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THE NORTH MULL PROJECT (2): THE WIDER ASTRONOMICAL POTENTIAL OF THE SITES

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The aim of the North Mull Project is to examine the apparent lunar significance of the orientations of the short stone rows of northern Mull in its fuller archaeological context through an integrated program of excavation, locational analysis, horizon survey, and statistical investigation. This is the second in a series of papers describing the progress of the project. In Part One (*Archaeoastronomy*, no. 14 (1989), S137–49) we gave a project overview and described the excavations and some of the related environmental and survey work at Glengorm during 1987 and 1988. This confirmed that the Glengorm site was indeed originally a stone row similar to the others in northern Mull, and that its orientation followed the general astronomical trend observed in the other sites. It was also discovered that the prominent distant peak of Ben More lay in this alignment, an observation suggesting more complex hypotheses relating natural horizon features and astronomical symbolism.

In this and the following paper we examine the wider astronomical potential of the seven sites, as evidenced by two factors: (i) the distribution of horizon distance with azimuth, and (ii) the presence and astronomical potential of prominent hills. In Section 4 we discuss potential problems in the analysis of such data, and explain the approaches that are taken. These include 'global' analyses and 'local' analyses in the vicinity of each site. We then proceed to describe the global results together with the local results for Glengorm, Section 5 dealing with the azimuthal distribution of horizon distance and Section 6, in the following paper, with the presence and astronomical potential of prominent hills. The local results at the sites other than Glengorm will be given in a later paper in the series.

Continuing aspects of the project, including excavations at Ardnacross which have been undertaken since 1989, will also be reported later in the series.

4. APPROACHES TO THE ANALYSIS OF WIDER ASTRONOMICAL POTENTIAL

4.1. *Introduction*

This and the following paper address aspects of the third and fourth of the general project objectives listed in Part One,[20] namely to explore factors that might have influenced the choice of location and the choice of orientation of the north Mull stone rows. A multivariate locational analysis considering factors such as topographic position, local geology, altitude, proximity to water and so on will serve to identify the physical factors influencing site location. Such an

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analysis is under way and will be fully reported in another paper. Here we shall concentrate upon factors directly related to the general astronomical potential of the sites.

One such factor is the distribution of horizon distance with azimuth. Observations of horizon astronomical phenomena such as the changing rising and setting position of the sun or moon, even at a relatively low precision of a degree or two, require a reasonably distant horizon that is not obscured by nearby land and vegetation. Thus an interest in a particular horizon astronomical event will require site locations to be chosen so as to avoid too local a horizon in the general direction of the event. This will restrict the options available to the builders given other factors influencing the choice of location: according to the nature of the local topography, this restriction might be a loose or very tight one.

Another factor is the presence and astronomical potential of prominent horizon features. Thom's work on high-precision astronomy[21] emphasized the possible use of features on distant horizon profiles as foresights accurate to a few minutes of arc, the 'ideal' type of foresight being a notch between two hills where the top limb of the sun or moon appears momentarily.[22] However, reassessments have challenged the evidence for high-precision astronomy on a number of grounds.[23] More recent work on the Scottish Recumbent Stone Circles (RSCs), a coherent group of sites for which there is overall evidence of a symbolic interest in the moon manifested to a low-precision in the site architecture, has drawn attention to the possible importance to the builders of prominent hills, possibly directly associated with astronomical events, but possibly as a separate concern.[24] The association of the original alignment at Glengorm with the peak of Ben More[25] raises the question of whether certain prominent hills were of significance to the builders of the western Scottish rows also, and, if so, what was the nature of the relationship (if any) between these hills and notable horizon astronomical events.

There are a number of potential problems in the collection and analysis of data relating to the two factors we have identified. The first relates to the data sample that is taken. The simplest approach is simply to compare data from each of the sites themselves. Such an approach can draw attention to common features relating to the chosen variables, but provides no data on other factors that might have influenced the choice of location. In the case of the Recumbent Stone Circles of eastern Scotland, where the number of sites was relatively large and the geographical distribution fairly wide, it is evident that topographical trends can explain neither the aversion towards local horizons to the south[26] nor, more particularly, the total lack of local horizons in the direction of orientation.[27] But because only seven sites are under direct consideration in northern Mull, such an approach can do little here but suggest some initial ideas.

A second approach is to compare the astronomical potential of the sites themselves with a set of 'control' locations chosen by a suitable selection procedure. This approach has two variations. The first is to choose the control group by a procedure that generates spatially pseudo-random points within the area under consideration. Other locational factors are not taken into consideration, except implicitly in restricting the area under consideration: for example, points at elevations greater than some stipulated limit may be excluded. The result is a univariate locational analysis that may, if the sample is sufficiently large, be used in the classical sense to test whether there is a significant difference between a group of sites and the control group.

The second variation represents a 'halfway house' between the univariate approach and the full multivariate approach mentioned at the beginning of this section. First, we attempt to identify locational factors other than astronomical potential that appear to link the locations chosen by the builders of the stone rows. Then, we attempt to identify alternative locations in the vicinity of each site that appear to satisfy the locational prerequisites just as well as the locations actually chosen. We can then undertake a 'local' analysis at each site, where the astronomical potential of the location chosen is compared with a set of alternatives that appear equally plausible on other grounds. Since it precedes the full multivariate analysis, the process by which the common locational factors linking the sites are identified is necessarily subjective; furthermore, the decision affects the choice of alternative locations. However, provided that care is taken *not* to let considerations of astronomical potential influence the choice of alternative locations, then the process will not result in a biased sample.

These three approaches — simple inter-site comparison, 'global' analysis comparing the site locations with a set of pseudo-random controls, and 'local' analyses comparing the astronomical potential of a site location with a set of alternative locations apparently equally plausible on other grounds — give us a number of ways to examine and attempt to analyse possible astronomical constraints upon site location. The other crucial element in the architecture of the stone rows is their orientation. Largely influenced by the work of Thom, archaeoastronomical investigations of prehistoric British megalithic sites have concentrated heavily on the astronomical potential of the horizon in directions indicated by the architecture of the site. Indeed, it was an apparent correlation between site orientation and lunar horizon events at these sites, revealed as part of a wider analysis,[28] that triggered this closer examination of the north Mull stone rows in the first place. However, as part of the closer examination of these sites we need to ask to what extent their orientation might have been determined by astronomical factors. This implies that we need to examine the astronomical potential of the horizon away from, as well as in, the direction of orientation.

It is relatively easy to explore the relationship between site orientation and the distribution of horizon distance. All that is required for each site is to convert absolute azimuths to azimuths relative to its orientation. The data are then combined. If the number of sites is sufficiently large and the scatter in their orientations is reasonably great, then unless orientation trends are related to horizon distance, any topographical effects giving rise to an uneven distribution of horizon distance with azimuth will tend to be evened out by the 'relativization' process, so that the expected distribution of horizons in any distance category will be uniform. Thus any significant deviations from uniformity, such as the total avoidance of local horizons behind the recumbent stone at the

Scottish RSCs,[29] can only be explained by a deliberate policy of orientation. The elegance of this approach is due to the way in which the influence of local topography upon horizon distance is eliminated. Its power is only decreased in two instances. The first is if the range of site orientations is limited, giving rise to a lower limit to the precision at which topographical effects will be eliminated and 'real' effects will be discernible. In the case of the Scottish RSCs, for example, all site orientations fall within a 90° span of horizon centred upon SSW, so that an apparent preference for distant horizons in a direction about 110–120° anticlockwise from the axial orientation towards the recumbent stone[30] is probably due to the general topography of the area in which the sites are situated, with wide views prevailing towards the east, which is the direction downhill towards the sea. The second limiting circumstance is if the number of sites is small, as in northern Mull, so that there are insufficient data to demonstrate whether observed deviations from uniformity are significant. Such deviations may still, however, be worthy of note.

A more complex problem is to establish the significance or otherwise of prominent hills, whether directly associated with an astronomical event or not, in directions other than the orientation of the site. An obvious difficulty is finding a suitably objective measure of prominence. This difficulty is compounded by the large number of candidate prominent hills which is to be expected at a typical (arbitrary) point in the landscape of western Scotland, and the large number of potential astronomical targets (especially stellar ones if the date of use is not known) no more than a handful of which could have been of significance at any particular location, however carefully it was chosen. This means that there is a noise level in the data so great that it is simply not viable to adopt an hypothesis-testing approach.[31] On the other hand, if we adopt a more interpretative approach, selecting particular sets of prehistoric structures, foresights and astronomical targets that seem to fit a noticeable pattern, we may well have omitted very many similar prehistoric structures, potential foresights and astronomical targets that were equally likely on *a priori* grounds. Discovering astronomical patterns is one thing; demonstrating convincingly that prehistoric people were interested in these phenomena, and located and designed sites with these influences in mind, is quite another.[32]

How, then, can we be interpretative but yet be demonstrably objective? A long-term answer may be to adopt an approach based on a different statistical methodology.[33] For present purposes, we favour an approach where a small number of particular candidate hills and astronomical targets are made the focus of attention, and conclusions are drawn by comparing the actual distribution of sites with a locational analysis of the potential use that could be made of them. This is essentially the approach adopted in a study of the stone rings at Machrie Moor on Arran,[34] but the process of obtaining control data was hugely labour intensive. During the course of the North Mull Project complete horizon surveys have been obtained at the sites themselves and are in progress at the local alternative locations. However, no attempt will have been made to provide all-round horizon surveys at general control points. The alternative strategies adopted and proposed are described in Section 6.2 below.

4.2. *'Alternative' Sites in the Vicinity of Glengorm*

The third, 'local' approach described above involves identifying 'alternative' sites in the vicinity of each of the stone rows that appear equally plausible on grounds other than astronomical potential. Teams of Earthwatch volunteers were charged with the task during the first season of fieldwork on the project in 1987. Each team was given a list of locational indicators including elevation, slope and aspect, topographic position (hill summit, ridge, terrace, saddle, valley bottom, etc.), soil cover (total, partial with rocky outcroppings, etc.), drainage, land use, ease of approach, proximity to fresh water and proximity to the sea, but excluding indicators that might have any bearing on astronomical potential such as the orientation of horizon visibility. The team was then asked to identify suitable alternative locations for a given site that appeared to satisfy the locational criteria just as well as the location actually chosen by the builders. Unaware of the exact details of the astronomical potential of particular horizon features as viewed from various locations, we can be confident that their choices were uninfluenced by the astronomical possibilities.

The common aspects of the locations of the seven north Mull stone rows appear to be that they are on level or gently sloping ground, easily approachable, and well drained. However, other factors vary from site to site. Topographic position is an example: Maol Mor is situated on the crest of a high ridge, though not at the highest point; Dervaig N is on a low ridge, a mere 400m from a higher ridge running parallel; Glengorm is on the end of a slightly sloping terrace, overlooked by higher terraces; Quinish, Balliscate and Ardnacross are on level platforms in generally sloping ground; and Dervaig S is in a narrow saddle.

Eight alternative sites were identified at Glengorm, five at Quinish, three at Ardnacross, four at Balliscate and eight at Dervaig (around the two sites). None was identified at Maol Mor owing to extensive afforestation. The sites local to Glengorm are considered in what follows, the remainder being left for a later paper.

The general location of the Glengorm alternative sites is indicated in Figure 5. Their positions were determined by survey and the locational notes are essentially those providedby the volunteers.

Glengorm standing stones. NM 4347 5715, 41m.
General situation. At the SE extremity of the NW–SE ridge of Druim Rèidh. Immediately to the NW of the stones the ground rises gently, until some 150m from the site there is a sharp rise to a rocky summit. Immediately to the SE is boggy ground that formed a lake in prehistoric times.[35] To the NE of the stones is a sharp rise to a terrace some 5m higher than that on which they are placed; some 100m away in this direction the ground starts to rise sharply up to the site of Glengorm Castle. To the SW the ground slopes away to a flat valley bottom.
Local topography. At the SE tip of small terrace sloping gently down from the NW.
Slope and aspect. Slightly sloping downhill to E.
Soil cover. Thin soil cover with some rocky outcroppings.
Drainage. Good.
Land use. Improved grassland.
Ease of approach. Easily accessible along terrace from NW or uphill from the valley bottom to the SW.
Proximity to fresh water. Small stream 250m to the SW.
Proximity to sea. Rocky bay 700m to the NNE.

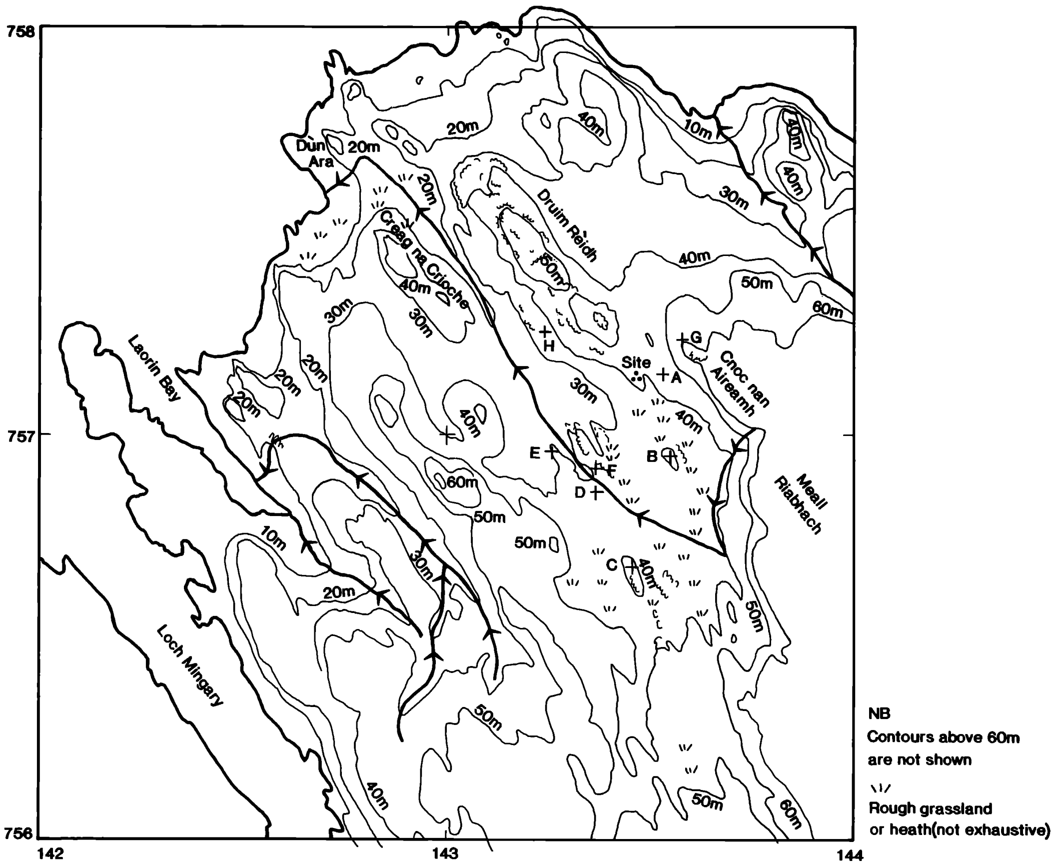

FIG. 5. 'Alternative' sites in the vicinity of Glengorm, based on Ordnance Survey map, © Crown copyright.

Site A. *NM 4353 5715, 47m.*
General situation. 50m ENE of the Glengorm stones, on an adjacent, higher, level terrace.
Local topography. Towards the SW edge of a wide, level terrace extending along the SW slopes of Cnoc nan Aireamh. To the N, the terrace rises gently towards a low saddle between Druim Rèidh and Cnoc nan Aireamh.
Slope and aspect. Slightly sloping downhill to S.
Soil cover. Total soil cover.
Drainage. Good.
Land use. Improved grassland.
Ease of approach. Easily accessible from any direction except the SW, where there is a sharp drop to a lower terrace.
Proximity to fresh water. Small stream 300m to the SW.
Proximity to sea. Rocky bay 650m to the NNE.

Site B. *NM 4355 5695, 42m.*
General situation. 200m SSE of the Glengorm stones, separated from them by boggy ground.
Local topography. On the top of a small hill plateau.
Slope and aspect. Slightly sloping downhill to SE.
Soil cover. A few rocky outcroppings.
Drainage. Good.
Land use. Unimproved grassland.
Ease of approach. Accessible from the W and S; boggy ground (formerly a lake) makes access difficult from the N and E.
Proximity to fresh water. Small stream within 150m to the E, S and W. Modern drainage alterations make its original course uncertain.
Proximity to sea. Bay near Dùn Ara, 1200m to the NW.

Site C. *NM 4346 5668, 41m.*

General situation. 450m S of the Glengorm stones, amidst flat boggy grassland on the far side of the small stream.
Local topography. On the top of a small hill plateau.
Slope and aspect. Level.
Soil cover. Thin soil cover with rocky outcroppings.
Drainage. Good.
Land use. Unimproved grassland.
Ease of approach. Accessible from the NW; otherwise surrounded by boggy ground.
Proximity to fresh water. Small stream some 100m to the NE. Modern drainage alterations make its original course uncertain.
Proximity to sea. Inlet at Laorin Bay, 1000m to the WNW, over hills via Bealach Breac pass.

Site D. *NM 4337 5686, 38m*.
General situation. 300m SSW of the Glengorm stones, on the far side of the small stream.
Local topography. On a platform on a low ridge running NW–SE.
Slope and aspect. Slightly sloping downhill to W.
Soil cover. Thin soil cover with rocky outcroppings.
Drainage. Good.
Land use. Unimproved grassland.
Ease of approach. Accessible from the W or SW, but the stream blocks access from the N and E.
Proximity to fresh water. Adjacent to a small stream.
Proximity to sea. Inlet at Laorin Bay, some 900m to the W, over hills via Bealach Breac pass.

Site E. *NM 4326 5696, 32m*.
General situation. 250m SW of the Glengorm stones, separated from them by boggy ground.
Local topography. On a platform towards the NW end of a ridge running NW–SE.
Slope and aspect. Level.
Soil cover. Thin soil cover with rocky outcroppings.
Drainage. Good.
Land use. Unimproved grassland.
Ease of approach. Accessible from the S, around the ridge, and from lower ground to the W, but the stream blocks access from the N and E.
Proximity to fresh water. 50m from a small stream.
Proximity to sea. Inlet at Laorin Bay, some 800m to the W, over hills via Bealach Breac pass.

Site F. *NM 4337 5691, 39m*.
General situation. 250m SSW of the Glengorm stones, separated from them by boggy ground.
Local topography. A narrow ridge running NW–SE.
Slope and aspect. Falling slightly away from a level summit in all directions.
Soil cover. Thin soil cover with rocky outcroppings.
Drainage. Good.
Land use. Unimproved grassland.
Ease of approach. Accessible from the NNW, but there is boggy ground to the N and E. Inaccessible from the S and W owing to a small ravine.
Proximity to fresh water. Adjacent to a small stream.
Proximity to sea. Bay near Dùn Ara, some 1100m to the NW, or inlet at Laorin Bay, some 900m to the W (involves heading NW, crossing the stream and then heading W over Bealach Breac pass).

Site G. *NM 4358 5722, 61m*.
General situation. 150m NE of the Glengorm stones, on a terrace in the NW slopes of Cnoc nan Aireamh.
Local topography. Hillside terrace.
Slope and aspect. Slightly sloping downhill to NW.
Soil cover. The terrace itself is soil-covered, but there are many nearby rocky outcrops.
Drainage. Good.
Land use. Unimproved grassland.
Ease of approach. Gentle ascent from the sea to the N and NE; fairly steep ascent from the W and S. Difficult access down steep hill from SE.
Proximity to fresh water. Source of stream some 300m to the SSE.
Proximity to sea. Rocky bay 600m to the N.

Site H. *NM 4324 5725, 38m*.
General situation. 250m NW of the Glengorm stones, on a small terrace in the otherwise moderately steep SW slopes of of Druim Rèidh.
Local topography. Hillside terrace.
Slope and aspect. Level.

Soil cover. Terrace itself is soil-covered, but there are many nearby rocky outcrops.
Drainage. Good.
Land use. Unimproved grassland.
Ease of approach. Narrow access path along hillside from the SSE; also accessible from the NNW, but involves a reasonably steep climb. Large rock outcrops with sheer drops make access difficult uphill from SW or downhill from NE.
Proximity to fresh water. Small stream some 100m to the SW.
Proximity to sea. Bay near Dùn Ara, 800m to the NW.

The nine locations (including the Glengorm site itself) fall within an area some 700m (NNW–SSE) by 400m (ENE–WSW). They represent a selection of reasonably flat, reasonably accessible and well-drained locations situated within 300m of the stream running from Cnoc nan Aireamh and Meall Riabhach down to the sea at Dùn Ara. On grounds other than astronomical potential, there is no obvious reason why any one site should have been chosen in preference to all the others.

5. THE AZIMUTHAL DISTRIBUTION OF HORIZON DISTANCE

Our general approach to studying the azimuthal distribution of horizon distance follows that applied by one of the authors (CR) to the Recumbent Stone Circles of eastern Scotland.[36] A similar approach has been applied, with coarser 'bins', by Fraser in a study of Orcadian chambered cairns.[37]

In short, horizon distances are divided into four categories: 'A' (up to 1km), 'B' (1–3 km), 'C' (3–5 km) and 'D' (over 5 km). At each survey point, the horizon is then 'scanned', which involves measuring the azimuths of junctions between different horizon categories to the nearest degree. This results in a horizon distance category being assigned to each degree of azimuth for that location. By combining data from different locations we obtain, for each azimuth, the number of cases in which the horizon distance is in each of the four categories.

In practice, a further category, 'X' (distance unknown), is needed wherever a horizon distance category cannot be directly measured owing to obscuration by trees. One strategy for dealing with category 'X' data is to reduce them to 'A', 'B', 'C' or 'D' by calculation from maps. If this is considered too inaccurate, an alternative strategy is simply to omit them from further consideration, so that the results for a given azimuth are expressed as percentages of the remaining data. The latter strategy should be satisfactory since the factors giving rise to

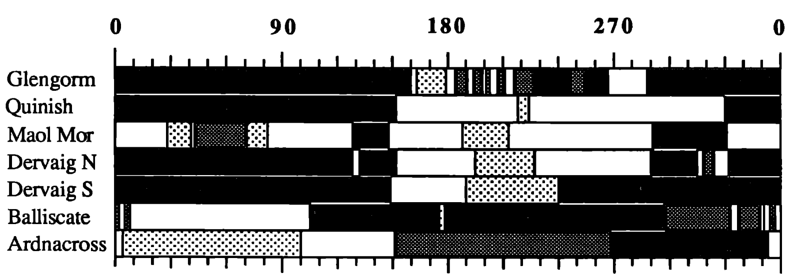

FIG. 6. The variation of horizon distance with azimuth: horizon scan data for the seven north Mull stone rows. Horizon distance categories are indicated by differential shading, from 'A' (black) to 'D' (white).

TABLE 2. The variation of horizon distance with azimuth: horizon scan data for the seven north Mull stone rows. The data are given in the form of junction azimuths in degrees separated by horizon distance categories (see text). The distance category following the final azimuth applies round to the first azimuth in the list. Azimuths shown in parentheses are subject to possible inaccuracy for reasons explained in the notes.

Site	Scan Data																Notes
Glengorm	160	D	163	C	179	D	184	B	191	D	194	B	199	D	201	B	
	203	D	207	B	211	D	(216)	B	227	D	228	A	246	B	255	A	
	267	D	288	A													*a*
Quinish	(152)	D	218	C	224	D	(330)	A									*b*
Maol Mor	28	C	41	D	43	B	71	C	(82)	D	(128)	A	(148)	D	188	C	
	213	D	(291)	A	(331)	D											*c*
Dervaig N	(128)	D	(132)	A	(152)	D	(195)	C	227	D	(290)	A	(315)	D	(318)	B	
	(324)	D	(332)	A													*d*
Dervaig S	(149)	D	(190)	C	(240)	A											*e*
Balliscate	1	B	2	D	5	B	8	D	105	A	175	C	178	A	297	B	
	333	D	337	B	349	D	350	B	351	D	354	B	357	D			
Ardnacross	4	C	100	D	151	B	269	A	353	D							

Notes

a The parenthesized azimuth was not directly measured and has been estimated from maps and photographs.

b The category 'A' horizon is very close and the azimuths of its junctions with more distant horizons can not be accurately determined.

c The data for Maol Mor have been obtained by offset from a point approximately 90m to the NW of the site and 15m above it. The quoted azimuths for junctions not involving category 'A' horizons are considered reliable.

d The data for azimuths between about 48° and 228° have been obtained by offset from a point approximately 50m to the SE of the site and level with it. One of the two quoted azimuths for junctions in this range not involving category 'A' horizons is considered reliable; the other was not directly measured and had to be estimated from maps and photographs. Junctions in the remainder of the horizon have been estimated from maps.

e The azimuths were not directly measured and have been estimated from maps and photographs.

present-day afforestation are unrelated to the potential for horizon astronomy. Both strategies may be employed in parallel.[38]

The results of the three analytical approaches described in Section 4 above are now considered in turn. Section 5.1 deals with a simple inter-site comparison, Section 5.2 with a 'global' analysis comparing the site locations with a set of random controls, and Section 5.3 with a 'local' analysis comparing the astronomical potential of the Glengorm site with that of eight alternatives considered to be equally appropriate on other grounds.

5.1. *Inter-site Comparison*

Horizon scans were obtained at the seven north Mull stone rows during the theodolite surveys of the whole horizon. The data obtained are given in Table 2 and illustrated in Figure 6. They show a distinct difference between what we might term the 'northern group' consisting of Glengorm, Quinish and the three sites in the vicinity of Dervaig, which share a number of common characteristics, and the two sites near the eastern coast. The sites in the northern group have distant views to the south and west but (in all cases except Maol Mor) local horizon to the north and east. The Glengorm site overlooks Glen Gorm itself and the remaining sites overlook Glen Bellart, stretching south-eastwards from

TABLE 3. The variation of horizon distance with azimuth relative to site orientation: horizon scan data for the seven north Mull stone rows. A relative azimuth of 0° indicates a southerly azimuth in the same direction as the site orientation. Notes on site orientation are given here. For other notes see Table 2.

Site	Orientation	Notes	Scan Data
Glengorm	156	*a*	−180 A +4 D +7 C +23 D +28 B +35 D +38 B +43 D +45 B +47 D +51 B +55 D (+60) B +71 D +72 A +90 B +99 A +111 D +132 A +180
Quinish	168	*b*	−180 A (−16) D +50 C +56 D (+162) A +180
Maol Mor	162	*b*	−180 D −134 C −121 D −119 B −91 C (−80) D (−34) A (−14) D +26 C +51 D (+129) A (+169) D +180
Dervaig N	150	*b*	(−180) D (−178) A (−22) D (−18) A (+2) D (+45) C (+77) D (+140) A (+165) D (+168) B (+174) D (+180)
Dervaig S	157	*b*	−180 A (−8) D (+33) C (+83) A +180
Balliscate	185	*b*	−180 B −177 D −80 A −10 C −7 A +112 B +148 D +152 B +164 D +165 B +166 D +169 B +172 D +176 B +177 D +180
Ardnacross	202	*c*	−180 C −102 D −51 B +67 A +151 D +162 C +180

Notes
a The orientation is derived from excavated evidence.[42]
b The orientation is determined from ground surveys.[43]
c The value quoted is the mean of the orientations, derived from surveys, of the NW row (197°) and the SE row (207°).[44]

Dervaig. At Balliscate, however, the most distant views are across the Sound of Mull to the NE, and at Ardnacross they are directly down the Sound to the SE.

Factors unrelated to astronomy may well explain the general concentration of sites in the northern group. Although the agricultural potential of the land in northern Mull has decreased since Neolithic times, the island's relief, climate and soil all suggest that it was never very great. The land between Caliach Head and Glengorm Castle slopes gently to the sea; it is virtually the only part of the north Mull coastline where this is the case.[39] This area, together with the wide Bellart valley stretching inland to the SE, combined agricultural potential with ease of access and are rare examples of areas that would have offered reasonable potential for settlement during prehistoric times. We must look to comparative analyses (see below) to tackle the question of whether the mere location of sites in these areas of good settlement potential can explain the observed horizon distance profiles, with their preference for distant horizons to the S and SW. However, some observations can be made at this stage.

First, there are no obvious particular locational preferences apart from a level or only gently sloping, well drained, and easily approachable site. Otherwise, the chosen locations are quite diverse. Quinish, like Glengorm, is situated on a flat terrace overlooking lower ground to the south and west but overlooked by higher terraces to the north and east: its elevation, about 35m, is only a little lower than that of Glengorm. Maol Mor, however, is situated high up on the broad crest of the ridge running NNW–SSE that forms the backbone of the Quinish peninsula. Itself at some 138m elevation, it is situated in a wide saddle between hill summits 100m to the NW (150m) and 300m to the SE (158m).

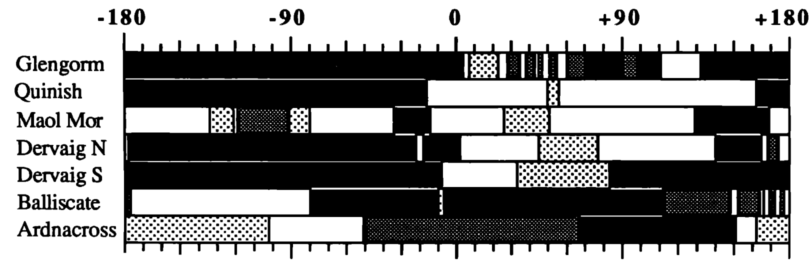

FIG. 7. The variation of horizon distance with azimuth relative to site orientation: horizon scan data for the seven north Mull stone rows. Horizon distance categories are indicated by differential shading, from 'A' (black) to 'D' (white).

Although this main ridge extends beyond Dervaig to the SE, the stones at Dervaig N are not situated upon it, but upon a lower ridge running parallel, some 300m to the SW, at an elevation of about 122m. Dervaig S, at an elevation of some 92m, is located in a saddle to the NE of a small hillock within ground that generally slopes steeply down to Glen Bellart in the SW. In summary, topographic situations are variable, and the elevations of the sites run from under 40m to over 130m.

Second, higher situations with wider views were often eschewed in favour of the sites actually chosen. At Glengorm, for example, there are knolls near to the site actually chosen that would have provided greater elevation and wider views where it would have required little extra effort to place the stones.[40] In fact, all of the five sites in the northern group have a higher summit in the near vicinity: Glengorm some 200m to the NW, Quinish some 200m to the NE, Maol Mor some 100m to the NW, Dervaig N some 200m to the NW, and Dervaig S a mere 20m to the NW. This implies that wide views were not an important consideration *per se*. However, it leaves the possibility that views in particular directions were of importance. As with any orientation hypothesis, there are three types of factor to be considered: azimuthal (i.e. particular compass directions were of importance), land-based (i.e. particular natural features, such as prominent hill summits, were of importance) and astronomical (i.e. particular horizon or near-horizon astronomical events were of importance).[41]

It is of immediate interest to ask whether site orientation is correlated with the orientation of horizon visibility, in other words whether orientation of horizon visibility might have been a factor influencing site orientation. Generally, given the choice of site location, there are no apparent local constraints on its orientation. The only possible exception is Dervaig S, where there are sharp changes in ground level only a few metres from the site.

In Table 3 the horizon scan data have been converted from absolute azimuths to azimuths relative to site orientation (the zero point being taken in the southerly direction). The data are illustrated in Figure 7. This fails to clarify any of the trends noted in the absolute azimuth data, although it should be pointed out that, at each of the sites in the northern group, the exact position of the junction between nearby category 'A' horizon to the left and distant category 'D' horizon to the right of the approximate orientation direction is subject to uncertainty and critically dependent upon the exact position of the observer in

TABLE 4. The variation of horizon distance with declination: horizon scan data for the seven north Mull stone rows. The data are given in the form of junction declinations in degrees separated by horizon distance categories, in a similar manner to the presentation for azimuths in Table 2. However, the first and last declinations in each list represent the highest or lowest declinations in the vicinity of north or south, and are not generally the declination of a junction point. The declinations of successive junction points do not always vary monotonically, owing to variations in altitude, especially near to north and south. Where a declination is visible at two or more different horizon points in different distance categories, the further distance category is listed in the table. Declinations shown in parentheses are subject to possible inaccuracy: in the case of the first or last in a list, this is because it has not been directly measured; in other cases the reason is given in the notes for Table 2.

RISING														
Glengorm	(+40)	A	−30.1	D	−30.6	C	−32.3	D	−32.3					
Quinish	(+35)	A	(−28)	D	(−32)									
Maol Mor	(+35)	D	+29.8	C	+25.4	D	+25.2	B	+12.7	C	+6.5	D	(−20)	A
	(−27)	D	−32.8											
Dervaig N	(+36)	A	(−17)	D	(−19)	A	(−28)	D	(−32)					
Dervaig S	(+37)	A	(−27)	D	(−32)									
Balliscate	+34.3	D	−7.5	A	−28.8	C	−29.0							
Ardnacross	+34.8	D	+33.3	C	−5.4	D	−27.4	B	−28.3					
SETTING														
Glengorm	−32.3	D	−32.3	B	−31.7	D	−31.1	B	−29.7	D	−29.5	B	(−29)	D
	(−28)	B	(−27)	D	(−26)	B	(−22)	D	(−21)	A	−12.8	B	(−8)	A
	−1.9	D	(+9)	A	(+40)									
Quinish	(−32)	D	−25.1	C	−23.2	D	(+28)	A	(+35)					
Maol Mor	−32.8	D	−32.1	C	−26.0	D	(+10)	A	(+27)	D	(+35)			
Dervaig N	(−32)	D	(−30)	C	−20.4	D	(+10)	A	(+22)	D	(+24)	B	(+26)	D
	(+29)	A	(+36)											
Dervaig S	(−32)	D	(−31)	C	(−14)	A	(+37)							
Balliscate	−28.8	A	+16.5	B	+30.0	D	+30.8	B	+33.0	D	+33.3	B	+33.4	D
	+34.3													
Ardnacross	−28.3	B	−0.5	A	+34.2	D	+34.8							

the alignment. At Glengorm, for example, the ground level rises along the alignment to the NW of the site, so that distant horizon is visible along the alignment from a position some 100m behind the stones. At Dervaig N there is a similar, although smaller, rise, but whether distant ground would be visible along the alignment is difficult to determine owing to afforestation. Thus, while it might be claimed that the orientation of each of the sites in the northern group is aligned with the extreme left-hand end of the distant range of horizon, the claim is dependent to some extent upon assumptions about observing position. On the other hand, to a much lower precision (i.e. about 15°) it is clearly true. The reason for this is not necessarily astronomical: it could arise, for example, simply if sites were roughly aligned so as to be clearly visible from lower ground to the SW.

While the ground level along the alignment to the N rises or stays level at each of the sites in the northern group, it falls away at Balliscate and Ardnacross. This fact, together with the more distant horizon in the north-easterly direction, gives the impression that if these two sites were oriented upon horizon

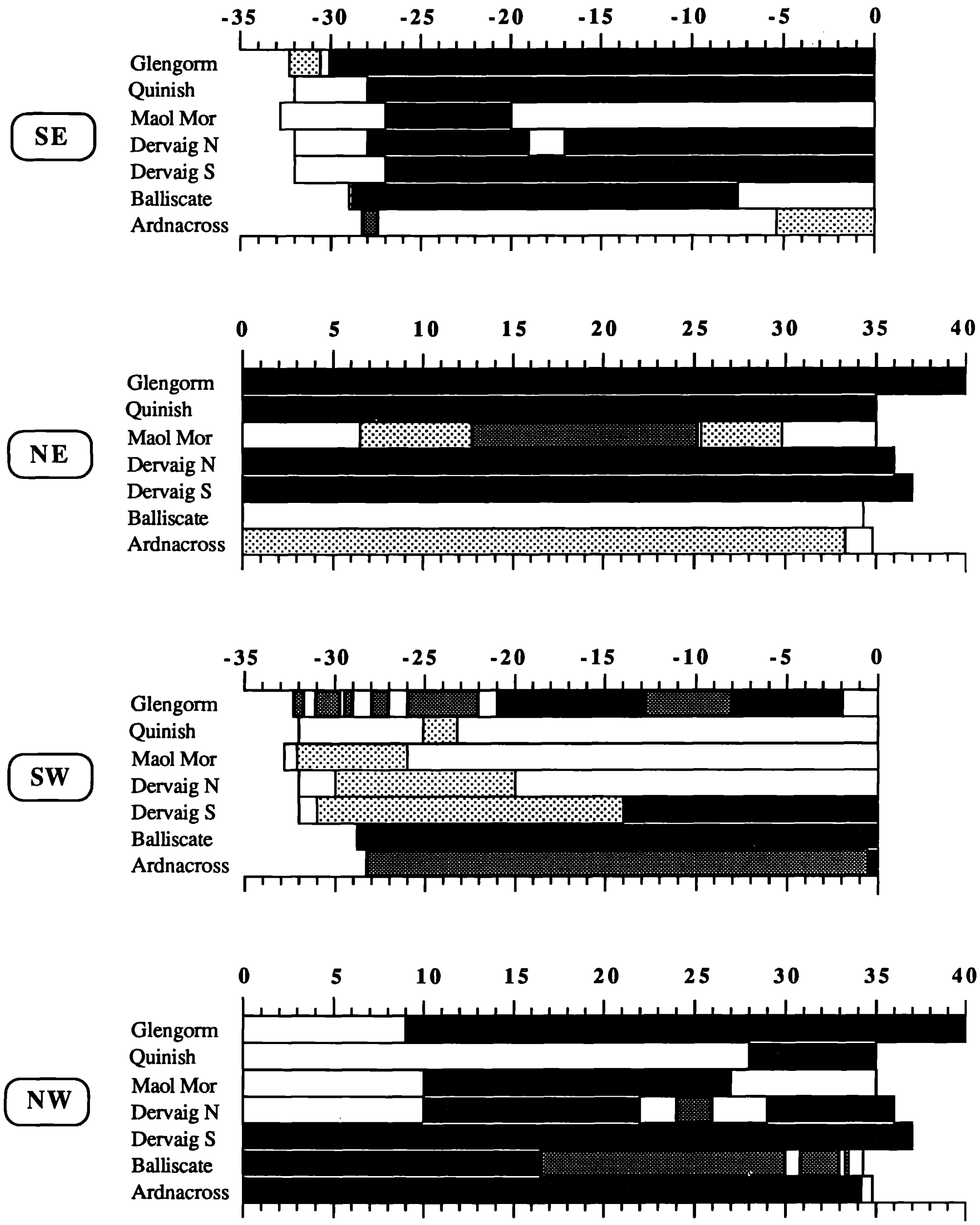

FIG. 8. The variation of horizon distance with declination: horizon scan data for the seven north Mull stone rows. Horizon distance categories are indicated by differential shading, from 'A' (black) to 'D' (white).

phenomena then the important direction was to the NE, not to the SW. This is true despite the fact that the southern profile has a lunar significance consistent with the trend established at other sites, both those in northern Mull and many others elsewhere in western Scotland.[45]

A final feature worthy of note is that at two of the sites, Dervaig N and Balliscate, a small section of more distant horizon appears between nearby hills roughly in line with the orientation of the site but in the direction opposite to that where there is a more extensive distant profile. At Balliscate, for example, the peak of Speinne Mór, 4.3km distant, is just visible through a dip in the local hills some 500m away; its azimuth is 176°.9, merely 8° to the left of the estimated orientation of the site.

In Table 4 the azimuth data have been converted to declination data. These data are illustrated in Figure 8. Undoubtedly the most interesting of the four charts presented is the SE one, where a clear trend is evident. At Quinish and the three Dervaig sites a distant profile is visible centred upon the rising major standstill moon at a declination of −30°. While the distant profile visible from the Glengorm site itself does not reach declinations above −30°, an observer positioned on the alignment but on higher ground between about 100m and 150m to the NW of the site sees the distant profile extending left to an azimuth of about 155° (including Ben More) and up to a declination of about −28°.5, in line with the other sites in the northern group. The question then arises as to whether this declination trend may simply be a consequence of the general location of the sites and the general NW–SE topography of northern Mull. This question is addressed later in the context of prominent hill summits and their significance (see Section 6.2 in the following paper).

At Balliscate and Ardnacross, the high altitude of the southern horizons means that declinations below about −29° are not achieveable. The lowest values at Balliscate are the junction points of Speinne Mór with nearer ground, yielding −29°.0. At Ardnacross the rightmost point on the distant profile to the SE, at its junction with Speinne Beag some 2km away, yields a declination of −27°.4 at an azimuth of 151°. Because the horizon rises to an altitude of more than 5° in the south, the lowest declination achieved to the right of this junction is −28°.3. Thus, in fact, the distant profile comes within a degree of the lowest available declination at Ardnacross, too.

5.2. *Global Analysis*

In this section we address the question of whether the mere location of sites in areas of good settlement potential can explain the horizon distance profiles observed. The working hypothesis is that there is a significant difference between the distribution of visibility from a site and that from a random point. In order to test it, one of the authors (PH) collected horizon scan data from a set of spatially pseudo-random control points.[46] The following formal procedure was devised in order to determine the control points.

Stage 1. *Define the 'available areas', i.e. those in which control locations are permitted to lie*. This is done by defining a 'study area' and then identifying various 'restricted areas' (i.e. non-permitted areas) within it. The study area is taken to be the smallest rectangle with 1km National Grid lines as its edges such that each of the known sites lies within it but not closer than 4km to any edge. Three types of restricted area are then identified. The first type consists of areas covered by the sea or freshwater lakes and hence unavailable for prehistoric settlement, together with land areas separated from the actual sites by sea. (These definitions of the study area and restricted area provide an independent criterion for defining a control area enclosing the sites being studied in a mainland setting where geographical, topographic or geological boundaries may not otherwise provide an obvious means for dividing the landscape into parcels for analysis. However, in an island setting, it will limit the study area to the island(s) where sites are located, and thus correspond to the choice that would have been made on geographical grounds.) The second type consists of areas unavailable for present-day study, either permanently (e.g. artillery impact areas and ornamental parks) or temporarily (e.g. forestry plantations). The assumption is made here that the location of such areas is unrelated to the orientation of horizon visibility. The third type of restricted area is suggested by a selected trait in the locations of the sites themselves, namely elevation. The lowest and highest elevations of the sites themselves are noted, and rounded down and up respectively to the nearest 10m. Areas with elevations not within these limits are then restricted.

Stage 2. *Define an ordered set of sample points within the available areas*. The following strategy is adopted. Sets of eastings are generated within the study area, each set containing one value within each 1km interval, at a random position within that interval. Sets of northings are generated in a similar manner. The number of sets is chosen so as to achieve a rough match in the numbers of eastings and northings: the match is then made exact by discarding a suitable number of values, selected at random, from the larger of the two. The eastings and northings are then each sorted into a random order and pairwise linked, so as to produce a list of points within the study area. Those points falling in restricted areas are discarded, but the order of the remaining ones is preserved.

Stage 3. *Define an ordered set of sampling paths within the study area*. A sampling path is defined for each sample point as the straight line joining it to its nearest neighbour, regardless of whether the path traverses a restricted area. Thus a sampling path may be represented as an ordered pair of sample points. The list of sampling paths is generated from the list of sample points, order being preserved. Whenever a point appearing in an ordered pair has already appeared in an earlier ordered pair in the list, the sampling path in question is omitted from the list.

Stage 4. *Fix the minimum required number of control points, a suitable control interval and maximum number of control points per sampling path*. The first value is determined by the requirement to provide an adequate comparison for the site data. The other two values determine the exact disposition of control points, which will be located on the sampling paths. The control interval is the minimum distance between control points on a single sample path. It should be set sufficiently large that there will normally be significant changes in the visible horizon between two points this far apart; but on the other hand the larger it is, the greater will be the distance that the investigator needs to walk between control points in the field. This is an important consideration if the time and other resources available for fieldwork are limited. The maximum number of control points per sampling path should be set sufficiently small that the control data are not dominated by a small number of (possibly unrepresentative) local areas; but the smaller it is, the greater will be the number of sampling paths that the investigator has to travel to.

Stage 5. *Identify and obtain measurements at suitable control points within the sampling paths*. The sampling paths are visited in order. In each case, the investigator starts at the first of the two sample points and takes it as the first control point. (S)he then walks directly towards the second sample point, stopping after the control interval has been traversed.

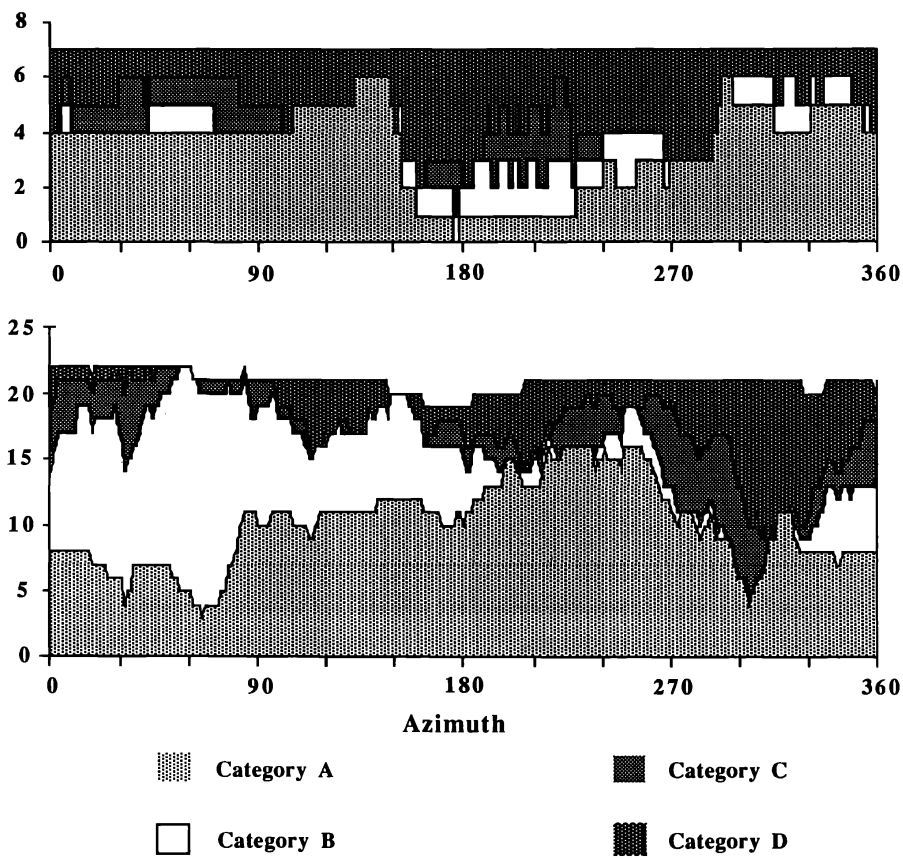

FIG. 9. The frequency of occurrence of the different horizon distance categories, (a, *above*) from the seven north Mull stone rows, and (b, *below*) from the 22 control points in north Mull. Some category 'X' data have been omitted in the case of (b).

TABLE 5. Sampling paths in northern Mull, listed in order of examination. The table gives the start and end points together with the total distance lying within 'available areas'.

Path No.	Start Point	End Point	Available Distance (m)
1	^{1}430 ^{7}560	^{1}422 ^{7}533	2700
2	^{1}460 ^{7}476	^{1}455 ^{7}474	600
3	^{1}510 ^{7}467	^{1}513 ^{7}461	500
4	^{1}354 ^{7}488	^{1}341 ^{7}483	1400
5	^{1}410 ^{7}456	^{1}428 ^{7}459	1600

The new position is the next control point, unless it is within a restricted area or there are unforeseen problems such as the presence of new plantations or buildings, or access is impeded. In these cases the intended route is resumed as soon as possible until a further control interval has been traversed. The process is repeated until either the maximum number of control points is reached or else the second sample point is reached. Sampling paths are visited in order until at least the minimum required number of control points has been measured.

This strategy has several advantages. First, stages 1–4 are completed prior to fieldwork and save strategic decisions having to be made in the field. Second, the use of sampling paths as opposed to individual pseudo-random points greatly reduces the distance to be travelled, and time spent, in the field. Finally, the strategy copes adequately with unforeseen confounding circumstances.

The study area for north Mull is the rectangle with SW and NE corners at (^{1}37 ^{7}45) and (^{1}59 ^{7}62) respectively. (This area excludes small parts of northern Mull, so in practice it was extended so as to include northern Mull in its entirety.) The omission of forestry areas has a significant effect, reducing the available area by about 10%. The elevation limits are 30m and 140m. Two sets of eastings (containing 22 values) and three sets of northings (containing 17 values) were taken, with seven of the northings being discarded, in order to produce 44 sample points. The minimum required number of control points was set at 20, the control interval at 200m, and the maximum number of control points per sample path at five. The first five sampling paths were visited and measurements for 23 control points were obtained. Details of the sampling paths are given in Table 5.

The horizon scan data at each control point were obtained by magnetic compass. This gives rise to the possibility of systematic error in individual cases due to magnetic anomalies, but since the latter are unrelated to astronomical potential they should not affect the efficacy of these data as a control sample. Category 'X' data were omitted on the basis that doing so should not bias the result of the statistical test (see above).

The distribution of visibility from the north Mull sites, derived from the data in Table 2, is shown in Figure 9(a). That from the control points is shown in Figure 9(b). The difference between the two distributions is striking. These general conclusions are confirmed by statistical tests. The general approach

TABLE 6. The variation of horizon distance with azimuth: horizon scan data for nine locations in the vicinity of Glengorm. For general notes see Table 2. Values shown in parentheses were not directly measured and have been estimated from maps and photographs; they are thus subject to possible inaccuracy.

Glengorm	160	D	163	C	179	D	184	B	191	D	194	B	199	D	201	B
	203	D	207	B	211	D	(216)	B	227	D	228	A	246	B	255	A
	267	D	288	A												
Site *A*	163	D	165	C	180	D	184	B	190	D	196	B	200	D	209	B
	211	D	217	B	226	D	231	B	232	A	247	B	257	A	267	D
	289	A														
Site *B*	159	B	181	D	(182)	B	(184)	D	189	B	(207)	D	(208)	B	213	D
	(215)	A	(249)	B	(250)	A	280	D	(297)	A	303	D	(325)	A		
Site *C*	(5)	A	(9)	D	12	A	(187)	D	(190)	A	(305)	D	(315)	A	(320)	D
	(335)	A	(356)	D	357	A	358	D								
Site *D*	(12)	D	(15)	A	(306)	D	(309)	A	(328)	D	(332)	A				
Site *E*	(304)	D	(307)	A	(326)	D	(328)	A								
Site *F*	(10)	D	17	A	(149)	B	153	D	(156)	B	(179)	D	(181)	B	(198)	D
	(199)	B	251	A	282	D	299	A	304	D	329	A				
Site *G*	58	B	(82)	A	162	D	167	C	171	D	177	B	180	D	185	C
	190	D	218	B	225	D	248	B	258	D						
Site *H*	160	D	164	C	169	B	177	D	182	C	186	B	197	D	208	B
	230	A	248	B	262	A	285	B	299	A						

adopted,[47] following earlier work by Fraser,[48] was to compare the distribution of horizons of a given distance category between two samples using a Kolmogorov-Smirnov one-sample test. Here, the stone row locations comprise the first sample and the control points the second. The null hypothesis that the two samples are taken from the same population — in other words there is no difference between the distribution of visibility from a site and that from a control point — was rejected at the 1% level for categories B and D and at the 5% level for category A.[49]

Although the number of control points is quite small, and any conclusions need confirmation using a larger sample, it is reassuring that many of the features evident in Figure 9(b) appear to confirm trends in the general topography of the area. For example, there is a preponderance of distant horizons to the NW and NNW, along the line of the ridges and valleys, but most horizons to the SW and WSW are restricted by the adjacent ridge. To the NE and ENE, and especially around azimuth 60°, there are virtually no horizons further than 3km. In contrast, the sites themselves are generally placed so as to avoid nearby horizons to the S and SSW, and appear to eschew distant horizons to the NW and NNW. We conclude that there was a conscious effort on the part of the builders of the north Mull stone rows to locate these monuments according to horizon visibility criteria that were not easy to achieve given the general topographical constraints in the area.

In order to provide comparative data, a similar analysis to that described above was performed on the aligned sites in mid-Argyll. This is especially appropriate since the group of short stone rows and aligned pairs in the Kilmartin area was the other of the two groups singled out in earlier work as exhibiting a pattern related to the rising and setting of the southerly moon.[50] The details of the study are given in the Appendix. This demonstrates that the

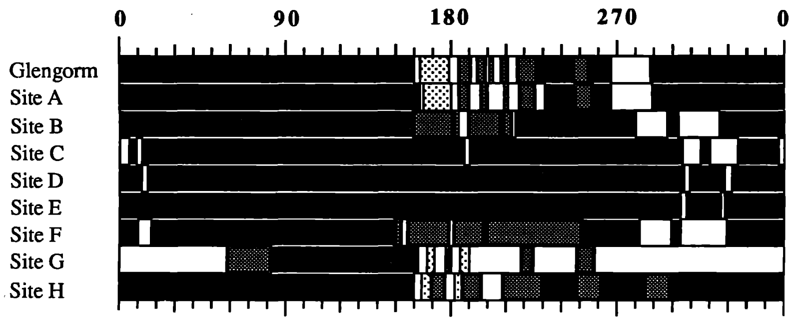

FIG. 10. The variation of horizon distance with azimuth: horizon scan data for nine locations in the vicinity of Glengorm. Horizon distance categories are indicated by differential shading, from 'A' (black) to 'D' (white).

two groups of monuments share a preference for non-local horizons between SSE and WSW. In northern Mull this is against the general trend of horizon visibility distribution, but in mid-Argyll, and particularly in the flat plain of Mòine Mhòr south of Kilmartin, clear views were generally available in this direction. The stone row builders of northern Mull, it seems, had to go to some lengths to achieve a desired horizon visibility that their counterparts in mid-Argyll were generally able to take for granted.

This evidence of an interest in the horizon quadrant centred on SSW is of particular interest as it mirrors what is found at the RSCs in eastern Scotland.[51] Here, as in the case of the northern Mull rows but unlike in mid-Argyll, the preference for non-local horizons around and to the west of south is at odds with the horizon distance profiles most often occurring naturally. This reinforces the idea that common goals may link the two types of site in the different geographical areas. There is already, of course, evidence of a common interest in the moon. At the same time, we must not lose sight of the fact that the orientation of the five north Mull rows in the northern group is to the SSE, not the SSW.

5.3. *Local Analysis at Glengorm*

We now turn to the local analysis in the vicinity of Glengorm in order to investigate whether this can help us develop the ideas discussed above. Horizon scan data were generally obtained at the eight Glengorm alternative sites during theodolite surveys. Missing data were estimated from 1:10000 Ordnance Survey maps. The data are tabulated in Table 6 and the results displayed in Figure 10.

These data emphasize the point that if wider horizons had been desired as an end in themselves, then the Glengorm stones could have been placed at an alternative location without compromising other considerations such as levelness of site, good drainage and easy accessibility. For example, wide views to the NE and NW, in addition to those to the S and SSW, could have been achieved by placing the stones 150m to the NE at Site *G*. Sites *A* and *H* provide comparable vistas to the south, and while the approach to Site *H* is arguably more difficult than that to the site chosen, this can not be said of Site *A*, which is a mere 50m from the site chosen and combines a slightly enhanced view with

TABLE 7. The variation of horizon distance with declination: horizon scan data for nine locations in the vicinity of Glengorm. For general notes see Table 4. Parentheses have the same meaning as in Table 6.

RISING

Glengorm	(+40)	A	−30.1	D	−30.6	C	−32.3	D	−32.3							
Site *A*	(+40)	A	−30.7	D	−31.1	C	−32.2	D	−32.4							
Site *B*	(+40)	A	−29.7	B	−32.4											
Site *C*	(+34.2)	D	(+33.8)	A	(+34.6)	D	(+34.3)	A	(−32)							
Site *D*	(+40)	A	(+34.0)	D	(+33.6)	A	(−31)									
Site *E*	(+40)	A	(−31)													
Site *F*	(+40)	A	(+34)	D	+33.0	A	(−27)	B	−28.1	D	(−29.0)	B	(−32.2)	D		
	(−32.3)															
Site *G*	(+34)	D	(+18)	B	(+6)	A	−31.6	D	−31.7	C	−32.2	B	−32.4	D		
	−32.6															
Site *H*	(+40)	A	−27.9	D	(−31)	C	(−32)	B	−32.4	D	−32.7					

SETTING

Glengorm	−32.3	D	−32.3	B	−31.7	D	−31.1	B	−29.7	D	−29.5	B	(−29)	D		
	(−28)	B	(−27)	D	(−26)	B	(−22)	D	(−21)	A	−12.8	B	(−8)	A		
	−1.9	D	(+9)	A	(+40)											
Site *A*	−32.4	B	−31.7	D	−30.9	B	−29.8	D	−27.5	B	(−27)	D	(−25)	B		
	(−22)	D	(−20)	B	(−19)	A	(−12)	B	(−7)	A	(−2)	D	(+10)	A		
	(+40)															
Site *B*	−32.4	D	(−32.0)	B	(−32.0)	D	−30.6	B	(−28.0)	D	(−27.7)	B	−26.6	D		
	(−25.7)	A	(−11)	B	(−10)	A	+5.2	D	(+14)	A	(+17)	D	(+26)	A		
	(+40)															
Site *C*	(−32)	A	(−31.4)	D	(−31.1)	A	(+18)	D	(+22)	A	(+24)	D	(+29)	A		
	(+34.2)															
Site *D*	(−31)	A	(+18)	D	(+20)	A	(+27)	D	(+29)	A	(+40)					
Site *E*	(−31)	A	(+17)	D	(+19)	A	(+26)	D	(+27)	A	(+40)					
Site *F*	(−32.3)	D	(−32.2)	B	(−29.9)	D	(−29.7)	B	(−10)	A	(+6)	D	(+15)	A		
	(+17)	D	(+28)	A	(+40)											
Site *G*	−32.6	C	−32.0	D	−25.5	B	(−23)	D	(−16)	B	(−7)	D	(+34)			
Site *H*	−32.7	C	−31.9	B	−30.7	D	−27.9	B	(−18)	A	(−11)	B	(−4)	A		
	(+8)	B	(+15)	A	(+40)											

being both visible and easily accessible from the east. (Placed on a lower terrace, the Glengorm stones are hidden from view when approached from this direction, and the last stage of the approach involves a steep scramble.) Unless one postulates that the *lack* of accessibility from this direction was a desirable attribute, then there is no readily discernible reason why the chosen site should have been chosen in preference to Site *A*—at least, that is, on the basis of the azimuth data.

In Table 7 the azimuth data have been converted to declination data. These data are illustrated in Figure 11. While these data do not throw any further light on the question of the chosen site versus Site *A*, they do emphasize a property of these two locations that is not shared by any of the others. This is that the gap in the S and SSW between local hills spans a range of horizon varying from the major standstill rising moon in the east to the minor standstill setting moon in the west, with distant peaks appearing at intervals throughout. Sites *F* and *H* share non-local horizons in these directions but have substantial stretches of

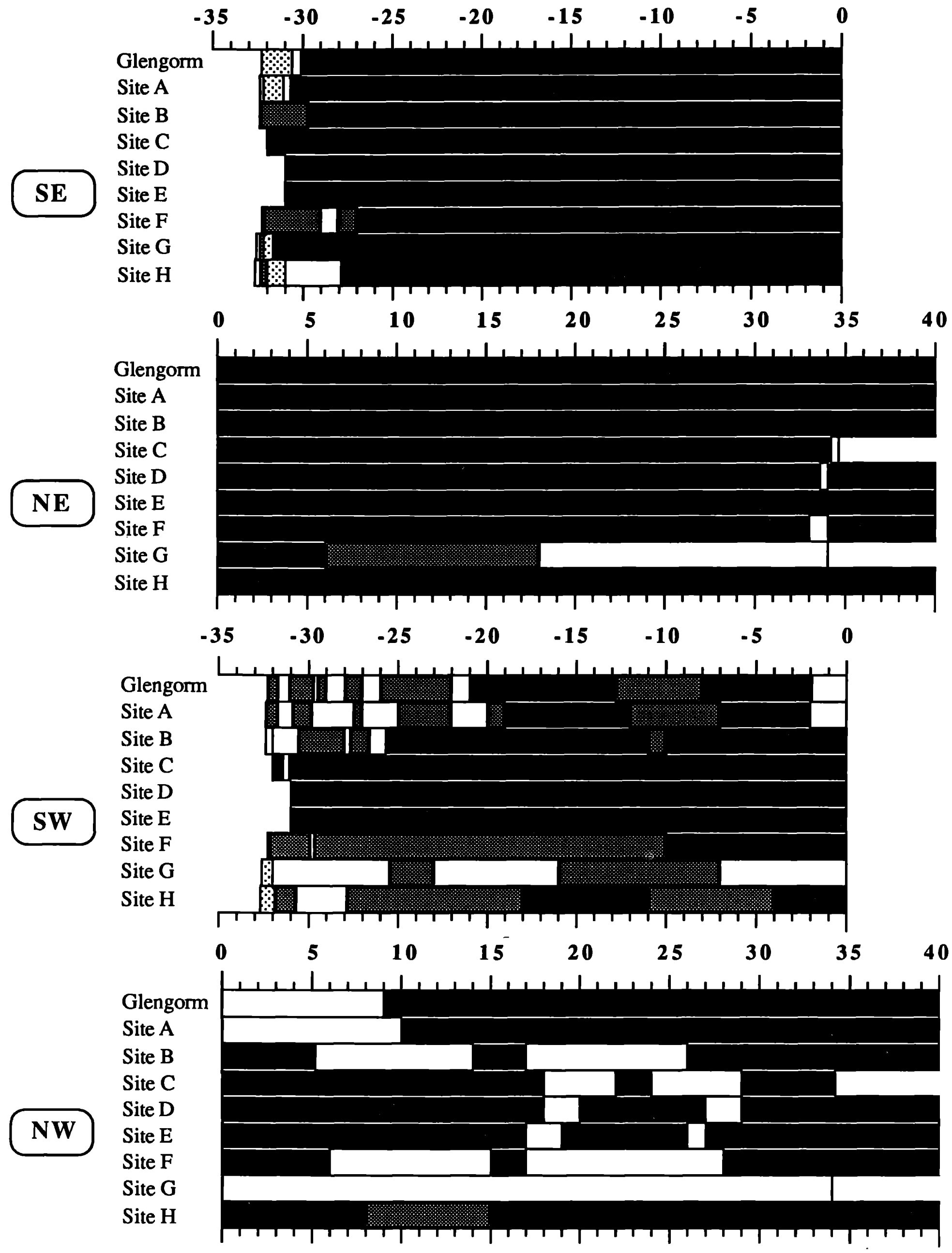

FIG. 11. The variation of horizon distance with declination: horizon scan data for nine locations in the vicinity of Glengorm. Horizon distance categories are indicated by differential shading, from 'A' (black) to 'D' (white).

unbroken category 'B' profile, throughout in the case of Site *F* and above a declination of about −28° in the case of Site *H*. Site *G* shares a distant profile to the SSW but local ground obscures the view to the east of south.

In Figure 8 it can be seen that the property just identified is also satisfied at the other four sites in the northern group: each of the other sites achieves an unbroken vista at least 3km distant throughout the whole range. It will clearly be of great interest to see whether the local analyses in the vicinity of the other sites support the conclusion that this was intentional, and needed careful site placement in order to achieve it.

Emphasizing the possible significance of the horizon range between major standstill moonrise and minor standstill moonset inevitably draws our attention once again to the eastern Scottish RSCs. For this pattern is exactly that first suspected on the basis of site orientations[52] and subsequently confirmed by survey fieldwork.[53] The conclusion following that work was that "there seems to be no simple, direct interpretation of the pattern of indicated declinations in terms of observations of the sun and moon".[54] The current findings force us to examine this horizon range afresh for possible significance. For example, it is perhaps not now too fanciful to suggest a scenario in which, as part of a ceremony around the time of summer solstice, the full moon, far down in the southern sky, is observed as it approaches a range of distant hills from the left and followed until it sets amongst them, the exact setting position depending upon the state of the 18.6-year cycle. But such speculations must be treated with caution. It should be borne in mind that the band between the setting positions of the major and minor standstill moon is the band within which all the brightest objects in the sky, moon, sun and planets, set at their southernmost extreme. We are perhaps wrong, even now, to restrict our attention to the moon alone.

ACKNOWLEDGEMENTS

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APPENDIX: A COMPARATIVE STUDY OF HORIZON DISTANCE PROFILES IN MID-ARGYLL

The sites considered were Barbreck (AR3; ^{1}8315 ^{7}0641; *c*.15m), Salachary (AR6; ^{1}8405 ^{7}0403; *c*.185m); Carnasserie (AR12; ^{1}8345 ^{7}0080; *c*.115m); Kilmartin, or Nether Largie (AR13; ^{1}8282 ^{6}9760; *c*.25m) S_2S_3; Kilmartin S_1; Kilmartin S_4S_5; Kilmartin (NNE–SSW); Ballymeanoch, or Duncracaig (AR15; ^{1}8337 ^{6}9641; *c*.35m) *abcd*; Ballymeanoch *de*; Dunamuck I (AR28; ^{1}8371 ^{6}9290; *c*.30m); Dunamuck II (AR29; ^{1}8484 ^{6}9248; 30m); and Achnabreck (AR31; ^{1}855 ^{6}901; *c*.30m). Note that, unlike at Ardnacross in Mull, multiple features at single sites are counted separately. Site descriptions (including stone nomenclature) and cross-references to other work are available elsewhere.[55]

The study area for these sites, determined by the same criterion as the north Mull study area, is

TABLE 8. Sampling paths in mid-Argyll, listed in order of examination. The table gives the start and end points together with the total distance lying within 'available areas'.

Path No.	Start Point	End Point	Available Distance (m)
1	^{1}795 ^{6}890	^{1}803 ^{6}971	1200
2	^{1}826 ^{6}945	^{1}842 ^{6}936	1900
3	^{1}859 ^{6}981	^{1}846 ^{6}976	1400
4	^{1}876 ^{6}961	^{1}871 ^{6}948	1500
5	^{1}880 ^{7}028	^{1}881 ^{7}010	1750
6	^{1}786 ^{7}036	^{1}783 ^{7}020	1600

the rectangle with SW and NE corners at ($^{1}78\ ^{6}85$) and ($^{1}90\ ^{7}11$) respectively. In mid-Argyll, the omission of forestry areas reduces the available area by about 15%. The elevation limits are 10m and 190m. Four sets of eastings (containing 12 values) and two sets of northings (containing 26 values) were taken, with four of the northings being discarded, in order to produce 48 sample points. The minimum required number of control points was set at 30. As in north Mull, the control interval was set at 200m and the maximum number of control points per sample path was set at five. The first six sampling paths were visited and measurements for 30 control points were obtained. Details of the sampling paths are given in Table 8.

The distribution of visibility from the mid-Argyll sites is shown in Figure 12(a). That from the control points is shown in Figure 12(b). Unlike the case of northern Mull, there is no striking difference between the two distributions. This general conclusion is again confirmed by a Kolmogorov-Smirnov one-sample test. The null hypothesis that there is no difference between the distribution of visibility from the sites and from the control points was only rejected (at the 1% level) for distance category C.[56]

There are major differences between the general terrain in northern Mull and that in mid-Argyll, resulting from their very different geological histories. This leads to major differences in the expected distribution of visibility from random points in the two areas, which are confirmed by the application of the Kolmogorov-Smirnov test to a comparison of the north Mull control points and the mid-Argyll control points. The null hypothesis that there is no difference between the distribution of visibility in the two samples was rejected at the 1% level for distance categories C and D and at the 2.5% level for category B, although it was not rejected for category A.[57]

The great NE–SW Caledonian trend commonly allows distant views in northerly and southerly

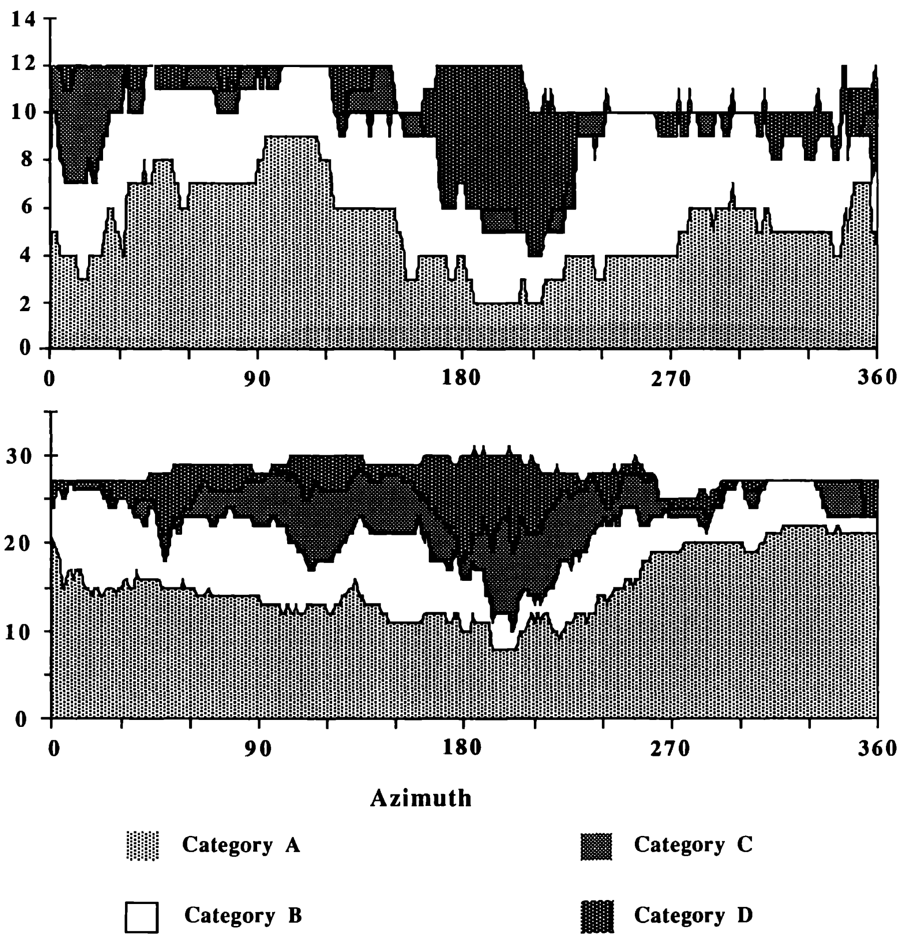

FIG. 12. The frequency of occurrence of the different horizon distance categories, (a, *above*) from the twelve structures in mid-Argyll, and (b, *below*) from the 31 control points in mid-Argyll. Some category 'X' data have been omitted in both cases.

directions, and more restricted views towards valley sides to the SE and NW. At the mid-Argyll control points, the bulk of category 'D' horizons occur around and slightly to the west of due south. A similar effect is evident at the sites themselves. However, the narrowing of the Kilmartin Valley above the stones at Ballymeanoch, Kilmartin and Dunamuck, the encroaching hillside at Achnabreck, and the narrowing Barbeck Valley above the Barbeck stones, all result in the absence of any complementary concentration of distant views to the north. This again is equally evident in the data from the sites and from the controls.

The majority of the mid-Argyll sites are located in the fertile plain of Mòine Mhòr to the south of Kilmartin. Given that this was dictated by other factors, the ability of the builders to choose sites manifesting any special horizon visibility trends was diminished. One can not, however, rule out the possibility that preferential horizon views *were* of importance. It may simply be that the distribution of visibility from the sites and the sample points is not significantly different because it did not need to be. The bulk of the more distant (category 'C' or 'D') views for the control points occur between azimuths of 165° and 230°. The site orientations fall in a similar range, namely 137° to 207°.[58] That the concentration of category 'D' views in this part of the horizon is much more apparent at the sites themselves than at the controls may indicate a slight enhancement of the natural distribution.

This view is confirmed by a direct comparison between the mid-Argyll sites and the Mull ones. In both cases there is a marked preference for non-restricted views around due south and to the west of it. There is no apparent correlation; however, between the more distant horizon categories. In the statistical test, the null hypothesis that there is no difference between the distribution of visibility from the Mull sites and from the mid-Argyll sites was rejected at the 1% level for distance categories B, C and D, but not rejected for category A.[59] An obvious explanation is that there was a preference in both areas for non-local horizons in the horizon quadrant centred on SSW, although whether the horizon in this direction was moderately or very distant was not of great concern and was generally dictated by the local terrain.

Two of the mid-Argyll sites, Carnasserie and Salachary, fail to adhere to the general pattern. The stones at Carnasserie lie below higher ground rising to the SW and offer a restricted view in this direction, although there are good views to the NE over Loch Awe. At Salachary the stones lie in a rather inconspicuous depression where proximate views predominate; somewhat more distant views are only available to the NNW. Yet, paradoxically, these two sites are situated north of Kilmartin, at higher elevations where it is possible to escape from the constraints on visibility distribution operating upon the inhabitants of Mòine Mhòr. Indeed, a mere 20m to the west of the stones at Salachary is a higher location with good, distant views. The fact that locally higher ground is often ignored, as in the case of a number of the north Mull sites, could well be of significance for the understanding of these monuments.

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