The Standing Stones in Argyllshire

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The illustrations with this paper are published with the aid of a grant from the Carnegie Trust for the Universities of Scotland.

Background

The standing stones on the two sides of Scotland differ in character. Aberdeenshire has many circles, most of which are of the Recumbent stone variety. Argyllshire has few circles but many single or multiple standing stones, some of which are arranged to mark the setting or rising points of the Sun or Moon on the horizon, at the turning points of their yearly or monthly cycles respectively.

It has been shown in detail that early in the 2nd millennium BC megalithic man was making highly accurate astronomical observations. (Thom, 1967, 1971: Thom & Thom 1978). Instead of merely showing that the rising or setting points of the Sun or Moon at the solstices, or turning points, lay in the general direction indicated, as he had previously done, he was using a backsight and a foresight to mark exactly, for example, where the limb of the celestial body would graze the horizon at rising or setting. The accuracy he obtained was remarkable, being of the order of less than 1 minute of arc. We have recently shown that the probability level at which we can accept that some existing stones were erected as backsights for this purpose is about 1 in 1000—that is that there is only 1 chance in 1000 that these arrangements of stones in relation to the horizon were due to chance (Thom & Thom 1978a).

It is necessary to be familiar with some of the technical terms used to describe astronomical alignments among standing stones. The Sun at the solstices has a declination δ (delta) corresponding to the obliquity of the ecliptic, which can be defined as the angle between the Earth's axis and a line perpendicular to the plane of its orbit; this angle, known as ε (epsilon) is now about 23°27′ though it has been calculated that about 4,000 years ago it was greater in value, about 23°54′. It is to this early solstitial position, not the modern one, that the alignments at sites claimed as solar observatories point. At midwinter, the Sun has a δ of $-\varepsilon$ and at midsummer, one of $+\varepsilon$.

For the moon conditions are much more complicated. The plane of the lunar orbit is inclined to the plane of the ecliptic (that is, of the Earth's orbit) at a mean angle, known as i (iota), of 5°8.7′. Moreover the line of nodes, the line of intersection of these two planes, rotates round the ecliptic once in every 18.61 years so that the maximum and minimum monthly lunar declinations themselves vary over that period of time. At one point, known as the 'major standstill', the Moon reaches its maximum monthly declination of $(\varepsilon + i)$; in other words the Moon's orbit reaches its greatest tilt with respect to the earth's equator. After 9.3 years the lunar orbit reaches its smallest tilt with respect to the earth's equator so that its maximum monthly declination can attain a value of only $(\varepsilon - i)$; this is the time of the 'minor standstill'. Taking into account the rising and setting points, and these two maxima of north and south declination, it can be seen that there are 8 main points on the horizon to be marked if the motions of the Moon are being recorded.

However there is another factor to be considered, namely that the Sun has a perturbing effect on the Moon's orbit so that the latter has a wobble with an amplitude of about ± 9 arc minutes. Since the period of this wobble is 173 days what happens is that at the standstill the lunar declination may be greater than the values mentioned by 9 minutes and then, 86 days (half the perturbation period) later, smaller by the same amount. The result is that at every one of the 8 possible horizon points for marking an extreme declination of the Moon we may find that megalithic man in fact marked one of the two positions corresponding to either the upper or lower declination caused by the wobble. If this is found, it shows that the knowledge of the lunar observers in the Late Neolithic period and the Early Bronze Age had advanced to a level not again reached until the work of Tycho Brahe in the 16th century AD.

Moreover, since the Moon is not dazzlingly bright like the Sun, our hypothetical prehistoric observers could have used either its upper or lower limb for observation against some horizon mark. Thus when the declination of an horizon foresight as seen from the backsight stone is measured we expect it to have one of the values

$$\delta = \pm(\varepsilon \pm i \pm \Delta \pm s)$$

where s is the semidiameter and Δ the perturbation or 'wobble' (the declination of the Sun and Moon is measured to the centre of the disc). By way of contrast we may note that the alternative values for the foresight for the Sun at the solstices are only four, namely $+(\varepsilon \pm s)$ and $-(\varepsilon \pm s)$ at midsummer and midwinter respectively.

Lunar sites in Scotland

In Scotland we have found altogether over 40 lunar lines which we might use but, in listing these, we were struck by the large proportion of them found in Argyllshire. It seemed worthwhile to re-examine these closely and accordingly they were all recalculated from the measured azimuths (bearings) and altitudes of the horizon. The calculation has been described (Thom & Thom 1978a, 176) but we have made some alteration here; we have for each line used only the case when the Moon was on the horizon in darkness (ignoring all new Moon cases) when calculating geocentric altitude (the altitude of a celestial body above or below the plane of the horizon as measured from the centre of the Earth, instead of from the surface).

The final results are given in Table 1. Correction for the effect of graze was made where deemed necessary and the Moon's parallax was carefully applied. Looking at equation (1) for the positive cases we see that if we deduct i, Δ and s from δ- the observed declination we are left with the observed obliquity of the ecliptic, namely ε_0. In the 7th column we give the date at which according to retrospective calculations the Earth's axis was at this inclination, and we give the mean date, 1657 ±54 BC, which compares very well with that for the latter part of the period of the standing stone sites as deduced from archaeological evidence. The ±54 years is simply the standard deviation of the mean, but the peculiar manner in which parallax affects the result produces much more uncertainty (Thom 1971, 81; Thom & Thom 1978, 14).

We did however use $\varepsilon = 23°53'.0$ for the mean ε_0 and so calculated β by deducting $\pm(\varepsilon \pm i)$ from δ_0.

In fig. 1 we show a histogram of the values of β which should thus be showing us in effect the apparent size of the Moon's disc (since there are foresights indicating both the upper and lower limbs) and the effect on the position of the disc of the 9′ 'wobble' (since there are other foresights which also show both extremes of the wobble). It will be seen that the values of β do indeed pile into heaps near the appropriate points and this strongly indicates that we are on the right track. However it is useless to calculate the probability level for such a solution because criticism will be aimed at the result, and perhaps with some slight justification because we have in fact included *all* the Argyllshire values where we had reliable measurements of azimuth and altitude indicating lunar declinations.

TABLE 1—Lunar Sites in Argyllshire.

Site	Stone Height (ft.)	Nominal Decl.	Decl.	β	ε_o	Date B.C.	Ref. Thom 1971, page
Ballinaby, Islay	18	$+(\varepsilon+i+s)$	$+29°16'.2$	$14'.5$	$23°52'.6$	1520	78, 170
Balemartin, Tiree	12	$-(\varepsilon+i+\Delta+s)$					71, 67
Ballymeanach, Argyll	13	$+(\varepsilon+i+\Delta)$	$+29°12'.8$	$11'.1$	$23°55'.5$	1960	71, 52
Beacharr, Kintyre	15	$+(\varepsilon+i-\Delta+s)$	$+29°10'.6$	$8'.9$	$23°53'.3$	1620	71, 60
Campbeltown	11	$-(\varepsilon+i+\Delta-s)$	$-28°54'.3$	$7'.4$	$23°52'.6$	1520	71, 61
Camus an Stacc, Jura	12	$-(\varepsilon+i-\Delta-s)$					71, 65
Crois Mhic Aoida, Kintyre	5	$-(\varepsilon+i-\Delta-s)$					71, 56
Dunadd, Argyll	13F	$+(\varepsilon+i+s)$	$+29°15'.9$	$14'.2$	$23°52'.3$	1470	71, 63
Dunskeig ,Kintyre	4	$-(\varepsilon-i+s)$	$-19°00'.6$	$16'.3$	$23°53'.0$	1575	78a, 172
Escart, Kintyre	10	$-(\varepsilon+i-\Delta-s)$	$-28°40'.5$	About $21'.2$	$23°56'.0$	2040	71, 60
Gigha	8	$+(\varepsilon+i+\Delta+s)$	$+29°26'.0$	$24'.3$	$23°53'.1$	1590	71, 62
High Park, Kintyre	5	$-(\varepsilon+i+\Delta+s)$	$-29°28'.0$	$26'.3$	$23°55'.1$	1900	71, 60
Kintraw, Argyll	F	$-(\varepsilon-i-\Delta-s)$	$-18°20'.4$	$23'.9$	$23°53'.3$	1620	71, 39
Knockrome, Jura	4	$-(\varepsilon+i+\Delta+s)$	$-29°26'.4$	$24'.7$	$23°53'.5$	1650	71, 65
Knockstaple, Kintyre	11	$+(\varepsilon+i+\Delta-s)$	$+28°52'.0$	$9'.7$	$23°50'.3$	1180	71, 63
Quinish, Mull	10	$-(\varepsilon+i+\Delta+s)$	$-29°29'.8$	About $28'.1$	$23°55'.5$	1960	71, 67
Skipness, Kintyre	F	$-(\varepsilon+i+s+s)$	$-29°24'.5$	$22'.8$	$23°51'.6$	1370	Here
Stillaig	5	$+(\varepsilon+i+\Delta-s)$	$+28°53'.4$	$8'.3$	$23°51'.7$	1390	71, 66
Temple Wood, Argyll							
to A_2	$9\frac{1}{2}$	$-(\varepsilon+i-s)$	$-28°48'.1$	$13'.6$	$23°55'.7$	1990	71, 45
Q to A_1	$9\frac{1}{2}$	$+(\varepsilon+i)$	$+29°01'.5$	$0'.2$	$23°53'.5$	1650	71, 45
S_1 to A_1	$9\frac{1}{2}$	$+(\varepsilon+i+\Delta-s)$	$+28°55'.4$	$6'3$	$23°53'7$	1680	71, 45
S_5, S_4 to A_1	9	$+(\varepsilon+i+s)$	$+29°18'.0$	$14'.9$	$23°54'.4$	1800	

i is the inclination of the lunar orbit
δ_o is the declination deduced from the observed Altitude and Azimuth
β (see Fig. 1) = $\partial_o \pm (\varepsilon \pm i)$ When $\varepsilon = 23°53'.0$
ε_o is the obliquity of the ecliptic deduced from δ_o and the date is the time when the ecliptic had this inclination BC.
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Mean date is 1657 BC$\pm$54.

The slight differences in declination shown in the above Table and those in the *Journal for the History of Astronomy 1978* are chiefly due to graze and the differences in weighting.

However we recently used for Scotland as a whole a much more severe test in which we excluded all lines which did not satisfy the following two conditions (Thom & Thom 1978, 1978a).

(1) There must be an indication at the backsight of the direction to the foresight; this might be two stones lined up on the foresight, or two mounds as at the Ring of Brogar in Orkney, or the flat face of a wide slab.

(2) At the horizon foresight there must be only one possible notch between limits such as $\varepsilon+i+\Delta+s$ and $\varepsilon+i-\Delta-s$. This is a particularly important criterion because of the many criticisms which have been levelled at the quality of the claimed lunar alignments.

The above procedure cuts out many important and accurate sites, but even with the smaller number of samples resulting it still shows a very low probability level (that the results are due to chance) and establishes beyond doubt that these stones really marked the sites of lunar observatories. There seems therefore to be no need to be so strict over criteria when examining what we find in a more limited district like Argyllshire.

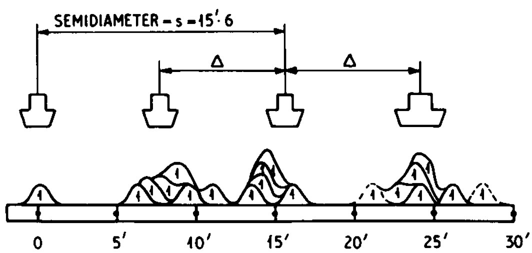

FIG. 1. Histogram of the difference(β) between the Moon's observed declination (δ_o) and $\pm(\varepsilon \pm i)$. Δ can be 7'.0 or 8'.6 or 10'.0 (near solstices).

There is a further complication in the case of lines which yield $(\varepsilon \pm i)$ without any Δ because, with these, the Moon is not at an extreme position or turning point, where it can be directly measured at an horizon mark, but midway between two points. Thus Megalithic man could not observe these cases directly and it seems that what he did was to establish the proper observing position on the ground by taking the mean of the positions, for example, of $\varepsilon + i + \Delta$ in March or September and $\varepsilon + i - \Delta$ in June or December.

Three moon observatories in Kintyre

The details of the stone at Skipness are given in pl. 1 and fig. 2. The photograph shows the theodolite standing over the fallen stone and, looking across to Arran, we can see above Lochranza the Bowman's Pass. Fig. 2 shows a careful survey of these hilltops and we see how the Moon at the major standstill rose out of the notch at the Bowman's Pass with the lower limb just in the corner. Here there are other possible notches within the range so this alignment cannot be used for *statistical* analysis. The Ordnance Survey shows the stone standing but it is now fallen. It is not a large stone but we can see alongside it the hole from which it came and this socket indicates that it may have been lined up on Bowman's Pass. It is many years since either of us came down from the A'chir Ridge to the Pass and up Ben Tarsuinn, but our memory indicates that a grazing ray of moonlight will not pass close to the ground for a particularly long distance so here as elsewhere we have used a graze of only 1′; (graze has to be added to the calculable effect of refraction: Thom & Thom 1978, 172).

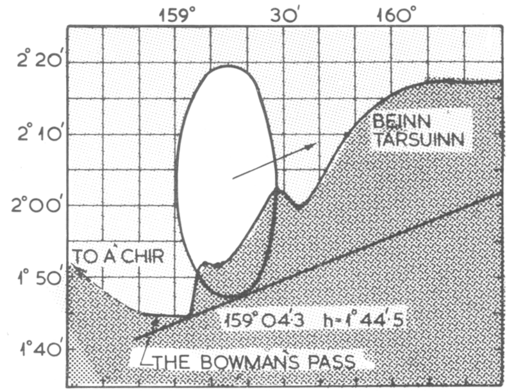

FIG. 2. Skipness, Kintyre; horizon profile seen from stone at NR 905588, the Moon rising behind Beinn Tarsuinn with declination —$(\varepsilon + i + \Delta)$.

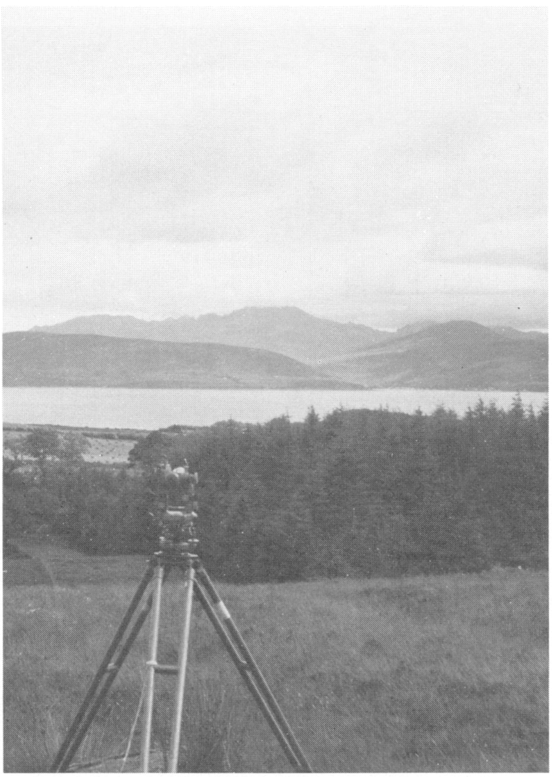

PLATE 1. View of the Arran Hills from the stone above Skipness, Kintyre.

These same hills on Arran form the foresight for the two stones forming the backsight at Dunskeig near Clachan (pl. 2). This site consists of two stones which are lined up on the foresight unequivocally, thus providing one of the most convincing sites in our lists.

Another convincing site is that at Escart. Here a row of massive stones points at the hilltop but unfortunately today trees intervene so that this site cannot be considered to be accurately surveyed. We had to run a traverse to clear the trees.

The site at Quinish consists of a single tall stone and some fallen stones to the N indicate

PLATE 2. The two stones at Dunskeig, West Loch Tarbert, Argyll, pointing towards the hills of Arran. Photograph by Chris Jennings.

that there has been a line here pointing to the foresight. Unfortunately the survey here had to be made somewhat hurriedly as bad weather was making the yacht's anchorage in Loch Cuan unsafe. There is another long lunar alignment near but we have not yet checked that the foresight for this is a point on the end of Canna. Further details will be found in the references given in Table 1.

It is interesting to compare the date of 1657 BC given there with that found for the solstitial sites.

SOLSTITIAL SITES IN ARGYLL

Argyllshire contains three of the best solstitial sites known to the authors, namely Ballochroy, Kintraw and East Loch Tarbert on Jura. The fact that these belong to different cases (rising, setting, summer and winter) enables us partly to eliminate the effects of temperature on refraction. The details have already been published (Thom 1971, 44) and the final value for the obliquity of the ecliptic obtained then was 23° 54′.2±0.7′, corresponding to a date of 1750 BC ± 100 years.

The solstitial method of obtaining the date of standing stone sites is perhaps more accurate than the lunar method, but unfortunately there are very few accurate solstitial lines known. Here we speak of potentially accurate observing instruments, with backsights and foresights; there are numbers of sites which merely give an indication of where the Sun will rise by using perhaps two circles or two stones with no clear distant horizon marker. These are completely useless for dating. In 1954 we gave the date of 1750 BC for the solstitial sites in a paper to the British Astronomical Association (Thom 1954) but no-one paid any attention. It is noteworthy that, in the twenty-five years that have passed since then, no great change has taken place in our estimate of date by the use of either Solar or Lunar lines. Recent work has indicated a date rather later.

It seems that, while megalithic man had been observing the Sun and Moon for hundreds of years during the Neolithic period, it was not until early in the 2nd millenium BC that he began to make precise recordings of these observations in standing stone sites.

Cup and ring markings

The question of whether these prehistoric rock carvings relate to the astronomical function of nearby sites is an interesting one.

Some yards from the stone at Skipness the living rock shows through the ground and inscribed on it are some cup marks. If we could read the code these might tell us what conditions the stone is intended for; major or minor standstills, time of year and so on. The large central menhir near Temple Wood has two rings and a number of cups. This stone takes part in two alignments indicating two foresights and this may explain why the marking is more complicated than that at Skipness. The large flat stone at Monzie has a great many cups and rings and an outlying stone seen from the marks is just below the setting point of the solstitial Sun and Morris (1977) reports that there are cup and ring markings on the solar/lunar alignment at Ballymeanach.

If cup and ring marks are a method of writing or recording it does not follow that the messages they contain always refer to something astronomical. We have shown elsewhere (Thom and Thom 1978) that sometimes the information carried is of a geometrical nature. It is a policy of despair to say that we shall never be able to read the messages contained in cup marks. The complexity of some of the designs made by the cups is a challenge. It also shows that they probably mean something. What is it? Are there any more examples near backsights?

GLOSSARY

azimuth (or bearing)—horizontal direction measured clockwise from True North at 0°/360°.

declination—angular position of an object in the sky measured north (+) or south (−) of the plane of the Earth's equator.

geocentric altitude—the altitude of a celestial body as viewed from the Earth's centre; obtained by adding the requisite parallax to the altitude observed at the site.

graze—the extra bend experienced by a ray as it grazes the ground at the foresight.

parallax—the correction added to the measured altitude to make it geocentric.

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