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THE TWO MEGALITHIC LUNAR OBSERVATORIES AT CARNAC

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In a previous paper[1] we showed that it is probable that there were two large Megalithic lunar observatories in the Carnac area. One was centred in the large menhir on the hilltop at Le Manio and the other, on what was (before it broke and fell) the largest menhir in Europe, namely Er Grah or Le Grand Menhir Brisé. At Stonehenge and at Brogar the observers worked near the main monument and looked outwards to distant foresights which were, at Brogar at least, natural features of the skyline. At Carnac on the other hand the observations seem to have been made from peripheral backsights by looking inwards to a universal foresight. Since our first paper was written we have controlled and directed much additional surveying in the area and think it likely that we have thereby uncovered several more backsights for both observatories. As a result of extensive surveys made over the years we are now able to give accurate estimates of the declinations given by most of the backsights and to correct one or two which previously depended on map estimates.

The Carnac Area

Most visitors to Carnac content themselves with a cursory examination of the main alignments, a look at one or two of the dolmens, and probably a brief visit to the remains of that huge stone Er Grah; but anyone who studies a modern 1/25000 map cannot fail to be surprised by the number of isolated menhirs, cromlechs and dolmens scattered over the countryside. By courtesy of the officials in Carnac Town Hall we were fortunate in having access to earlier cadastral maps, and a comparison of these with modern maps showed how much had been lost in the interval. It is impossible to form an estimate as to how much was destroyed before the date of the cadastral maps and, in spite of the efforts of the French Government, the destruction is still going on. In 1972 we found a part of the Kermario alignments being dug away, and in 1973, Monsieur Eric Bonnet drew our attention to the removal of what was evidently a Megalithic site just below the farm at Kervilor—as we shall see shortly, this was possibly one of the backsights for the lunar foresight at Er Grah. (At both sites the property owners were presumably within their legal rights because the ground had not been taken over by the Government.) We might also mention the site at Le Champ de Menhirs where an irate farmer assured us that there were "pas de menhirs ici". To the Breton peasant a menhir is a tall upstanding stone, but there are places in the woods where one finds upright slabs perhaps only a foot high. The grid coordinates of such stones ought to be recorded to within a metre before they are destroyed.

The Survey

Our activities were restricted almost entirely to the area shown in Figure 1. We believe that we have recorded to within a foot or two the relative positions of all the upright stones in this area known to us, except for one or two which

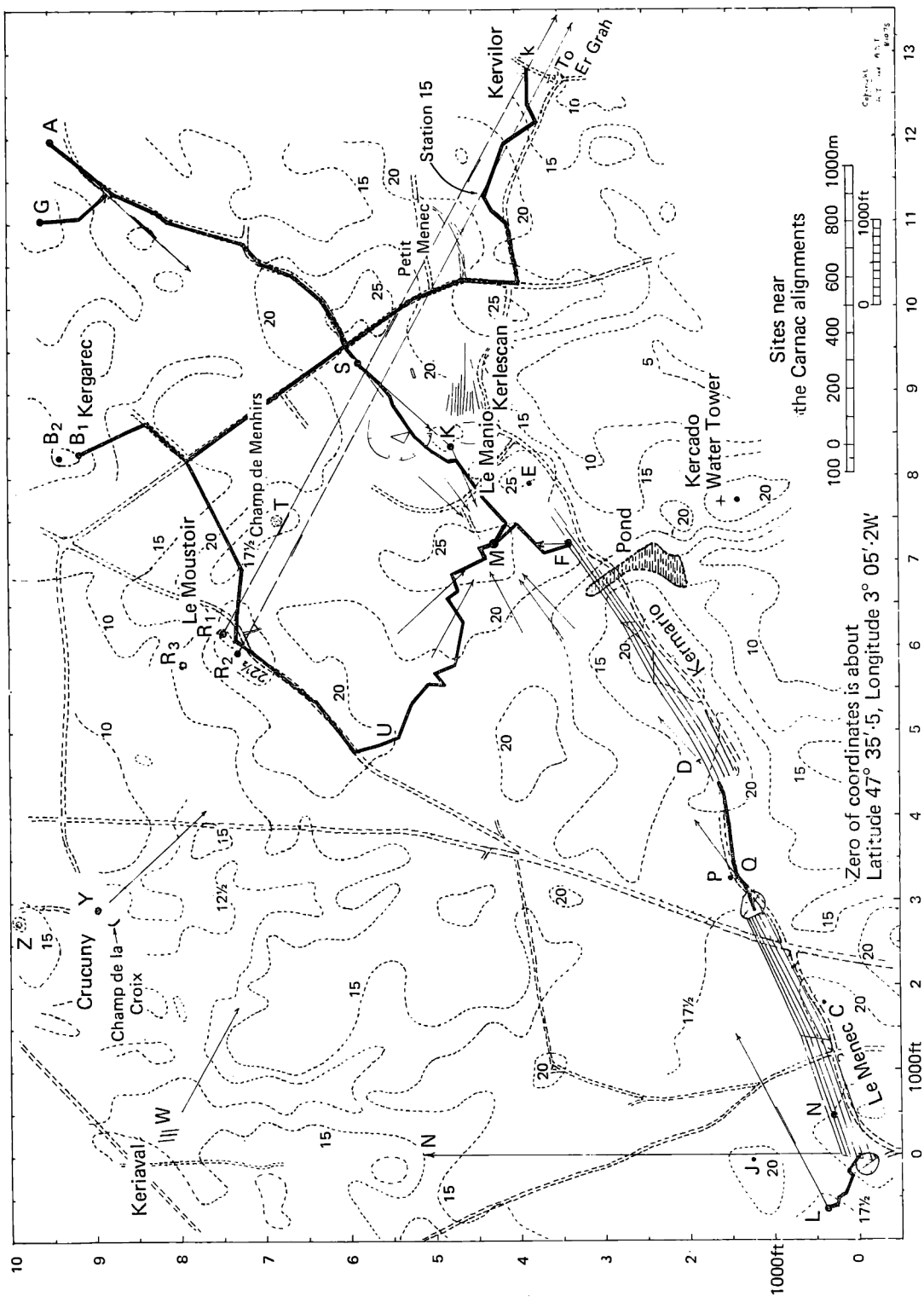

FIG. 1. Sites near the Carnac alignments.

TABLE 1. Sites which may be backsights for the hill-top at Le Manio (see text for other possibilities).

Site	Distance (ft)	Azimuth	Altitude	Parallax used	Declination	Compare
Kerlagad, Stone *A* to Menhir *M*	7032	222°39′	14′	57′	−29°10′	$-(\epsilon+i+s-\Delta) = -29°10'$
Menhir *S* to Menhir *M* (see first paper)	2652	233°42′	21′±	0′	−23°38′	$-(\epsilon-s) = -23°38'$
Menhir *L* to "tumulus" wall	8700	62°19′	14′	57′	18°46′	$(\epsilon-i) = 18°45'$
Boulder *Q* to Menhir *M*	4894	53°30′	25′±	0′	23°35′	$(\epsilon-s) = 23°38'$
Keriaval, most southerly menhir in alignments to Menhir *M*	8000±	118°56′	18′	57′	−18°28′	$-(\epsilon-i-s) = -18°30'$
Crucuny, Menhir *Y* to Menhir *M*	6470±	137°18′±	26′	57′	−29°02′±	$-(\epsilon+i) = -29°02'$

Note: At Keriaval the most southerly menhir now standing has been tabulated merely to give a point of reference and not because there is anything to mark this stone as different from the others. The values for Crucuny depend entirely on coordinates taken from the 1/25000 map.

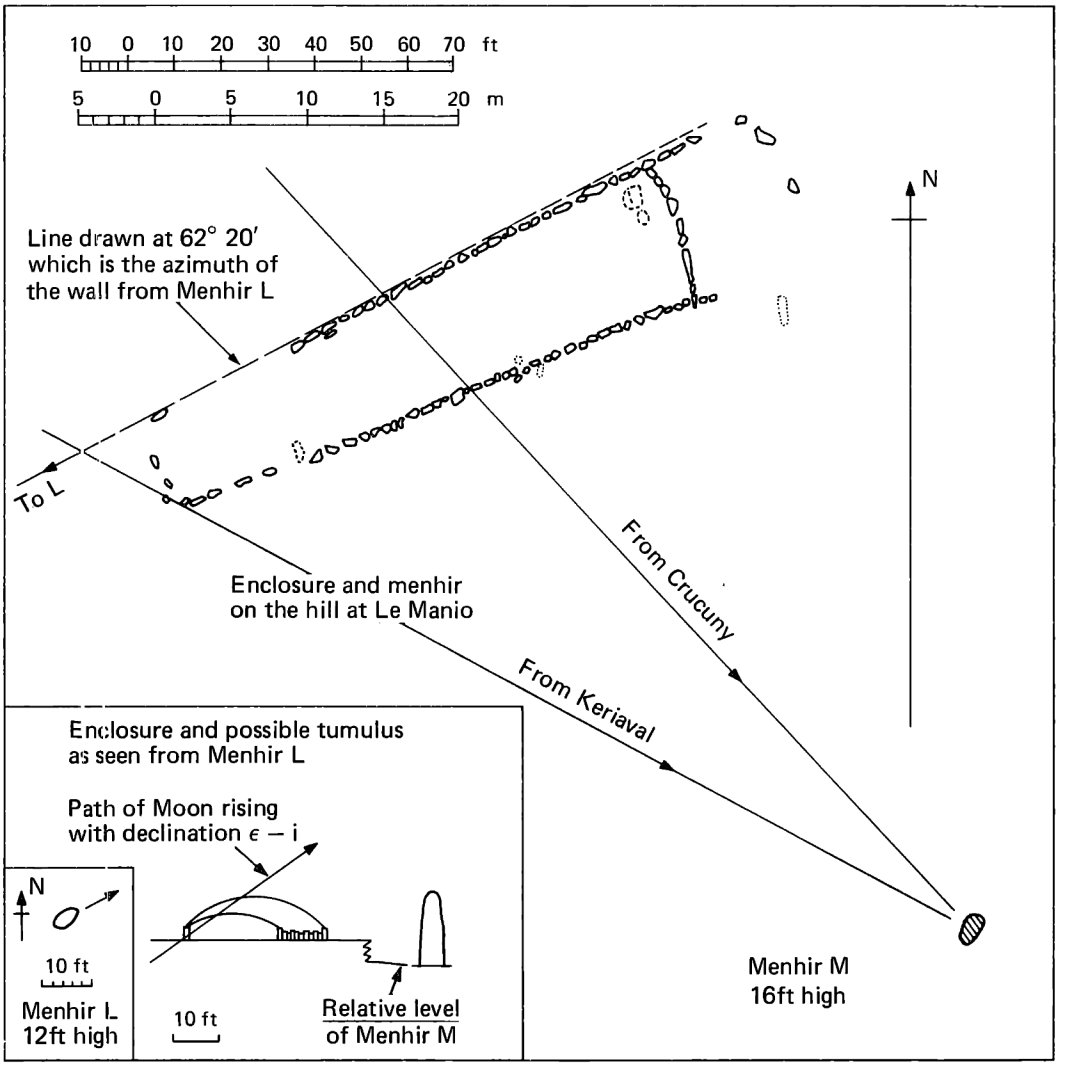

FIG. 2. Menhir *M* at Le Manio and the enclosure, with small inset showing the ground plan of Menhir *L*.

will be mentioned later. Relative levels were difficult to obtain; in France there are no convenient bench marks at close intervals such as we find in Britain and often we had to depend on spot levels on the map which are recorded only to a metre.

In order to obtain the information from which Figure 1 was constructed we ran accurate traverses throughout the area, as shown on the figure. It will be seen that in the middle there is a large closed traverse. This had 36 sides and a total periphery of about $2\frac{1}{2}$ miles, and was found to close to within a foot. We did not attempt to connect on to the French national grid, but all our traverses were worked on a conical projection with the zero meridian at Le Menec. To prevent accumulation of error in bearing in the traverses, at about 30 points in all we measured azimuth accurately by astronomical means. The open traverse to Kerlagad was checked by tacheometer to make sure that there was no gross error.

Lunar Observatories

In recent papers in this journal[2] we have described the lunar observatory at Brogar and shown how the observers worked from the centre and looked out to the foresights, and we believe that Stonehenge was operated in the same manner.[3] At the two large lunar observatories in Carnac a different method was used: the observers looked inwards to a common foresight consisting in each case of a huge menhir. We suggest that of these two observatories the first to be built was centred on a foresight on the hill-top near Le Manio. This is the highest hill in the neighbourhood and in the absence of trees would have been visible from all round. As Professor Atkinson has pointed out,[4] it is probable that the trees which had once grown in the area were absent in Megalithic times and that, in fact, they have grown again only in recent years.

With a view to obtaining declinations, our activities have been largely directed towards the accurate determination of the azimuth, from the various backsights, of the centre stone *M* which stands on the top of the hill. In those places where the rays run very close to the ground we have shown by doubling the lines in Figure 1 where grazing occurs. The difficulties attending examination of the exact conditions of the graze are very great—dense woods and huge whin hedges make levelling difficult. We have done what we could in the time available and believe that in each case the ray clears the ground.

The Hill near Le Manio

We show in Figure 2 a small-scale reproduction of a survey of the menhir *M* and the enclosure which stand practically on the top of the hill. The enclosure is described in Le Rouzic's inventory[5] as an "Enceinte rectangulaire formée de petits menhirs, acquise et restaurée par l'Etat. Ce monument était primitivement enfoui dans un tertre tumulaire allongé, qui a été complètement enlevé". If all the stones were formerly covered as suggested by Le Rouzic, there must have been a large mound and we suggest that there was originally a tumulus retained by the "petit menhirs" which we see today but that these became covered as the tumulus subsided and spread. The ground is now flat and level at the enclosure but at the menhir it is some six feet lower. The menhir is one of the tallest in the district, but was re-erected by Le Rouzic who admits it was scarred during the process.

When the hill was viewed from the surrounding country (except perhaps from the north) there would have been two projections on the skyline: the tumulus and the menhir. It is not entirely without interest that the north wall of the enclosure as it stands today has an azimuth of about 62°36′ while the azimuth of the wall from the stone *L* is 62°20′.

In our first paper[6] we showed that the declination given by the menhir *M* from the menhir *L* is too low for a lunar maximum declination at the minor standstill, but the particulars given in Table 1 show that the use of the north side of the enclosure as a foresight gives a declination of almost exactly $(\epsilon - i)$, where ϵ is the obliquity of the ecliptic and i the inclination of the Moon's orbit to the ecliptic. It is seen in the inset in Figure 2 that the tumulus we have imagined as filling the enclosure provides the necessary foresight for the rising Moon. Two observers would, of course, be necessary, one bringing the upper limb and the other the lower limb into the corner of sky provided by the north

wall of the tumulus and the ground. Here as usual we refer to declination and not to altitude when we speak of "upper" and "lower". Reference should be made to our second paper on Brogar[7] for a possible explanation of how such foresights for $\pm(\epsilon \pm i)$ were established. It will be seen that the present paper provides three or four more cases.

In assessing the probability that L is really a lunar backsight, note that the menhir itself might be said to be orientated on the hill-top and that the wall is on the exact azimuth (see Figure 2).

We shall now look at the other sites in the area which may have been placed to use the hill-top as a foresight (Table 1).

Kerlagad

The large menhir (marked G in Figure 1) at Kerlagad is obviously not a backsight for the stone M at Manio; they are not intervisible, and in any case the azimuth is not correct. This stone perhaps served another purpose, possibly in connection with the stones at Kergarec. We believe, however, that the small stone at A was intended as a lunar backsight for the Moon setting behind the menhir M at the lowest declination at the major standstill.

Stones S and K

In our first paper[8] we showed that from stone S the upper limb of the midwinter setting Sun appeared to graze the bottom of the menhir M on the hill-top, and that in an exactly similar way the Moon with declination $-(\epsilon+i)$ set behind the large menhir K at Kerlescan. From the stone K itself the Sun set over M at the important calendar dates, Martinmas and Candlemas.[9]

Stones P and Q

These stones lie one on each side of the road between the east cromlech at Le Menec and Kermario. Q is a large 8ft egg-shaped boulder and from it the south limb of the midsummer Sun would have been seen to rise close to the menhir M. From the stone P the upper limb of the solstitial Sun would have risen over the tumulus but since we do not know the shape of the tumulus no accurate value of the declination can be given. Neither of these stones can be accepted as a well-established backsight.

The Stones at D

This collection of stones (see Figure 2 of Thom VI), which perhaps formed a backsight, is now in a ruinous condition. It *may* be the remains of a lunar backsight because, from the most southerly stone, the Moon at the major standstill would have appeared to rise near to the menhir M.

Stone F

This is the stone (marked S in Figure 4 of Thom VI) which Atkinson described as belonging to a long barrow which was older than the alignments.[10] From F, M bears due north. In fact, the two stones are within a foot of being on the same meridian.

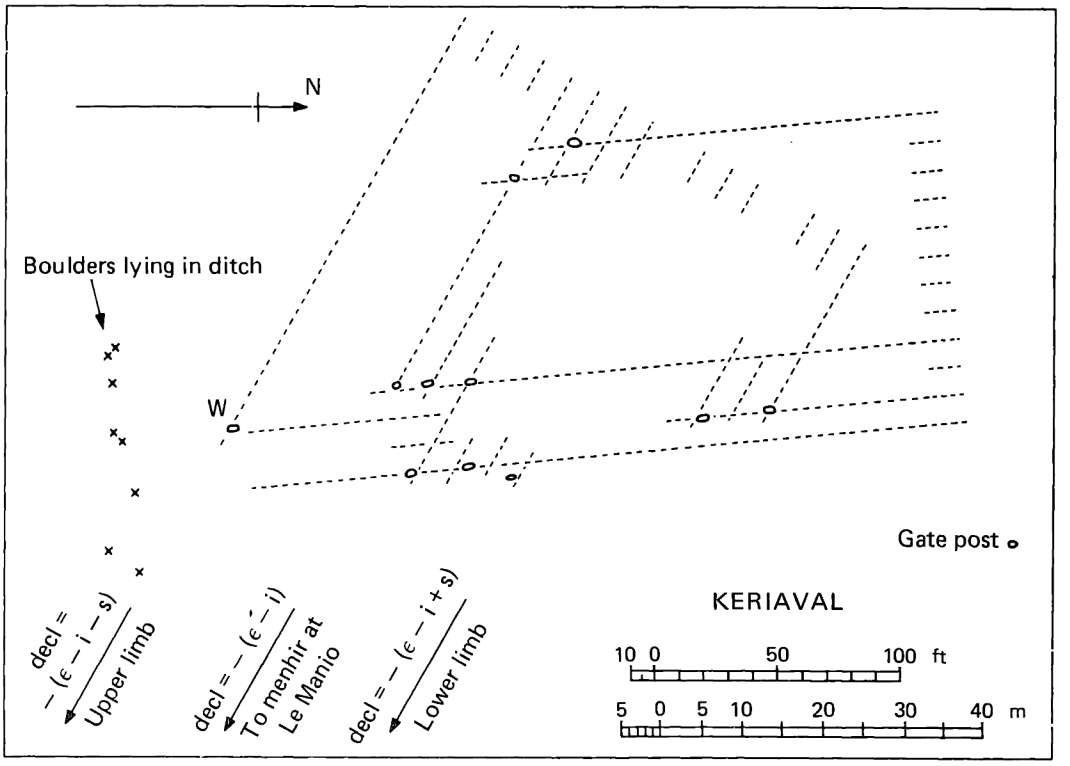

FIG. 3. Remains of rows at Keriaval. The menhirs range up to 6ft high.

The Stone at C

This small unimpressive stone stands near the south side of Le Menec alignments. Seen from it, the solstitial Sun rose with its centre near the top of the tumulus covering the enclosure. There seem to have been three stones in all near *C* and so perhaps an accurate backsight existed in the vicinity.

The Stones N, L and J near Le Menec

We have as yet no explanation for the stone *N* but it is interesting to note that stone *J* lies exactly due north from the centre of the smaller end of the western Le Menec cromlech and due west from the main centre of the eastern cromlech. The stone *L* has been discussed in our first paper[11] and shown to give too low a declination with *M*, but as described above it appears to be an exact backsight for the tumulus wall.

The Alignments at Keriaval

This site is in a depleted condition, but from our survey (Figure 3) it is evident that these upright stones are remains of alignments. We did not have time to run a traverse to this site, but from a position near the alignments we were able to see the water tower at Kercado and we know the coordinates of this relative to *M*. Accurate solar observation gave us the azimuth of the water tower, and so we were able to calculate the approximate azimuth from the site to stone *M*. An examination of Figure 3 shows that Keriaval is evidently an

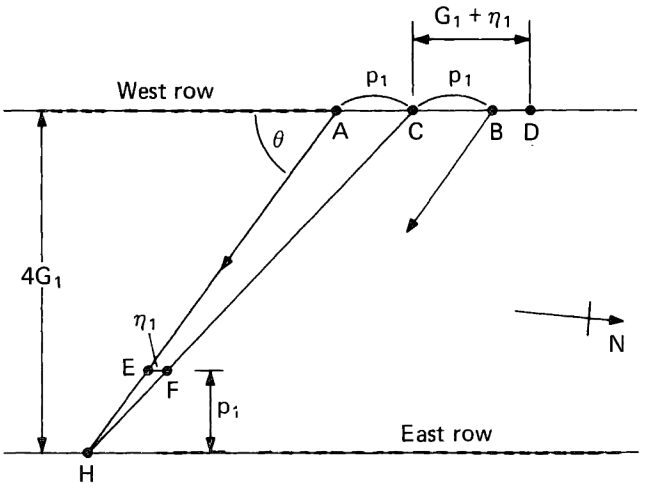

FIG. 4. Suggested method of using the stone rows at Keriaval.

interesting backsight; but how is it to be interpreted? Perhaps the only certainty is that from the menhirs the Moon at its most southerly declination at the minor standstill would have been seen to rise at menhir *M*. Until the site is excavated we cannot be certain that the rows were really as shown by the dotted lines, but these lines seem to be the only possible solution with the information given by the stones as they are today. They form, not a sector, but two sets of equidistant parallel lines, and one of the sets points straight to the menhir *M* at Le Manio. In other words, these lines show where the Moon would have risen at the minor standstill and before Moonrise would obviously have assisted in finding *M*, which would at this site be only some 2 arc minutes wide, past the corner of the enclosure.

The perpendicular distance between the east and west rows, as they are, is 124ft, and it is interesting to note that this is the necessary length $4G$ for an extrapolating sector for use with the Moon rising at *M*, provided that the line of movement of the observer is at right-angles to the sight line.[12]

We might speculate that observers, instead of moving at right-angles, moved along the west row of stones. Let *A*, Figure 4, be the position from which the Moon was seen to graze the foresight *M*. Points *A* and *H* were marked. The next night the observer had to place himself at *B*. *AB* was bisected at *C* and the distance *AC* which we shall call p_1 was set out from the east row. Now measure *EF* parallel to the rows and note that by similar triangles $EF = p_1^2/4G_1$ which we shall call η_1.[13] We must now set out a distance $(G_1+\eta_1)$ from *C* and consider *D* to be the extrapolated position, *i.e.* the position the observer would have occupied if it so happened that the maximum negative declination had occurred at the instant when the Moon was rising.

The procedure just described is, however, theoretically correct only if the fundamental distance G_1 had been measured[14] by moving *along* the rows, and in that case it would have been larger than $G = 124/4 = 31$ft. It is indeed possible that there were other rows, now destroyed, which made the width greater than 124ft but until the site is properly excavated we cannot assume this with any certainty. Obviously, excavation of the area is desirable.

Why did the observers not place the rows normal to the sight-lines? In thinking of this, one must bear in mind that there may have been another foresight to the northeast for positive declination, *e.g.* the stone *Z* on the tumulus at Crucuny. These rows might then have served a dual purpose, but it must be emphasized that with our existing knowledge of the site the above suggestions are entirely speculative.

There are other sites, *e.g.* at the Communion stones in Dumfriesshire and at a site near Dounreay in Caithness, where there are parallel rows, and these should be examined to see if perhaps they were associated with a lunar foresight.

We have indicated on Figure 3 the ideal positions for the observation of declinations $-(\epsilon - i)$, etc., but it would be more satisfactory to have these checked by running a traverse to the site to determine the coordinates more exactly.

The Site at Crucuny known as Le Champ de la Croix

In Figure 5 we show our survey of this site but knowledge of its *position* comes from the large-scale French maps. The stones in all that remains of the cromlech form a field boundary round the outside of which runs a cart track. Nearby there is a large upright menhir *Y* and it is likely that this formed a backsight for the stone *M*. We have shown on the plan the theoretical stance for observing the declination $-(\epsilon + i)$ but this position cannot be accurately plotted until we have run a traverse to determine exactly the position of the site relative to *M*.

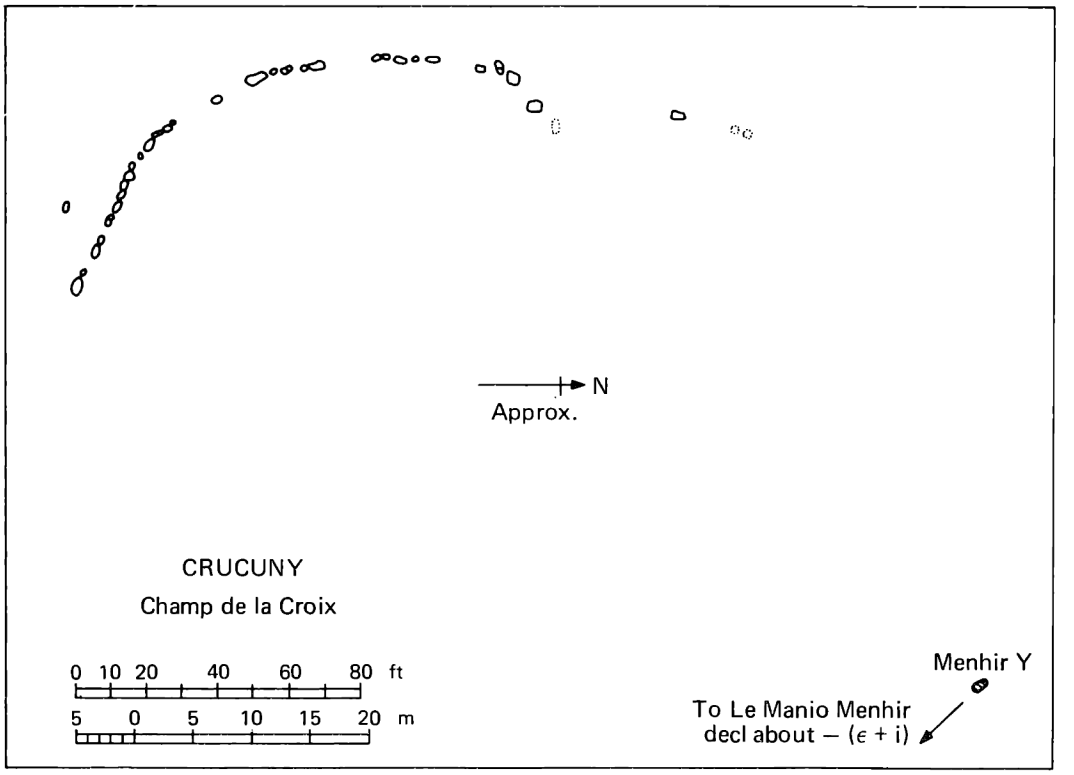

FIG. 5. Remains of cromlech at Crucuny, showing position of upright Menhir *Y*.

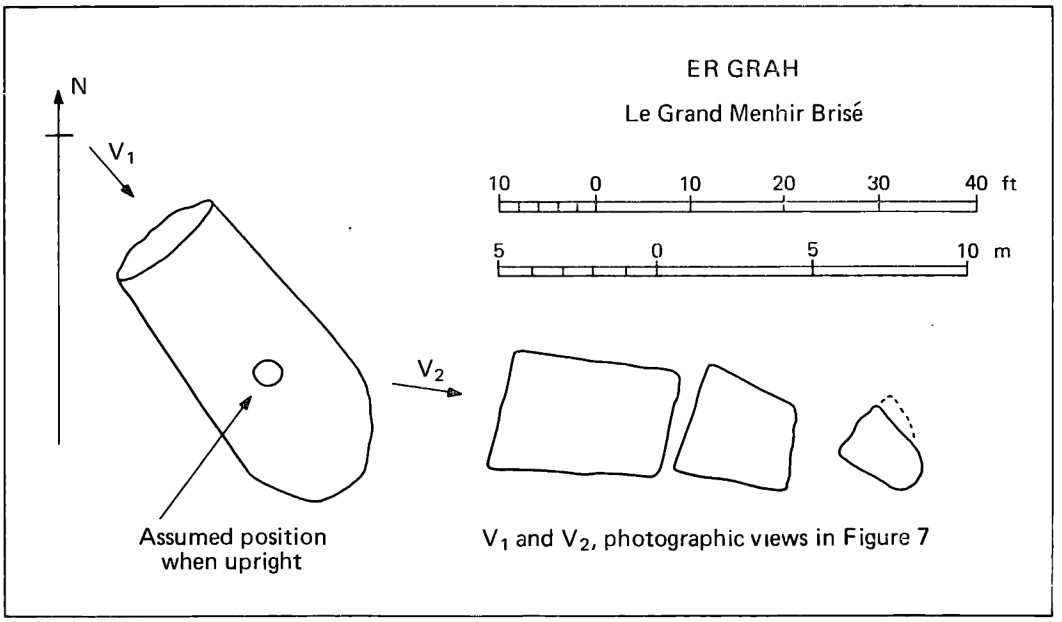

FIG. 6. *Le Grand Menhir* as it lies today.

The Hill at Le Manio as a Universal Foresight

Above we have described ten possible backsights, namely *A*, *S*, *K*, *F*, *L*, *D*, *P*, *Q*, *W* and *Y*. The uses of *A*, *S*, *K*, *F* and *L* seem to us to be well established and it is likely that further work will establish *Y*. It seems reasonable to conclude that this complex was a lunar observatory.

We assume that Le Rouzic re-erected the menhir *M* in its original position. Why then is this position so far to the south and not on a slightly higher position near the enclosure? In examining what we find it is necessary to remember that Megalithic activity of the kind we are considering was spread over perhaps a thousand years and so we must not be surprised to find one system superimposed on another. We suggest that *M* was erected at a later date than the tumulus to fit into a new pattern being developed for the backsights.

The ray from *A* grazes the hillside, which slopes down to the southeast, where shown. Taking levels here was difficult because of trees and scrub but the graze seems to be close, so close that it may have been considered necessary to site *M* in its present position instead of at the enclosure. Perhaps also it was sited well away from the tumulus to avoid confusion.

M. Jacq, son-in-law of Le Rouzic and, before he died, curator of the Miln–Le Rouzic museum in Carnac, told us that there had been a cromlech at the east end of the Kermario alignments on the high ground immediately to the east of *E*. Perhaps there were backsights for *M* on this hill, but the site seems to be very near *M* and so the backsights may have been further away, near Kerdreneven.

Once *M* was erected, the backsights *S*, *K*, *A* and perhaps *W* and *Y* were built where we now find them. This is entirely speculative, but if it is correct then we suggest that at this stage work on this observatory was dropped (including

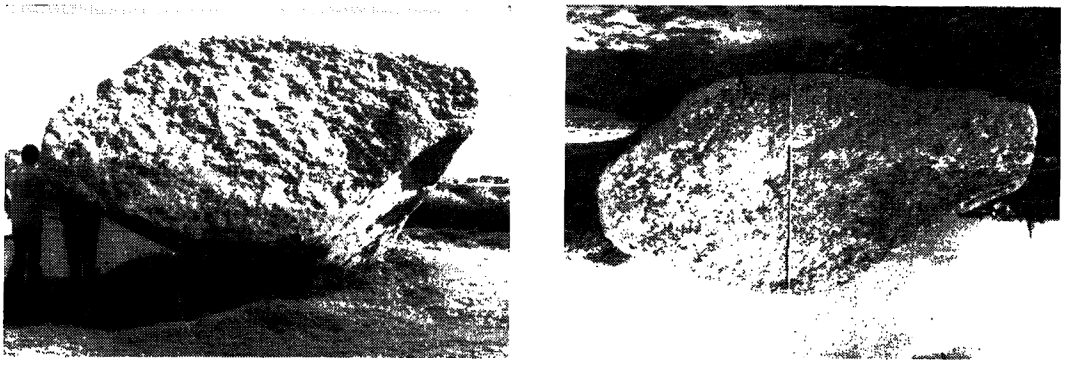

FIG. 7. (a) Direct photograph of the end of the base section of *Le Grand Menhir*, from northwest.
(b) Inverted mirror image of photograph of the end of the next section, from northwest (obtained by printing the negative from the back).

the re-siting of the 12ft menhir at *L*) and activity was diverted to the much larger scheme involving the erection of the huge foresight at Er Grah known as Le Grand Menhir Brisé. As has been explained in our first paper,[15] it would not have been possible to select a site for Er Grah without a knowledge of the Moon's movements, and this knowledge may have come from the earlier observatory centred on the hill-top at Le Manio.

Le Grand Menhir Brisé

We show in Figure 6 a plan of the parts of this huge menhir as they lie today. We also show photographs of the ends of the two bottom sections in Figure 7. It will be seen how perfectly these parts fitted together, and that apparently little or no weathering has taken place; this suggests that the break is comparatively recent. Le Rouzic apparently found Roman remains under the bottom section, so presumably the stone was upright in Roman times. In our first paper we made our measurements to the centre of the northwest end of the bottom section, but in the present paper we have measured to the point shown by a circle on the plan.

We agree with Atkinson[16] that the only explanation (short of Cyclopean intervention) for the present position of the sections is that the lower break (or at least the separation) occurred while the stone was still upright, and that it must have been produced by a shake due to an earthquake. Experiments with blocks piled on a tray show that it is quite impossible to produce the arrangement which we find by any other way than by shaking the tray. But the shake must have been very violent to produce a break in this huge stone. Are there any records of a violent earthquake in Brittany?

Fresh Backsights for Er Grah

In our first paper we mentioned the possibility that two stones above Kervilor might be the remains of backsights for Er Grah at the minor standstill. We now show that for this case there are three other possible backsights.

Referring to Figure 1, the reader will see that we have connected the menhirs at Le Moustoir by a traverse to Station 15 on our survey situated on the high

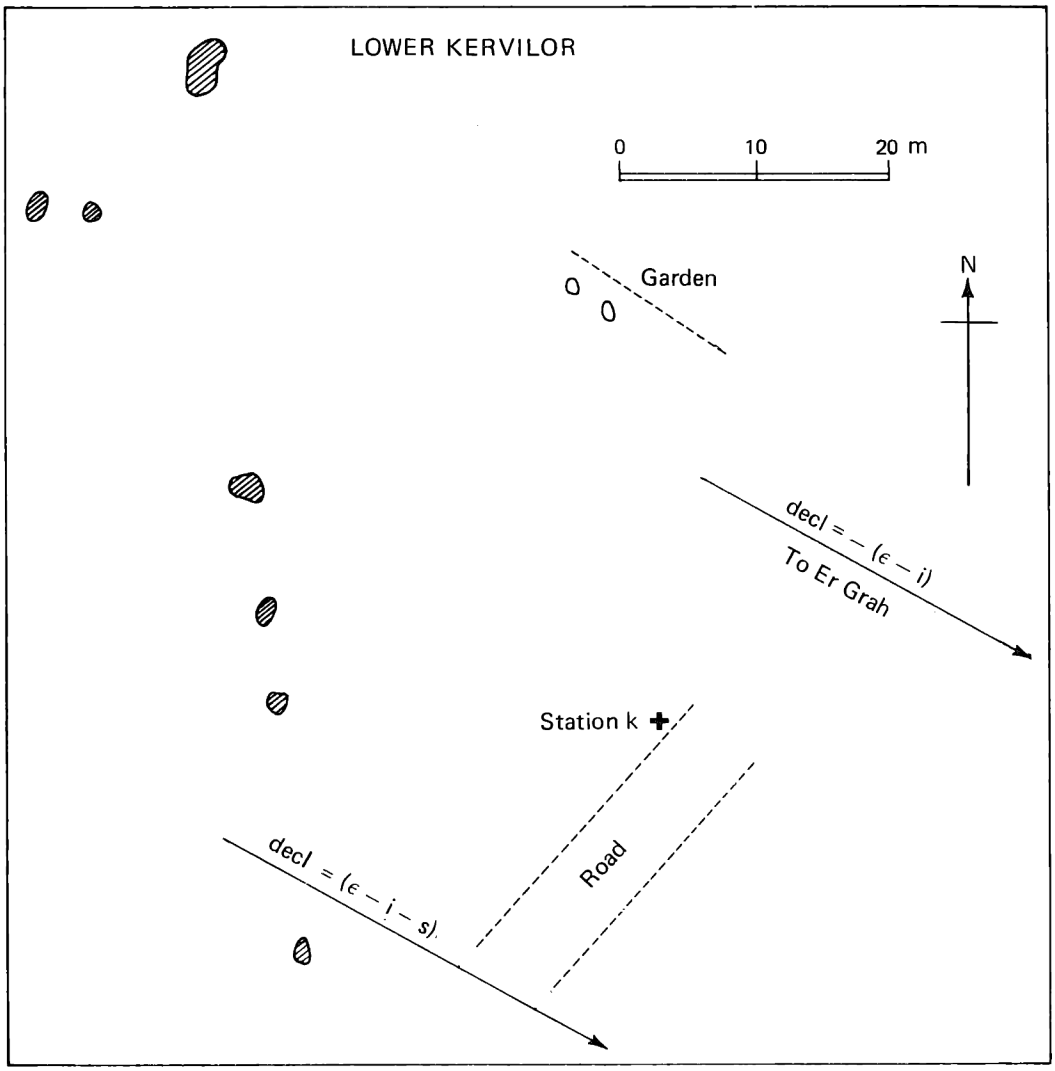

FIG. 8. The site below Kervilor Farm (in process of being removed in 1973).

ground above Kervilor. This point was chosen because from there it was possible to see the water tower near Le Grand Menhir, and the relation between this water tower and the stone is given in our first paper. The *distance* from Station 15 to the water tower was calculated carefully from the 1/25000 French maps. From what has just been said it will be clear that we were able to obtain the azimuth of Le Grand Menhir from Le Moustoir, but there remains the question of intervisibility—at several points the rays were very close to the ground. Levels were determined all along this traverse, and short open traverses were run to the points where the rays seemed likely to run into the ground; it appeared that in every case they just cleared. These points are marked on the survey by doubling the line showing the ray.

With regard to the site just below Kervilor which was being bulldozed to make way for a house, we made a survey of what remained at Easter 1973 (Figure 8), and connected it to Station 15 by a tacheometric traverse. Although

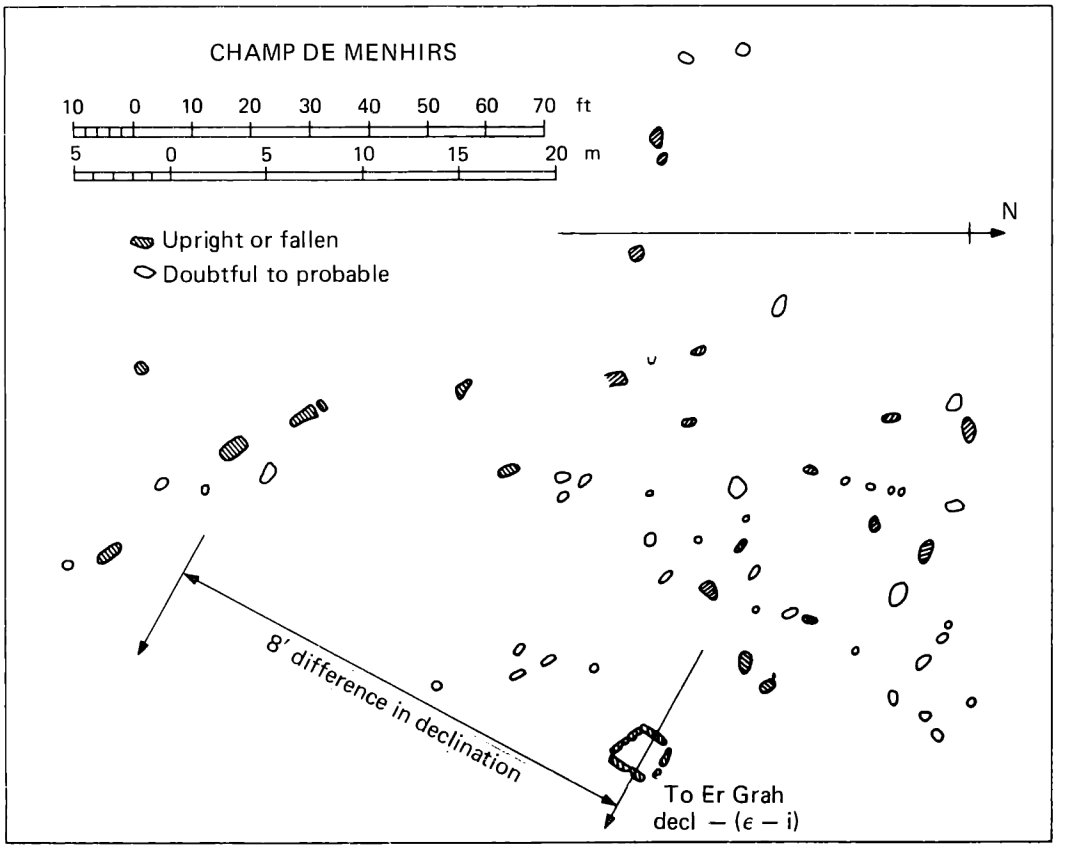

FIG. 9. Champ de Menhirs, near Le Moustoir. Some of the stones shown may be outcrops, but those shown hatched are considered to be menhirs, upright or fallen. The site is on a low flat-topped hill.

this site is low, the top half of Le Grand Menhir would have been visible (see Figure 4 of our first paper) and as it is in the correct position the stones are probably the remains of a backsight for this menhir. We picked up another site along these rays, called Le Champ de Menhirs. Some of the stones which we have marked on our survey of this site (Figure 9) may be natural outcrops. Others have fallen, but there are undoubtedly 'menhirs' amongst them, and there is also a peculiar trapezoidal enclosure. An examination of the figure or of Table 2 shows that this site is another probable backsight for Le Grand Menhir.

In our second paper on Stonehenge we show how a ray passing close to the ground may suffer under certain conditions an additional refraction of about 2 arc minutes.[17] It appears that the rays from Le Moustoir and Le Champ de Menhirs might be affected in this way, but at present we can make no realistic estimate of the exact amount of the necessary corrections.

In Table 2, which gives particulars for the possible backsights for which we can determine definite declinations, we have used a mean parallax of 57′·0 and taken refraction as 35′ for altitude −3′ with *no* allowances for the grazes. The values in the column headed "compare" have been formed by taking $\epsilon = 23°53'{\cdot}8$ (1700 B.C.), $i = 5°08'{\cdot}7$, $s = 15'{\cdot}5$ and $\Delta = 8'{\cdot}0$, where s is the Moon's mean

TABLE 2. Sites which may be backsights for use with Er Grah as a foresight for lunar observations.

Backsight	Azimuth	Altitude	Declination	Compare
Le Moustoir, menhir on tumulus, R_1	118°42′	−3′	−18°38′	$-(\epsilon-i) = -18°45'$
Le Moustoir, menhir near tumulus, R_2	118°12′	−2′	−18°19′	$-(\epsilon-i-s-\Delta) = -18°22'$
Champ de Menhirs, trapezium	118°53′	−3′	−18°45′	$-(\epsilon-i) = -18°45'$
Kervilor, Stone *C* (see first paper)	119°09′	−1′	−18°54′	$-(\epsilon-i+s-\Delta) = -18°53'$
Kervilor, Stone *D* (see first paper)	118°27′	0′	−18°28′	$-(\epsilon-i-s) = -18°30'$
Kerran, small menhir	136°13′	+3′	−28°46′	$-(\epsilon+i-s) = -28°47'$
Kerran, dolmen	136°29′	+3′	−28°54′	$-(\epsilon+i-s+\Delta) = -28°55'$
Kervilor, lower	118°45′	0′	−18°39′ as seen from *k* (Fig. 8)	

semidiameter and Δ is the mean perturbation of i. The value used for ϵ was chosen merely to allow comparisons to be made, but it should not be assumed that the date 1700 B.C. is necessarily the date of the site. To see how difficult it is to assign a date any more accurately than ± 200 years reference should be made to our second paper on Brogar.

We suggest that there were perhaps four sets of backsights for the minor standstill with negative declination, along the line from Le Moustoir, namely Le Moustoir, Champ de Menhirs, stones above Kervilor, and stones below Kervilor. Did the erectors discover that the first two of these were being badly affected by changes in the graze effect due to weather and so discarded them for the others which do not graze? It should perhaps be said that we are not certain that R_1, which stands on top of the tumulus, is in its original position.

Other Menhirs in the Area

There are two or three places where the modern 1/25000 map marks "menhir" but where we could not find anything. One of these places we have marked *U*. We did find some small stones near *U* a few inches high and ran a particularly difficult traverse from Le Manio to pick them up. They proved to have no significance, but we later continued the traverse along the road to Le Moustoir and so completed the circuit.

There are two stones B_1 and B_2 near the top of the hill at Kergarec but the map seems to show three. The thick growing whin makes these almost unapproachable, but we did succeed in determining their coordinates. The south stone lies if anything to the west of the ridge, but the next stone is roughly on the summit. We suggest that the south stone may have formed a foresight from the large menhir R_3 just to the north of and below Le Moustoir to give a declination of about $(\epsilon-i)$. The position of R_3, however, remains to be checked. If the third stone, the most northerly shown on the map at Kergarec, exists (or existed) it probably gave an equinoctial declination viewed from the large

TABLE 3. Coordinates of key points in the area (in feet). The origin is near Le Menec and the N axis in the meridian there. Any bearing AB calculated from these coordinates should have $1{\cdot}78\ E_A \times 10^{-4}$ arc minutes added to it to give the azimuth of AB from the A end.

Point	E	N	Point	E	N
L	−636	379	S	9338	5858
M	+7203	4288	15	11362	4357
R_1	6149	7480	k	12801	3861
R_2	5912	7304	Water Tower	7685	1593
B_1	8286	9162	E	7909	3861
B_2	8238±	9356±	F	7204	3398
G	11015	9595	T	7512	6846
A	11964	9462			

menhir G at Kerlagad. There are, however, the *remains* of other broken stones just to the west of G and a further examination of the area might give a clue as to the use of this stone G.

Growing crops prevented an approach to the menhir at Kerluir which lies just outside the southern boundary of the area. Thus it appears that inside the rectangle of Figure 1 there are only two or three upright menhirs (apart from the alignments and cromlechs) for which we cannot tentatively suggest a use. Mean sea level is several metres higher than it was in Megalithic times, witness the submerged cromlech on the island of Er Lanic. The result is that any menhirs perhaps placed to use small islands or reefs out at sea as foresights are now meaningless.

Conclusion

We have made an intensive study of a definite area (see Table 3 for the coordinates of the key points) and consider that a large proportion of the upright stones in this area have astronomical significance. Perhaps if we could see all the material which formerly existed we should find that all the stones were astronomical. We exclude the alignments but in earlier papers we have shown the possibility that some of them were used for extrapolation in connection with the Er Grah lunar observatory. This explanation of these great alignments may not be universally accepted, but there must have been some strong conviction to motivate an enterprise of such magnitude.

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