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OBSERVATION OF THE MOON IN MEGALITHIC TIMES

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1. FURTHER REFINEMENTS IN THE EVALUATION OF OBSERVED DECLINATIONS

Introduction

To reduce any lunar observation at standstills we require the data given in Table 1. Then, with the declination previously calculated for the site, enter Table 2 and determine the nominal declination and the time of year. From the azimuth and altitude of the foresight calculate the hour angle and the hour of day, and from Figure 1 determine the temperature *T*, and so obtain the correction to the mean refraction to find the geocentric altitude for each line. Thus obtain the observed declination δ_0 and so $\beta = \delta_0-(\epsilon \pm i)$. The tables and the figure are for general use with any lunar observation at the major or minor standstills.

Lunar Lines

We took from our previous lists of sites all lunar lines for the major and minor standstills, positive and negative declinations. Discarding those for which we had reason to believe that either the altitude or the azimuth was uncertain, we finally ended with the forty lines listed in Table 3. These we divided into two classes: Class I comprises the twenty-six lines where there was a backsight with

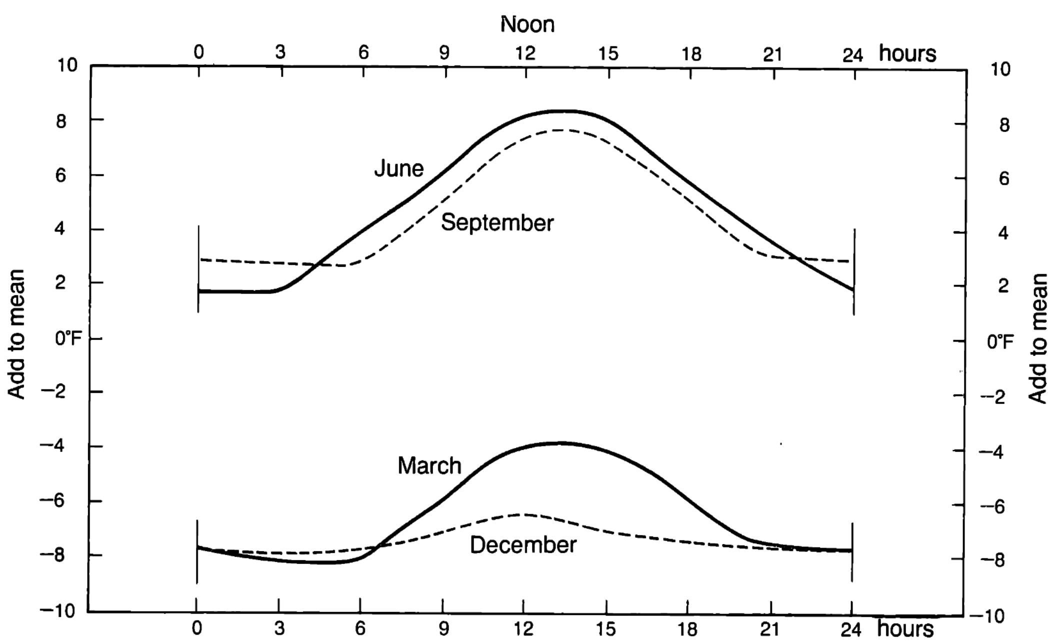

FIG. 1. Temperature differences to be applied to mean annual site temperature at equinoxes and solstices. (Based on a diagram of Kirkwall temperatures prepared by the late Alexander Strang Thom in 1976.)

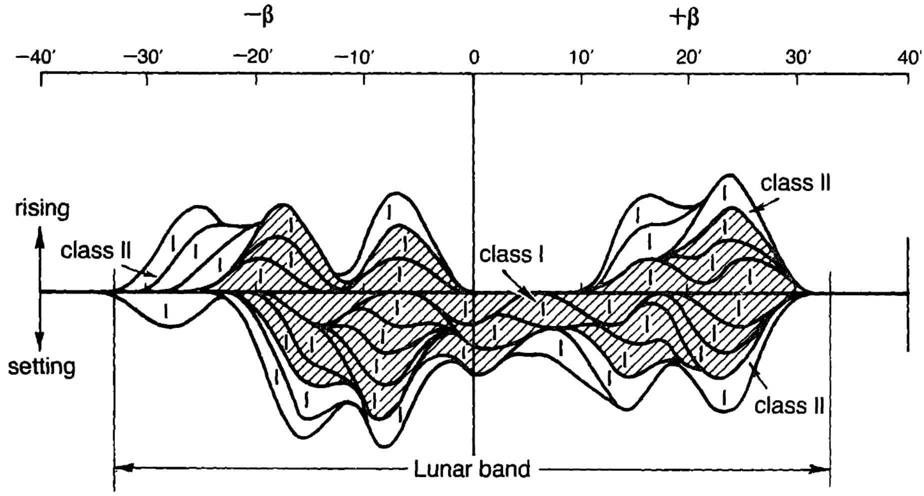

FIG. 2. Histogram of β values for rising and setting Moon shown above and below axis β is the amount by which δ_0 is greater than $\pm(\epsilon \pm i)$.

some indication of the direction to the foresight, and Class II the fourteen lines where there was no indication of the foresight. The basic data are listed in Table 4.

Declinations

For each line we recalculated the declination using every refinement known to us. Unfortunately we had not measured the temperature at the time we made the measurements in the field, and so we have assumed this in every case to be 50°F. Fortunately this simplifies matters as the *mean* refraction is tabulated in the *Nautical almanac* for 50°F. The correction for barometric pressure and temperature is given on a partly graphical page in the *Nautical almanac.* To obtain the temperature T that existed at the time of day and time of year, use Figure 1. For graze we used $-1'$ and for the parallax we used Table 1. We thus obtained the geocentric altitude from the measured altitude and so we calculated by the spherical triangle the final declination δ_0. We then deducted $\epsilon \pm i$ from δ_0 to obtain the quantity which we call β. Sample calculations for two sites may be found in Table 5.

Histograms

β should not differ greatly from the quantity we call Q, the theoretical value. Q is one of the values of $\pm \Delta \pm s$ (see Table 1 for the relevant values). We show

TABLE 1.

Nominal declination $\delta = \pm \epsilon \pm i \pm \Delta \pm s$
Inclination of lunar orbit $= 5°08'{\cdot}7$
Δ is the perturbation of the Moon's orbit by the Sun
s is the lunar semi-diameter
At equinoxes, $\Delta = 8'{\cdot}6$; parallax $= 56'{\cdot}4$; $s = 15'{\cdot}4$
At solstices, $\Delta = 10'{\cdot}0$; parallax $= 57'{\cdot}4$; $s = 15'{\cdot}6$
By definition, $\beta = \delta_0 - (\epsilon \pm i)$
By definition, Q is one of the values of $\pm \Delta \pm s$
δ_0 is the observed declination of the line
T is the present-day site temperature for the time of year and the time of day

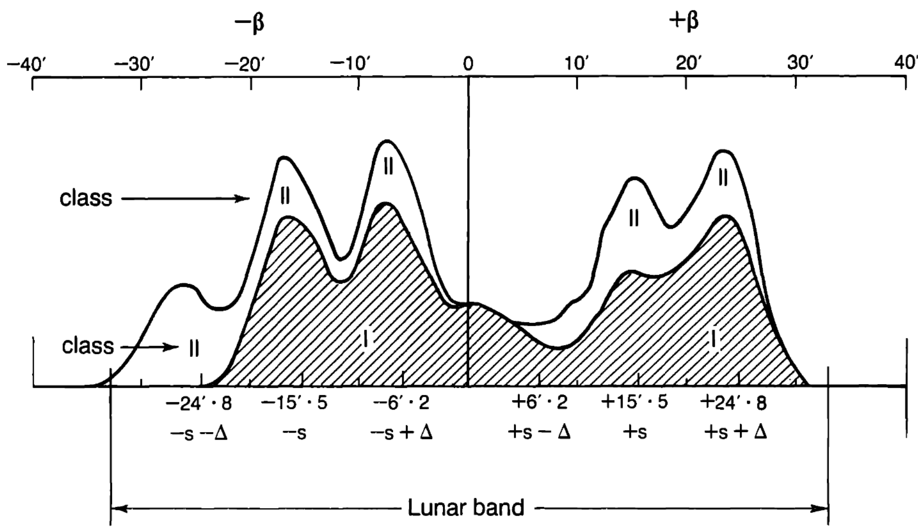

FIG. 3. The sum of the histogram ordinates in Figure 2.

the values of β in the histograms in Figures 2, 3, 4 and 5. Here we plot for the Moon the rising values above the axis and the setting values below the axis. We plotted first the Class I lines shown hatched, and added the Class II lines above and below. We then added the histograms together as shown in Figure 3 and the lower part of Figure 5.

Lunar Band

The histograms drawn in Figure 3 for both Class I and Class II consist of four main heaps. It is seen that these peaks are near the values $(+s+\Delta)$, $+s$, $(-s+\Delta)$, and $-s$. The values we have marked below the histogram are plotted

TABLE 2. Time of year *versus* declinations.

Declination Nominal	Numerical	Time of year
$\epsilon+i-s-\Delta$	$= 28°36'{\cdot}2$	June and December
$\epsilon+i-s$	$= 28°46'{\cdot}3$	Mean of solstitial and equinoctial values
$\epsilon+i-\Delta$	$= 28°51'{\cdot}8$	June and December
$\epsilon+i-s+\Delta$	$= 28°55'{\cdot}0$	March and September
$\epsilon+i$	$= 29°01'{\cdot}8$	Mean of solstitial and equinoctial values
$\epsilon+i+s-\Delta$	$= 29°07'{\cdot}4$	June and December
$\epsilon+i+\Delta$	$= 29°10'{\cdot}4$	March and September
$\epsilon+i+s$	$= 29°17'{\cdot}3$	Mean of solstitial and equinoctial values
$\epsilon+i+s+\Delta$	$= 29°25'{\cdot}8$	March and September
$\epsilon-i-s-\Delta$	$= 18°20'{\cdot}4$	March and September
$\epsilon-i-s$	$= 18°28'{\cdot}9$	Mean of solstitial and equinoctial values
$\epsilon-i-\Delta$	$= 18°35'{\cdot}8$	March and September
$\epsilon-i-s+\Delta$	$= 18°38'{\cdot}8$	June and December
$\epsilon-i$	$= 18°44'{\cdot}4$	Mean of solstitial and equinoctial values
$\epsilon-i+s-\Delta$	$= 18°51'{\cdot}2$	March and September
$\epsilon-i+\Delta$	$= 18°54'{\cdot}4$	June and December
$\epsilon-i+s$	$= 18°59'{\cdot}9$	Mean of solstitial and equinoctial values
$\epsilon-i+s+\Delta$	$= 19°10'{\cdot}0$	June and December

$\epsilon = 23°53'{\cdot}1$ (see *Archaeoastronomy*, no. 2, S86, Table 2)
$i = 5°08'{\cdot}7$

TABLE 3. List of the forty lunar lines used.

Number	Name	δ_0	β	Q	$(\beta-Q)$	Class
A2/8	Temple Wood from S_5	29°17′·9	+16′·1	+14′·8	+1′·3	I
A2/8	Temple Wood from Q	29°01′·3	− 0′·5	− 0′·7	+0′·2	I
A2/8	Temple Wood from S_1	28°54′·9	− 6′·9	− 6′·8	−0′·1	I
A4/5	Beacharr	29°10′·0	+ 8′·2	+ 8′·6	−0′·4	II
A4/19	Knockstaple	28°53′·7	− 8′·1	− 6′·8	−1′·3	I
A4/17	Gigha to A_2	29°25′·0	+23′·2	+24′·0	−0′·8	II
A10/5	Stillaig	28°53′·2	− 8′·6	− 6′·8	−1′·8	I
L1/16	Blakeley Moss	28°44′·7	−15′·0	−16′·2	+1′·2	I
O1/1	Ravie Hill from Comet Stone	28°47′·2	−14′·6	−16′·2	+1′·6	I
O1/1	Ravie Hill from *HT*	28°52′·8	− 9′·0	− 6′·8	−2′·2	I
O1/1	Brogar to Kame Lower	29°27′·5	+25′·7	+24′·0	+1′·7	I
O1/1	Brogar to Kame Upper	29°24′·2	+22′·4	+24′·0	−1′·6	I
P1/10	Fowlis Wester	29°17′·2	+15′·4	+14′·8	+0′·6	I
P1/10	Fowlis Wester notch	18°46′·4	+ 2′·0	+ 0′·7	+1′·3	I
O1/2	Stenness	19°07′·7	+23′·3	+25′·6	−2′·3	II
A7/5	Ballinaby Lower	29°16′·3	+14′·5	+14′·8	−0′·3	I
A7/5	Ballinaby Upper	29°24′·3	+22′·5	+24′·0	−1′·5	I
G3/2	Haggstone Moor A_1 from Long Tom	19°09′·2	+24′·8	+25′·6	−0′·8	I
A2/8	Temple Wood to Bellanoch Hill	−28°49′·0	+12′·8	+16′·2	−3′·4	I
A4/14	Campbeltown	−28°45′·2	+16′·6	+16′·2	+0′·4	II
A4/21	Skipness	−29°25′·2	−23′·4	−24′·0	+0′·6	II
A4/23	Dunskeig	−19°01′·3	−16′·9	−16′·2	−0′·7	I
O1/1	Brogar *L* to Hellia	−18°51′·2	− 6′·8	− 6′·8	0′·0	II
O1/1	Brogar *M* to Hellia	−18°59′·8	−15′·4	−16′·2	+0′·8	II
O1/1	Brogar Comet Stone to Mid Hill	−18°51′·2	− 6′·8	− 6′·8	0′·0	I
O1/1	Brogar *JK* to Hellia	−18°45′·2	− 0′·8	− 0′·7	−0′·1	I
O1/1	Brogar *M* to Mid Hill	−18°21′·2	+23′·2	+24′·0	−0′·8	I
P3/1	Glen Prosen	−28°55′·3	+ 6′·5	+ 6′·8	−0′·3	I
P4/1	Lundin Links	−19°01′·3	−16′·9	−16′·2	−0′·7	I
A4/2	High Park A_1	−29°27′·5	−25′·7	−24′·0	−1′·7	II
A4/2	High Park A_2	−28°46′·6	+15′·2	+16′·2	−1′·0	II
N1/17	Dirlot to Scarabin A_1	−29°19′·8	−18′·0	−14′·8	−3′·2	II
N1/17	Dirlot to Scarabin A_2	−28°48′·9	+12′·9	+16′·2	−3′·3	II
N1/1	Mid Clyth to Durn Hill	−29°09′·4	− 7′·6	− 8′·6	+1′·0	II
N1/1	Mid Clyth to Culvie Hill	−29°29′·5	−27′·7	−24′·0	−3′·7	II
G9/13	Kell Burn	−19°04′·2	−19′·8	−16′·2	−3′·6	I
A4/1	Escart	−28°40′·7	+21′·1	+25′·6	−4′·5	I
B3/5	Kempston Hill	−19°01′·7	−17′·3	−16′·2	−1′·1	I
A4/17	Gigha A_1	+28°33′·0	−28′·8	−25′·6	−3′·2	II
A3/8	West Loch Tarbert	−29°07′·8	− 6′·0	− 8′·6	+2′·6	I
					Average 1′·44	

$\epsilon = 23°53'\cdot 1$ $\qquad i = 5°08'\cdot 7$

$\epsilon + i = 29°01'\cdot 8$ $\qquad \epsilon - i = 18°44'\cdot 4$

$\beta = \delta_0 - (\epsilon \pm i)$ $\qquad Q = \pm(\Delta \pm s)$

At solstices, $\Delta = 10'\cdot 0$, $s = 15'\cdot 6$; at equinoxes, $\Delta = 8'\cdot 6$, $s = 15'\cdot 4$. Information as to rising or setting is obtained from Table 4, column 5.

from the mean $s = 15'\cdot 5$ and mean $\Delta = 9'\cdot 3$ (refer to Table 1). There is also some indication of a smaller heap of four values at $(-s-\Delta)$. We note that three of these lines, representing as they do the rising lower limb, do not require any indication at the backsight (Class II): the Moon is already up.

We can think of no better visual proof that the majority of these lines were set up for astronomical purposes. They all occur at the correct positions inside the lunar band.

Another indication that we are on the right lines is as follows. Entering Figure 4 with β, we chose the nearest Q. In Figure 4 we show by narrow arrows, those values which contain no Δ. These values are the means of the equinoctial and

TABLE 4. Basic data for the forty lines.

Number	Name	O.D. level	Latitude	Azimuth	Observed altitude
A2/8	Temple Wood from S_5	100 ft	56°07′·3	317°52′·5	4°37′·2
A2/8	Temple Wood from Q	100 ft	56°07′·3	317°12′·6	4°37′·7
A2/8	Temple Wood from S_1	100 ft	56°07′·3	316°59′·0	4°37′·7
A4/5	Beacharr	282 ft	55°37′·7	326°38′·0	0°39′·0
A4/19	Knockstaple	450 ft	55°21′·1	326°09′·0	0°20′·0
A4/17	Gigha to A_2	0 ft	55°42′·4	34°15′·0	1°14′·0
A10/5	Stillaig	400 ft	55°51′·5	326°00′·0	0°44′·0
L1/16	Blakeley Moss	700 ft	54°30′·8	325°12′·0	−0°03′·0
O1/1	Ravie Hill from Comet Stone	0 ft	59°00′·1	336°23′·0	0°15′·0
O1/1	Ravie Hill from *HT*	0 ft	59°00′·1	336°47′·0	0°14′·0
O1/1	Brogar to Kame Lower	0 ft	59°00′·1	24°13′·2	0°58′·4
O1/1	Brogar to Kame Upper	0 ft	59°00′·1	24°40′·0	1°01′·5
P1/10	Fowlis Wester	800 ft	56°24′·3	30°55′·0	0°32′·0
P1/10	Fowlis Wester notch	800 ft	56°24′·3	299°20′·0	2°51′·0
O1/2	Stenness	0 ft	58°59′·7	307°35′·5	0°27′·8
A7/5	Ballinaby Lower	150 ft	55°49′·0	328°49′·2	0°11′·2
A7/5	Ballinaby Upper	150 ft	55°49′·0	327°28′·0	0°44′·2
G3/2	Haggstone Moor A_1 from Long Tom	740 ft	55°00′·2	304°25′·0	−0°04′·0
A2/8	Temple Wood to Bellanoch Hill	100 ft	56°07′·3	207°56′·0	0°18′·0
A4/14	Campbeltown	200 ft	55°25′·9	177°20′·0	5°00′·6
A4/21	Skipness	300 ft	55°46′·6	159°04′·3	1°44′·5
A4/23	Dunskeig	300 ft	55°45′·2	129°03′·8	1°24′·6
O1/1	Brogar *L* to Hellia	0 ft	59°00′·1	227°36′·0	1°04′·6
O1/1	Brogar *M* to Hellia	0 ft	59°00′·1	227°13′·0	1°05′·0
O1/1	Brogar Comet Stone to Mid Hill	0 ft	59°00′·1	135°07′·5	2°08′·8
O1/1	Brogar *JK* to Hellia	0 ft	59°00′·1	227°50′·0	1°05′·1
O1/1	Brogar *M* to Mid Hill	0 ft	59°00′·1	133°27′·8	2°00′·1
P3/1	Glen Prosen	1000 ft	56°43′·6	197°57′·0	1°58′·0
P4/1	Lundin Links	50 ft	56°12′·8	126°49′·0	0°08′·0
A4/2	High Park A_1	450 ft	55°28′·3	156°20′·0	1°20′·0
A4/2	High Park A_2	450 ft	55°28′·3	152°40′·0	1°00′·0
N1/17	Dirlot to Scarabin A_1	300 ft	58°25′·0	191°54′·0	0°59′·0
N1/17	Dirlot to Scarabin A_2	300 ft	58°25′·0	194°25′·0	1°08′·0
N1/1	Mid Clyth to Durn Hill	450 ft	58°19′·7	158°30′·0	−0°13′·0
N1/1	Mid Clyth to Culvie Hill	450 ft	58°19′·7	160°05′·0	−0°12′·0
G9/13	Kell Burn	950 ft	55°52′·0	129°50′·0	1°39′·0
A4/1	Escart	100 ft	55°50′·8	207°17′·0	0°49′·0
B3/5	Kempston Hill	400 ft	56°59′·7	231°24′·0	0°36′·0
A4/17	Gigha A_1	0 ft	55°42′·4	323°45′·0	1°06′·0
A3/8	West Loch Tarbert	0 ft	55°51′·0	166°29′·0	3°17′·0

solstitial values. The broad and narrow arrows alternate on Figure 4, and if the β values were merely random there would be no reason why a given β would fall always near the correct kind of arrow. In every case it worked out correctly. For Dirlot (Scarabin A_2) the β falls between the two Qs (about half-way in fact) and it follows that $\beta - Q$ is large compared with the mean value (1′·44). These facts make us suspect that there is something wrong with our information about Dirlot. Either the altitude/azimuth is wrong, or else it is in the lunar band purely by chance and is not a real lunar site at all.

In Table 3 there are fourteen foresights (A2/8 Temple Wood from Q, A2/8 Temple Wood from S_1, A4/5, A10/5, L1/16, O1/1 Brogar to Kame Lower, P1/10 Fowlis Wester azimuth 30° 55′, A7/5 Ballinaby Lower, A4/21, A4/23, O1/1 Brogar *JK* to Hellia, O1/1 Brogar *M* to Mid Hill, P3/1, B3/5) where there is only one possible notch to use as a foresight inside the lunar band. When used to plot the histogram shown in Figure 5, these foresights, irrespective of being in Category I or II, show the humps occurring at the positions required by the

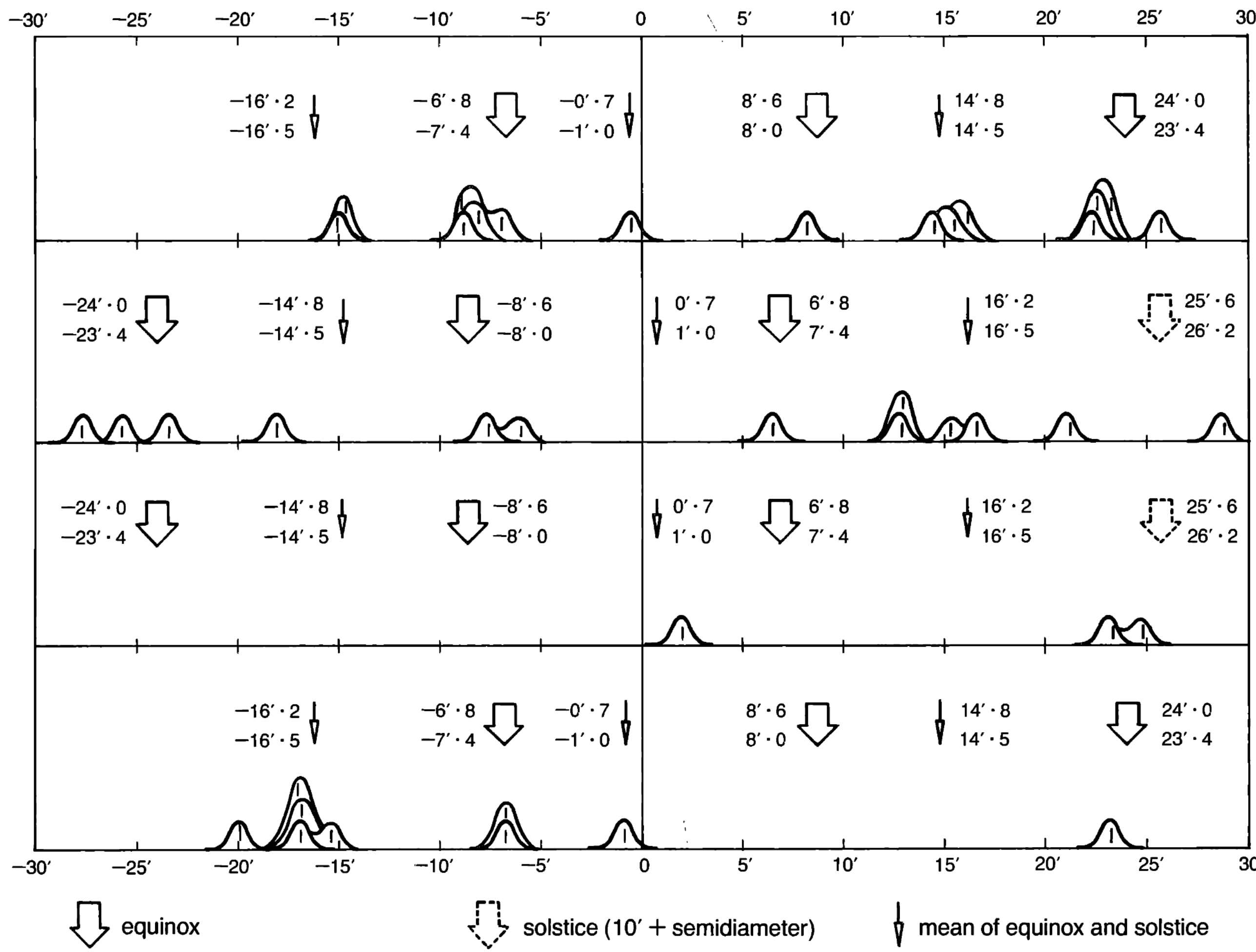

FIG. 4. Four histograms of β values, where $\beta = \delta_0 - (\epsilon \pm i)$; the expected values of β, namely Q, are shown by arrows for major and minor standstills at positive and negative declinations. Lower numbers beside each arrow are in each case the values of Q with the curvature corrections (see *Archaeoastronomy*, no. 2 (*JHA*, xi (1980)), S79–89) but these lower values have not been used in this paper.

TABLE 5. Sample calculations of declinations.

	A7/5 Ballinaby Lower				O1/1 Brogar, Comet Stone to Mid Hill	
Ordnance datum	+150 ft				0 ft	
Azimuth	328°49′·2				135°07′·5	
Observed altitude	0°11′·2				2°08′·8	
Latitude	55°49′·0				59°00′·1	
Assumed declination	29°16′·0				−18°51′·0	
	$\epsilon+i+s$				$\epsilon-i+s-\Delta$	
	Equinox		Solstice		Equinox	
Month	Mar.	Sept.	June	Dec.	Mar.	Sept.
Hour angle	324°				132°	
Longitude Moon	90°				−90°	
Sum	414°	414°	414°	414°	42°	42°
Longitude Sun	360°	180°	90°	270°	0°	180°
Difference	54°	234°	324°	144°	42°	222°
Hour (from midnight)	4h	16h	22h	10h	3h	15h
Mean temperature	48°	—	48°	—	47°	
Correction (Fig. 1)	−8°	—	+3°	—	−8°	
Temperature (T+0°F)	40°	—	51°	—	39°	
Observed altitude	0°11′·2		0°11′·2		2°08′·8	
Mean refraction	−32′·1		−32′·1		−17′·6	
Barometric and temperature correction	−1′·0		+0′·1		−0′·6	
Graze	−1′·0		−1′·0		−1′·0	
Parallax	56′·4		57′·4		56′·4	
Geocentric altitude	0°33′·5		0°35′·6		2°46′·0	
Mean geocentric altitude	0°34′·5				—	
Declination δ_0	29°16′·3				−18°51′·2	
$\epsilon+i$	29°01′·8				−18°44′·4	
$\beta=\delta_0-(\epsilon+i)$	+14′·5				−6′·8	
Q	+14′·8				−6′·8	
$\beta-Q$	−0′·3				0′·0	

hypothesis; this surely refutes the criticism that we may have been inadvertently selecting the concentration of clumps necessary to produce the result.

($\beta-Q$) *Assessment*

Looking at Figure 4, we see that the narrow arrows and the broad arrows alternate: they occur 'time about'. It follows that when a β occurs near the middle of an interval, we can choose either the broad arrow or the narrow arrow for Q. If there is no Δ in a nominal value, then for Q we should take the nearest narrow arrow. When we first prepared Table 3 we were taking the nearest Q irrespective of whether the arrow was broad or narrow. We did not think of the possibility that we had sometimes to take the narrow arrow. In fact when we chose the Q-values we had not realised the necessity for this. Some time later we decided to check up and found that in practically every case we had chosen the correct Q. There was only one exception, Dirlot, discussed above. This agreement is in itself clear indication to us that our lunar hypothesis is correct.

But perhaps the clearest indication is that all the ($\beta-Q$)-values are so small (average 1·44 arc minutes). For those who prefer a more visual demonstration we have plotted the histograms of β (see Figures 2 and 3).

TABLE 6. Calculated values of $(\beta - Q)$ for three temperatures, each of which is the estimated site temperature plus t°F. (The 'estimated site temperature' is that of the present time.)

Number	Name	$t =$ 0°F	4°F	8°F
A2/8	Temple Wood from S_5	+1·3	+1·5	+1·6
A2/8	Temple Wood from Q	+0·2	+0·3	+0·4
A2/8	Temple Wood from S_1	−0·1	0·0	+0·1
A4/5	Beacharr	−0·4	0·0	+0·3
A4/19	Knockstaple	−1·3	−0·9	−0·6
A4/17	Gigha to A_2	−0·8	−0·5	−0·2
A10/5	Stillaig	−1·8	−1·6	−1·4
L1/16	Blakeley Moss	+1·2	+0·3	−0·2
O1/1	Ravie Hill from Comet Stone	+1·6	+2·0	+2·4
O1/1	Brogar to Kame Lower	+1·7	+1·9	+2·2
O1/1	Brogar to Kame Upper	−1·6	−1·4	−1·4
P1/10	Fowlis Wester	+0·6	+0·9	+1·2
P1/10	Fowlis Wester notch	+1·3	+1·5	+1·7
O1/2	Stenness	−2·3	−2·2	−2·0
A7/5	Ballinaby Lower	−0·3	+0·1	+0·6
A7/5	Ballinaby Upper	−1·5	−1·2	−0·9
G3/2	Haggstone Moor A_1 from Long Tom	−0·8	−0·3	0·0
A4/14	Cambeltown	+0·4	+0·5	+0·6
A4/21	Skipness	+0·6	+0·8	+1·0
A4/23	Dunskeig	−0·7	−0·5	−0·3
O1/1	Brogar L to Hellia	0·0	+0·2	+0·5
O1/1	Brogar M to Hellia	+0·8	+1·0	+1·3
O1/1	Brogar Comet Stone to Mid Hill	0·0	+0·1	+0·3
O1/1	Brogar JK to Hellia	−0·1	+0·1	+0·4
O1/1	Brogar M to Mid Hill	−0·8	−0·6	−0·4
P3/1	Glen Prosen	−0·3	−0·1	0·0
P4/1	Lundin Links	−0·7	−0·4	0·0
A4/2	High Park A_1	−1·7	−1·5	−1·2
A4/2	High Park A_2	−1·0	−0·8	−0·6
B3/5	Kempston Hill	−1·1	−0·8	−0·5
A3/8	West Loch Tarbert	+2·6	+2·7	+2·9
	R.m.s. of first nineteen values	1·21	1·17	1·23
	R.m.s. of all thirty-one values	1·16	1·12	1·16

2. THE TEMPERATURE IN MEGALITHIC TIMES

We have shown in Part 1 that practically all lines that fall inside the lunar bands were definitely the result of lunar observations. We also showed that these lines were not necessarily all Class I; that is, they did not necessarily all have an indication of the direction to the foresight. We now propose to show that if we could obtain a sufficient number of lines we could perhaps deduce the value of the temperature in megalithic times. By "a sufficient number", we mean perhaps a hundred. At present we have only one-third of this number, and we propose to use these to show the method, which is to investigate the effect that such calculable refraction change has on the values of $(\beta - Q)$ given in Part 1.

With such a small number it is necessary to select the best. The only criterion we can suggest is the size of $(\beta - Q)$. Neglecting the sign, the arithmetical mean of the values of $(\beta - Q)$ in Part 1 was about 1′·44. Thus megalithic man could work to an accuracy of perhaps ± 2 arc minutes. Consequently we decided to ignore all lines that had a value of $(\beta - Q)$ of 3′ or more.

Dirlot Hill A_2, with Dirlot Hill A_1 and Kellburn, will be neglected here because their $(\beta - Q)$ values are all greater than 3′. The two lines from Mid

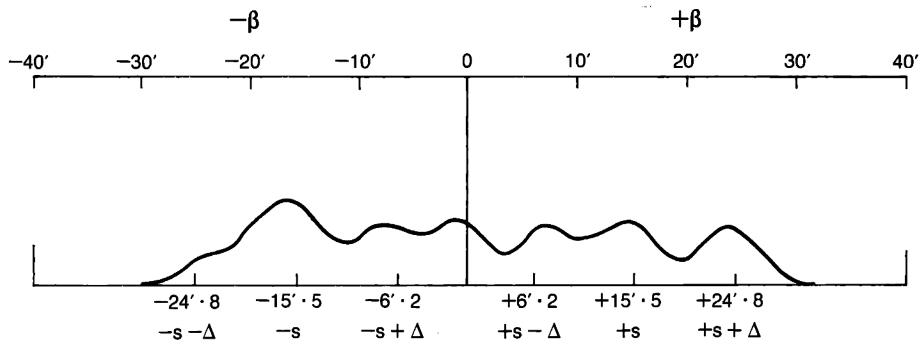

FIG. 5. Lunar band: fourteen lines where only one possible notch exists within the band.

Clyth across the Moray Firth to Durn Hill and Culvie Hill have very low angular altitudes. Since refraction at very low altitudes is uncertain we neglected these two lines. For Escart A4/1, Gigha A4/17, Ravie Hill from *HT* O1/1, and Temple Wood to Bellanoch Hill A2/8, the profiles are uncertain and these lines are also neglected. We end up with thirty-one lines out of the forty. The average value of $(\beta - Q)$ for these lines is 0′·95 (at temperature $T+0$°F).

In Table 3 we give for each of the forty lines the $(\beta - Q)$ values for the present-day site temperature ($T+0$°F) (see sample calculation, Table 5). We now repeat the whole process for temperature $(T+t)$ where t = 4°F and again for t = 8°F, but this time only for the thirty-one lines; that is, we use $T+4$°F and $T+8$°F in the calculations for $(\beta - Q)$ values listed in Table 6. We took the greatest care in extracting the refraction from the *Nautical almanac* table and diagram for all three temperature increments (t = 0, 4, 8°F). Corrections for heights of sites above sea-level were applied for barometric pressure and temperature departures from sea-level values. The method of calculation is identical to that described in Part 1 and so we can now tabulate in Table 6 the values of $(\beta - Q)$ for each line for each of the three values of t. At the foot of the table we give the values of the r.m.s. for each column. As a matter of interest we also give the r.m.s. values for the first nineteen lines of the table. We see in Figure 6 that both for the first nineteen and for the total thirty-one lines the lowest r.m.s. of $(\beta - Q)$ values occurs when t = 4°F. Had we been able to use enough lines, this would have meant that temperatures in megalithic times were about 4°F higher than those at the present day, but it will be remembered that the thirty-one lines that we used were those that remained after neglecting, on perhaps insufficient grounds, nine lines taken from the forty used in Part 1.

It is easy to show that we have not got nearly enough lines. Suppose that the next line that comes along is poor, that is, it has a high $(\beta - Q)$. Then its effect on the three values at t = 0, 4 and 8°F will be very serious. If we had a large number of lines, however, then the effect of poor lines would be much reduced. We therefore need many more observations. We think that probably there are enough lines in Britain still to be discovered. Lunar lines are being found frequently, and there are also large numbers in countries such as France and Germany. The real difficulty is to find observers. Very few people can use a theodolite correctly; but one can learn to use it after a few weeks' tuition—provided a suitable tutor can be found.

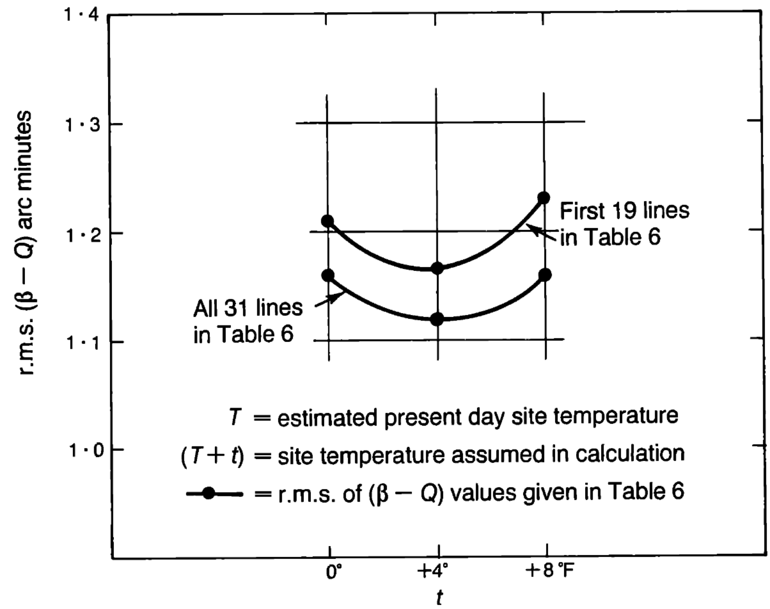

FIG. 6. Effect of three different values of t on the r.m.s. of $(\beta - Q)$.

We believe that future observers should record the temperature and barometric pressure when they make the readings. Here we have simply assumed that during each of our surveys the mean temperature was about 50°F. Many refinements will still have to be made in the calculations; for example, bringing in the present-day temperature and barometric pressure measured during the site surveys. We hope that eventually the results will give the mean annual temperature in megalithic times to within a degree or two; but perhaps this is wishful thinking.

The efficacy of the whole process depends on the accuracy with which the *Nautical almanac* has given the data on refraction.
