

# Background notes to Neolithic Cosmology

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Interest in the cosmological significance of the design and use of Scottish Neolithic monuments began early with the work of Sir Norman Lockyer (1909....) who, excited by his analysis of the solstitial alignments at Stonehenge, sought to extend his observations to the avenues and circles of Callanish, Isle of Lewis, and, also, to examine the stone circles surveyed by F.R. Coles –the recumbent stone circles of Aberdeenshire.

Lockyer's basis for this interest was his research among Egyptian monuments, their alignment on primary solstitial events and the relevance of these to the practice of farming. He also had conceived the interesting idea that if astronomical alignments could be tied to the observation of particular celestial bodies, then the movement of those bodies over time would allow calculations to be made that would reveal the date of construction of the monument. His inspection of the Recumbent Stone Circles of Aberdeenshire led him to conclude "that the Aberdeen circles are more than a thousand years younger than those of Cornwall and the West coast" (1909, 408). Indeed, as Richard Bradley has demonstrated, this was an entirely appropriate estimate .

Lockyer's work at Callanish focused on the N-S alignment of the main orthostatic avenue and his work was succeeded at the site almost immediately by Captain (later Admiral) H. Boyle Somerville (of the family who generated one of the 'Somerville and Ross' girls, Somerville became the first naval officer seconded to the British Secret Service in 1919 and was murdered by the IRA in 1936). A hydrographic surveyor , he was fascinated by Lockyer's book and proceeded to carry out a series of surveys himself. His survey of Callanish is the first accurate plan of the monument to be produced and while critical of many of Lockyer's more abstruse stellar linkages, he supported the solar and lunar associations and, furthermore, established the absolutely accurate alignment of the main stone avenue at the site to true north. Indeed he was the first to observe the lunar alignments at Callanish. (Somerville, 1912, 1923).

Lockyer's ideas were, however, largely ignored by archaeologists, but nevertheless the issues raised were to be redolent of things to come. One principal source of opposition was what Mitchell (1989) introduces as a German concept 'Urdummheit' (original stupidity) – the notion that prehistoric populations were incapable of such sophistication – a tendency which still dominates much thinking about the prehistoric past and that in some respects still stunts its growth.

Scotland had its own pioneer in this regard, however, in the person of Magnus Spence, an Orcadian dominie, who in 1893 published an article in the *Scottish Review* reprinted as a booklet (1894). In it he reorganised (and was partly supported by Lockyer in recognising) a number of solstitial linkages in the relative placement of monuments around Lochs Stenness and Harray including, implicitly, the midwinter sunset alignment of the Maeshowe passage.

Astronomy in Archaeology never went away and 'Old Straight Trackery' and Ley Lines prevailed in England but in Scotland there was an intermission that interrupted development. Born in Carradale, however, in the same year that Spence published his booklet, was Alexander Thom, an engineer and keen sailor who at the age of 39 was sailing among the Western Isles and, perceiving the Pole star gleaming directly over the avenue at Callanish (as observed by Somerville), committed himself (and his family) to spend most spare days from his work as an academic engineer, latterly at Oxford, to the investigation of the astronomical associations of prehistoric stone settings . The War years

passed with Thom designing high speed wind tunnels at Fleet, Hants., but from the moment of his retirement in 1961 he was already in possession of a mass of surveyed material (much of which is held in the NMRS) and had, in fact, commenced his very substantial bibliography in 1955.

It is difficult to condense Thom's work to a short span, but his ideas, in essence, can be viewed under three headings:-

- 1) His attempt to demonstrate that stone circles were not always laid out as simple circles and that a number had complex geometrical shapes, betraying a profound understanding of Pythagorean geometry with possible astronomical significance. Andrew Fleming's response (1975) was to suggest that such distortions of a simple circular outline were made in order to create a more effective auditorium for dramatic effect.
- 2) His attempt to demonstrate the existence of a common unit of measurement, initially the "megalithic yard" (2.72 feet) by survey and mensuration. This has met serious objection from archaeologists who have indicated that the monoliths used as points of measurement are themselves big enough, in whatever dimension, to defy such usage. (Heggie, 1981, Ruggles 1999, 83, Burl 1991, 125-6).
- 3) As with his predecessors, Thom's observation, of the layout of the sites revealed the alignment of elements of the structure that in association with prominent/distinctive features of natural or man made origin on a skyline at some distance enabled the recognition or the forecasting of particular solar, lunar or even stellar events that were of crucial calendrical significance.

Thom had, thus, postulated that existence of elites in Neolithic societies, synchronously current from Brittany to Orkney who appear to have been aware of at least the rudiments of Pythagorean mathematics and were capable of carrying out and recording observations over cycles sometimes running for many years. Once again many archaeologists opposed these ideas, on 'Urduhmheit' principles in some instances, but also upon the principle that given a circular structure such incidents of alignment with various elements of the cosmos were likely and that just because coincidences did occur did not mean that they were either designed or used as such. Issues relating to former circumstance were also raised – whether, for example, vegetation or weather would have reliably allowed intervisibility behind the fore-sights and back-sights that Thom postulated. This issue became all the more pressing as Thom began to postulate longer sight-lines – as long as 15-20kms – that revived memories of The Old Straight Track, Ley Lines and whole Alfred Watkins/ T.D. Kendrick imbroglio that once again alarmed archaeologists.

It took the gentle clarity of Aubrey Burl's consideration of Stone Circles (1976, 1976a, 1981, 2006) and the pioneering work of James Heggie (1981) to moderate the climate of debate and to promote a careful analysis of the claims and counter claims. In looking at events concerning lunar observation Burl felt, in regard to both the situation at Stonehenge and that applying at a number of Recumbent Stone Circles, that the coincidence of lunar movement with the recumbent placements, and with timber posts (the A posts) at Stonehenge, that lunar observation to determine the arrival of a period of full moon and its monthly risings and settings and the prediction of these was the concern that was achievable by the observation of the objective against these rough and ready markers.

Clive Ruggles, an astrophysicist and prehistorian, has drawn the same conclusion (1999, 1998 Ruggles and Barclay G. 2000). At Stonehenge, matching burial sites over the whole of southern England, there was a focus of ceremonial towards the east and the association of that ceremony with interment of either inhumed or cremated human remains. The concern with the east would appear simply to be a 'tradition', not a matter of very precise observation, the concern with the moon, which both Burl and Ruggles agree is 'significant', (i.e. cannot be coincidental) is widespread and is a feature of Early Neolithic sites.

The only site with the stratigraphy to assist us, Stonehenge, sees a prominent change at the outset of Phase 3i with the first appearance on the site of stone features and the orientation of the site to very clearly align on the midsummer sunrise at a date currently accepted as 2600-2500 cal.BC Ruggles together with Aubrey Burl, from the late 1970s, the latter working from a more archaeological perspective, were the advance guard of the “non-precisionist school”. Their contention was that the precise, observational hypothesis of Thom that sought, and thought it had found, evidence for an advanced mathematical, Pythagorean capacity in early farming culture, was not well-founded. The suggestion that Neolithic populations were capable of refined measurement of distance and angle by the laying out of great ground-based ‘protractors’; by the establishment of a baseline with a backsight, a standing stone or similar marker, and a foresight that would be a natural feature, a notch in a hillside or a peak at perhaps some considerable distance (distances of 20-40kms were occasionally mooted) enabling the registration of measurements of minutes of arc, was unlikely. This would have enabled the putative registration of the ‘wobbles’ of the moon as it reached the extremities of its setting position on the horizon thus allowing the accurate prediction of the lunar cycle and putatively even the understanding of an 18.61 year cycle of lunar appearance. Thom also thought he could detect stone settings and sitings that would be ideal for the observation of stellar phenomena that would support these precise calendrical calculations – stellar objectives such as Regulus, Capella, Arcturus and Spica for identification of the equinoctial and solstitial periods. Thom paralleled these predictive measurements of the lunar and solar, reinforced by stellar, seasonal indicators with the four great festivals of the Celtic year – Imbolg, Lughnasadh, Beltane and Samhain. (Thom 1967, 92-106).

Thom also expounded a statistical argument for the existence of a basic unit of lateral measurement for the laying out of megalithic structures (1967, 34-55) that, with some statistical heavy lifting he calculated using distances between disparate elements (usually orthostats) on different sites. The megalithic yard (MY) of  $2.72 \pm .003$ ft that was applied widely throughout Britain was postulated.

Finally he demonstrated that many stone circles were, in fact, sub-circular - ovals, egg shapes etc - and he demonstrated how a knowledge of complex Pythagorean geometry and use of the megalithic yard would permit the construction of these complex forms. (Thom 1967, 56-83). Thom was to elaborate on his observational theories in 1971 (revised with corrections 1973) in which he gives detailed consideration to solstitial and lunar observatories detailing the *modus operandi* of such sites and the information that could be observed.

Such a mass of unfamiliar material, produced in an unfamiliar format, was bound to evoke a lively (or, indeed a totalled numbed) reaction. Some archaeologists rejected it, feeling that the astronomical tail was, so to speak, wagging the archaeological dog, and that this single, if complex, strand of evidence could not be allowed to upset the view of prehistoric society so laboriously built upon the basis of multiply intersecting evidence from a range of sources. Others, as Burl put it (Burl, 1981, 244) “vacillated or just hoped that it would all go away”. Thom’s theories did, thankfully, attract some archaeological support which served to frame the implications of Thom’s work in archaeological terms. Dr Euan Mackie (1977) published his polemic ‘Science and Society in Prehistoric Britain’ in which he set out his ....experimental excavations at Kintraw, Argyll, and observations at the site of Ballochroy, Kintyre and the reinterpretation of excavations at Cultoon on Islay which he felt were, in their different ways, ‘blind tests’ of Thom’s observational theories. He described Thom’s theories in, perhaps, far more accessible terms (a major service to non-astronomers!) and attempted to place the expertise that Thom postulated within a feasible Neolithic society by creating the notion of astronomer priests, an exclusive group, highly privileged for which he garnered evidence and attempted to place this group and its cognate society on an ethnographically informed scale. He tested the credibility of the theories to destruction(?) by suggesting not only that the MY was a unit of measurement that was standard over 1000 linear

miles of territory during the Neolithic but that the existence of the unit continued for nearly 3000 years to be found in the construction of brochs in W and N Scotland and in the existence of astronomer priests at this late date.

Mackie's work, in pointing out the inevitable conclusion to be drawn from Thom's hypothesis, stimulated the debate that drew Dr Ruggles to the enquiry.

As ever with the conclusions drawn from the analysis of large quantities of scientifically measured data, the *point d'appui* is the methodology and use of statistics. In a series of papers Dr Clive Ruggles, building on Heggie's ideas, has shown that the statistics that allowed Thom to identify alignments suggesting complex observational skills are, in terms of probabilistic analysis, flawed in that the chances that they could occur together randomly is altogether higher than Thom allowed. The severely statistical approach to archaeoastronomy is discussed in Ruggles, 1988, 246-250.

Similarly any (and there have been many) attempts to justify the statistics of the derivation from Thom's surveys of a  $2.72 \pm .003$  ft unit of measurement applied from Brittany to Orkney has been found to be wanting (see Pitts M., 2000,504 for references). The possibility that a standardised pace was used individually at each site must remain a strong likelihood.

Even the complex sub-circular shapes – ellipses, egg shapes and ovals have been shown to be capable of layout by pragmatic means involving the use of a length of cord and the establishment of multiple diameters (see Cowan 1988).

Alexander Thom has gifted us with a massive archive (held in NMRS) of excellent plans of stone circles and other megalithic monuments and his ideas have compelled us to evaluate, test and test again the extraordinary hypotheses that he generated. In doing so he has prompted intervention in prehistoric reconstruction by qualified astronomers that has allowed a measured and probably stable reassessment of the architectural significance of this whole sector.

Remaining on the *tapis* are some instances of evidence for the observation of lunar rising and setting (to within c.1° of arc in accuracy). In Scottish latitudes the moon at standstill is seen to hover and move horizontally along the N and S horizon "a rare and spectacular sight that could have led to this phenomenon ....assuming great importance" (Ruggles, 1988)

There is weaker evidence for observation of solar alignments for the winter solstice and there is no evidence at all for observation of the summer solstice. The observations are of low accuracy and could not be used to predict or to create a calendar (Norris, 1988). Burl in reviewing the Cumbrian stone circles (1988) could scarcely detect a single precise alignment and considered that the whole fabric could be fortuitous. It is clear that massive stones cannot be used as precise origin. Such objects also move under natural or anthropogenic impulse.

Following hot upon the emergence of Clive Ruggles (1981) account of his doubts about lunar observation in Thom, in 1981 Douglas Heggie, a mathematician and theoretical astronomer, in Edinburgh University, who had, like Lockyer, been attracted by the controversy at Stonehenge undertook a review of astroarchaeology in North west Europe. Heggie's analysis of the work current at that time that included all of Thom's published work. His study led to a very downbeat commentary that was, importantly, based upon rigorous statistical analysis of the great range of data so immaculately presented by Thom. He in adopting this approach, quite quickly disposed of the significance of complex geometry in the layout of the sub-circular series of stone settings – ovals, ellipses etc – that Thom hypothesised. He pointed to Cowan's analysis and the work of I.O. Angell, a mathematician at the University of London at the time, who (1977) had already indicated simpler

cumulatory methods of the construction of such forms without recourse to the complexities of geometric finesse required by Thom. He was equally quick to dismiss the statistical coincidences that would be necessary to allow the acceptance of megalithic units of length as transferred widely and used recurrently in prehistory.

In the same year Ian Thorpe (1981) examined the ethnographical record where he saw the almost universal interest in the heavens among human societies – hunting and farming and that, as far as stellar interest was concerned, constellations not single stars were usually the focus of interest. The lunar month is the easiest, most obvious heavenly calendrical unit to be encountered by looking at the sky, apart, of course from the observation of the passage of day and night. Circles are, as Burl had suggested before, not a good layout for observation and are a very infrequent occurrence in the ethnographic record. Where calendrical schemes have been created they are almost always uncomplicated. Thorpe concludes 'Instead of applying the principles of Occam's Razor, unnecessarily complex hypotheses have been developed to explain what, to the non-western observer, is not a particularly surprising phenomenon.' It is also clear from the examination of the ethnographic record that not only are our prehistoric remains not particularly suitable as 'astronomical aids' but astronomical observation can be carried out without having any archaeological trace whatsoever.

But we are left with a number of unambiguous and a larger number of less absolute phenomena that point to the significance attached to alignment, directions and timing. The alignment to due N displayed by the Callanish main avenue and by three of the Caithness stone rows; the alignment of the passage at Maes Howe that coincides with the setting sun at Midsummer solstice (or perhaps the sunrise, Burl 1981, 251). The consistent alignment of the Recumbent Stone Circles of North – east Scotland so that the recumbent slab, often carefully levelled, is set in the SW arc of the circles and, similarly, the SW axis of the passage of the Clava Cairns (Welfare 2011, Bradley ). Furthermore, archaeologists have long recognised the existence of individual preferences of alignment, orientation and siting for a number of classes of monument, defined on distributional or morphological grounds.

- 1) The heel-shaped tombs of the Shetland Islands have a total adherence to entrance orientation aligned between E and SSE
- 2) The stalled cairns of Orkney have a similar propensity
- 3) Orkney Cromarty Hebridean Tombs are biased towards the arc NE-E-SE with the Caithness showing some preference for the SE and Ross-shire and Inverness for the E.
- 4) In SW Scotland Clyde tombs have axes between NNE and ESE.

To the north Caithness produces a quite unique kind of monument – far from monumental. It comprises small flat slabs of local sandstone placed on edge and embedded in the mineral soil with the thin axis of the slab facing down the rows with multiple rows of slab forming a fan or an arrangement of parallel lines (in two cases). These monuments are very vulnerable – the stones have always been easily kicked over, the growth of peat can easily engulf them, even a vigorous growth of heather can completely conceal them. Of those that survive the majority favour an axis with the narrow end of the fan focused on NW-NE (three of them due north). The fans are often but not always set on rising ground with narrow part of the fan at the highest point. On plan it has been suggested that these layouts were used to observe and possibly predict the southern extent of moonrise although any observation of these diminutive structures on the ground makes it difficult to conceive of these being used effectively to observe anything.

For the final current statement on this issue it is perhaps appropriate to quote Clive Ruggles: 'Monuments played a fundamental role in the organisation of the prehistoric landscape, helping to mark and characterise important places in the perceived scheme of things. They were key elements in 'sacred geographies': landscapes charged with meaning. By understanding symbolic associations

between monuments and the natural landscape around them we may hope to gain insights into the prevailing world-view. But non-Western world-views do not separate the land and the sky; astronomy is an integral part of every indigenous cosmology, and this means that we are unwise to study sacred landscapes in isolation from the sky.

Perhaps astronomical alignments simply helped to affirm a monument's place at 'the centre of the world' (Renfrew 1984, 178-80); perhaps they had more to do with making its power unchallengeable and thereby affirming ideological structures and political control (Bradley in Barrett *et al* 1991, 56). Perhaps they were framed from a straightforward concern to harmonise the monument, or the place where it was located, with the cosmos.'

### Research Questions

- The excavation of a Caithness stone row/fan structure, perhaps, like that at Camster, buried deep in peat where more complete survival and the possibility of floor deposits would be available for study. Dr Kenny Brophy has already embarked upon a project of this kind.
- Adopting the general practice, where possible, of excavation 'around', and at significant points in sight of monuments drawing upon the lessons indicated by MacKie's excavation at Kintraw.
- The conduct of surveys of orthostatic settings to a standard employing both survey and photography, perhaps like that explored in Mercer (1998).
- The examination, as Burl has long advocated, of regional groups of monuments ..."regional characteristic spectra" with the objective of comparing spectra and the points of coincidence and non-coincidence.
- There should be further study of the ethnological/ethnographic record of monumental construction (which has often gained rather scant attention by social anthropologists in the past) as well as renewed attention to European folk-lore in an attempt to broaden the parameters of the interpretation of such sites.

The people who appeared in Britain during the closing centuries of the fifth millennium BC had to travel by sea, in turbulent waters with boats capable of carrying livestock, however young, as well as themselves. The course of such voyages would have largely been dictated by wind and by tide but the directional significance of the sun, moon and certain 'constellations' of stars almost certainly was realised. As these commuters moved into Atlantic France and the Lower Rhine and especially as they traversed the channel to Britain and Ireland they would have encountered some expression of that more temperate climate that dilutes the impact of seasonal change so that March can sometimes seem like September and April like February. Continental colleagues find this strange, accustomed as they have been, to the very smell of the earth changing and knowing that Spring has come. In these circumstances these courageous sea farers may have continued to require the 'reassurance' of knowing the turn of the year (winter solstice) from which point they could measure the hungry days through to 'Spring' (however February-like) and the sowing season.

It is widely accepted that the movement of farming as a practice was comparatively rapid across the British Isles – probably only 2-300 years between the first settlement in the SE of England (Whittle, Healy and Bayliss, 2011, Fig 15.8) and the arrival of fully fledged farming culture in the NE of Scotland – 8-10 generations moving on average c.100+ km per generation. Long kinship linkages may well have been maintained throughout this process and the evidence for this may exist in the widespread distribution (with its very generally N-S/W-E distribution of stone implements and by the 'heirloom' distribution of jadeite axes in the opposite direction. The focus to the E and S of monuments of many classes thus may take on another significance and ancestor and lineage issues and the appropriate and visible marking of these may also be linked.

Modes of burial were clearly derived from the south. The split tree trunk post gabled burials of Slew Cairn and Lochhill, Dumfries and at Edzell, Angus with links to the NE, and ultimately the S, of England; Clyde Cairns where the input was as clearly western and ultimately southern in the Irish Sea zone. However soon that inheritance became lost in the emergence of distinctly northern regional styles, the linkages to a past of migration, exchange, observation and navigation may have formed a basis to a form of 'creation myth'. Communal centres, where different groups came together to interact and transact are not so obvious in Scotland as they are on the South, but it may be that other centres, less recognisable archaeologically, served this purpose – whether it be 'halls' (roofed or not) or, perhaps, the forecourts of long cairns, where some of the deeper and wider ones could have focused quite large numbers of people. Indeed the plans of some of the 'halls' have in the mirrored plans of their opposed ends a close resemblance to the ritual house beneath the Nutbane Long Barrow in Hampshire.

The close relationship in terms of linearity closely succeeded, often, particularly in northern chambered tombs, by circular structures (see Brophy 2006, 31) is demonstrated with the communal monument that is common, in one sense, to both south and north Britain – the long parallel sided enclosure that seems, so often, to be a kind of 'strap' extended to unite and hold together a landscape unit – frequently a valley bottom or a boundary area. The frequently asserted likelihood of cursus monuments and circular enclosures reflecting age-old patterns of dance and procession should not, of course, be forgotten. Such 'cursuses' seem to be the first monuments of a ceremonial move to the centre of affairs whereby in many instances they occupy top quality land. Before then the use of such land was perhaps sparing – for 'halls' for example. Causewayed enclosures in the south were often confined to marginal land or territorial limits. In Scotland these may not have been so practicable of access or predictable of hospitality. Burial sites, chambered cairns etc, were generally confined to relatively near-marginal areas at the earlier neolithic stage.

With the move c.3200 calBC into the later Neolithic, this ceremonial aspect moves to 'centre stage'. The cursus begin to metamorphise into or are replaced by circular monuments, often of major constructional investment. It can be suggested that hereby the ritual and ceremonial affiliation of the earlier period are comprehended by or comprehend the material hierarchy of the earlier stage

While at an earlier period perhaps the relevance of the sun and its predicted 'resurrection' has been relevant, with sites after the turn of the 3<sup>rd</sup> millennium the solar connection becomes more important. As command of the environment is exaggerated (by an hierarchy?) so personal attributes, direct lineage, and, perhaps, individual genetic heritage became more important and there is some considerable evidence for that in North Britain but not in Scotland where massive funerary structures built about and after 3200 BC still contain massed communal burials – but sometimes in a manner which does not seem to reflect the design of the tomb, and anyway possibly exceptional in Orcadian isolation. Elsewhere evidence is scarce indeed.

#### The notion of Belief and Cosmography

This is a story notoriously difficult to construct through archaeology. Modern phenomenological studies may appear to be too inseparably linked to their roots – here in our own perceptions and pre-conceptions. Questions remain about those issues that relate to diet, demography and 'domestic' activity and 'ceremonial'. Nevertheless the human mind remains obsessed and compelled by a desire for the consolidation of a sense of security in a world, indeed a universe, of the unknown. This sentiment cannot have been any weaker than now.

In seeking this the questions remain:-

- 1) Was the sky important? Almost certainly, although ethnographic studies suggest not be any means universally. Possibly the importance of celestial observation is linked to latitude and climate and growing season as well as a degree of dependence on marine travel.
- 2) The idea of the encompassing of landscape as an initial statement (or illusion) of amalgamation with/control by, humanity.
- 3) The idea of validation of right and identity by burial in prestigious circumstances (i.e. insofar as these can be recognised in modern times)
  - where encompassing the landscape as an over arching illusion (or perhaps bald statement of) control occurs
  - where evidence of violence is substantial (see Knüsel *et al*, 200)
  - where power and influence in the landscape may be influenced by structure – structures that we are aware may sometimes be altered, disassembled.
  - where the landscape itself is something to be shackled
- 4) Where 'individual burial' does not as in the earlier neolithic, place weight upon the individual but upon the lineage/descent/linkage situations.

The above is about as far as it is possible to go. As Heggie says:

'If this conclusion is correct, it is likely that we already have before us the broad outlines of as much about megalithic science as we are ever likely to discover, unless somehow a completely new method of analysing megalithic sites can be devised. As Thom has written, 'We do not know the extent of Megalithic man's knowledge of geometry and astronomy. Perhaps we never shall.' What we do know about megalithic science may be less than is often claimed, but yet it is intriguing enough, and it is largely Thom's remarkable contribution which has shown us how to turn some of the speculation and guesswork into fact.' (Thom 1981,235)

#### Research Questions

- To examine by sampling and geophysical survey and consequent follow up the area around apparently ceremonial monuments.....which should be made a condition of their disturbance,
- To continue to test the reduced 'horizon' of 'astrological' observation. Midwinter solar and lunar observations and some other objectives,
- Develop 'other ideas' – the theoretical potential of enclosures – the carriage of sound, the effect of sound, the fall of light on monuments at particular times of year.
- Develop an in-depth, where possible, understanding of the local prehistoric environment of any ceremonial monument.
- Seek sites where EN ceremonial sites occur in close proximity to/are superimposed by LN sites to establish relationships, observe material distinctions and environmental differences.
- DNA studies and other related genetic and related matters.

He was given more pause by the question of alignment and observation of solar, lunar and stellar 'movement'. He pointed to three distinct basic flaws in the prior approach to this study –

- 1) Non-objectivity of selection of alignment. Each survey was a 'fishing expedition' with alignments realised as encountered. The alignments ought to be sought *ab initio*, not stumbled upon.
- 2) There is a fatal circularity in the suggestion of phenomena from the analysis of data and then demonstrating the accuracy of the suggestion by reference to the same data.
- 3) There was a general failure to recognise the very real possibilities that sites, perhaps especially circular sites, may fit theories entirely by chance.

Heggie moved from reference to these flaws to a reflection on the need for more data to test theories – yet the finite number of sites now extant (and their often damaged states) –



may limit the quality and informativeness of any such data that may be garnered there. There may be real limitations upon what can be known about prehistoric cosmography.