Trebetherick Point

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Highlights

This classic locality has featured in numerous reconstructions of the Pleistocene history of South-West England. Its highly controversial 'boulder gravel' has been used as evidence by some for glaciation of the north Cornish coast.

Introduction

Sections at this site reveal a complex sequence of raised beach, blown sand, 'boulder gravel' and head deposits. The controversial 'boulder gravel', in particular, has attracted much interest and debate, and has been interpreted variously as a beach deposit reworked from glacial sediment, as a head or solifluction deposit, as river or outwash gravels and as till *in situ.* The precise origin of this bed and its stratigraphic relationship to sediments exposed elsewhere are of prime importance in establishing the sequence and nature of Pleistocene events in the region. The site was described in early studies by Ussher (1879a), Rogers (1910) and Dewey (1913, 1935). It also featured in more detailed studies by Reid *et al.* (1910), Clarke (1965a, 1965b, 1969, 1973), Stephens (1966a) and West (1973): the classic account is that of Arkell (1943). It has also been referred to in regional evaluations of Pleistocene history by Robson (1944), Arkell (1945), Balchin (1946), Clarke (1962, 1968), Mitchell and Orme (1967), Macfadyen (1970) and Edmonds *et al.* (1975), and in more extensive correlations (Green, 1943; Mitchell, 1960; Bowen, 1969; Stephens, 1970a, 1973; Kidson, 1971, 1977). More recently, the site has featured in studies by Clarke (1980), Sims (1980), Campbell (1984), Bowen *et al.* (1985) and Scourse (1985a, 1985b, 1987, 1996a, 1996c). A detailed description of the site is also provided by James (1994).

Description

Trebetherick Point [SW 926 779] is a promontory of Devonian rocks on the east side of the Camel Estuary. Pleistocene sediments are well exposed for *c.* 0.75 km around the Point between the southern end of Greenaway Beach [SW 928 783] and the dunes at the north end of Daymer Bay [SW 928 777]. They fringe an ancient rock cliff and rest on a conspicuous shore platform of Upper Devonian purple and green slates which varies in height between *c.* 1–7 m OD. Stephens (1966a) divided the platform into upper and lower elements: the Pleistocene deposits rest on the higher of these.

The Pleistocene sequence is both laterally and vertically extremely variable. Arkell (1943) figures three sections and Stephens (1966a) provides eight separate stratigraphic sections to illustrate this variability. (Figure 6.10) shows Arkell's 'Section A' and a revised stratigraphy for the principal exposure of the boulder gravel at *c.* [SW 927 781]. The following succession can be generalized from the descriptions given by Arkell (1943), Stephens (1966a) and Scourse (1985a, 1996c) and from field observations (maximum bed thicknesses in parentheses):

9. Soil

8. Sand (dune sand) (2.0 m)

7. Stony loam/pebbly clay (colluvium) (0.5 m)

6. Breccia (upper head) (1.0 m)

5. Diamicton ('boulder gravel') (2.0 m)

4. Breccia (lower or main head) (3.0 m)

3. Sand (dune sand) (6.0 m)

2. Boulders, gravel and sand (raised beach deposits) (2.0 m)

1. Breccia (lowest head) (0.3 m) Shore platform

The lowest breccia (bed 1) is not widely developed at the site and consists predominantly of fine slate fragments. Stephens (1966a) states that it rests directly on the shore platform and beneath raised beach deposits (bed 2), but Arkell (1943) shows the material to interdigitate with raised beach sediments towards the fossil cliff (Figure 6.10).

The overlying bed comprises a highly variable deposit of boulders, gravel and sand. Some of the sand is bedded and contains stringers of shingle, fine slate and occasional pebbles (Arkell, 1943). In other places, the bed consists of a poorly cemented, clast-supported deposit of pebbles and cobbles (Scourse, 1985a, 1996c). Clasts are subangular to rounded and of both local and non-local origin. Arkell (1943) recorded quartz, grit, slate, elvan (dyke rock of granitic composition), dolerite and flint from the bed as well as some very large boulders of 'greenstone' (sill material).

Bed 3 consists overwhelmingly of sand which exhibits large-scale cross-beds and is unevenly cemented. The latter gives rise to alternating hard and soft layers which make bedding conspicuous. Stephens (1966a) and subsequent authors have referred to the material as 'sandrock'. It is most steeply bedded (28°) at its junction with the fossil cliff, but more gently bedded to the west (Figure 6.10). The sand contains impersistent layers of slate and greenstone fragments, broken limpet shells, whole crab (*Cancer pagurus* Linné) carapaces (Arkell, 1943) and comminuted shell material (Rogers, 1910). Large solution pipes run from the top of this bed to its base (Figure 6.10).

The overlying breccia (bed 4) has sometimes cutout or 'channelled' the sands beneath (Arkell, 1943; Stephens, 1966a; Scourse, 1985a), but elsewhere it interdigitates with the sand (Stephens, 1966a). It consists of angular slate fragments with some larger pebbles of quartz and other rocks (Arkell, 1943) and is generally coarse and 'blocky' in nature: it sometimes has a sand-clay matrix (Stephens, 1966a). The deposit exhibits cryoturbation structures, fossil ice-wedge casts and, according to Stephens (1966a), is highly weathered. In places, it directly overlies the shore platform.

The stratigraphic relationships of the boulder gravel (bed 5) are not entirely clear, although most authors record that it overlies bed 4. This diamicton is restricted in outcrop; its main exposure is at [SW 927 781], although Scourse (1985a, 1987, 1996c) also records it at Tregunna [SW 960 740] and other localities around the Camel Estuary. (Figure 6.10) (section 2) shows that the deposit extends for *c.* 20 m (Scourse has traced its lateral extent for *c.* 60 m) and that it grades laterally into a coarse breccia of angular slate and quartz fragments. It may, therefore, be a facies variation of bed 4 (the lower or main head). It is a largely matrix-supported, mixed lithology gravel with cobbles and occasional boulders. Many of the clasts are locally derived (purple and green slate, vein quartz, phyllite), but others appear to have come from farther afield. The latter include sandstone, conglomerate, granite, porphyry, dolerite, basalt, ironstone and flint (Arkell, 1943), mica-schist (Clarke, 1965b; Scourse, 1996c) and chert (Scourse, 1996c). Some clasts are in excess of 0.5 m diameter and many of the larger ones are subrounded to rounded. In places, the matrix consists of a breccia of very fine slate fragments (Figure 6.10). Arkell (1943) described the sediment as conspicuously bedded in its lower layers, but Stephens (1966a) contradicts this, and today there is little evidence of stratification.

The overlying breccia (bed 6) is also laterally impersistent, and elsewhere rests directly on the lower head (bed 4). It always has a sharp junction with the lower head (bed 4) and is sometimes separated from it by a thin sand layer (Stephens, 1966a). It is a highly variable deposit consisting mostly of fine angular slate fragments, but with some larger slate blocks, quartz and other pebbles. Locally, it appears to contain material similar to, and probably derived from, the boulder gravel (Stephens, 1966a). Bed 6 sometimes grades into a stony loam. This dominantly fine-grained and matrix-supported deposit contains occasional slivers of slate and pebbles of quartz. Arkell (1943) notes that its upper surface is flat and even. It is overlain in places by partially cemented dune sand which contains abundant land snails (*Pomatias elegans* (Müller)), shells of mussels, and Mesolithic flint flakes (Arkell, 1943).

Interpretation

Ussher (1879a) was the first to establish the importance of the sections at Trebetherick. He remarked that at no other site in South-West England has so interesting a collection of Pleistocene, or Post-Tertiary, phenomena been observed within so small a space.' (Ussher, 1879a; p. 6). He recorded erratic stones set in clay (presumably the boulder gravel — bed 5), and interpreted the deposit as flu-viatile in origin. In contrast, Reid *et al.* (1910) suggested that the boulder gravel was a head deposit and that the underlying sand (bed 3) was a 'cemented sand reef' and, by implication, waterlain. Dewey (1913) fired the controversy over the boulder gravel by hinting at a glacial origin. He later referred to it unequivocally as 'boulder clay' and correlated it with the beds of clay and striated erratics at Croyde Bay and Fremington in north Devon (Dewey, 1935; p. 67) (Chapter 7).

Arkell's (1943) description of the sequence at Trebetherick is still one of the best, although some of his interpretations have since been revised. He regarded beds 2 and 3 as raised beach deposits and aeolian sand respectively, and correlated them with comparable deposits at Saunton in north Devon. He assigned the beds to the 'Boyn Hill or Middle Acheulian Interglacial' (equivalent to the Hoxnian of later terminology). He argued that the absence of shells in the raised beach deposits (bed 2) indicated deposition under relatively cold but high sea-level conditions at the beginning of an interglacial, with the constituent erratic boulders having been transported on ice-floes. He refuted the suggestion of Reid *et al.* (1910) that bed 3 was waterlain. Instead, he suggested it was an aeolian deposit derived from the north-west, and cited the inverted arrangement of crab carapaces within the deposit as evidence for wind action. Arkell argued that the deposit showed a fall of sea level, while the profusion of comminuted marine molluscs in the bed was taken to indicate a concurrent marked climatic improvement.

Arkell (1943) interpreted the overlying breccia (bed 4) as a solifluction deposit formed under periglacial conditions during the 'Cornovian Glaciation' (= Wolstonian Stage). He did not concur with a periglacial or glacial origin for the boulder gravel (bed 5) which he interpreted as either a river gravel or, more probably, a raised beach deposit. In favouring the latter hypothesis, he argued that the bed had accumulated during warm conditions and high sea levels (*c.* 17 m OD) in his Wolvercote or Micoquian Interglacial' (= Ipswichian Stage) and that the constituent erratics had all been derived from relatively local sources within the catchment of the River Camel, flints and Tertiary pebbles having been reworked from inland plateaux (Arkell, 1943). In the discussion following Arkell's paper, Bull claimed that the boulder gravel could equally well be a solifluction deposit, while George noted that its erratic content was … quite different from the Irish Sea drift.' (George in Arkell, 1943; p. 148). Arkell regarded the pebbly clay (bed 7) as a mixture of solifluction and sheet-wash deposits reworked from the boulder gravel. Together with head deposits found elsewhere around Daymer Bay (= bed 6), these deposits were believed to represent a return to periglacial conditions during the 'Cymrian Glaciation' (= Devensian Stage). Arkell noted that the evenly planed upper surface of bed 7 supported a fossil soil which contained Mesolithic artefacts and which was believed to represent an ancient land surface.

The overlying sands (bed 8) were regarded as wind blown in origin and of Holocene age. Their contained fauna of indigenous land snails and derived marine molluscs was taken as indicating temperate conditions subsequent to a period of vigorous forest growth around the coastal margin, as attested by a now submerged forest bed in parts of Daymer Bay (Arkell, 1943).

Stephens (1966a) regarded the raised beach deposits (bed 2) at Trebetherick as Hoxnian in age and suggested that the overlying sands (bed 3) had been blown inland from an exposed sea bed as sea level fell at the beginning of the Wolstonian (Saalian Stage). The lower or 'main' head (bed 4) was interpreted as a solifluction deposit which had both accumulated and been cryoturbated during periglacial conditions in the Wolstonian. Stephens (1966a) groups the boulder gravel (bed 5) with the main head (bed 4), but implies that it may originally have been deposited as outwash from an Irish Sea ice sheet of Wolstonian age (the same ice sheet was believed to have been responsible for depositing the Fremington Clay; Chapter 7). Whether it lies *in situ* or has been solifluted is not made clear (Stephens, 1966a). Stephens also draws attention to the very different nature of the principal solifluction deposits at Trebetherick (beds 4 and 6), arguing that the upper (Devensian) is relatively 'fresh' and unweathered, whereas the lower (Saalian) is much disturbed by frost-action (Saalian and Devensian) and significantly weathered (Ipswichian).

Sections at Trebetherick Point and elsewhere around the Camel Estuary have also been described and interpreted in a series of papers by Clarke (1962, 1965a, 1965b, 1969, 1973) who proposed a variety of mechanisms to explain the boulder gravel (bed 5). In 1962, he refers to it as 'head', but hints that it may have originated as a glacial deposit. Clarke's

(1965a, 1965b) papers return to the thinking of Arkell (1943), by proposing that the boulder gravel is an Ipswichian raised beach deposit derived by … marine erosion of a moraine in the Bristol Channel … ', but then reworked by solifluction processes in the Devensian (Clarke, 1965b; p. 274).

His later papers (Clarke, 1969, 1973) reflect the influence of a growing body of evidence for the presence of an ice sheet in the Bristol Channel and Western Approaches during Wolstonian (Saalian) times (e.g. Mitchell, 1960, 1968, 1972; Stephens, 1966b; Mitchell and Orme, 1967). His 1969 paper attempts to cover several eventualities by stating … a tongue of this ice invaded the north projecting Camel estuary, gathering beach pebbles in its progress and leaving a patch of till.' (Clarice, 1969; p. 90). He argued that this explanation of the boulder gravel was consistent with Mitchell's (1968) evidence that Saalian Stage (Wolstonian) Irish Sea ice had surrounded Lundy Island to a height of 105 m, and also with Stephen's (1966b) evidence for Irish Sea till in the Barnstaple Bay/Fremington area, and finally with evidence for an incursion of the same ice sheet on to the Isles of Scilly (Mitchell and Orme, 1967).

In 1973, Clarke reported a further exposure of the boulder gravel west of Tregunna House on the south side of the estuary [SW 960 740], and alluded to the possibility that the material was deposited by a glacier originating on Bodmin Moor. In his 1980 paper, however, he returns to the Irish Sea ice sheet hypothesis and explains the boulder gravel as part of a recessional moraine, occurrences of material at Tregunna and Little Petherick being used to define lateral margins of the moraine. This ingress of ice into the estuary was believed to have impounded the proto-Camel, forming a 'lake flat' at Trewornan [SW 988 743]. However, Scourse (1985b) has since shown that this feature comprises Holocene estuarine sediments.

Mitchell (in Mitchell and Orme, 1967) regarded Arkell's pebbly clay (bed 7) as a weathered facies of the north Devon Fremington Clay — a till believed by him to be of Wolstonian age: the boulder gravel (bed 5) beneath was regarded either as an outwash gravel or raised beach deposit. Stephens (1970a, 1973) disputed this interpretation, concluding that the boulder gravel was a mixture of head, glacial outwash and Irish Sea till, subjected to later frost-action and weathering.

Kidson took quite a different view of the evidence, rejecting a glacigenic origin for any of the deposits at Trebetherick. He noted that the boulder gravel (bed 5) graded laterally into head and might therefore be soliflucted river gravels — forming one element in a multiple facies head sequence. Moreover, George (*in* Arkell, 1943) had shown that the erratic content of the boulder gravel and pebbly clay was quite different from that of glacial deposits elsewhere which had been derived from the Irish Sea basin, the Cornish origin of many of the clasts supporting the idea that they had been derived by solifluction from within the catchment of the River Camel itself (Kidson, 1977). In refuting the presence of an in *situ* Wolstonian glacial deposit in the sections at Trebetherick, Kidson followed Zeuner (1945, 1959), Arkell (1945) and Bowen (1969) in assigning the raised beach sediment and blown sand (beds 2 and 3) to the Ipswichian Stage, and the overlying beds of head to the Devensian.

Although recent studies have clarified several important issues posed by the succession at Trebetherick, they have failed to reach a firm conclusion regarding the origin of the boulder gravel. Campbell (1984; in Scourse, 1996c) analysed quartz sand grains from the boulder gravel using Scanning Electron Microscopy (SEM). He concluded that the constituent grains showed features characteristic of a subaqueous origin (unspecified) but none indicative of a glacial or glaciofluvial environment of deposition.

Scourse (1996c) assigns the raised beach deposits and overlying sands (beds 2 and 3) to the Godrevy Formation of his lithostratigraphical classification, and the overlying head deposits (bed 4) to the Penwith Formation: the boulder gravel is afforded special status as the Trebetherick Boulder Gravel Member of the Tregunna Formation (the latter includes head deposits overlying bed 5 which locally contain materials reworked from it). He interpreted the bed as a partially soliflucted outwash gravel or ablation till, and provided fabric data in support of this conclusion. Its lithological content, however, was regarded as typical of the Variscan outcrops which occur both inland from the Camel Estuary and seaward of it. In determining the height of various boulder gravel outcrops around the margins of the estuary, Scourse (1996c) has concluded that only the lower-level occurrences, such as those exposed at Trebetherick Point, have been soliflucted, whereas those at higher level lie in *situ* and were the source of the reworked material. Additional clast lithological analyses from the material now point strongly to an inland source, perhaps as far afield as Bodmin Moor. The mechanism for emplacement, however, is still uncertain, although Scourse cites river ice as a possibility. Although this mechanism would explain its lithological content, Scourse concedes that the reconstructed gradient of the various boulder gravel outcrops around the Camel would be more consistent with a glacigenic (outwash) origin.

Bowen *et al.* (1985) provided an amino-acid ratio of 0.113 from a specimen of *Littorina saxatilis* (Olivi), collected by H.C.L. James, from the raised beach deposits at Trebetherick (bed 2), and ascribed the beach to Oxygen Isotope Stage 5e (Ipswichian) of the deep-sea record. Scourse (1996c) uses this geochronological evidence as well as stratigraphical evidence from the Isles of Scilly (Chapter 8) to assign a Devensian age to the boulder gravel whatever its origin.

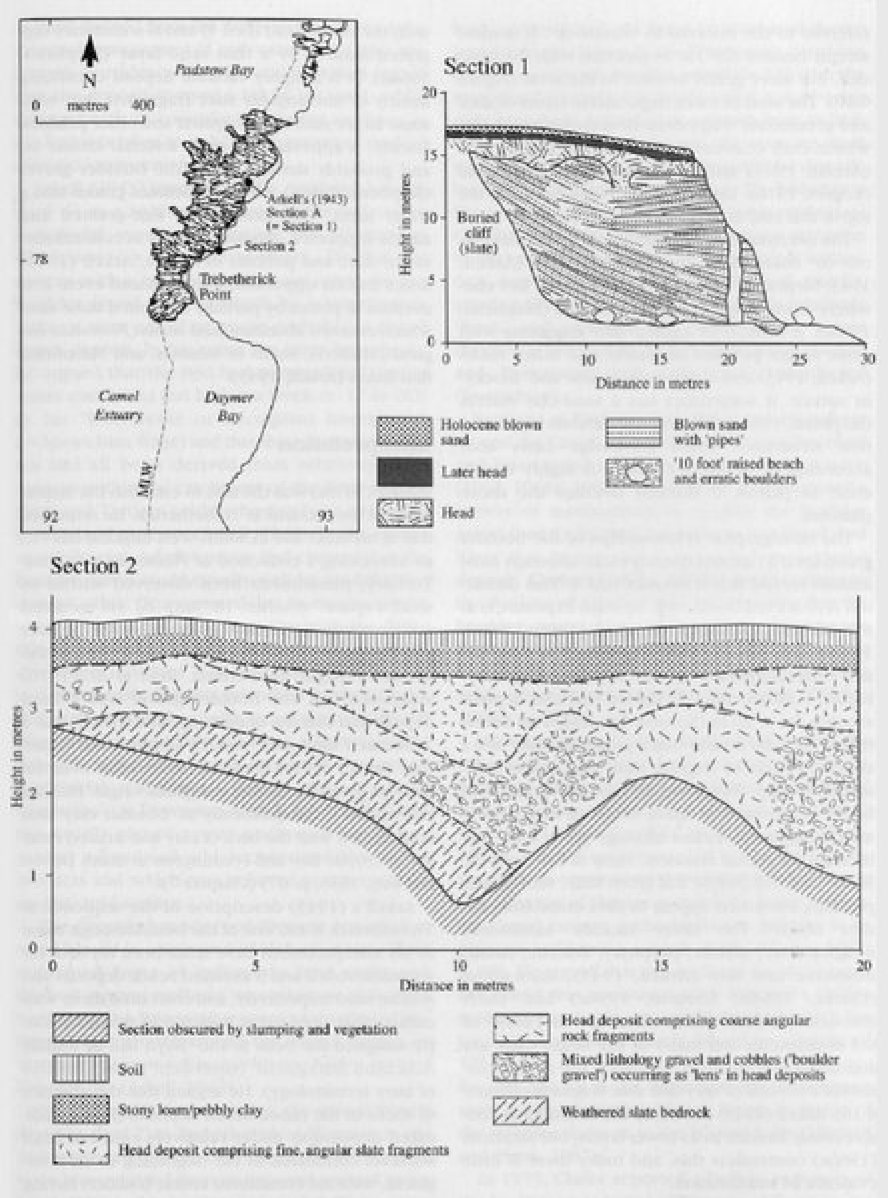
Scourse (1996a) described trace fossils (burrows of the talitrid sandhopper) from the sand beds (bed 3) at Trebetherick. He argued that they provide independent evidence of a backshore-frontal dune environment of deposition. He notes that the ecological requirements of *Talitrus saltator* (Montagu) — the most likely burrowing agent — support an interglacial depositional environment.

Morawiecka (1993, 1994) studied the palaeokarstic 'pipes' found in the upper part of the 'sandrock' profile at Trebetherick (cf. Arkell, 1943; (Figure 6.10), section 1). She concluded that they had been formed beneath a cover of head deposits under cold climatic conditions during end-Pleistocene times (cf. Godrevy).

Conclusion

Trebetherick Point is one of the most controversial Quaternary sites in South-West England. It shows a sequence of raised beach deposits, wind-blown sand and periglacial 'head' deposits. Of particular interest is the deposit known as the 'boulder gravel' which occurs within the head sequence. This highly controversial deposit has been interpreted by some as a glacial sediment and used as evidence to reconstruct the southern margin of a Wolstonian' Irish Sea ice sheet. Others have interpreted the material as fluvial sediment or raised beach deposits. Whatever its original mode of deposition, most agree that it was finally moved into place by periglacial (solifluction) processes. The latest suggestion is that the boulder gravel was derived entirely from within the catchment of the River Camel (some rock-types may have come from Bodmin Moor), having been transported to Trebetherick on floes of river ice similar to those seen in present-day Arctic Canada. Preliminary geochronological evidence from the site shows that the raised beach sediments were probably formed during Oxygen Isotope Stage 5e (Ipswichian) and that the overlying head deposits, including the boulder gravel, accumulated during the Devensian.

References



(Figure 6.10) The Quaternary sequence at Trebetherick Point: Section 1 after Arkell (1943); Section 2 compiled by S. Campbell.