SOME PROBLEMS IN CORRELATING ARCHAEOLOGICAL MATERIAL AND OLD SHORELINES

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In recent years it has become apparent that the problems of correlating archaeological material with ancient shoreline changes are often more complex than has generally been assumed. The writer nevertheless feels that such work can be worthwhile in terms of both environmental and chronological studies.

For certain archaeological sites, an understanding of the former relationship between the site and shoreline is of cardinal importance because the economy and form of the settlement under investigation is related to an environment since altered by rise or fall in the relative level of sea and land. Saliagos in the Aegean is an example of this type of site. Recent excavations there, directed by Professor John Evans and Dr Colin Renfrew, disclosed remains of a considerable Neolithic settlement on a tiny and inhospitable islet (covering only 40 x 100 metres) in the midst of the strait between Paros and Antiparos. At the request of the excavators, the writer undertook two seasons of work in the area with teams of divers. Submarine geomorphological and hydrographic surveys were made of the floor of the strait, and in addition many submerged archaeological sites were located and recorded photogrammetrically on the sea bed. On this evidence, it was possible to show that it is likely that Paros and Antiparos were linked by an isthmus in Neolithic times, and that Saliagos was then not an islet but a low hill at the tip of a promontory on that isthmus (Morrison 1968). Many aspects of the Neolithic occupation of the site became more understandable (Evans & Renfrew 1968, p. 5).

The archaeological relevance of shoreline changes extends beyond the elucidation of relationships between environment and economy at individual sites. Changes in the level of the oceans are essentially synchronous in effect on a world-wide scale, and although changes in the level of land masses vary in nature and amount from place to place they frequently follow orderly patterns over great areas. Events characterised by as widespread geographical distributions as these offer considerable potential for the development of chronological frameworks of value to the archaeologist. Besides allowing the cross-checking of archaeological dates proposed on the basis of other kinds of chronological argument, the stratigraphic or geomorphological correlation of archaeological material with episodes of sea

level change can sometimes offer a means of giving a chronological context to sites or material which cannot be readily dated otherwise. For instance, flint artifacts of problematic typology found isolated from material suitable for radiocarbon dating can sometimes be placed relative to a sequence of local sea level changes which can be radiocarbon dated. Unlike the archaeologist, who characteristically has to deal with exceedingly rare material from unique assemblages set in unique stratigraphic contexts, the field scientist seeking to date episodes of sea level change very often has at his disposal deposits of which hundreds or indeed millions of tons survive. Furthermore, unlike the archaeologist for whom 'excavation is destruction', he can usually reinvestigate and resample his field evidence at will if he comes to suspect that new concepts have outrun the standard of previous observations of the natural evidence. Providing that the original findspot and stratigraphy of the archaeological material is recorded satisfactorily, the dating of the site in terms of sea level change may thus be subjected to repeated reassessments of a kind independent of archaeologically-based arguments. Despite the complexity of the problems involved, it thus seems worthwhile for archaeologists to give serious consideration to the possibility of establishing correlations between antiquities and shoreline changes whenever coastal sites are investigated.

This is certainly so in Scotland, for it has become clear that evidence of a rich history of sea and land level changes exists along the Scottish coastline for the period covered by Scotland's known prehistory, i.e. the majority of the post-glacial period. The model of Scotland's former shorelines that has emerged during the last decade differs in important respects from the picture which had come into acceptance over the previous century. The traditional picture was dominated by the concepts of '100 foot' and '25 foot raised beaches'. Archaeological material was considered only in relation to the latter, since only this was reckoned to be post-glacial in date. This so-called '25 foot raised beach' has been attributed at one time or another to most periods from the Roman occupation to the Mesolithic, with general feeling during the last few decades settling on the latter period. It was also generally agreed that the feature was not everywhere 25 feet above the present sea level. It seemed higher in the central areas of Scotland, perhaps reaching almost to 50 feet, and appeared to slope outwards, towards or indeed to below present sea level on the periphery. Measurements of actual height were few and far between however, and the old '25 foot' name was maintained. It is undeniable that there are many former shoreline features of post-glacial date around the Scottish coasts which coincide approximately with the 25 foot O.D. contour of the Ordnance Survey maps. Similarly, the 100 foot O.D. contour crosses many late-glacial shoreline features. Moving

from place to place with a map, it is thus tempting to assume that features on the same contour belong to the same shoreline. Detailed measurements made in the last decade show that this is however a misleading assumption. The writer has been involved in a long-term programme of quantitative geomorphological survey that has covered the entire estuaries of the Forth and Tay, together with the intervening coastline of East Fife. In conjunction with detailed large scale (6" to 1 mile) geomorphological mapping, stratigraphic and pollen studies by R.A. Cullingford, D. Kemp, W.A. Newey, J.B. Sissons, and D.E. Smith, the heights of former shorelines and related features were established in terms of Ordnance Datum at well over 10,000 places. By accurate levelling, keeping closing errors small, and heighting shorelines not just at single points but throughout their lengths with measurements at intervals of only 60 to 80 yards, a high resolution picture of the three-dimensional layout of the former shorelines has been obtained for this considerable area (summary, with references, in Sissons 1967). This work has shown that although many features are to be found along the 100 foot and 25 foot O.D. contours, these belong not to '100 foot' or '25 foot raised beaches', but to a much more complex suite of sloping shorelines which pass through these height bands.

The newly revealed pattern is somewhat formidable in its complexity. For instance, for the post-glacial period alone, at least eight successive shorelines are distinguishable in the Forth-Tay area. Three of these, all of archaeological interest, are now wholly underground, buried beneath later marine deposits. Older shorelines have been displaced further from the horizontal than more recent features (see below), so the planes of these features converge on each other, and indeed still earlier late-glacial shorelines descend into the post-glacial shorelines, intersect with them and disappear beneath them. The level of complexity of the record of relative sea level changes revealed in the Forth-Tay area is so much at variance with the simplicity of the traditional '25 foot raised beach' concept that, despite its size, one might be tempted to dismiss this sector of Scotland as an exception. This would however be to neglect the fact that this high level of complexity also characterises the results of most recent intensive investigations by workers elsewhere along the western seaboard of Europe. The writer is at present engaged on an analysis of the comparative stratigraphy of some 700 radiocarbon dates relevant to post-glacial changes of relative sea level along this seaboard (see below), and this has emphasised for him the basic unlikelihood of so simple a model as that of a single '25 foot raised beach'. This concept has seldom been questioned in the Scottish archaeological literature since the turn of the century, but it would seem that the archaeological assumptions drawn from it are ripe for reassessment.

The present remodelling of the geomorphological concepts relating to Scotland's former shorelines does not arise from any discovery of previously unsuspected mechanisms of change. The basic processes involved have been appreciated in qualitative terms for over a hundred years (e.g. Jamieson 1865). The reassessment of their implications has arisen directly from the recent move towards more precise quantitative observations. The dominant mechanisms are those of glacio-eustasy and glacio-isostasy. The locking-up of vast amounts of water as ice and snow on the continents during the ice ages lowered the level of the world's oceans by something of the order of 300 to 400 feet. This low world-wide ('eustatic') sea level rose as the climate ameliorated and the meltwater returned to the oceans. The decay of the ice sheets was not simple or continuous. The ice margins fluctuated, and accordingly so did world sea level. The last 20,000 years or so has however been characterised by an overall rise, marking the passing of the latest phase of the Ice Age. This rise continued into the present 10,000-year period, conventionally classed 'post-glacial', going on long after Scotland was clear of ice, as glaciers that had survived later nearer the poles melted out. It is not yet clear just when world sea level reached its present level, and it is also a matter of contention whether the eustatic rise in these last 10,000 years has been smooth or broken by oscillations. These uncertainties arise mainly because of the difficulty of identifying any coastline which may be taken as a stable 'measuring mark' for the purpose of assessing the eustatic sea level movements. In areas such as Scotland local movements of the land mass complicate the issue, making all indications of sea level change a relative matter, resulting from the interplay of the local land movements and the ocean surface movements. Land movements in Scotland have been dominated in the recent past by isostatic recovery from the release of the pressure exerted by the weight of the ice sheet. At the height of glaciation, the vast mass of overlying ice loaded the earth's crust sufficiently to depress it. As the superincumbent ice decayed and eventually melted out altogether, the unloaded crust gradually recovered. The response of the crust was sufficiently slow to continue through the majority, and perhaps even the whole, of post-glacial time. Unlike eustatic sea level changes, which are essentially equal in amount and synchronous in timing on a world-wide scale, the isostatic land movements have seldom been exactly the same even in adjacent stretches of the Scottish coasts. The areas most deeply depressed by the weight of the ice have risen furthest and, initially at least, fastest. From these areas, probably centred on the southwest Grampians, the amount of recent displacement has decreased outwards, until on the periphery of the country some compensatory depression is conceivable. Around the coastline, the former shorelines therefore mark phases in a continuous interplay between

two variables, eustatic sea level varying with time, and isostatic land level varying with both place and time. The concept of a warped '25 foot raised beach' sloping outwards from the central areas was perhaps the simplest hypothesis that could describe Scotland's well developed post-glacial raised shorelines in terms of glacio-eustasy and -isostasy. In many respects it is not surprising that the concept survived so long. That the interplay of those processes in post-glacial times has been of a kind to give rise to a whole complex of sloping shorelines is seldom obvious on the ground, for although individual shoreline features are often well marked or indeed spectacular, the departure of the lines of these old shores from the horizontal is sufficiently subtle as to be detectable only through the medium of extensive and rigorously controlled programmes of measurement. The slopes of the main post-glacial raised shorelines in the Forth-Tay area are, for instance, of the order of only 2 feet in 5 miles. It is clear that neither height estimates made by eye from contour maps nor occasional approximate instrumental measurements are capable of resolving the three-dimensional patterns of features with slopes of this subtlety. Yet over distances of the order encountered in a country the size of Scotland, even slopes as slight as these can have major effects.

It has already been mentioned that even within the confines of the Forth-Tay area, the planes of sloping shorelines converge and indeed intersect with each other. It thus seems clear that when dealing with an area the size of Scotland it would be wrong to assume that sloping shorelines would necessarily appear in the same vertical order in different regions. Late-glacial and post-glacial shorelines certainly do cross each other, and even fully post-glacial shorelines do in fact also appear to reverse their vertical positions. For instance, in the Forth-Tay area the main post-glacial shoreline is well above the present-day shore (it reaches almost 50 foot O.D.), yet in the Shetlands, Orkneys and Outer Isles it appears to lie submerged below present sea level. This shoreline dates from about 3,500 B.C., in the Forth-Tay area, and it has been shown that Shetland has in fact undergone something of the order of 30 feet of submergence since 3,500 B.C. (Hoppe 1965). Even in areas where the basic order of the shorelines is similar, differences in the nature of the local interplay between eustatic sea level movements, the particular local land movements and local conditions of deposition or erosion may lead to a quite different emphasis in the evidence. For instance, some of the shorelines which are well marked in the Forth-Tay area may either have developed only poorly or have been destroyed by later changes, while other events which have left little or no trace in the Forth-Tay area may come into prominence in other localities. Even where an individual shoreline may be traced continuously from one

area into another, it would be wrong to be entirely confident that its date was everywhere the same. The possibility that some of the post-glacial shorelines of Scotland may be time transgressive features has not been eliminated.

At present, the study of the correlation of archaeological material with shoreline changes is at an essentially transitional stage in Scotland. The intensive studies in the Forth-Tay area, together with smaller scale investigations by other workers elsewhere, have given a clear indication of the nature of the complexities involved, but with little detailed quantitative geomorphological information for so much of the rest of the Scottish coastline, for the moment the new information tends to pose more questions than it answers. The writer has accordingly undertaken an extensive analysis (mentioned above) of radiocarbon dated data on relative sea level changes during post-glacial times along the western seaboard of Europe, from the North Cape to Biscay. The purpose of this study is to obtain a detailed perspective of the whole spectrum of evidence, from the Scandinavian areas dominated by isostatic uplift to the presumed subsidence region by the Low Countries, so that the internal variability of the picture may be judged and the relative importance of local and eustatic factors assessed with a view to interpreting the available Scottish evidence in a controlled way. Specific aims are, firstly, to identify which events of sea level change affected the whole of this western European area, and, secondly, to assess in quantitative terms which of the events of more localised distribution are likely to be represented within the range of conditions now known to have prevailed within Scotland.

What conclusions may the archaeologist working in Scotland draw from all this? Certainly it would seem injudicious to place much weight on archaeological arguments involving the '25 foot raised beach'. The writer is working on a reassessment of the numerous Scottish sites that have been claimed in the past to relate to sea level change, and it is clear that the way that sites have been reported and indeed excavated has not infreqnently been influenced in a most unfortunate way by preconceptions involving the '25 foot raised beach'. Any present-day excavator working on a site in the vicinity of a former shoreline or of marine deposits should keep a very open mind indeed as to the date of the marine features. The recently current assumption that Scottish post-glacial raised shorelines were 'Mesolithic' accords ill with the fact that at least four of the abandoned shorelines in the Forth-Tay area postdate the beginning of the fourth millennium B.C. Although fully 'pre-Neolithic' post-glacial shorelines are present, in this area at least they are invisible, underground.

In view of the complexity, and as yet incompleteness, of the picture of shoreline change that is now emerging in Scotland, many may view the obsolescence of the '25 foot raised beach' concept with some regret. This concept, however, offering only a single dating horizon for the post-glacial period, could at best have been of only limited value in archaeological chronology compared to the rich sequence of shoreline changes, spread throughout the post-glacial period, which is now becoming apparent. It should shortly be possible for archaeologists to turn this complexity to substantial advantage, in terms of environmental as well as chronological studies.

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