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THE STONE RINGS OF BEAGHMORE: GEOMETRY AND ASTRONOMY

by A. S. THOM

INTRODUCTION

When A. E. P. Collins invited us to survey the Beaghmore site on behalf of the Archaeological Survey (N. Ireland) we accepted with alacrity because the complex layout of the rings, alignments and cairns had interested us for some time. Situated in the foothills of the Sperrin Mountains, the reason for their existence presents a challenge. Would their geometry and metrology turn out to be similar to what we had already discovered elsewhere in NW. Europe? Why were the rings laid out apparently so carefully, with short and long alignments made of high and low stones forming tails radiating in tangential fashion from the rings or cairns? Were the rows intended to indicate the rising points of the sun and/or moon on the horizon and, if so, at what season?

SURVEY

The site plan, prepared to a scale of 1 in 240, is too large for reproduction here and it is shown at reduced scale in Fig. 1. Orientation of the plan was obtained by solar observation and, in an attempt to ascertain whether or not the dozen or so alignments were intended for astronomical use, horizon altitudes were measured in most of the azimuths (directions) indicated. Two of four menhirs standing alone to the SW. of the site appear to indicate a notch formed by the south-eastern ridge of Carntogher some 8 miles away, and the N. hillside of Altihaskey at a level of about 800 ft. Called 'Mickey Bradley's stones', these were included in the survey and measurements were made of the azimuth and altitude of the notch from them.

Stones over 18 in. high are shown in black at ground level (several stones are not vertical). On the plan, capital letters have been retained for the ring names as used by Pilcher (1969, fig. 11). Numbers 21 to 27 indicate survey stations used. Metal pins were buried in the ground at these points.

Symbols and definitions

A = azimuth or bearing from true N.
eA = differential azimuth; error in azimuth.
δ = declination = angular distance, taken from the centre of the earth, of the body from the plane of the equator.
eδ = differential declination; error in declination due to eA.
Δ = cyclical perturbation of moon's movement caused by sun and earth.
ε = obliquity of the ecliptic = slope of the plane through the earth's equator with respect to the plane of the ecliptic. $\pm\ \varepsilon$ is the declination of the sun at the equinoxes. In 1800 B.C. $\varepsilon = 23° 54'.5$.
ϕ = latitude of observer.
g = graze, additional refraction caused when light ray passes for a distance closely over a rounded ridge on the horizon.
h = corrected altitude of body = observed altitude less refraction, plus parallax = altitude as though observed from the centre of the earth.
i = constant mean inclination of the moon's orbit to the ecliptic = 5° 08′ 43″.
mr = 2½ megalithic yards = 6.80 ft.
my = megalithic yard = 2.72 ft.
p = horizontal parallax. For the moon, p varies from 53′.9 to 61′.5. For the sun, p = 8″.
R = refraction, bending of ray of light from the heavenly body which makes it appear higher.
s = semi-diameter. For the moon, s = 0.2725p.

GEOMETRY OF THE RINGS

At first sight it might be thought that the erectors of this monument could not even construct straightforward circular cromlechs and it is only after searching carefully by trial and error that we find two well-shaped type I eggs (Thom 1967, 29), namely rings E and G, where megalithic yard units appear to have been used in the layout. These eggs, built up as shown in Fig. 2 from two integral Pythagorean triangles (see Table 1), have circumferences which, as shown by calculation, differ only by about ¼ megalithic rod from an integral number of megalithic rods. This property of having a circumference of an integral number of megalithic rods was used by the erectors of rings, eggs and ellipses elsewhere (Thom 1967; Thom and Thom 1978).

TABLE 1

Suggested geometry of Beaghmore Rings drawn in Fig. 2

Enclosure	Circle, ring or type I egg	Radius or Triangle sides	Perimeter my	Perimeter mr	Remarks
A	Circle	7 my	43.98 for 45.0	17.59 for 18	16 my to centre of B
B	Circle	6 my	37.7 for 37.5	15.08 for 15	16 my to centre of A
C	Ring	10, 10, 14 Triangle	65.2 for 65.0	26.08 for 26	Two diameters same if radius of end taken as 6, not 5.86 my
D	Circle	10 my	62.83 for 62.5	25.13 for 25	15 my to cut of two diameters of C
E	Egg	8, 6, 10 90° Triangle	69.42 for 70.0	27.78 for 28	Centre line cuts centre of G or cairn 10 near G
F	Circle	5 my	31.42 for 30.0	12.57 for 12	15 my from centre line of G
G	Egg	3, 4, 5 my Triangle	34.45 for 35.0	13.78 for 14	Centre line 15 my from centre of F

Of the other rings, A, B, D and F appear to be circles having diameters respectively of 14, 12, 20 and 10 megalithic yards. Ring C appears to be like a type I egg with a flat end instead of a semi-circle. The layout probably intended is shown in Fig. 2. Set out symmetrically about a diameter of circle D produced, it can be constructed from two isosceles right-angled triangles, having their equal sides 10 megalithic yards long. In order to close the figure smoothly the small end radius has to be 5.86 megalithic yards and the peripheral or circumferential length for this shape is 26.08 megalithic rods. These are quantities calculated from the assumed triangles and radii. Little difference occurs in the shape and circumferential length if the hypotenuse of each triangle is made 14.00 instead of 14.14 megalithic yards as above. The suggested layout leaves one megalithic yard between circle D and ring C; one diameter of ring C is 20 megalithic yards and the other diameter is either 19.86 or 20 depending upon how the ring is set out. It is remarkable how close the periphery is to being integral in megalithic rods.

The centres of ring C and circle D are 15 megalithic yards apart. It is worth noting that circle F as drawn is 15 megalithic yards from the centre line of egg G and that circles A and B have centres 16 megalithic yards apart. The longitudinal diameter of egg E could be drawn to pass either through the centre of egg G or the centre of the mound 10 to the S. of G. On Fig. 2 the line is drawn to pass halfway between the centres.

INSIDE OF EGG E

This cromlech is unique in that several hundreds of small stones about 15 in. high have been placed upright separately inside of the periphery. Lack of time prohibited us from measuring the position of each stone. It is possible that they are not as randomly placed as they appear to be at first sight, and that some sort of pattern exists. We feel that an aerial photograph would be of great interest. A single 31 in. high stone stands alone amongst the small ones near the middle area of this cromlech.

ALIGNMENTS

Ten rows of stones exist on the site. Some of the rows are slightly dog-legged and the stones have different heights. During and before the survey it was thought possible that some of the lines might indicate rising points of the sun and moon at certain seasons and so horizon altitudes were carefully measured from eye level at the western end of each line. No altitudes were measured to the SW., because of the nearness of the horizon. The lines are indicated on Fig. 2 and observed altitudes are given in Table 2 along with azimuths (A) measured from the 1 in 240 plan.

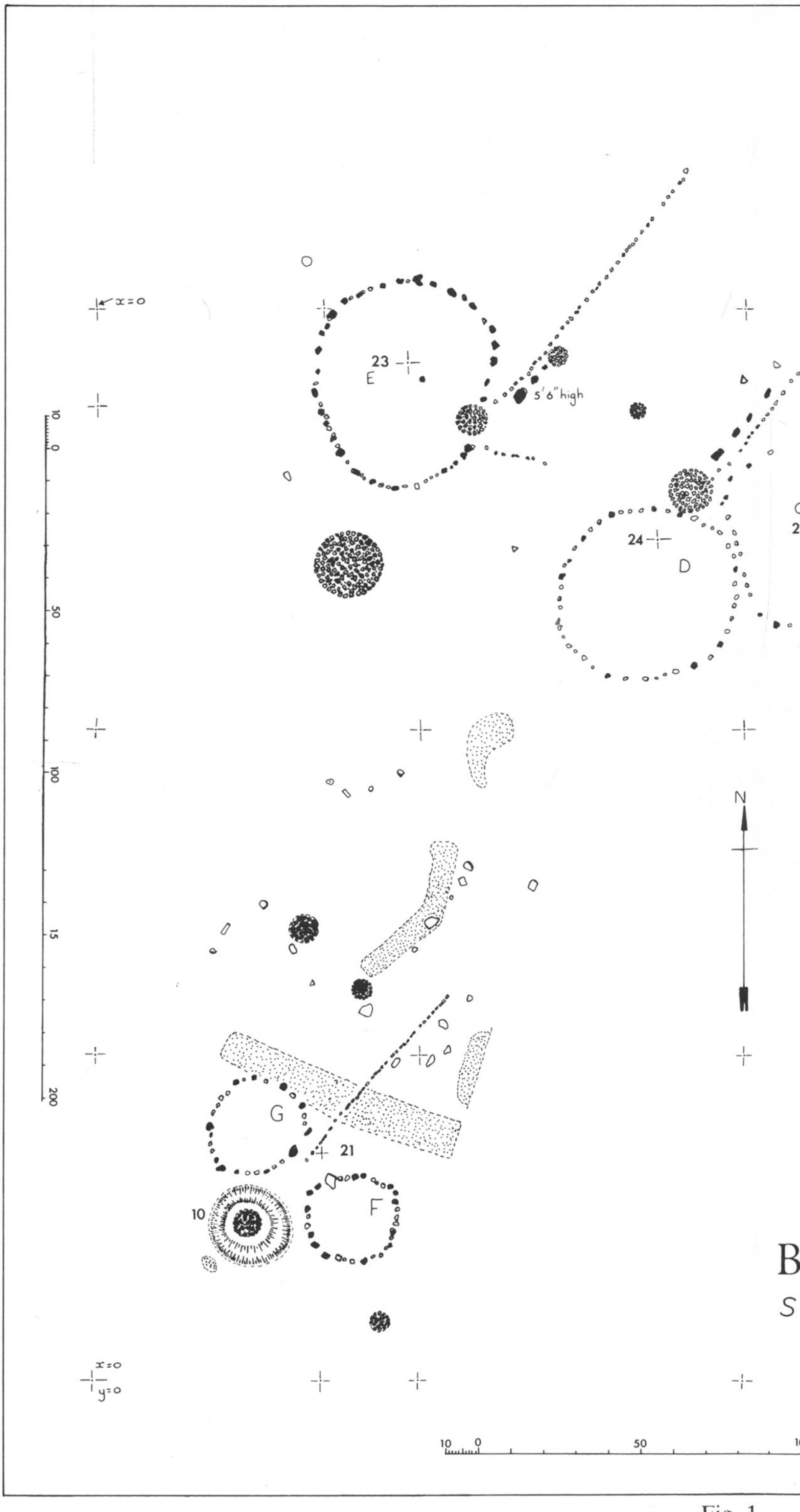
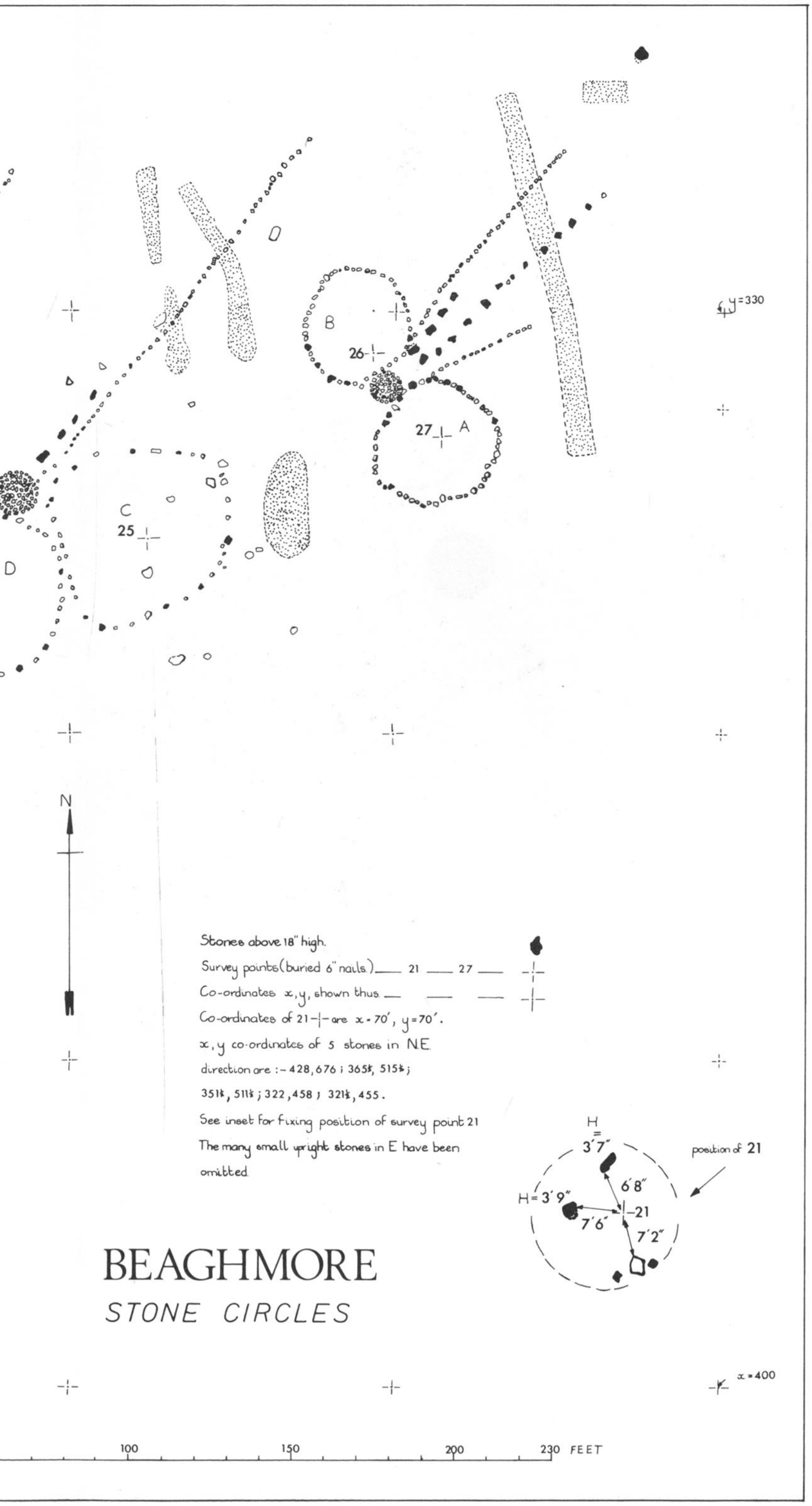


Fig. 1.



A
B
C
D
25
26
27
y=330
x=400
N
Stones above 18" high.
Survey points (buried 6" nails) 21 27
Co-ordinates x, y, shown thus
Co-ordinates of 21 are x=70', y=70'.
x, y co-ordinates of 5 stones in N.E direction are :- 428, 676 ; 365½, 515½ ; 351½, 511½ ; 322, 458 ; 321½, 455.
See inset for fixing position of survey point 21
The many small upright stones in E have been omitted
H = 3' 7"
H = 3' 9"
6' 8"
7' 6"
7' 2"
21
position of 21
BEAGHMORE
STONE CIRCLES
100
150
200
230 FEET

Fig. 1.

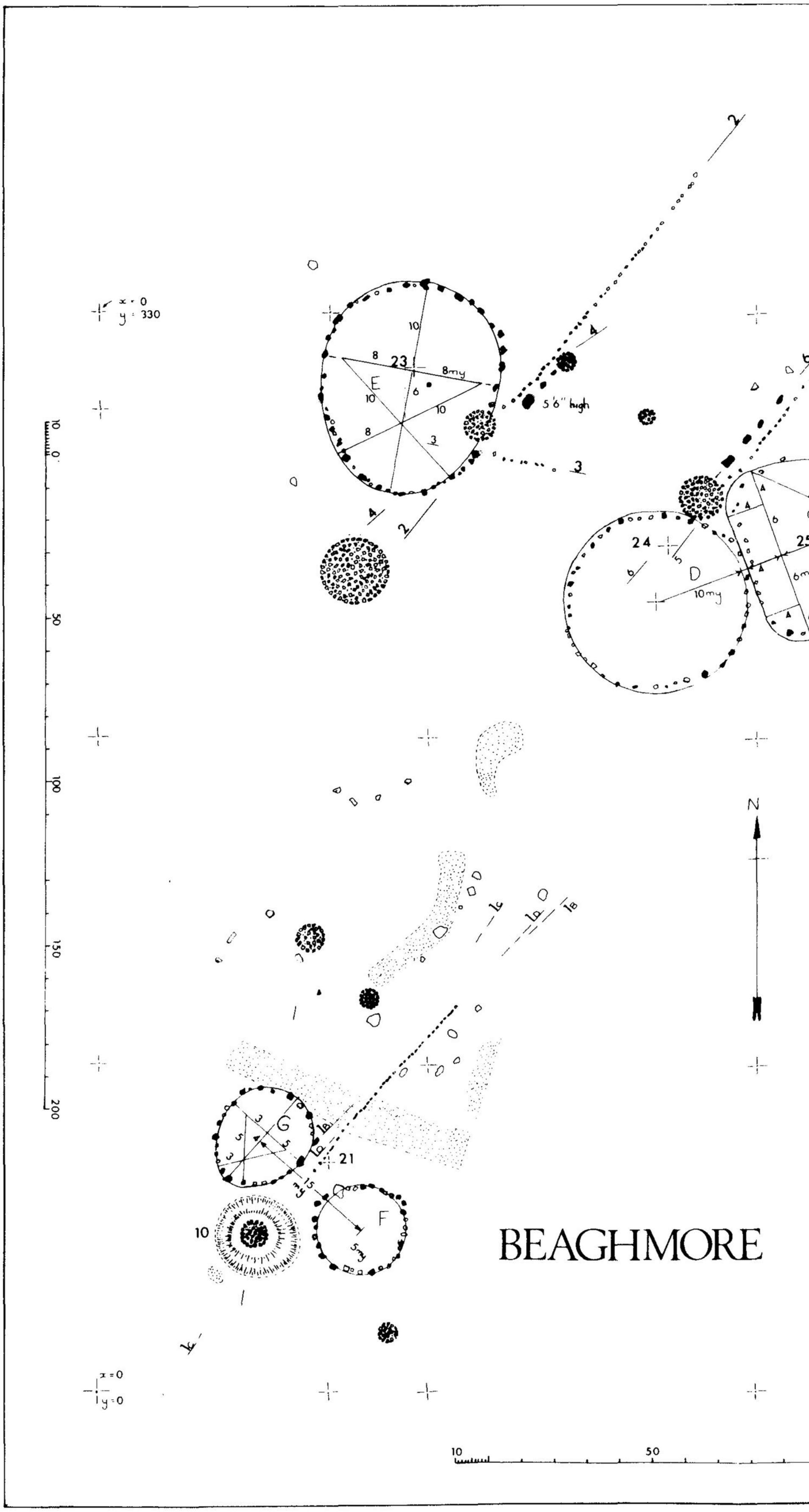
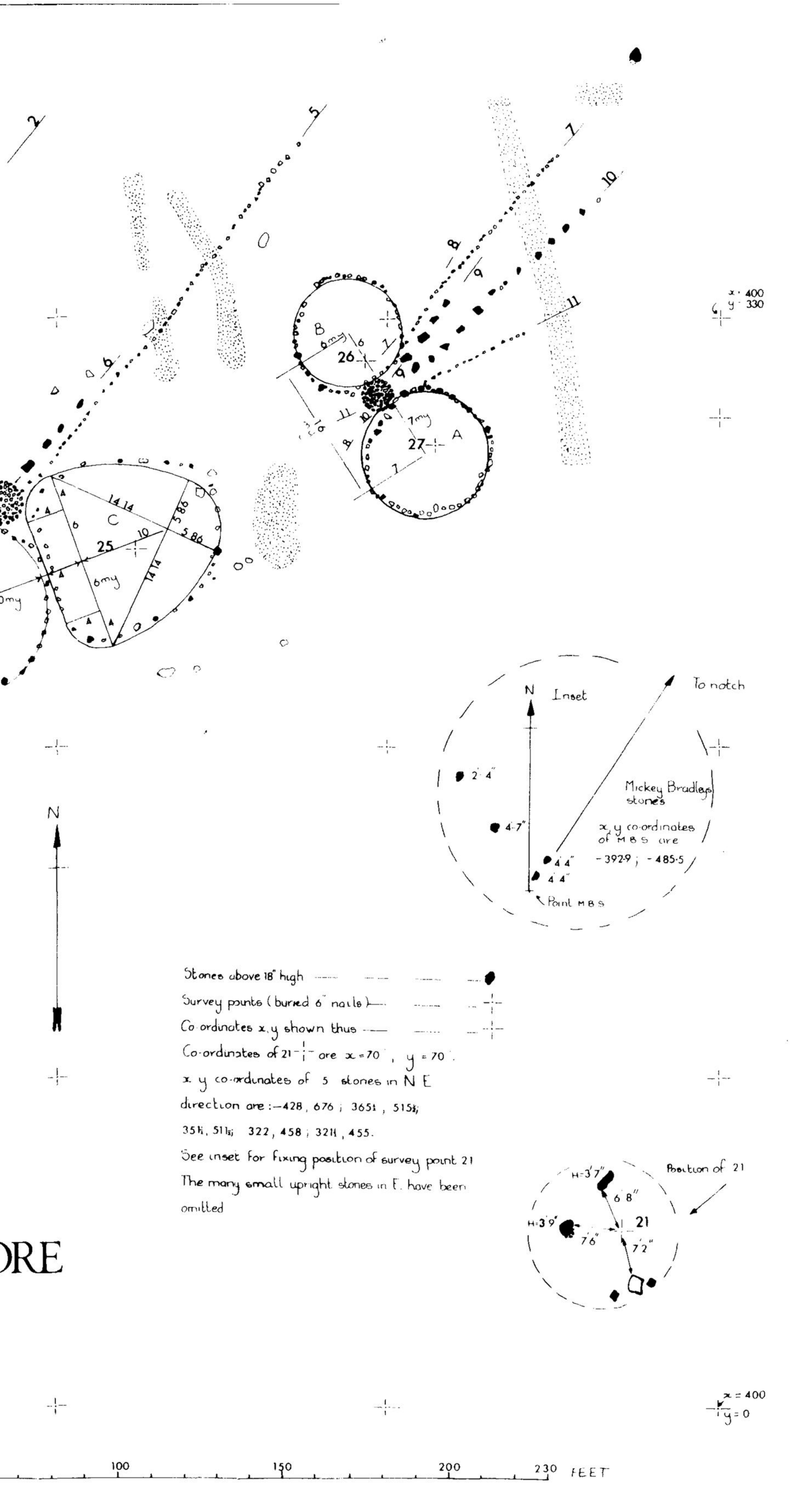

BEAGHMORE
N
x = 0
y = 330
x = 0
y = 0
E
D
G
F
23
24
25
21
10
5'6" high
10my
8my
5my
50
100
150
200

Fig. 2.



B
26
A
27
C
25
x = 400 y = 330
N
Inset
To notch
2' 4"
4' 7"
Mickey Bradleys stones
x, y co-ordinates of M B S are
- 392·9 ; - 485·5
4' 4"
4' 4"
Point M B S
Stones above 18" high
Survey points (buried 6" nails)
Co-ordinates x, y shown thus
Co-ordinates of 21 are x = 70', y = 70'.
x y co-ordinates of 5 stones in N E direction are:— 428, 676; 365½, 515½; 351½, 511½; 322, 458; 321½, 455.
See inset for fixing position of survey point 21
The many small upright stones in E. have been omitted
Position of 21
H=3'7"
6' 8"
H=3'9"
7'6"
7'2"
21
ORE
x = 400 y = 0
100 150 200 230 FEET

Fig. 2.

Declinations (δ) are given in the table worked out as indicated in Thom (1967 and 1971) and Thom and Thom (1978).

An estimate was made, from the plan, of the maximum error in azimuth ± eA which might arise while using each line to determine a point on the horizon. These errors are tabulated along with eδ, the error which each eA produces in the declination of the indicated point.

Searching for solar and lunar lines, we have separated the lines accordingly into those having declination near to 23° 55′ and 29° 04′, the maximum declinations of the centres of sun and moon respectively about 1800 B.C. (see Thom 1967 and 1971). This date was chosen for a starting base as it was about the date found in Scotland for lunar alignments. The peak of Dart Mountain is clearly visible in the NW. and it seems to be an attractive foresight but none of the lines indicates this direction. However, its azimuth and altitude were measured from 21, a point representative of the whole site. The values obtained (A = 326° 22′, observed altitude 1° 36′.4) do not lead to any germane declination.

Line number 11 in Table 2 has been included as a possible solar line. Was it a line for epoch 6 in megalithic man's solar calendar (Thom 1967, chap. 9)? A declination of + 16° 48′ is expected for this. Line number 3 with δ = −3° 45′ is meaningless and, as its length is only 25 ft, it has been neglected.

SOLAR ALIGNMENTS

With lines 3 and 11 omitted, the mean observed declination, δ, for the five solar lines is 24° 23′, which is 28′ too high. It is tempting to suggest that the sun's upper limb at mid-summer sunrise (23° 55′) was being marked and so the semi-diameter s = 15′ might be deducted from 24° 23′ thus bringing the mean observed declination for the sun's centre to 24° 08′. With the uncertain data given by such short lines any further surmise or accurate calculation would be fruitless. Of the five solar lines under discussion, two of them, lines 1B and 10, might definitely be said to be solar and to indicate the lower limb, observed through a small peep-hole or slit. Line 1B, using the two large stones in egg G and the long line number 10 of large stones all of which are collinear, gives a fairly definite direction, but the stones in line 10 are not visible to an observer near egg G unless he raises his level by moving backward several paces.

TABLE 2

Altitude, azimuth and declination data for horizon points indicated by Beaghmore lines. For position of each line, see Fig. 2. For each calculation, latitude ϕ = 54°42′ 01″.

Lines (1B-10) and 10 consist of large upright stones (average height 31 in. ± 6in). Line 9 consists of four large upright stones and one large fallen stone 94 ft away.

Line number	Observed altitude ° ′	Refraction R ′	Parallax ′	Corrected altitude h ° ′	Azimuth A ± eA ° ′ ° ′	Declination δ ± eδ ° ′ ° ′
			POSSIBLE SOLAR LINES			
1B	25	30.0	0.1	−04.9	45 30 ± 0 00	23 49 ± 0 00
10	25.4	30.0	0.1	−04.5	45 30 ± 0 00	23 50 ± 0 00
1D	29.6	29.2	0.1	+00.5	42 30 ± 0 45	25 13 ± 0 19
3	3 12	13.6	0.1	2 58.5	100 45 ± 2 30	−3 45 ± 1 25
4	23.9	30.2	0.1	−06.15	48 30 ± 4 00	22 25 ± 1 52
4B	24.6	30.1	0.1	−05.4	39.00 ± 0.40	26 36 ± 0 16
11	1 05.3	23.7	0.1	41.7	63 50 ± 1 15	15 21 ± 0 40
			POSSIBLE LUNAR LINES			
1C	22.3	30.5	57.2	49.0	34 50 ± 2 00	29.04 ± 0 48
1D	29.6	29.2	57.2	57.6	42 30 ± 0 45	26 04 ± 0 21
2	24.6	30.1	57.2	51.7	39 00 ± 0 40	27 28 ± 0 16
4B	24.6	30.1	57.2	51.7	39 00 ± 0 40	27 28 ± 0 16
5	22.6	30.5	57.2	49.3	37 36 ± 0 40	28 00 ± 0 16
6	24.5	30.1	57.2	51.6	39 10 ± 0 45	27 24 ± 0 18
7	22.3	30.5	57.2	49.0	41 00 ± 1 00	26 36 ± 0 25
8	29.9	29.1	57.2	58.0	28 40 ± 0 50	31 23 ± 0 16
9	23.0	30.4	57.2	49.8	37 12 ± 0 15	28 10 ± 0 02

LUNAR ALIGNMENTS

The mean of the first nine listed lunar directions indicated by lines (see Table 2) shows a declination of 27° 58′ which, at major standstill (Thom 1967 and 1971), falls short of the maximum declination of the moon's centre by 1° 06′. Again, with such uncertain data, further calculation would not yield any more information. However, it could be argued that the lower limb of the rising moon was observed at major standstill. This would require a declination of 29° 04′ minus 15′ or 28° 49′ (about 1800 B.C. as stipulated above).

There appear to be no further alignments and if those which we have recorded were positioned to show the rising moon at major standstill, they were not sufficiently definite for accurately recording this event. Were the erectors beginners and learning about the moon's movement or were the rows put there for other purposes? It is worthy of note here that one only of the nine declinations, that for line 8, has a value greater than 29° 04′, a declination value never exceeded by the moon. It has, naturally, over the whole 18.61 year lunar cycle, declination values observably less than 29° 04′ at each monthly peak. If no definite means of extrapolation (Thom 1971, chap. 8; Thom and Thom 1978, Appendix B) were being used and if, consequently, they simply recorded the maximum position found, then the recorded Moon's declination could have been lower by 12′.3 (Thom 1971, 85). This is the declination deficiency half of a lunar day after the occurrence of the declination maximum. Horizon declination then required for the moon's lower limb for such a condition would be 28° 49′ minus 12′.3, i.e. about 28° 37′ which differs from the above mean observed declination by 39′.

In view of the uncertainty of the azimuth of the lines it is really superfluous to bring in Δ, the moon's perturbation, caused by the sun and earth. However, if Δ is included, 9′ would be deductable from the above 39′ and the declination given by the *mean* of the nine lines under discussion (and assumed to be used for the lower limb) would be low by 30′ which is one lunar diameter. In the same way the large stones in row 9 can be shown to indicate a lunar declination too low by 18′.

MICKEY BRADLEY'S STONES

At a distance of 680.4 ft from survey station 21, bearing 209° 11′42″, four stones stand erect as shown in the inset in Fig. 2. As described earlier, two of these might be considered as pointers to a notch in the NE. horizon. A careful survey was made linking the stones to the main site. Sun observations were made for the azimuth of a chosen referring object and later this work was used to verify the orientation of the survey lines on the main site.

Unfortunately, the notch to the NE. was not visible from M.B.'s stones because of a copse of young trees in the Davagh Forest area. The horizon of each hill-side was observed down as far as allowed by the forest trees. The tree-top altitude was observed and later the ground level was estimated by visiting the site and measuring the tree height. Undoubtedly, the notch would be visible over bare ground, Fig. 3. In the circumstances

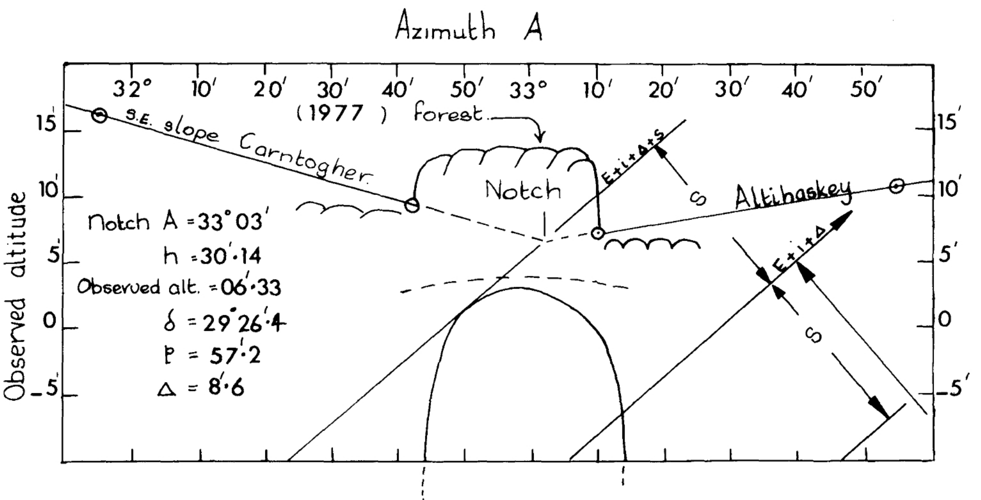


Fig. 3. Moonrise viewed from Mickey Bradley's stones. ε = 25°53′.4.

the azimuth of the notch could be ascertained to closer than A = 33° 03′ ± 2′.

Using the above azimuth, A = 33° 03′, with the observed altitude of 0° 06′ 20″ (scaled from Fig. 3) and observer's latitude ϕ = 54° 41′ 55″ (scaled from the 1976 one-inch O.S. map), the declination indicated by the notch is 29° 26′.4. Calculations for this follow the methods used in Thom and Thom (1978) where details are given of the method of obtaining the best values to use for refraction, graze and parallax. The moon at major standstill would rise about 8.6 hours after midday and in darkness at or about the equinox when a temperature of 51°F might reasonably be assumed. As the actual date is unknown, mean parallax (57′.2) and mean perturbation (8′.6) were used. The figures indicate that M.B.'s stones could have been used to observe the upper limb of the rising moon about 1640 B.C. ± 200 years.

For accurate recording and observing of the moon on the horizon over the years, some method of extrapolation was necessary. Perhaps the other two large stones nearby (Fig. 2), along with several other smaller stones which were not surveyed, will turn out to have been part of the required extrapolation sector (Thom 1971, chap. 8 and Appendix B). Certainly sufficient room exists to the N. of this back-sight for the observers to have moved into position to watch the moon rise on earlier or later occasions. Higher ground behind the back-sight could have been used by assistant observers to warn those below that moonrise was imminent.

Large menhir near egg E and lone menhir inside of egg E

Near egg E we find the largest stone on the site, 5 ft 6 in. high. Was it perhaps also used as a back-sight for the same notch viewed from M.B.'s stones? The notch was not surveyed from here as it was hidden by the same copse. It is not certain that the same shape of notch would be clearly seen, but a fairly rough calculation indicates that the obtainable declination is approximatrely 29° 22′ 09″. Further survey work would have to be done here. Inside of egg E there stands a lone menhir 31 in. high. Was this stone a back-sight for the notch? Movement to here from the menhir near E would raise δ by about 1′.2. Without some indication that this was a back-sight we cannot proceed further.

CONCLUSIONS

Rings

The geometry of the rings conforms to previous discoveries regarding shape and metrology used by megalithic man. Inspection of the suggested geometry indicates that the stones in circle F and in eggs E and G all stand very close to the hypothetical geometrical outlines; the fit of stone ring C and circle D could be said to be fairly good and that of circles A and B to be fair. The shape of the ring C with the flat end is distinctly odd; none like this has been discovered before.

Rows

In general the fairly short rows do not point to any obvious markers or foresights on the horizon and so it is not possible to give much weight to their use for accurately observing the moon at major standstill.

Without doubt row 1B – 10 pointed towards solstitial sunrise but no significance can be attached to the date of 1800 B.C. The stones involved are much larger than the others. Were big stones chosen purposely to designate a solar alignment? To a lesser extent the large stones in row 9 might be considered to point to moonrise at major standstill at the same period. As for the remaining rows the average declination indicated is low by about one lunar diameter. We have no idea of what the horizon was like but had observations been made over a thick belt of trees, observed declinations would have been raised. It is left to the reader to decide whether or not moon movement was being recorded.

Mickey Bradley's stones

Calculations show that moonrise observed in the NE. from Mickey Bradley's stones occurred at major standstill about 1640 B.C. ± 200 years.

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REFERENCES

Pilcher, J. R. (1969). 'Archaeology, palaeoecology, and the [14]C dating of the Beaghmore stone circle site', *Ulster J. Archaeol.*, **32** (1969), 73–91.

Thom, A. (1967). *Megalithic Sites in Britain* (Oxford, 1967).

——— (1971). *Megalithic Lunar Observations* (Oxford, 1971).

Thom, A. and Thom, A. S. (1978). *Megalithic Remains in Britain and Brittany* (Oxford, 1978).