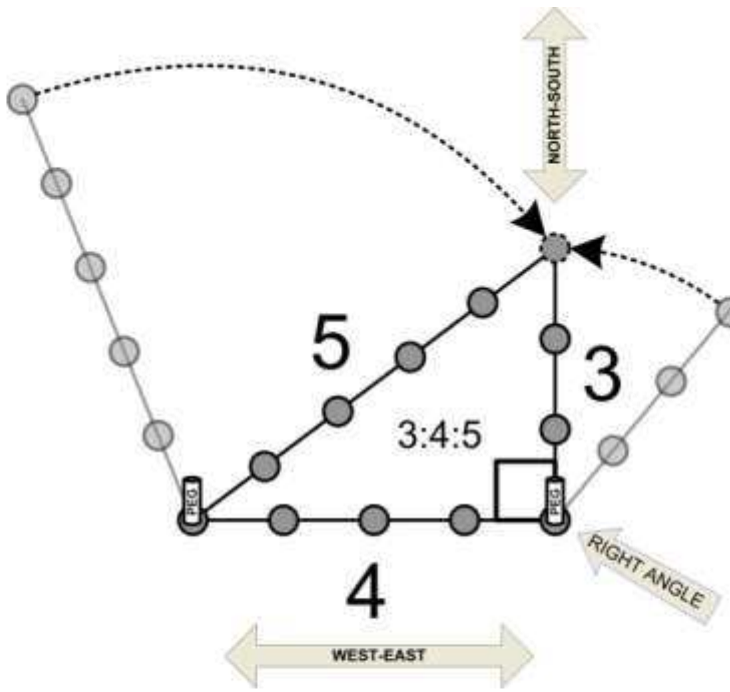


Figure 1-4 A rope with 12 equal divisions can come together to form a 3:4:5 triangle and an accurate right angle. Any Pythagorean triangle, made of whole numbers on each of its sides, can be used in this way in building right angled triangles that instead have day-inch counts on their two longer sides. This then allows celestial time ratios to be studied geometrically.

During the summer solstice of 2009, Robin Heath discovered a day-inch encoded sightline at the site called Le Manio, within a construction called the Quadrilateral[4] (see figure 1-5), supporting the above theory about day-inch counting[5]. Having established that the solstitial sun would always shine down the longest side of a 3:4:5 triangle at the latitude of Carnac, the megalithic astronomers chose such a sightline to begin their count in day-inches. The length of the line in day-inches was found to equal three solar years (1095 and ¾ day-inches), a time period already identified above as having particular

[3] Proposed Itinerary for Megalithic Astronomical Development, Richard Heath, 2009
[4] The angle of the Quadrilateral to the east appears oriented at the angle of a 5:12:13 Pythagorean triangle.
[5] The discovery of a Soli-lunar calendar device within an Astronomical Ritual Complex at Le Manio, Morbihan, Brittany, by Robin Heath, June 2009, available at www.skyandlandscape.com

advantages to inch-counting astronomers. A second line – the diagonal of the Quadrilateral – runs parallel and is found to equal four solar years, exactly 1461 day-inches.

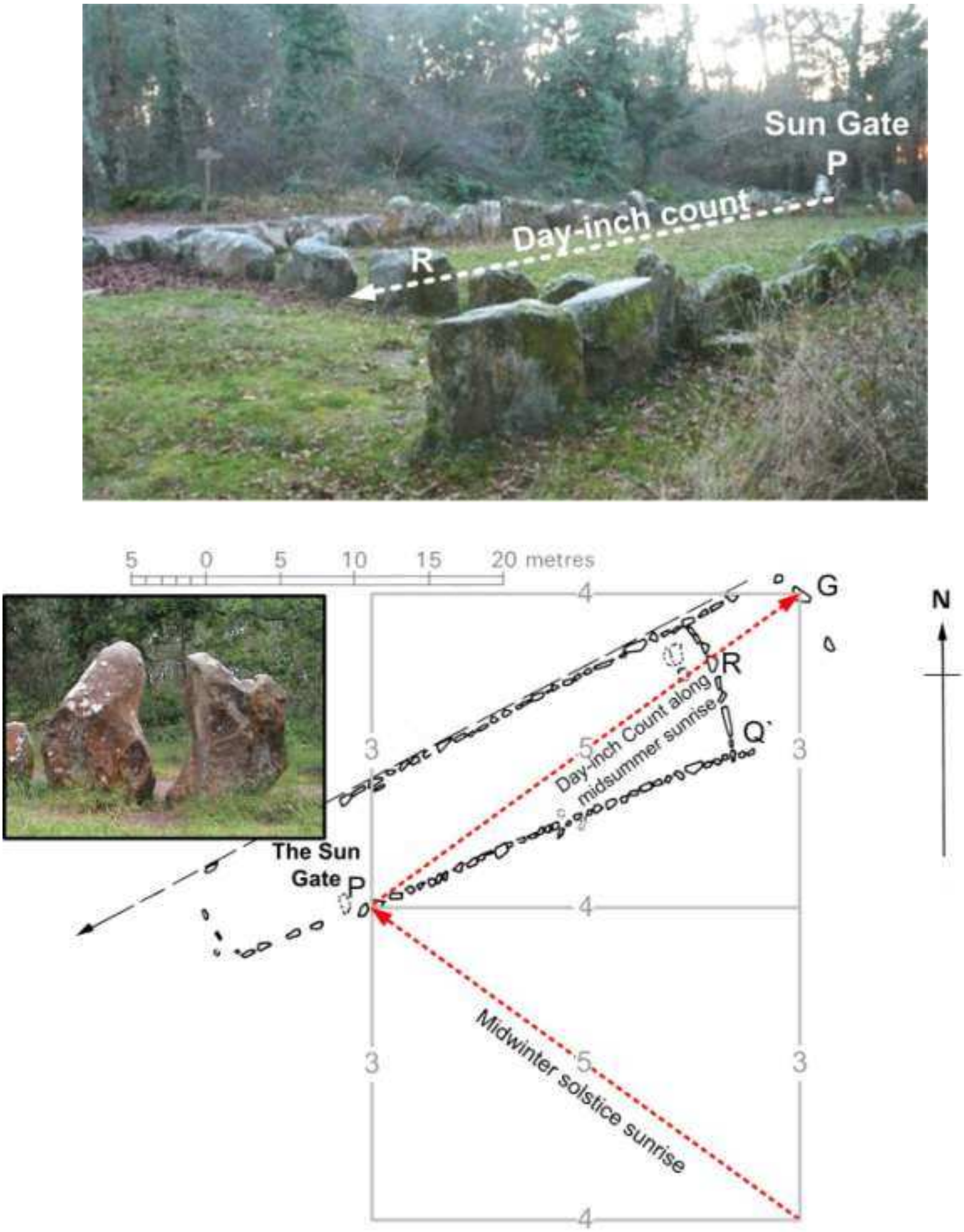


Figure 1-5 The day counting line defined by the midsummer solstice at Le Manio Quadrilateral. Above: Photo of the site from the north-east. Left: Photo of the distinctive *“sun gate” including stone P where the counting began.*

In a three year count, it would be reasonable to mark each day-inch within which a full moon occurred. Thirty six such full moons would then be clear and, if the count was begun on a full moon day, the extra length required to reach the end of three solar years would reveal the difference between three lunar and three solar years. After three solar years, one more lunar month has occurred to make 37, and it is this approximate anniversary of the third solar year and the 37th lunar month's end, forms a unique opportunity for day-inch astronomers.

Forming a soli-lunar triangle generates the Megalithic yard

A triangle was formed out of these two counts by dropping one end of the three lunar year count until it formed a right angled triangle with the three solar year length. This new, lunar baseline runs along the southernmost kerb of stones now making up the Quadrilateral (see figure 1-6 and following text for a more detailed description). It demonstrates that the Quadrilateral was defined in its shape by the activity of day-inch counting applied to the geometrical properties of right angles.

This procedure would have enabled the invariant proportion of the two types of year, solar and lunar, to be captured as a pure geometrical ratio - which is what the slope angle of any right angled triangle represents. A solar hypotenuse above a lunar base line gives the ratio between the two lengths in an iconic form, which today we call the cosine of the angle between the two sides; in the megalithic period the geometry itself gave the ratio in as useful a way. We will see that the Megalithic Yard found in megalithic constructions at Carnac was exactly the difference between three solar and three lunar years, 32 5/8th day-inches, as follows:

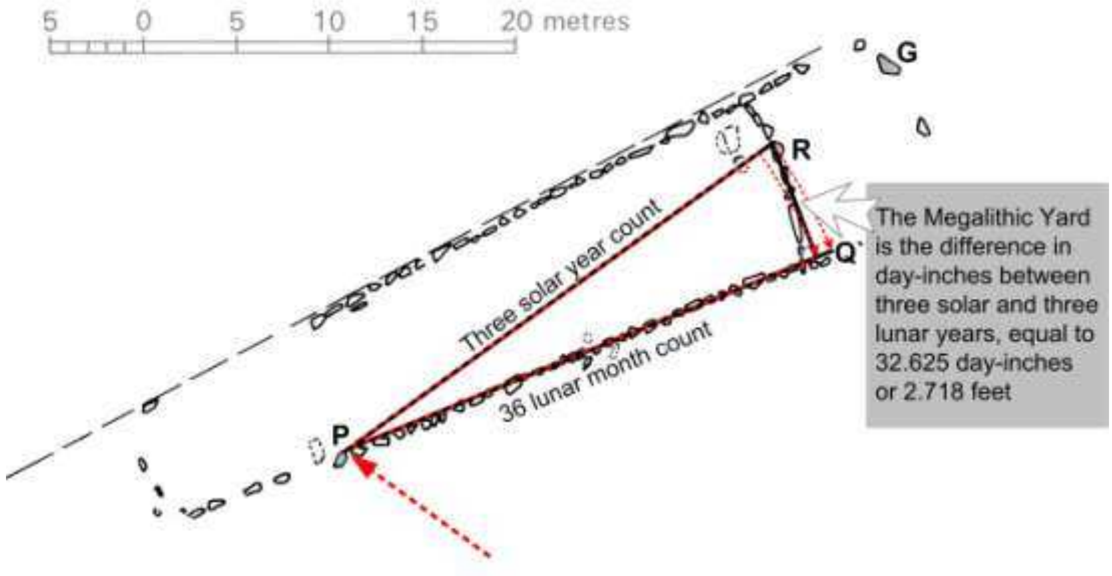


Figure 1-6 The triangle constructed at Le Manio from counting three solar years and *"dropping" the count of three lunar years, to create a right angled triangle with baseline running along the southern kerb's stones.The difference in length between the longer sides is* the megalithic yard.

As already mentioned the Le Manio site represents both early and later development and we can now propose a timeline for the earliest part of this development.

1. A suitable line was established that ran along a sightline aligned to the midsummer solstice sunrise. Stone P was erected to indicate the starting point for a day-inch count and stone G has a groove aligned to midsummer sunrise seen from P.

2. A three solar year day-inch count was started that progressed from point P towards stone G. This could have used a measuring rod (ruler) designed to accommodate a counting marker.

3. Full moons could have been shown in the count (as with an inch marker made of quartz) as the count progressed to its three year end, where stone R would eventually be installed and dressed to provide an accurate reference.

4. The distance between the 36th Full moon (lunar month) and the end of the three year count then equals 32 and 5/8th inches, a length directly countable in inches. This length became the megalithic yard of 2.718 feet for later use within the Le Manio site and beyond. A standard rule of this length could then be constructed, possibly calibrated as a ruler using a set of inch markers, grooves or notches.

5. To form a triangle: Make up a second rope whose length corresponds to 36 Full moons (lunar months) and attach it to the "left hand" end of the original three solar year rope (at point P on Fig 1-6). The longer rope (the three year count rope)

could then be pivoted from the join point at P until its end stands vertically above the end of the smaller (36 Full moon) rope. A right angle has been formed between the count for 36 months and the three year count of just over 37 lunar months. A 12 section rope would have helped achieve such a right angle.

6. Stones R and Q' were only later prepared and installed to mark the end of the three solar year count and the end of three lunar years, respectively, and to "set the triangle in stone" down two of its sides as part of the Quadrilateral.
7. The count itself, on the hypotenuse, was dismantled but probably stored as a rope and available for re-measurement as we have done.

The above procedure explains the variation found in the megalithic yard between megalithic sites according to the accuracy achieved in the geometrical derivation from the day-inch. The day-inch measure was always the original measure based upon regularized day counting. Wherever a megalithic yard was not available, a three year day-inch count could have re-provided it. However, by storing new lengths such as the megalithic yard and developing new geometrical shortcuts, we shall see later how megalithic astronomical skills became portable cultural artifacts.

There is evidence therefore that the Megalithic developed a geometrical tool, with mathematical properties[6], that enabled scientific discoveries through first constructing a metrology of time and then a geometry of proportion on the ground where they built monuments. The size of monuments is then directly related to the number of day-inches between astronomical events as well as the need for long alignments to the horizon.

A Basis for a Twelve Month Year

Having generated such a triangle the builders could see a further proportionality between lunar years and solar years, in that lunar months on the base would translate to (longer) mean solar months on the solar count

[6] The slope of the longer side relative to the baseline will cause any sub-length on the baseline to correspond to a longer sub-length above it, on the longer side (the hypotenuse). A lunar month count on the base therefore points to a longer, mean solar month (1/12 of a solar year) on the longer side. This difference in the growth of a hypotenuse relative to a baseline results from the proportional growth in length between the two sides, an inevitable consequence of its slope.

hypotenuse. This naturally projects the twelvefold division of the lunar year (by lunar months) into an equivalent division of the solar year by twelve solar 'months'. Mean solar months are not marked by a directly visible phenomenon as for the phases of the moon (where a full moon divides the lunar year into twelve) but this triangle naturally presents the division of the ecliptic into a Zodiac of twelve equally spaced regions through which the sun travels in the year.

It is this expansion of the lunar month into a solar month that generates the difference between the shorter, lunar baseline and the longer, solar hypotenuse after 36 (3 times 12) expansions. At Le Manio, the count would have generated a difference between three solar years and three lunar years of 32 and 5/8ths inches or 2.72 feet, which is the length discovered independently by Alexander Thom and which he named the megalithic yard. It is important to note that this is shorter than a yard of English feet, which is 36 of the same inches long.

The builders therefore appear to have used a day count to establish their megalithic yard, defined as the excess of three solar years over three lunar years, in day-inches. This unit of length was then chosen for subsequent constructions, such as the 3, 4, 5 triangles, using measuring rods and ropes originally derived from the day-inch counting, to then form the complex yet practical geometries found at Carnac. The "excess length" or megalithic yard contains the secret of calendar construction in which the sun and moon can integrated since it contains their relative motions as a ratio, based upon day-inch counting.

The Metre and the Moon

We returned to Le Manio in the equinox of 2010, to see how a theory of day-inch counting would correspond to the Quadrilateral once an accurate theodolite survey had been undertaken. A number of facts emerged that further explain the design of this unique megalithic monument[7].

The third side of the soli-lunar triangle for three years was discovered to be the equivalent of nine months of day counting. The 36 months of the base line can therefore be divided by this length exactly four times since 36/4 = 9. This provides a geometrical method to accurately reconstruct this triangle over any period, not just three years, to generate day-inch counts without actually counting days.

By generating four squares with equally sized sides, of length equal to three lunar months, the size of the triangle's third side (the diagonal) is then the solar year count which is effectively, 12.369 lunar months (as a day count), the square root of the square of the baseline of 12 months plus the square of the third side of 3 months[8]. The achieved accuracy of this diagonal relative to a day count for the given number of solar years is one part in twenty thousand. This geometry therefore exceeds the accuracy of an actual day count, corresponding to 45 minutes per solar year, and this simpler geometrical technique can replace day counting.

[7] The survey details and its full set of conclusions are published in Appendix 1.

[8] Today we use Pythagoras' theorem by adding the squares of 12 and 3 to give 144 + 9 = 153 the square root is 12.369 (months).

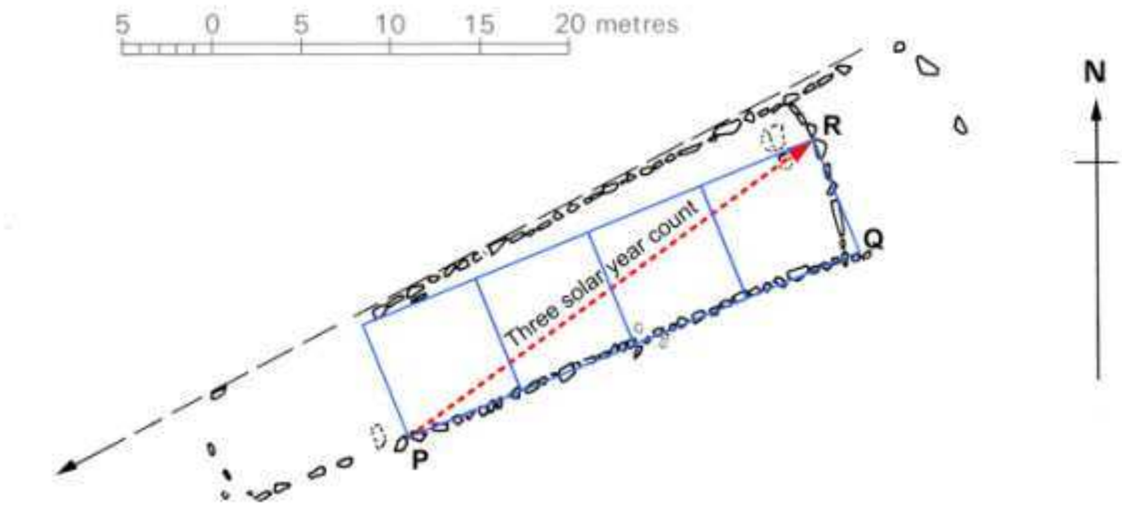


Figure 1-7 - The four squares geometry whose diagonal represents the solar year. Once discovered, this leads to a greater accuracy than day counting and provides a portable geometrical device for reconstituting the solar-lunar triangle's day-inch count.

This "four squares" geometry offers a portable procedure for reproducing the soli-lunar triangle's slope angle and day-inch counts, for any number of solar years. Its reproduction also requires a convenient unit of measure with which to build this geometry, a unit more convenient than 29.53 inches. Such a natural unit emerged during our survey when we noticed that 36 months measured exactly 27 metres on the baseline for three lunar years. The modern metre is therefore 36/27 (4/3rds) of the day-inch count for a lunar month, to high accuracy, since 3/4 metre equals 29.528 inches. Three metres then becomes a useful measure equivalent to a four lunar month day-inch count, then being 118.11 inches long. This 3 to 4 relationship, between the month and the metre, then plays itself out in the 3 year and 4 year triangles at Le Manio since the four lunar year baseline is then 36 metres, the number of months in three lunar years.

The three lunar year day count of 1063 divided by 36 (months) gives a month of 29.528 inches which is ¾ of 39.370 inches, the length of the modern metre. Using eights of an inch therefore, 39.375 inches[9] (39 and three eighths) is then an almost identical length, three quarters of which give a month of 29.53125 day-inches long. The above rational metre[10], divided by ¾, gives a lunar month accurate to one part in forty five thousand or a single minute in 29.53 days.

The metre joins the megalithic yard as a measure naturally generated by day-inch counting, in this case useful for the reproduction of longer time periods without a day count or suitable longer rope. Metres can make lunar baselines and reproduce the four squares geometry whilst containing within them the original day-inch count for the lunar month.

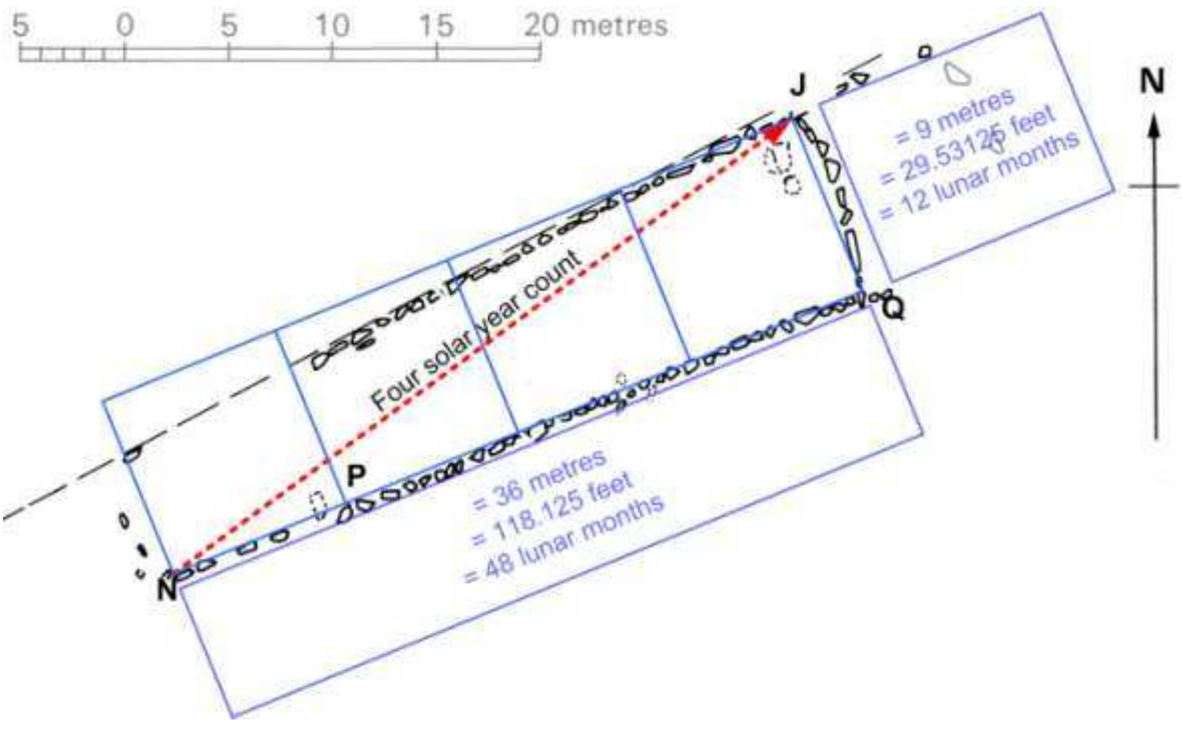


Figure 1-8 The *4 year Triangle at Le Manio's Quadrilateral*. The metre is shown to be a measure of 4/3 of a day-inch counted month whilst the twelve inch foot enables the lunar year to appear, numerically, as twelve lunar months of feet instead of inches. The metre is more convenient because three metres yields a whole number of four lunar month counts, in day-inches. The metre lengths measured during the survey revealed integer numbers of metres, evidently then used at Carnac as a shortcut in constructing these triangles.

[9] Compared to the 39.370 inches of the modern metre.
[10] Of length 105/32 feet long, and one part in 8000 greater than the modern metre.

The ‘four years’ triangle at Le Manio (see figure 1-8) shows the metre’s utility very clearly since it is made up of four squares, each with 12 lunar month sides which are then, equally, three metres by three metres in size. The eastern corners and southern kerb are defined by the three and four year triangles.

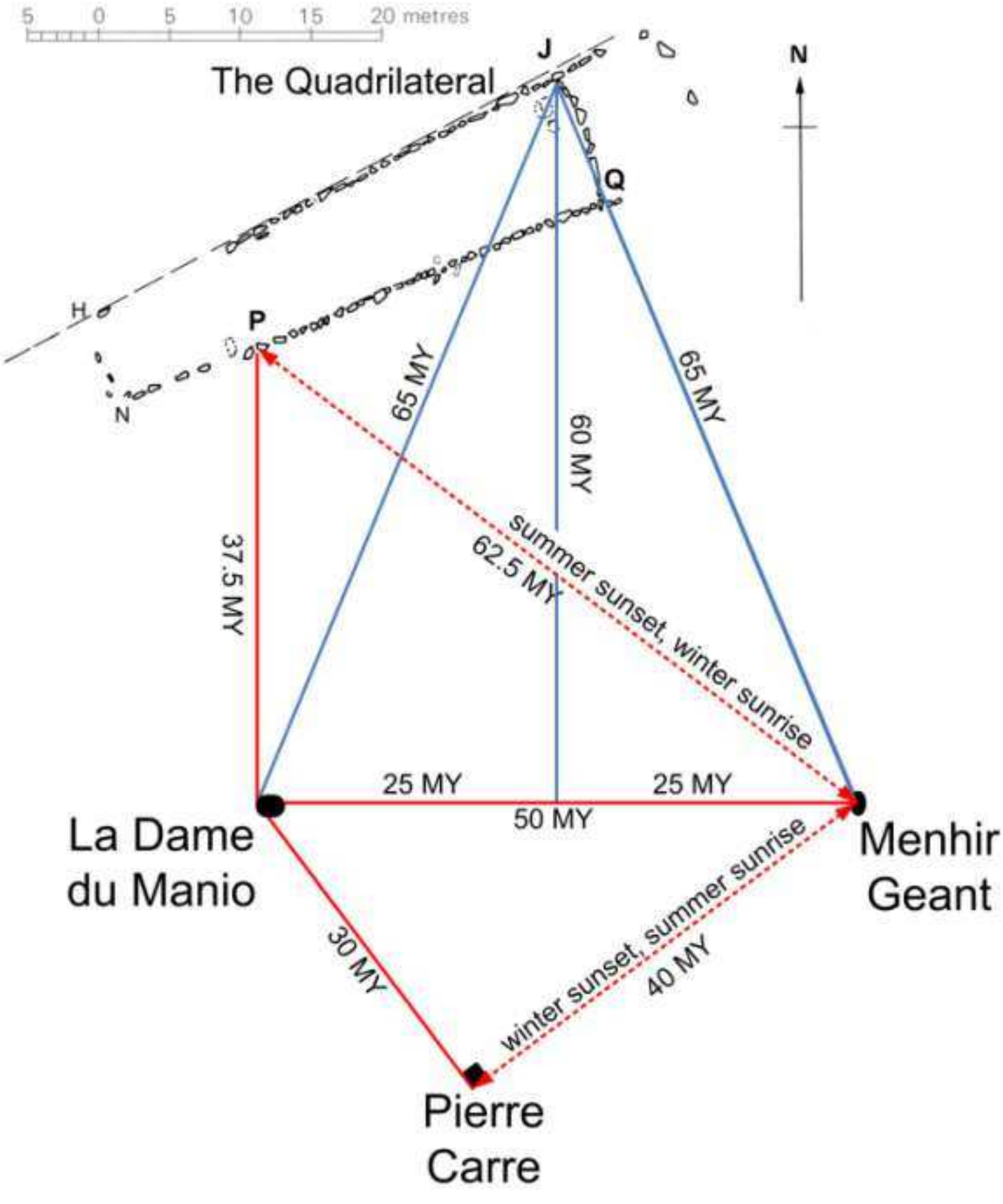


Figure 1-9 The ACEM interpretation of Le Manio using 3:4:5 and 5:12:13 triangles within an integrated scheme. The metre lengths within their survey have been converted into rational numbers of the megalithic yards evidently involved in constructing these triangles.

Conclusions

1. Our survey has shown that day-inch counting is very likely to have been practiced at Le Manio by the culture responsible for the Quadrilateral. This conclusion leads to next steps that may have been taken around the same time, using this unique form of geometrical metrology for astronomy.
2. The megalithic yard is inherently the product of day-inch counting over three years, in one of its known variations found by Thom, 2.718 feet or 32.625 inches. This confirms the practice of day-inch counting whilst also giving this megalithic yard an inception date, as a unit, of 4000+ BCE.
3. The use of four squares to easily recreate the invariant form of the solar to lunar year triangle, as a $\sqrt{17}$ diagonal, would have enabled this astronomical relationship to be a portable technology. Three quarters of the modern metre equals the day-inch count for a lunar month so that three metres equals the lunar year day-inch count. This unit would have enabled easy reproduction of four square geometries in achieving lunar and solar year day counts.
4. The southern kerb appears designed to accommodate both the Pythagorean design concept discovered by ACEM (see figure 1-9) and, at the same time, the astronomical triangles based on three and four year day-inch counting. The southern kerb stones towards the east veer south and away from the Pythagorean design so that the terminal stones can conform to the location of the right angle formed by the three year triangle (see Appendix 1: Resolving the different Q Points relevant to ACEM and HEATH Surveys). In the 3 year triangle at Le Manio, the three solar year length is available at the end of stone Q' found at the very end of the southern kerb, to the east; having already been brought down to the southern kerb, when measuring the megalithic yard excess between Q' and the three lunar year baseline[11].

[11] The four solar year hypotenuse was also coincident with this point so as to form a common end point for the three and four solar year day-inch counts.

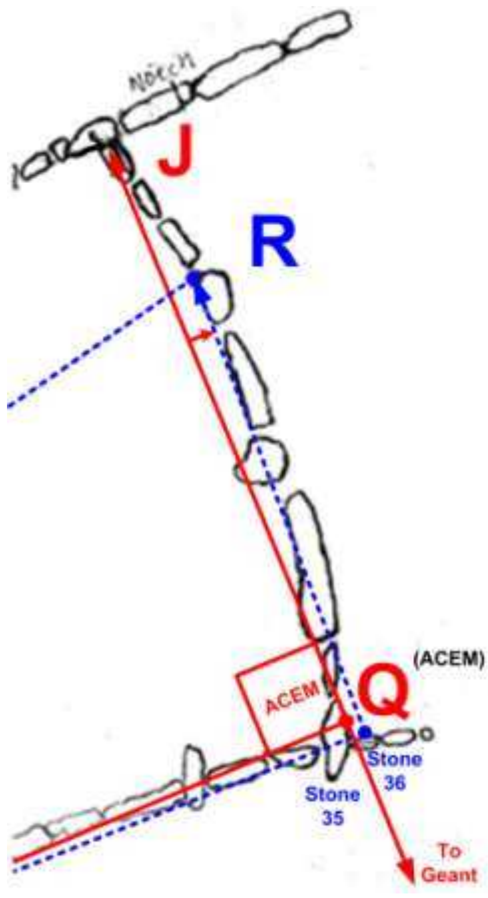
APPENDIX 1: DIFFERENT Q POINTS RELEVANT TO ACEM AND HEATH SURVEYS

The geometry found by ACEM within the Quadrilateral (see figure 1-9) involve Pythagorean triangles (5, 12, 13 and 3 ,4 , 5) that locate its southern kerb, eastern corners, the "sun gate", Geant menhir, and Dame in a single (intended) design that was oriented to other monuments further away.

The geometry of day-inch counting confirmed by our survey employs a triangle related to the 5, 12, 13 triangle but based on a length at the angle of midsummer solstice sunrise, between the "sun gate" and a "dressed stone" R in the eastern kerb, which stone might be responsible for that kerb's outward bowing. The hypotenuse generated by counting three solar years, terminating on stone R, naturally generates an alternative frame to ACEM's at the right angle between the southern and eastern kerbs, as shown.

There are then *three different points* around Q,

1. **ACEM**: The 'lichen mark' to the north of cross stone (35) that is part of the eastern kerb and which cuts the southern kerb as one of its stones. This was used in the ACEM survey and led to an angle from it to the ACEM survey pin (4" south of the Heath survey pin) of around 22.62 degrees, the angle to east of a 5, 12 ,13 triangle with the survey pin as the apex.
2. **HEATH**: The stone Q, identified as stone 36 of the southern kerb in our photo montage, just north of the junction between stone 34 of the southern kerb. This stone was used to mark the length of the kerb from sun gate P to stone 35 in our survey, as 1063 inches – implying it to be the right angle of the 'three-year' solar-lunar triangle including stone R (aka stone 6 of eastern kerb)
3. **PHOTO MONTAGE**: The pointed junction of stone 34 with stone 35, which was only used in the photo montage of the eastern kerb (Appendix 3), which includes stone R, can be used as a metrological reference as follows:



The length of the 3rd and shortest side of the solar lunar triangle can be calculated as placing its right angle 22 feet and 2 inches from the dressed edge of stone R.

The photo montage of the eastern kerb shows the dressed edge as being measured in the Heath survey as being 22 feet and 5 inches from the junction of stone 34 with stone 35 of the southern kerb, a figure which therefore differs by 3 inches from the position of the triangles right angle.

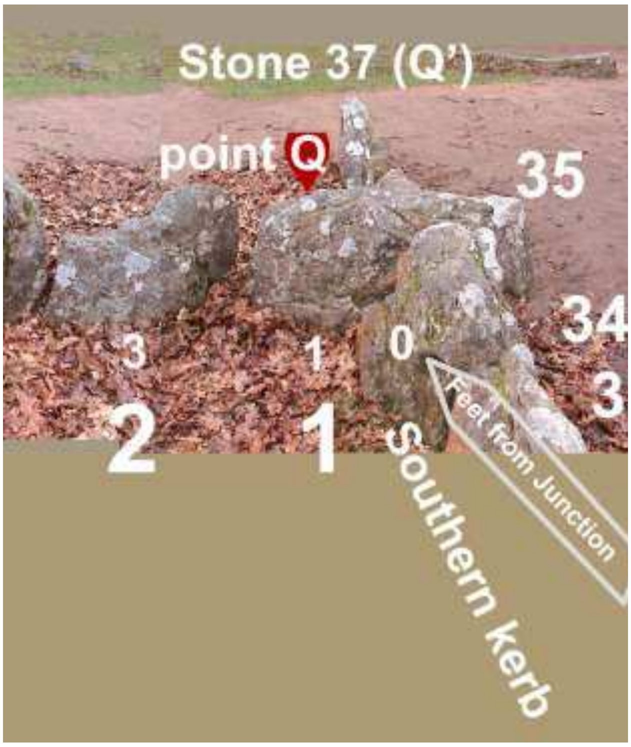


Figure 1: A close up of the photo montage from the west shows where the ACEM Q point is located, north of Q stone 36 (and 37).

Figure 2: The junction of stone 34 (centre) is shown to be further south in figure 1 than the Q stone 36. Zero feet, in our photo montage, is therefore south of where it is shown, by 2-3 inches.

The Q point of ACEM must be about 12 inches north of the junction with stone 34 and the above calculation of the triangle's third side places its right angle 3 inches north of the junction, so as to,

1. Locate the 'right angle' somewhere on the quite narrow Q stone 36 and in line therefore with stone 37, where the megalithic yard can be realised.
2. Locates the ACEM Q point 9 inches north of this triangle's right angle.

This confirms the use of the Q stone, with respect to the solar-lunar triangle, in the Heath survey in which the pin at point P was also 4 inches further north than ACEM's corresponding survey pin.

Figure 3: Our station 4 over the ACEM point Q shows that, after *'cross' stone 32, the* southern kerb deviates to the south.

The location of Station 4 seen from the east (figure 3) and located over the ACEM point Q displays the southern kerb as deviating after cross-stone 32 to the south whilst the point P follows the general line of the Quadrilateral. Thus point Q is good for stones 1 to 31 of the southern kerb and goes to the ACEM pin, further south than our pin at point P.

This means that the frame used by ACEM displays a 5,12,13 geometry whilst our frame focussed on point R, as origin of the three solar year day-inch count to P, displays a "point Q" corresponding to the stone Q and the deviation of the southern kerb at its end.

The above findings are compatible with the following conclusions:

1. **ACEM**: The Quadrilateral was constructed on a line angled according to a 5, 12 13 triangle relative to east. In constructing the southern kerb, the relationship with the many other Pythagorean features surrounding the Le Manio complex could then form part of an overall design.
2. **NEW**: The Quadrilateral was adjusted at its south-eastern corner to correspond with the solar lunar triangle terminating there after three years from the sun gate. The ACEM pin cannot give a view, on the ground, between point P and stone R and the solar count length also would have to be where our pin was then placed, north of the ACEM pin.
3. **RESOLVED**: From the point of view of the solar-lunar triangle's baseline therefore, the angle given for it, as being the southern kerb between our point P and (effectively) stone Q or 36, is less than 22.6 degrees ***exactly because*** that line is east of ACEM's survey due to the points defining each of the ends being different.

An angle around 22.3 degrees is therefore an appropriate finding for the abstract baseline of the solar-lunar aspect of the Quadrilateral along the southern kerb.

APPENDIX 2: SURVEY AT LE MANIO 22-25TH MARCH 2010 BOOKINGS & PRELIMINARY ANALYSIS

28th March 2010 Robin Heath

Equipment employed:

1. Wild T16 Theodolite – calibrated by Zenith Survey Equipment in November 2009 (calibration certificate 116007820), zero defined at zenith (i.e.horizontal reading is 90 or 270 degrees)
2. Measuring Tapes: 200 foot steel surveyor's tape and two 100 foot carbon fibre and fibreglass surveyor's tapes – checked together and calibrated.
3. Radio controlled chronometer
4. Nautical almanac

22/3/2010: DETERMINING THE AZIMUTH OF G>R>P

Intent: to determinee the azimuth of G>R>P (the 3yr idealised hypotenuse of 91.3106 feet)

First station at G (photo below) (3ft 9.5" from G along line P>R>G (pin left)

The pin at P is placed 5" away from HC survey pin and perpendicular to line Q>N (photos exist to show this position)

GPS of station 1.

N47* 36’ 14”; W 3* 03’ 22” : Elevation 117 feet : accuracy 30’

SUNSHOOT 1

TIME 9:26:40 GMT PABZ set to P (RO) (equals 0 degrees)

	Horizontal	Vertical
Measured	253* 12’ 10”	30* 03′
Actual Sun Azimuth	127* 51’	+30* 02’
Swing:	106* 47’ (360* - 253* 12’ 10”)	

Azimuth of line G>R>P = swing + sun az = 234* 38′
Reversed azimuth P>R>G = 054* 38′

Elevation from station -2* 52’

Measurement – distance from dressed stone R to groove in stone G = 24’ 4.5” (straight run) and - 24’ 5.635” to pin below R.

commentary: this divided by 9 gives MYs of 2.708’ and 2.71875’

comment: the angle P>R>G calls into question the azimuth of line Q>P>N

22/3/2010: DETERMINING THE AZIMUTH OF J>N

Intent : to determine the azimuth of J>N (the 4yr idealised hypotenuse of 121.7474 feet and to identify a position for point N.

The pin placed directly in the corner between the end stone at N and the angled recumbent stone along line N>H (photos exist to show this position)

Commentary: the notched stone beyond line N>J extended appeared to form an alignment through the termination of the three solar year length of P>R when brought down to the line P>Q, and Le Geant, and a theodolite station (2) was first set up behind this notch to both confirm this and measure the azimuth of this putative alignment.

View (a) to station 2 from Menhir (above) and (b) from station 2 to Menhir (below) showing alignment to Q_{dash} stone that ends the easytern end of the southern kerb.

Azimuth of le Geant (RH 'edge' = 166* 46'

Commentary: earlier in our survey we used the datum to the left – see inset photo of RDH kneeling. Later we moved to the same datum point as used by Howard Crowhurst during the previous ACEM survey. The two positions are shown above. The ACEM datum is higher and to the right of our initial datum.

Point J at north-east corner of Quadrilateral

Point N at south-west corner of Quadrilateral

GPS of station 2.

N47* 36’ 27”; W 3* 03’ 43” : Elevation 116 feet : accuracy 20’

SUNSHOOT 2 TIME 13:07:35 GMT

PABZ (zero degrees) set to lichen mark (HC survey) on Menhir M

	Horizontal	Vertical
Measured	37* 09’	41* 57′
Actual Sun Azimuth	196* 22’	+41* 56’
correction	159* 13’	

Azimuth of line station>notch>point on Q>Q’ > Menhir M

= 159* 13’

Commentary: this angle will be useful in defining the final plan of site.

Note that two earlier sunshoots were undertaken on this station, both under variable cloud and difficult conditions, but these are included below as additional data:

sunshoot(i)

Time 12:50:45 Hz 31* 30’ 35”; Vz 47* 21’ 50” (Corrected Left Limb)

Actual sun azimuth 190* 45’ ; elevation (47* 24’)

Azimuth of line station>notch>point Q-Q’>Menhir M = 159* 14’

sunshoot(ii)

Time 12:53:19 Hz 32* 24’ 40”; Vz 47* 27’ 6” (Corrected Left Limb)

Actual sun azimuth 191* 37’ ; elevation (47* 29’)

Azimuth of line station>notch>point Q-Q’>Menhir M = 159* 12’

Conclusion: these additional sunshoots support the more reliable (i.e. sunny) shoot, despite the larger variation in refractive effects.)

Third station at J (pin placed in corner)

Intent : to investigate the azimuth of J>N (the 4yr idealised hypotenuse of 121.7474 feet)

The theodolite is above and one inch to the south
of the pin at J

GPS of station 3.

N47* 36’ 27” ; W 3* 03’ 46” : Elevation 117 feet : accuracy 17’

PABZ to lichen mark on Menhir M (RO = 0*)

SUNSHOOT 3: TIME 14:21:56 GMT

Actual Sun Azimuth and Elevation: - 219* 10’ ; +36* 06’

	Horizontal	Vertical
Measured	61* 11’ 40”	+56* 04′
Actual Sun Azimuth	219* 10’	+36* 06’
Correction:	157* 58’	

Actual azimuth of RO (M) = 157* 58’

Intent: To determine theodolite bearing along J>N = 76 12′ 15″*

Azimuth of line J>N = Az of RO (M) + 76* 12’ 15” = 234* 10’

commentary: compare this azimuth with that of the 3yr hypotenuse,234* 38’

We then investigated where the major and minor moonset azimuths cut the quadrilateral. As the line J>N is a putative line to the midsummer sunset point, then the addition and then subtraction of 8* 8’ (5.145*/cos(Lat)) should provide two angles which can identify where the major and minor moon set.

1. Based on the azimuth of J>N, these azimuth angles are 226* 2’ 15’ for the major moonset and 242*18’ for the minor moonset.
2. In addition the ‘doorway gap’ in the southern side of the quadrilateral was determined as having an azimuth of 221* 30’ .
3. We determined where on the southern side of the quadrilateral the two 5-12-13 triangles cut. From Q the first hypotenuse cuts after 12’ 4.5”, and 18 feet to the second hypotenuse.
4. In an investigation of a prominent arc of small stones on the footpath, a measurement was taken to establish the radius of the arc. This was found to be 18’ 5” and centred on the large flat topped stone along Q>N. To the end of this arc from the southern end of stone Q, = 32 feet.

22/3/2010 THE NORTHERN LINE J>H

Fourth Station placed over Joint J (the abutment of the eastern with the northern side of the quadrilateral)

SUNSHOOT 4 14:00:44 GMT

PABZ (RO 0*) on penultimate stone in line J>H

	Horizontal	Vertical
Measured	329* 56’ 00”	38* 13′ 24″
Actual Sun Azimuth	213* 04’	+38* 12’
Correction:	360* - 329* 56’ = 30* 04’	
	Sun Az + correction = actual azimuth of RO (line J>N)	

Actual azimuth of RO (joint J>H) = Sun Az + correction = 243* 08’

A second sun shoot was then undertaken

SUNSHOOT 5 14:02:50 GMT

PABZ (RO 0*) on penultimate stone in line J>H

	Horizontal	Vertical
Measured	330* 33’ 45”	+38* 01″
Actual Sun Azimuth	213* 41’	+38* 00’
Correction:	360* - 330* 33’ 45” = 29* 26’ 15”’	
	Sun Az + correction = actual azimuth of RO (line J>N)	

Actual azimuth of RO (joint J>H) = 243* 07’ 15”

Conclusion: quad side J>H has azimuth 243” 7’ 37” (average value)

23/3/2010 Fourth Station, Survey along Southern Kerb

INTENT: To establish the azimuth of line Q>N using an average figure based on the tops of all the visible stones along the line viewed from theodolite at Q

Theodolite station over Q. Height of station 4’ 10”

GPS 47N 36.241’ ; 3W 03.376 (accuracy19’)

Reference object (RO) lichen mark (HC survey) on Menhir M (PBZ=0*).

Fourth Station looking west along Southern Kerb

SUNSHOOT 6-1 : 15:18:59 GMT

	Horizontal	Vertical
Measured	76* 37’ 00’	+29* 22′ 40″′
Actual Sun Azimuth	234* 18’	+29* 24’
Correction:	234* 18’ – 76* 37’ = 157* 41’	
	= actual azimuth of RO (line Q>M)	

Actual azimuth of RO (lichen M) = 157* 41’

Results along profile of visible stone in row Q>N

1. Actual Azimuth of easterly stone at P in line Q>N = 247* 55′
2. Actual Azimuth of top of next visible stone (7) in line Q>N = 247* 27′
3. Actual Azimuth of top of next visible stone (16) in line Q>N = 247* 31′
4. Actual Azimuth of top of next visible stone (17) in line Q>N = 247* 50′
5. Actual Azimuth of top of next visible stone (18) in line Q>N = 247* 31′ 07″
6. Actual Azimuth of top of next visible stone (19) in line Q>N = 247* 3′ 57″
7. Actual Azimuth of top of next visible stone (23) in line Q>N = 247* 57′
8. Actual Azimuth of top of next visible stone (24) in line Q>N = 249* 25′
9. Actual Azimuth of top of next visible stone (27) in line Q>NJ = 247* 22'

commentary: note the spread of azimuths along line Q>N whose average value is 247* 47′. Average excluding stone 24 = 247* 31′

Note: two later sun-shoots were taken, each giving actual azimuths for the RO (M) of 157* 40′, confirming the first sunshoot results.

Other useful azimuths for modelling the site.

Same Station(Q) onto pin at R (dressed stone defining end of '3year hypotenuse)

1. Actual Azimuth from Q to pin at R = 341* 59′
2. Q>J - Azimuth of point J = 338* 07′ 27″
3. Actual azimuth from Q to North Stone along line J>H = 264* 36′ 27″
4. Actual Azimuth from Q to extreme NW stone (H) = 258* 22′
5. Angle dip (V) to top of stone H : - 00* 59′ 20″
6. Actual Azimuth to limit of visibility of corner stone (flat and angled) near point N = 248* 37′
7. The centre of this flat stone near to N = 248* 56′
8. Elevation dip (V) to both above points - 2* 24′

24/3/2010 THIRD DAY OF SURVEYING

Some additional tape measurements taken from various places around the site.

1. Edge of Stone that defines H to edge of stone defining N = 20′ 8.5″

2. Distance from right angle of 5-12-13 triangle (now called point O) whose hypotenuse is line Q>N = 34' 6″
3. Distance from O to joint J (end of line H>J) = 64′ 00″
4. Distance from O to RH of furthest stone of eaxtension to line H>J = 68′ 11.5″
5. Distance from Q (HC survey point) to dressed stone R = 21′ 5″
6. Distance from right angle stone near Q to RH to R = 22′ 2.25″
7. Distance from pencil mark on next stone after Q = 22′ 7″
8. Distance from right angle stone near Q to Q′ (end of ext. N>Q) = 22′ 8″
9. Distance from Q t(HC survey point) to J = 30′ 8″
10. Distance from Joint J to end of H>J extension = 13′ 1.5″
11. Distance from pin J to end of H>J extension = 13′ 6″
12. Distance from pin J to end of notch on H>J extension = 4′ 5″
13. Distance from pin J to RH end of next stone along H>J extension = 10′ 0.5″
14. Distance from pin J to H (northern line of quad.) = 119′ 1″
15. Distance from Q (HC survey point) J to N (southern line of quad) = 118′ 2″
16. Distance from Q (HC survey point) to P = 87′ 6″

****[provide equivalent lengths in metres?? RDH to decide]

Possible Stone Circle (SOUTH OF Q)

Jutting up out of the footpath near Q are several similar sized and shaped stones arranged in an arc of 18' 5" centred on stone 27 (see above). These are seen as evenly spaced, lying right across the present footpath, and the spacings of these stones was therefore measured and distances apart are listed below.

Stone nearest Q (platform stone 1 or PS1) to next stone (PS2) = 17"

1. PS2 to PS3 = 17″
2. PS3 to PS4 = 17″
3. PS4 to PS5 = 17″
4. PS5 to PS6 (part stone) = 17″
5. Ps6 to PS7 (to base of disturbed stone 7) = 17.5″

Commentary: If the radius is taken as 18′ 5″ then perimeter of circle would be 115.71532 feet or 1388.5839 inches. At a spacing of 17″ per stone, this would place 82 stones (81.68 calculated) to complete the circle.

Note: This number of markers around a circle would provide an effective soli-lunar calendar, by moving a moon marker 3 positions anticlockwise per day, and a solar marker 3 positions per 13 days.

25/3/2010 FOURTH DAY OF SURVEYING

1. A 9m length of steel tape runs from joint J to the (sharp) edge of adjacent stone north of Q (HC survey point)
2. The steel tape run from Joint J to the nominal N of the idealised hypotenuse has length 118’ 1.44” and ends at flat edge of penultimate stone on line Q>N.
3. From pin J the same tape run of 118′ 1.44″ ends within a small alcove between the penultimate and ultimate stone along line Q>N
4. An arc of 118′ 1.44″ cuts J>H at the end of the the top of the stone which defines the end of line J>H
5. 36 m from N along line N>Q at point Q (HC survey point) and the 4 SY length (121′ 9″ terminates at the end of the top of the final stone on the extension from N>Q at Q′. In metres the distance is 37.1m. In effect this is the proposed four year count brought down to Q′
6. From point H to end point of H>J this same length is marked along line q>q′ by pencil mark. Swung round from H to the line H>J, this same length terminates at the W end of the notch stone, and 118′ 1.5″ is directly over pin J.
7. A 27 metre tape from pencil mark along Q>Q′ terminates on the survey pin at P
8. The 9m distance from J (see 1. above) rotated eastwards (arc almost parallel to Q - Q′)but 1′ 8″ from it makes Q>N steeper. From HC’s survey point Q to the 9 m point is 12″, which increases the steepness of angle N>Q by 0.485* (29′ 06″). The calculation is arctan (one foot/118.14 feet).

26/3/2010 VISIT TO STONE L on THOM PLAN

Intent: This stone was identified by Thom as providing a lunar backsight with *the northern kerb of Le Manio’s quadrilateral as a foresight for the Minor* Standstill moonrise in the north..

GPS COORDINATES 47*N 35’ 34”; 3*W 05’ 15.72”

(38’ AMSL? Accuracy 20′)

Calculate bearing from L to Quadrilateral northern kerb

Azimuth bearing along line L>M is 62* 16’ 35”

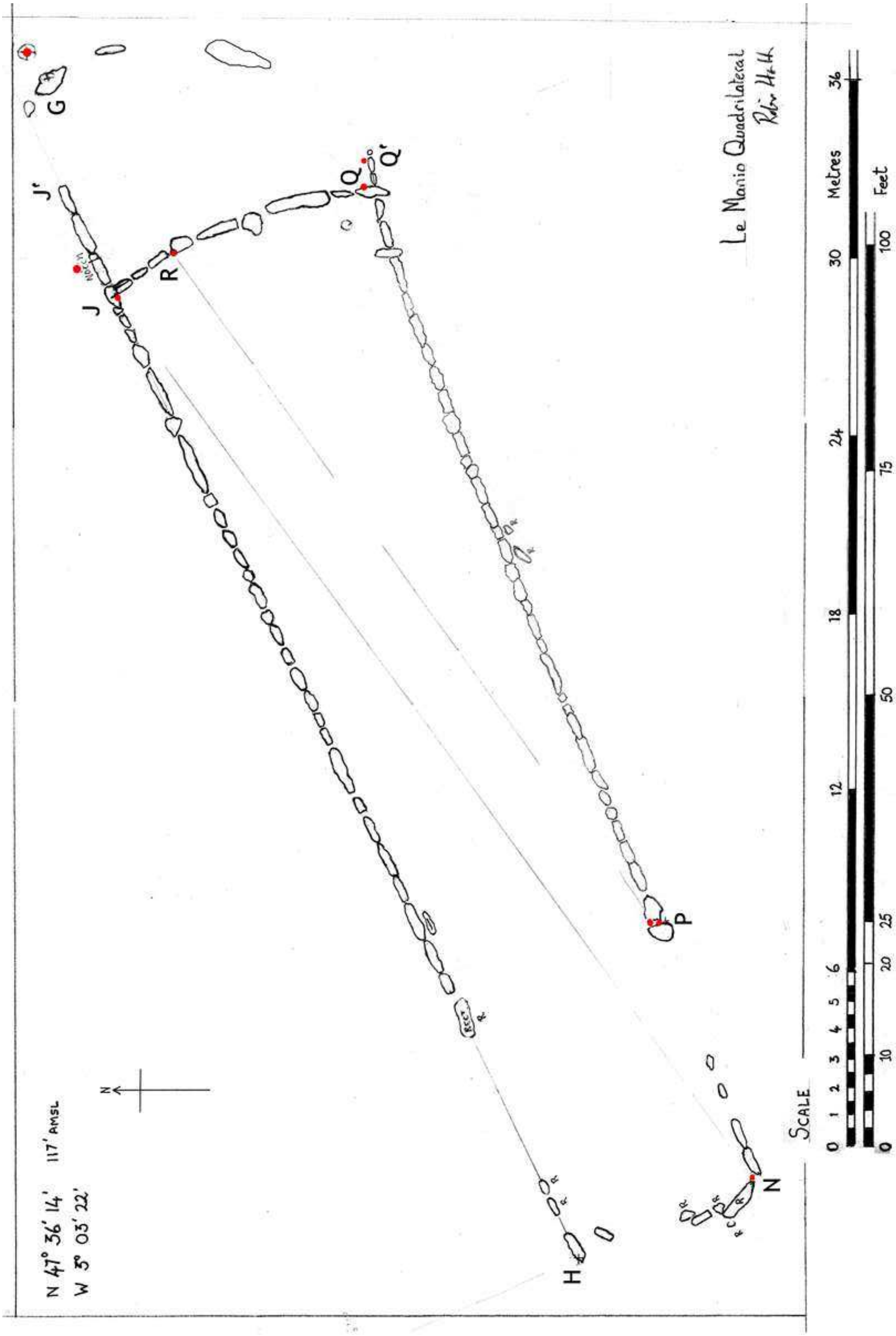
(reverse Az = 242* 16’ 35”)

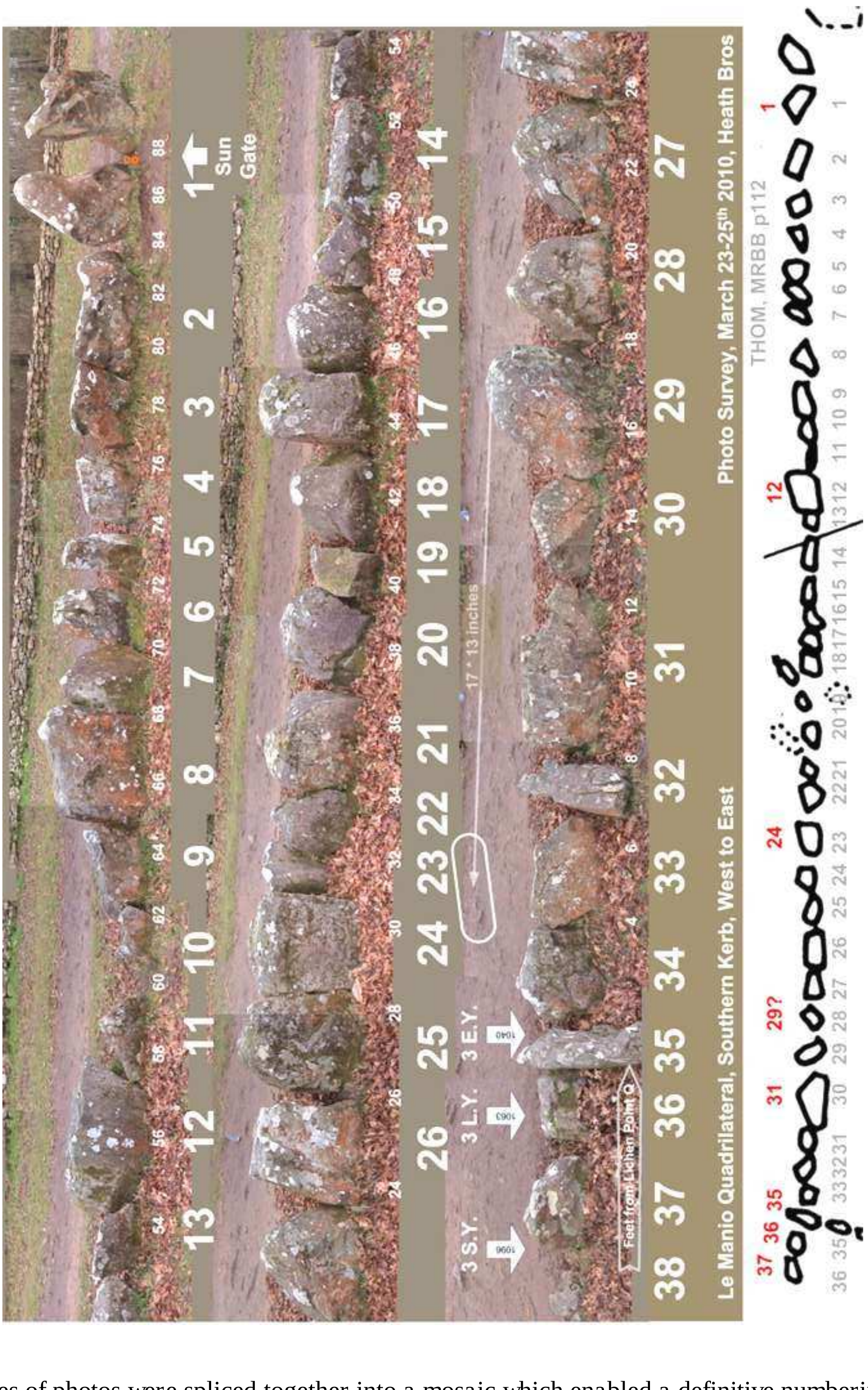
Commentary on the plan of the quadrilateral site.

Within the time restrictions of our visit, the survey plan represents a structurally accurate ‘map’ of the overall quadrilateral and outliers. Each individual stone is placed with longitudinal accuracy along the rows, and the photo-montage assists in establishing their individual shapes. However, further work would be required to more accurately define their individual widths.

APPENDIX 3:
PLAN & PHOTO MONTAGES OF LE MANIO QUADRILATERAL

The Plan (next page) is based upon survey data. It aims to harmonise the angular readings and major dimensions whilst also accounting for the definite number of stones involved. The number and locations of stones found completely revises the number and location of many of the stones found in Tho*m’s survey, though the two plans compare well for the purposes of* day-inch counting. A more detailed analysis is underway but what follows is an improvement on the Thom plan, which he had possibly inherited from others.


Le Manio Quadrilateral
N 47° 36' 14'
W 3° 03' 22'
117' AMSL
SCALE
Metres
Feet
G
J'
J
R
Q
Q'
P
H
N



A series of photos were spliced together into a mosaic which enabled a definitive numbering *of the southern kerb stones. A video survey using a tape from the "lichen point" Q was* transcribed to locate where the feet from Q were located. This gives a useful picture of where stones are located, their shape and size, with regard to further work.

A photo montage and video survey with a tape, from a datum at the southern end,
enables the locations, sizes and shapes to be defined within a definite numbering for the stones.

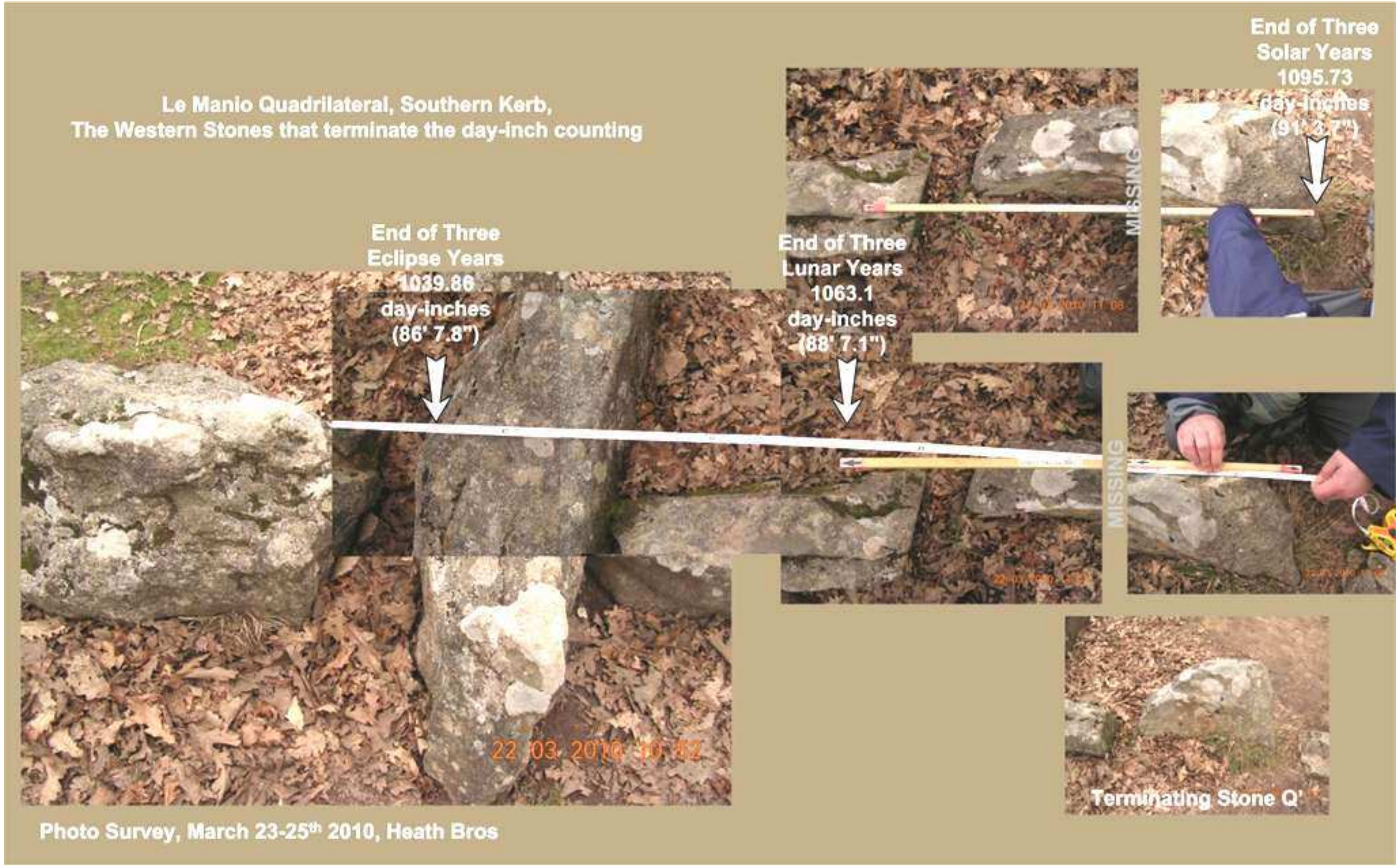


Photo montage scavenged from the existing photos of the eastern end of southern kerb,
with tapes and rods indicating the key termination lengths within the stonework.

APPENDIX 4: *QUICKAZ* CALCULATIONS FOR SUNRISE, 2000-4500 BCE

Latitude 47.6041 Parallax 0.002 (sun)

Table 1

Horizon altitude 1.5* Refraction 0.32*

Epoch	Declination	firstflash	half risen	Full disc
(BC)	(degrees)	(degrees)	(degrees)	(degrees)
2000	23.93*	54.23817	54.57171	55.23247
2500	23.98*	54.1546	54.48848	55.1499
3000	24.03*	54.07098	54.40519	55.06728
3500	24.07*	54.00404	54.33853	55.00114
4000	24.11*	53.93706	54.27183	54.93497
4500	24.16*	53.85329	54.18841	54.85222

Table 2

Horizon altitude 1* Refraction 0.45*

Epoch	Declination	firstflash	half risen	Full disc
(BC)	(degrees)	(degrees)	(degrees)	(degrees)
2000	23.93*	53.42872	53.76756	54.43855
2500	23.98*	53.3443	53.68349	54.35519
3000	24.03*	53.2598	53.59937	54.27177
3500	24.07*	53.19217	53.53203	54.20499
4000	24.11*	53.1245	53.46465	54.13818
4500	24.16*	53.03985	53.38038	54.05463

Table 3

Horizon altitude 0.5* Refraction 0.5*

Epoch	Declination	firstflash	half risen	Full disc
(BC)	(degrees)	(degrees)	(degrees)	(degrees)
2000	23.93*	53.36068	53.69997	54.37184
2500	23.98*	53.27618	53.61584	54.28841
3000	24.03*	53.19162	53.53164	54.20492
3500	24.07*	53.12392	53.46424	54.1381
4000	24.11*	53.05619	53.39681	54.07123
4500	24.16*	52.97147	53.31246	53.9876

APPENDIX 5: *QUICKAZ* - MINOR MOONRISE AZIMUTHS FROM STONE L

Latitude 47.6041 Parallax 0.95* (moon)

Table 3

Horizon altitude + 0.216* (*after Thom 1978, MSBB, table 9.2, p 113*)

Refraction 0.5*

Epoch	Declination	First flash	Half risen	Full disc
(BC)	(degrees)	(degrees)	(degrees)	(degrees)
2000	23.93*	61.98852	62.29699	62.90968
2500	23.98*	61.90898	62.21767	62.83079
3000	24.03*	61.8294	62.13832	62.75187
3500	24.07*	61.76572	62.07481	62.68871
4000	24.11*	61.702	62.01128	62.62553
4500	24.16*	61.62233	61.93184	62.54652
5000	24.21*	61.54263	61.85236	62.47748