Chapter 6 The Quaternary history of the Dorset, south Devon and Cornish coasts

Introduction

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Marine and periglacial deposits of the Dorset, south Devon and Cornish coasts

The Pre-Mesozoic rocks of South-West England, together with the harder Jurassic formations, provide the platforms which support intermittent outcrops of raised marine sediments and associated periglacial ('head') deposits. These deposits have an extremely protracted history of research with notable sites, such as Godrevy, having been described early in the nineteenth century (De la Beche, 1839). Although most coastal exposures comprise a simple sequence of raised beach deposits covered by head, in sheltered localities virtually throughout the Peninsula, 'sandrock', consisting of ancient dune sediments, accompanies the marine deposits. Periglacial 'heads' and related sediments occur widely throughout the region and testify to the effectiveness of frost-dominated and other (e.g. slope-wash) processes between the various phases of marine action.

At Trebetherick Point on the north Cornish coast, the occurrence of erratic boulders between the sandrock and the bulk of the head has caused some authors to consider the possibility of a glacial encroachment on to the Peninsula at some stage of the Pleistocene. The isolated gneiss boulder, known as the Giant's Rock, at Porthleven in south Cornwall also seems to suggest the former presence of glacier ice in the region (see Early glaciation; Chapter 2).

The generally acid rocks of most of South-West England provide superficial formations which are deficient in calcium. However, at a few locations (e.g. Godrevy) the calcium content is sufficient to preserve shell. Together with shells found in raised marine deposits on Devonian and Jurassic limestones at Torbay and Portland, these have provided the raw material for amino-acid age determinations which have gone some way to providing a geochronological framework for the raised beach deposits of the South-West.

The raised marine deposits

Pleistocene marine deposits found around the Peninsula occupy low topographic positions and rest on platforms cut between modern mean sea level and *c.* 5 m above it. Overwhelmingly, the beach deposits consist of gravel and cobbles, with the spectacular west-facing boulder beds of Porth Nanven, near Land's End, providing the coarsest grade material. Prior to the advent of amino-acid geochronology, the beach sediments had been regarded mostly as a coherent unit of similar age around the coast. The age of these deposits, however, was not certain, with some authors (Arkell, 1943; Mitchell, 1960; Stephens, 1970a) regarding the beaches as Hoxnian in age, on the basis of perceived stratigraphies in the overlying head, and others (Zeuner, 1959; Bowen, 1973b; Kidson, 1977) preferring an Ipswichian age.

With the revisions of chronology spearheaded by the amino-acid method, current opinion is that the sea has reoccupied the same platform on a number of occasions and that the currently visible raised beach deposits, although at roughly the same altitude and occupying the same geomorphic position in the landscape, date from at least two separate stages of the Pleistocene: Davies (1983) regarded these as being equivalent to Oxygen Isotope Stages 5 and 7 of the deep-sea record, and further detailed work by Bowen *et al.* (1985) has confirmed these ascriptions.

The general lack of fossils, in all but the beaches on the limestones, precludes any detailed comment on climatic conditions at the times the beaches were formed. Despite early statements of a 'glacial' or at least cold-climate origin for the beach deposits (Reid and Flett, 1907), there is now wide agreement that the beaches were formed by high sea levels during temperate interglacial conditions. The exact temperatures and conditions prevailing during deposition of the beaches can be determined more precisely by shells recovered from the beach deposits at Torbay (Hope's Nose and Thatcher Rock) and Portland Bill. Authors in the 1930s (Baden-Powell, 1930) still regarded the beaches here as having accumulated under cool climate conditions and cited the occurrence of molluscs, also currently found in Scottish waters,

as evidence of temperatures several degrees below those of the present Channel. More quantitative analyses of raised beach molluscs at Portland Bill (Davies and Keen, 1985) and at Torbay (Mottershead *et al.,* 1987), however, show that sea temperatures during both Stage 7 and Stage 5 were no cooler than today. Indeed, the Portland Bill fauna provides some evidence that during Stage 5 the sea was warmer than now by two or three degrees.

The sediments contained in the raised beaches also reflect deposition under conditions of wave approach and energy little different to those of the present, with the calibre of the beach gravels being similar to those of the modern beaches in the same area. This is even true for the spectacular raised beach deposit at Porth Nanven which comprises water-worn boulders commonly up to 0.5 m in diameter: this west-facing site on the exposed Penwith Peninsula appears to have been subject to the same, extremely high energy conditions during both present and past interglacials.

Blown sand and fossil dunes

The common occurrence of fossil dune material overlying the raised beach deposits around the coasts of the Peninsula is exemplified by the sequence at Trebetherick Point, but similar sequences can also be found where there has been a suitable coastal configuration and sediment supply. These sands are generally lightly cemented with iron and calcium carbonate and were probably deposited during times of falling sea level. This mechanism was suggested by Arkell (1943) for the dune sands at Trebetherick Point, although he also thought that the sands were a product of a warming climate. Current views would suggest that deposition at a time of climatic cooling is more consistent with falling sea level.

The specialized nature of modern dune habitats might suggest that ancient dune deposits would be poor in fossils. However, in the dunes with a moderate calcium carbonate content, as at Godrevy and especially on the Devonian limestone at Torbay, shell does occur. This consists mostly of comminuted marine shell debris blown from the strandline, but occasionally land shells also occur, as at Hope's Nose, Torbay (Mottershead *et al.,* 1987), thus confirming the terrestrial origin of some of the sand in which they are found.

Head and related sediments

From the earliest descriptions by De la Beche (1839), it was recognized that the deposits overlying the marine horizons were of terrestrial origin and their vernacular name in the South-West, 'head', is now widely adopted. Perhaps the most representative section in the South-West is that described by Mottershead (1971) between Start Point and Prawle Point. The vital characteristics of head development are all demonstrated by this section, with easily broken bedrock to provide the clasts in the sediment, a wide marine platform to provide a foundation for head accumulation and a sheltered aspect (on the east side of Bolt Head) which has preserved the deposits from excessive stripping by modern westerly waves. Where these three criteria are met, the thickest head sequences occur. However, even at exposed places such as Porth Nanven, some head has been preserved because the original sediment bodies (Tans' or 'aprons') were large and have not therefore been removed totally by Holocene marine action.

Although numerous facies of head can be recognized in the coastal sections, many workers have divided the head deposits into a Lower or Main Head and an Upper Head (e.g. Stephens, 1970a; see Chapter 2): traditionally a 'Wolstonian' (Saalian) age has been preferred for the lower and a Devensian age for the upper. At many locations, however, the head deposits contain lenses and layers of finer-grained sediments including silts and muds. Pollen recovered from organic-rich muds in the head sequence at Boscawen, on the south Cornish coast, indicates that the periglacial processes involved in head formation may have ceased, temporarily, when tundra vegetation colonized pools on the surface of the solifluction deposits: radiocarbon dating of these organic-rich sediments suggests that the upper head here can be no older than *c.* 30 ka BP (Scourse, 1985a). Recent lithostratigraphical comparisons of head sequences in the region suggest that this twofold division is in fact widespread (Scourse, 1985a), and a Late Devensian age for the upper head is supported by thermoluminescence (TL) dating of aeolian sediments ('sandloess') intercalated with it (Wintle, 1981). However, the precise age of the lower head, at most localities, is unknown: continuing uncertainty surrounding the age of raised beach deposits which underlie the head precludes precise dating. Detritus from a number of Pleistocene cold stages (equivalent to Oxygen Isotope Stages 4 and 6) may be present, but such ascriptions must remain provisional. In this context, it is worth noting that head deposits at least as old as Stage 8 have been recognized in the similar Pleistocene sequences of the Channel Islands and Normandy (Keen, 1993; Keen *et al.,* 1996; Chapter 2).

Further subdivision of regional head sequences has, however, been possible at Portland Bill, where the thin head overlying the West Beach (Davies and Keen, 1985) is divided in two by a marked palaeosol. Below this horizon, intense weathering has caused decalcification of the head. Above it, silty head with a high shell content is indicative of sub-tundra conditions and its upper layers are highly cryoturbated suggesting a further intense periglacial phase. The evidence from Portland Bill therefore suggests three separate periglacial phases after deposition of the West Beach during Oxygen Isotope Stage 7: tentatively, these could be ascribed to cold Oxygen Isotope Stages 6, 4 and 2 (Keen, 1985).

Evidence of glaciation

In the area under consideration there is little evidence for glaciation, but at Trebetherick Point the erratic boulders, perhaps separating the two heads, may be an exception. It is nonetheless difficult to see how a glaciation extensive enough to deposit erratics at Trebetherick could avoid leaving them elsewhere (but see Chapter 7) and none has been found in the area between Trebetherick Point and Land's End. If the Trebetherick erratics were brought by ice, it is perhaps more probable that it was in the Middle or Early Pleistocene and that only remnants of the tills survived to be reworked into the head.

Further evidence for an incursion of glacier ice on to the South-West Peninsula may be provided by the Giant's Rock at Porthleven. The provenance of this famous gneiss boulder is far from certain, but the highly metamorphosed terrain necessary to provide such a rock-type can lie no nearer than Scotland or Brittany, and indeed its source may be much farther afield (see Chapter 2). A Scottish source would fit with a glacial origin, but virtually no theoretical reconstruction of ice sheets, except that of Kellaway *et al.* (1975), would allow a Breton source. Whatever its provenence, it is difficult to imagine any agency other than ice which could have been responsible for its emplacement. The type of ice is a further uncertainty. The lack of any till in south Cornwall has led to the suggestion of icebergs as the mechanism of deposition (Flett and Hill, 1912), and this still seems the most probable explanation, although a sea cold enough to carry icebergs of the size capable of floating the Giant's Rock should have occupied a much lower sea level than that of the modern intertidal platform where the rock is stranded. For the Giant's Rock alone to have survived from the glacial phase which deposited it, the glaciation would need to have been of Middle or Early Pleistocene age to allow the time for the destruction of all other glacial material. There is no other trace of such an episode in the South-West.

Geochronology

Prior to the 1980s, the age of the raised marine deposits was variously determined from their altitude (and inferred related sea level) or from the lithostratigraphy of the overlying head(s) and associated deposits. According to Mitchell (1960) and Stephens (1970a), nearly all raised beach deposits in the region were of Hoxnian age: a Lower or Main Head was of Wolstonian' age, the last interglacial (Ipswichian) was represented by an unconformity or weathering horizon in the head sequence, and the last major cold phase of the Pleistocene, the Devensian, saw deposition of the uppermost head layers. A different scheme proposed by Bowen (1973b), which also used evidence from Wales and southern Ireland, suggested that the raised beach deposits everywhere in the region were of the same, Ipswichian, age. The raised beach deposits and overlying head, therefore, could be accommodated by a single interglacial/glacial cycle which spanned the Ipswichian (warm) and Devensian (cold) stages.

The application of amino-acid, thermoluminescence (TL), Uranium-series and radiocarbon dating techniques has not solved all the problems, but has provided much clarification. The principal discovery, revealed by amino-acid analyses on marine mollusc shells, is that the raised beach sediments were deposited in two or more episodes (Davies and Keen, 1985; Bowen *et* al., 1985). The most likely ascriptions for these marine phases are Stages 7 and 5 of the oceanic oxygen isotope record. An alternative interpretation of the data involves deposition of marine sediments in more than one of the sub-stages of Stage 5 (Bowen *et al.,* 1985).

Although not obtained from the GCR sites described in this volume, the Uranium-series dates derived from the caves on Derry Head, Torbay, by Proctor and Smart (1991) and Baker and Proctor (1996) are significant because they date three major high sea-level events equated by the authors with Oxygen Isotope Stages 5e, 7 and perhaps 9, and provide the potential to calibrate the amino-acid chronologies obtained from shell carbonate outside caves (Bowen, 1994b). Although it has been suggested that the amino-acid ratios obtained from shells from raised beaches below 10 m OD may indicate

ages in either Stage 5e or 7 (Bowen *et al.,* 1985; Davies and Keen, 1985; Bowen, 1994b), or within Stage 5e (Bowen *et al.,* 1985), the evidence from the speleothem dates from Berry Head reinforces the former chronology of two separate high sea-level events, and adds a third series of dates around 328 ka BP for a sea level at *c.* 25 m above mean sea level (see above; Chapter 2).

The thermoluminescence and radiocarbon dating of the uppermost parts of the head and related sediments to the last 30 000 years (Wintle, 1981; Scourse, 1985a), suggests that the lower parts of head sequences could be either Early Devensian in age (Oxygen Isotope Stage 4), or date from Stage 6 (see above; Head and related sediments). Unless the underlying marine deposits are dated (see Portland West), the age of any individual head deposit cannot be determined except within these broad limits.

In the following account, the selected GCR sites are described in order around the coast from Portland Bill to Trebetherick Point (Figure A; Preface).

References