Quaternary of South-West England

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Chapter 8

The Quaternary history of the Isles of Scilly

INTRODUCTION
J. D. Scourse

The Isles of Scilly contain a wealth of exceptionally important and interesting Quaternary sediments and landforms quite out of proportion to their relatively small area. Situated 45 km west-south-west of Land's End (Figure 8.1), the group consists of some 100 islands, most of which are devoid of soil and terrestrial vegetation. Most major appraisals of the Quaternary stratigraphy and geomorphology of the islands (Barrow, 1906; Mitchell and Orme, 1967; Scourse, 1991) have been based on evidence from the five largest and permanently inhabited islands of St Mary's, St Martin's, St Agnes, Tresco and Bryher, and the larger uninhabited islands of Samson, St Helen's, Northwethel, Tean, Nornour, Great Ganilly, Great Arthur, Little Arthur and Annet (Figure 8.1).

The Quaternary significance of the islands lies in the evidence they contain for: 1. changes in relative sea level, in the form of raised beaches; 2. former periglacial conditions elucidated from sedimentary, geomorphological and palaeobotanical sites including the first radiometric dates for the coastal 'head' deposits of South-West England; 3. glaciation of the northern islands with a well-defined glacial limit straddling the archipelago, indicated by a range of glacial, glaciofluvial and associated aeolian sediments; 4. some of the finest granite landforms in the British Isles whose evolution and form can be demonstrated to be intimately linked to the periglacial and glacial history of the islands; and 5. the successful establishment of forest tree taxa on the islands during the Holocene post-dating the severance from mainland Cornwall by sea-level rise. Of particular significance and importance are the palaeobotanical records from periglacial sequences which provide evidence of the vegetation of the late Middle and early Late Devensian, a phase very poorly covered by sites elsewhere in Britain, and the glacial sequences, which, together with glacigenic sediments from the adjoining continental shelf, provide evidence of the most southerly advance of ice during the Quaternary in north-west Europe.

The solid geology of the islands is almost exclusively granite (Figure 2.2), Scilly representing the highest parts of an almost completely submerged elliptical cupola which is the westernmost extension of the Variscan batholith of South-West England. Barrow (1906) divided the granite into coarse- and fine-grained facies and believed the only existing exposures of country rock to be the highly tourmalinized slates ('killas') of White Island, St Martin's. Although this material has been re-interpreted as either sheared or greisened granite (Hawkes, 1991), one small exposure of phyllitic country rock containing sporadic perthite megacrysts does occur on Shipman Head, Bryher (Hawkes, 1991). Although no *in situ* Mesozoic sediments occur on the islands, Barrow (1906) interpreted gravel, consisting largely of flint and greensand, on the summit of Chapel Down, St Martin's, to be of Eocene (?) age. This he correlated with the Eocene fluvial gravel capping the Haldon Hills in east Devon.

The homogeneity of the bedrock assisted in the early identification of pebbles of 'foreign' lithology on the northern islands. Smith (1858) recorded chalk-flints and greensand from Castle Down, Tresco. These were later interpreted by Whitley (1882) as glacial in origin. Barrow exhibited a striated boulder from the islands to the Geological Society in 1904 (Barrow, 1904), and he was later (1906) able to place the occurrence of the erratics within a stratigraphic framework. He took Chad Girt (see below), on White Island, St Martin's as his type-site for the Pleistocene of the islands. At Chad Girt, and at many other sites, Barrow observed that in cliff section the erratics were usually set within a silty matrix often cemented by iron oxides, and that this 'glacial deposit' was both underlain and overlain by head deposits, the whole resting on a raised beach. Barrow accepted Whitley's (1882) glacial hypothesis, but preferred deposition from 'floe-ice'.

In 1957 Dollar attributed the St Martin's gravels to the Pliocene, and in 1960 Mitchell further revised their probable age to Lower Pleistocene, citing a fluvial origin. Mitchell and Orme (1965, 1967) undertook a major re-examination of the Pleistocene stratigraphy of the islands and identified a more complex sequence than Barrow:

6. Upper Head
   Weichselian (= Devensian)
5. Raised Beach (Porth Seal)
   Eemian (= Ipswichian)
4. Glacial Deposit
   Gipping (= Wolstonian)
3. Lower Head
   Gipping (= Wolstonian)
2. Raised Beach (Chad Girt)
   Hoxnian
1. Shore platform

(revised stage names from Mitchell *et al.*, 1973b)

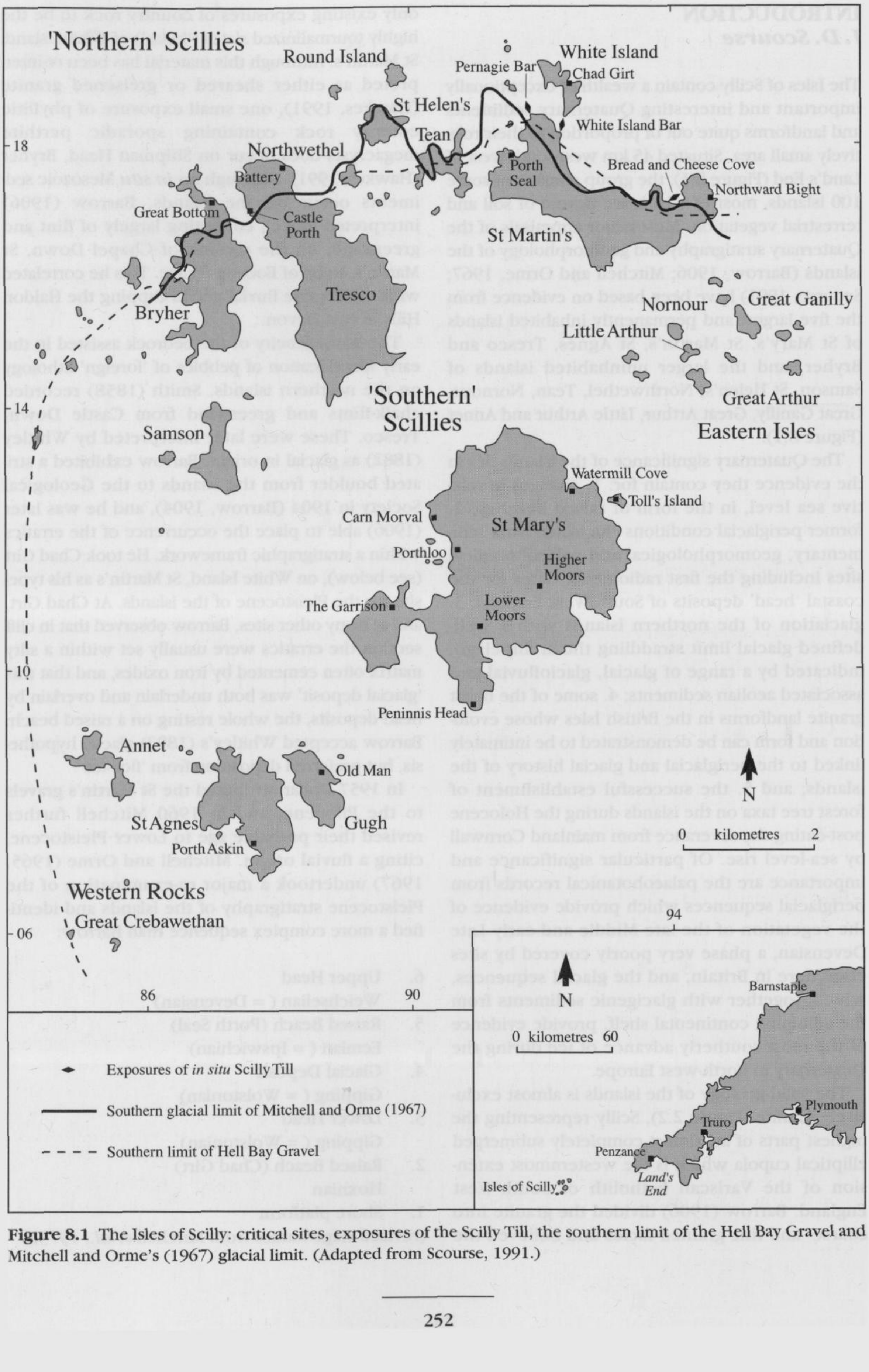

Figure 8.1 The Isles of Scilly: critical sites, exposures of the Scilly Till, the southern limit of the Hell Bay Gravel and Mitchell and Orme's (1967) glacial limit. (Adapted from Scourse, 1991.)

Figure 8.2 Carn Morval on St Mary's (Figure 8.1) is one of five sites on the Isles of Scilly where organic sediments, which have yielded pollen evidence and radiocarbon dates, lie beneath or interbedded with periglacial head. Although yielding the most detailed of these palaeoenvironmental records, Carn Morval was not selected as a GCR site because coastal erosion has since removed much of the critical organic sequence. (Photo: J.D. Scourse.)

They divided Barrow's (1906) 'glacial deposit' into two facies, till and outwash gravel, and identified an ice limit running across the northern islands based on the distribution of these sediments (Figure 8.1). By comparing their stratigraphy with similar sequences in mainland South-West England and in Ireland, Mitchell and Orme suggested a Gipping (= Wolstonian) age for the glacial event. This interpretation was largely based on the suggestion that the erratic-free Chad Girt raised beach is Hoxnian in age by correlation with other raised beaches of supposed Hoxnian age at similar elevations elsewhere, for example, the Courtmacsherry raised beach in southern Ireland. Direct correlation of lithostratigraphic units with chronostratigraphic stages on a one-to-one basis then dictated that the Porth Seal raised beach should be Eemian (= Ipswichian) in age. The interpretation of a Wolstonian glacial limit on the islands as a result became firmly established in the literature (cf. Catt, 1981; Lowe and Walker, 1984), despite some speculation that the glacial material on the Isles of Scilly might be younger in age (John, 1971; Synge, 1977, 1985).

Bowen (1969, 1973b) questioned Mitchell's and Orme's interpretations, proposing that the lenticular form of the glacial material and its geomorphic association with coastal valleys was more consistent with an origin as soliflucted till. He later (1981) suggested that the critical stratigraphy identified by Mitchell and Orme (1967) at the Porth Seal site was 'inferred and superposed' and argued that granite corestones had been misinterpreted as a marine deposit. Bowen (1973b) regarded the *single* raised beach as Ipswichian in age, the soliflucted glacial deposits having been originally emplaced in the Wolstonian.

Coque-Delhuille and Veyret (1984, 1989) proposed a much more southerly ice limit on the islands. They concurred with Mitchell and Orme (1967) and Bowen (1973b) that the glaciation was Wolstonian in age.

The dating of the glacial material on the Isles of Scilly by Mitchell and Orme (1967) and Bowen (1973b) was therefore heavily dependent on the number and age of stratigraphically juxtaposed raised beach units, and lithostratigraphic correlation with neighbouring regions.

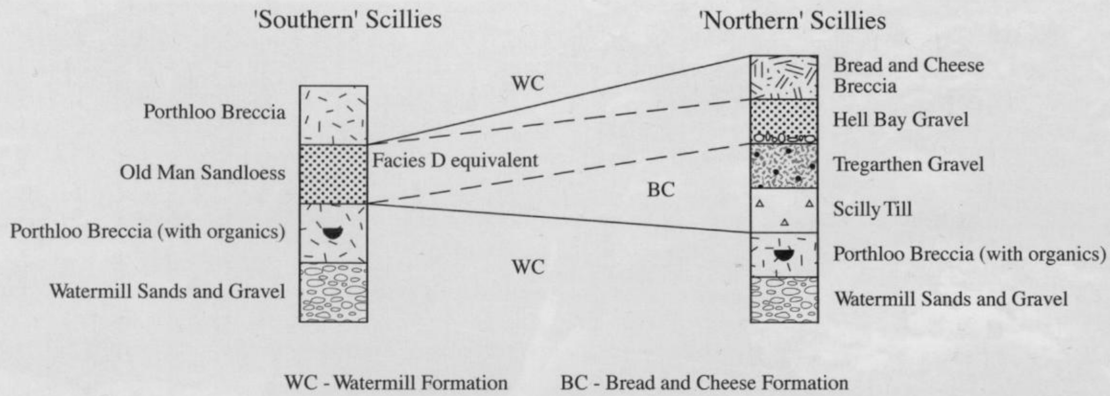

Figure 8.3 A lithostratigraphic model for the Isles of Scilly. (Adapted from Scourse, 1991.)

Scourse (1991), in the most recent re-examination of the islands, proposed a revised local stratigraphy independent of the stratigraphies erected in neighbouring regions. He reported organic sediments (Figure 8.2) from a number of sites which provided a chronology through multiple radiocarbon determinations, and which yielded palaeobotanical evidence critical in palaeoenvironmental reconstruction. Thermoluminescence (TL) dates (Wintle, 1981) and optical dates (Smith *et al.*, 1990) further assisted in the establishment of a radiometric chronology for the sequence.

Scourse (1991) defined eight lithostratigraphic units of member status which he incorporated into two lithostratigraphic models for the 'southern' (extra-glacial) and 'northern' (glaciated) Isles of Scilly (Figure 8.3). The southern limit of the Hell Bay Gravel defines the boundary between these two areas, and corresponds closely to the ice limit identified by Mitchell and Orme (1967; Figure 8.1). The same lithostratigraphical units are used, albeit in slightly modified form, in the Geological Society's recently revised correlation of British Quaternary deposits (Campbell *et al.*, in prep.).

Overlying the raised beach sediments of the Watermill Sands and Gravel in the southern Isles of Scilly is the Porthloo Breccia, a variable unit of soliflucted material derived entirely from the weathering of the granite bedrock (Scourse, 1987). The organic deposits were found towards the base of this unit at five sites (Figure 8.1); Carn Morval (SV 905118), Watermill Cove (SV 925123), Toll's Island (SV 931119), Porth Askin (SV 882074) and Porth Seal (SV 918166). Scourse interpreted these organic sequences as the infillings of small ponds or lakes impounded by active solifluction sheets or lobes.

Radiocarbon dates from these organic sediments are critical since they pre-date the units associated with the glacial advance (Figure 8.3), the Scilly Till, the Tregarthen Gravel, the Hell Bay Gravel and the Old Man Sandloess. The radiocarbon determinations indicate deposition of the organic material between 34 500 + 885/− 800 (Q-2410) and 21 500 + 890/− 800 (Q-2358) BP. They provide a maximum age for the glacial event and the first radiometric dates for the coastal 'head' deposits of South-West England.

All samples of organic sediment used for these radiocarbon determinations were taken from permanent open coastal sections which posed considerable problems of contamination by younger carbon derived from rootlet and groundwater sources. However, multiple dates of both humic and humin fractions of samples from different locations within the deposits enabled Scourse (1991) to identify the extent and sources of contamination and therefore to assess the reliability of the resultant determinations.

The pollen sequences from the Pleistocene organic deposits are all very similar in recording open grassland vegetation. Carn Morval on St Mary's (Figure 8.1) yielded the most detailed pollen profile, but has not been selected as a GCR site because its organic material has now been largely removed by coastal erosion. The organic beds at the site were situated towards the base of the Porthloo Breccia, and the pollen assemblages (Scourse, 1991; Fig. 10) are dominated by Gramineae (grasses), Cyperaceae (sedges) and other herb taxa. *Pinus* is the most important tree taxon, but Scourse (1991) interprets this as a long-distance component rather than indicating local presence; the increase in *Pinus* towards the top of the diagram is probably the result of the relative decline in the pollen productivity of the local herbaceous flora set against a relatively constant supply of long-distance *Pinus*.

These pollen sequences represent the earliest Quaternary vegetational record for South-West England west of east Devon. The spectra are broadly similar to others of the same age from elsewhere in north-west Europe (Bell *et al.*, 1972; Morgan, 1973; West, 1977b).

In the southern Isles of Scilly, the Porthloo Breccia is overlain by the Old Man Sandloess, a coarse aeolian silt with subdominant fine sand and minor amounts of clay (Catt and Staines, 1982). This has yielded two TL dates, both of 18 600 ± 3700 BP (QTL1d and QTL1f) (Wintle, 1981) and two optical dates, 20 ka ± 7 ka and 26 ka + 10/− 9 ka BP (738al and 741al; Smith *et al.*, 1990). This material occurs in a variety of facies related to different modes of reworking.

In the northern Isles of Scilly, the Porthloo Breccia is overlain by three units that are all related to a single glacial event. The Scilly Till, a massive, poorly sorted, clay-rich, pale-brown diamicton containing abundant striated and faceted erratics of northern derivation, occurs at Bread and Cheese Cove, at Pernagie Bar and White Island Bar (Figure 8.1). The precise depositional environment of this material is uncertain but Scourse (1991) argues, on the basis of sedimentological, structural, lithological and fabric (eigenvalue) data, that it is likely to be of lodgement origin. This conflicts with the suggestion by Eyles and McCabe (1989), echoing the 'floe-ice' hypothesis of Barrow (1906), that this material is of glaciomarine origin. At Bread and Cheese Cove the Scilly Till occurs in association with a matrix-supported sandy gravel, the Tregarthen Gravel, which has a similar erratic assemblage. The Tregarthen Gravel is best displayed at its type-site, Battery (Castle Down) on Tresco (see below – Battery; Figure 8.1).

Aeolian loessic processes in association with the glacial advance resulted in the deposition of the Old Man Sandloess in the southern Isles of Scilly. The relative coarseness of this material is interpreted by Scourse (1991) as a function of its proximity to glacially derived source material. The mineralogy of the Scilly Till is sufficiently similar to that of the Old Man Sandloess (Catt, 1986) to suggest a genetic link between the two units.

Overlying the Scilly Till and the Tregarthen Gravel in the northern Isles of Scilly is the Hell Bay Gravel, an extremely widespread matrix-supported gravel containing a similar assemblage of striated and faceted erratics to the underlying till, but alongside a considerable proportion of locally derived granitic material. The lithology and mineralogy of the Hell Bay Gravel is identical to colluvially reworked facies (facies D) of the Old Man Sandloess (Figure 8.3). This material represents an initial phase of solifluction, post-dating the glacial event, in which the Scilly Till, Tregarthen Gravel and Old Man Sandloess were mixed and transported downslope. In situations where these sediments were stripped from the land surface, weathered granite once again became the dominant raw material for solifluction, this subsequent phase being represented by the Bread and Cheese Breccia in the northern islands and the upper Porthloo Breccia in the south. The Hell Bay Gravel is synonymous with Barrow's (1906) iron-cemented 'glacial deposit'.

There is a strong spatial relationship between the distribution of the glacigenic and glacial-derived sediments and marine bars, tombolos and granite landforms in the Scillies. Many marine bars occur within the limit of the Hell Bay Gravel, and two of these, Pernagie Bar and White Island Bar (Figure 8.1), are directly underlain by Scilly Till. Although most of the boulders comprising these bars are granite, many are erratics, dominantly flint, red siltstones and sandstones. Whereas contemporary marine processes clearly control their detailed morphology, the internal structure of the bars and their distribution in relation to the sedimentary units discussed above suggests a possible morainic origin (Scourse, 1991).

Scourse (1987) defined four tor forms from the Isles of Scilly, and there appears to be a good correlation between highly smoothed, eroded tors and the southern limit of the Hell Bay Gravel, suggesting that the glacial advance, though unable to penetrate far into the Scilly massif, was nevertheless capable of eroding the solid granite. Tor forms in the southern islands are, by contrast, 'mammilated' or 'castellated' (see below – Peninnis Head; Figure 8.6).

The evidence presented by Scourse (1991) therefore indicates that ice advanced as far as the northern Isles of Scilly during the Dimlington Stadial of the Late Devensian around 18 600 ± 3700 BP. However, this may not have been the first glacial event to affect the islands because erratics are widespread in some exposures of the Watermill Sands and Gravel, the basal lithostratigraphic member of the Pleistocene sequence. The age of this earlier event remains uncertain.

Scourse's (1991) interpretation clearly conflicts

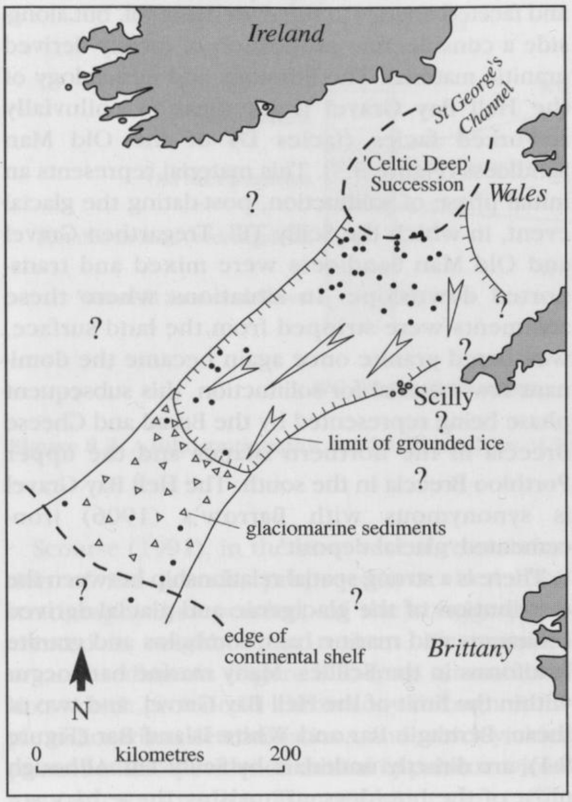

Figure 8.4 A reconstruction of the Celtic Sea ice lobe and glaciomarine terminus at 19 ka BP, adapted from Scourse *et al.* (1991). Dots represent vibrocoring sites which have yielded glacigenic sediment.

in a number of important respects with Mitchell and Orme's (1967) sequence of events. The main differences include: 1. recognition of only one raised beach unit stratified with other sediments; 2. recognition of widespread loessic sediments, and the interpretation of a sedimentary suite of till, outwash gravel and loess related to a single glacial event; and 3. independent radiometric dating rather than relative dating based on the inferred ages of raised beach units.

The interpretation of the Late Devensian glaciation of the Isles of Scilly, and the evidence on which it is based, have proved controversial. Scourse (1991) identifies the main points of contention as: 1. the reliability of the radiometric dates; 2. the validity of the lithostratigraphic correlations between sites and islands; and 3. the *in situ* status of the Scilly Till. Scourse (1991) discusses these points in turn and concludes that the evidence in support of the Late Devensian model is much more substantial than that proposed by Mitchell and Orme (1967) to support the hypothesis of Wolstonian glaciation.

Glacial and glaciomarine sediments have been discovered on the continental shelf adjoining the Isles of Scilly as far south as 49° (Scourse *et al.*, 1990, 1991). These sediments have been grouped into a northern facies containing sparse reworked microfaunas, interpreted as either overconsolidated lodgement tills or proximal glaciomarine sediment, and a southern facies containing abundant cold-water microfaunas, interpreted as distal glaciomarine silty clays. Scourse *et al.* (1990, 1991) correlate both facies with the Scilly Till, thereby enabling a quantitative reconstruction of ice thicknesses, grounding-line, sea level and shoreline elevations in the Celtic Sea at *c.* 19 ka BP.

The Late Devensian ice advance responsible for the glaciation of the northern Isles of Scilly and the adjoining shelf is thought to have terminated in marine waters towards the shelf edge break and is likely to have constituted a thin lobate surge over deformable marine sediments at the southern terminus of the Irish Sea ice stream (Scourse *et al.*, 1990, 1991; Figure 8.4).

Many of the GCR sites on the Isles of Scilly have been selected because they provide critical evidence relating to this glacial event and its dating; these sites include Bread and Cheese Cove (St Martin's), Watermill Cove (St Mary's), Porth Seal (St Martin's), Battery (Castle Down, Tresco), Castle Porth (Tresco) and Old Man (Gugh, St Agnes). Other sites have been chosen for their historical significance or because they contain evidence which has proved controversial in the evolving ideas on the Quaternary history of the islands; these include Chad Girt (White Island, St Martin's), Northward Bight (St Martin's) and Porthloo (St Mary's). Peninnis Head (St Mary's) has been selected because it contains spectacular granite landforms typical of features which lie outside the limit of the Hell Bay Gravel, and Higher Moors (St Mary's) because it contains the palaeobotanical evidence for Holocene forest development (Scaife, 1984, 1986).

PORTHLOO, ST MARY'S

J. D. Scourse

Highlights

Fine exposures of head at this easily accessible site have been chosen as the stratotype for this material on Scilly since the early twentieth century. The stratigraphical relations of this material to underlying raised beach sediments are also clearly demonstrated.

Introduction

Barrow (1906) defined the section of granitic head at Porthloo (Figure 8.1) as the type-site for the 'Main Head' on Scilly. He commented that occasional exposures of raised beach could be observed at the base of the section. Mitchell and Orme (1967), while confirming the quality of the head outcrops at the site, commented that the raised beach exposures here were inferior to those at other sites, and did not correlate the raised beach here with either their 'Chad Girt' or 'Porth Seal' raised beaches. Scourse (1991), following Barrow (1906), took Porthloo as the type-site for the Porthloo Breccia (Figure 8.3), and correlated the raised beach with the Watermill Sands and Gravel.

Description

Two sedimentary units are exposed at Porthloo (SV 908115). Up to 5 m of coarse granitic head overlies occasional large rounded granite cobbles at the base of the section. The clasts within the head are all extremely angular, vary in size from pebbles to boulders, and are exclusively of granite. Barrow (1906) noted that the deposit locally varies in texture. The unit is mostly clast-supported and the matrix is extremely poorly sorted. In places it is stratified and occasionally displays lobate structures with clast concentrations along the margins of the lobes. The clast fabric is consistently oriented parallel with the local slope, but with a predominant dip into the flow direction.

Interpretation

The head at this site has been consistently interpreted as a solifluction deposit, and the underlying rounded cobbles as the remnants of a raised beach. In explaining the variation in texture of the deposit, Barrow (1906) commented that this '... is clearly due to the fact that the steep rock-face behind the Head alternately recedes from and approaches the present low cliff-face; in the former case, the Head is finer, in the latter coarser' (Barrow, 1906; p. 19). In terms of the model put forward by Scourse (1987) to illustrate the stratigraphic and sequential development of such deposits, this variation is between facies B (coarse blockfield/felsenmeer facies) and facies D (finer solifluction facies).

Barrow further noted that there had been little lateral transport of these deposits parallel to the shoreline as shown by the disposition of fragments of the Porthloo elvan or quartz-porphyry; these do not extend more than a few feet on either side of the dyke. He contrasted this with the occurrence of transported raised beach cobbles within the deposit testifying to considerable forward and downward movement. This downslope movement has been confirmed through clast fabric studies in deposits of the Penwith Breccia at other sites (Scourse 1987, 1991). The characteristic dip of clasts into the section at angles between 5° and 45° from the horizontal have been explained by Scourse (1987) in terms of penecontemporaneous upfreezing accompanied by mass movement of material under gravity processes in the seasonally thawed layer characteristic of periglacial environments (French, 1976).

The source material for the head was overwhelmingly weathered local granite, though in places local lenses of silt occur within it which are probably of loessic origin, aeolian deposits derived from a wider source area.

Conclusion

This site affords excellent and accessible exposures of sediments deposited downslope as a result of the seasonal thawing of ground in cold Arctic-type environments. These sediments are quite widespread on the Isles of Scilly, but the exposures at Porthloo have long been regarded as the best available.

WATERMILL COVE, ST MARY'S

J.D. Scourse

Highlights

This is the most important Quaternary site south of the glacial limit on the Isles of Scilly. Exposures here contain the finest raised beach sequence, and the most impressive Middle–Late Devensian organic sequence, on the islands. The raised beach is unique because it is the only example on Scilly to contain a distinct bed of unconsolidated sand above the beach shingle, cobbles and boulders. The organic sequence has yielded pollen assemblages indicative of open grassland vegetation thought to be contemporary with periglacial conditions. Radiocarbon dates from the organic material are critical in showing that it pre-dates the glacial event which impinged on the northern islands.

Introduction

Mitchell and Orme (1967) recorded raised beach sediments at Watermill Cove, noting that the beach of small cobbles and boulders is overlain by *c.* 2 m of 'coarse sand stained black and red by manganese and iron', in turn covered by undifferentiated head. Though they did not explicitly correlate the raised beach here with either their upper 'Porth Seal' or lower 'Chad Girt' raised beaches, Page (1972), in a paper concerned with the radiocarbon dating of organic interglacial deposits in Britain, argued that both the 'Upper Head' and 'Lower' or 'Main Head' of Mitchell and Orme's scheme (1967) could be identified at the site. He therefore implied that raised beach sediments underlying the Lower Head were 'pre-Gipping or Hoxnian' in age, thereby effecting a correlation of these deposits with the earlier Chad Girt raised beach. Page (1972) was the first to identify organic beds lying stratigraphically between the raised beach and the head at Watermill Cove. He interpreted this material as Hoxnian in age in view of its stratigraphic position in relation to the units identified by Mitchell and Orme, and reported radiocarbon dates of around 22 ka BP from bulk organic samples from the site. He used these dates, along with others from sites of Hoxnian or supposed Hoxnian age elsewhere, to argue that the Hoxnian occurred between about 25 500 and 21 100 BP. Page's (1972) controversial paper was criticized by Shotton (1973) on the basis that there is no evidence to justify Page's assumption that the organic material at Watermill Cove is Hoxnian in age.

Scourse (1991) described the sections at Watermill Cove and, on the basis of further radiocarbon dating, pollen analysis and correlation with other sedimentary units on Scilly, proposed that the entire sequence above the raised beach is Middle or Late Devensian in age, much younger than envisaged by either Mitchell and Orme (1967) or Page (1972).

Description

The section containing organic material lies at SV 925123, to the south-east of Watermill Cove proper on the north-east coast of St Mary's (Figure 8.1). Lying below 1–2 m of coarse granitic head (Figure 8.5; bed 7) there is a relatively undisturbed unit of sand and silt containing organic material (Figure 8.5; beds 3–6). The unit averages between 1 and 1.5 m thick, and extends laterally for about 20–25 m along the base of the section at around 4.4 m OD. This unit can be subdivided into four beds (Figure 8.5; beds 3–6). The lowest (bed 3) is a brown to black organic silt, highly humified, containing some quartz granules. It is overlain by a fawn to light brown sand (bed 4), less organic than bed 3, again containing quartz granules; the contact between beds 3 and 4 is gradational. Bed 5 is a black, richly organic, highly humified silt, while bed 6 is very similar to the upper parts of bed 4.

Pits dug at the base of the section (Scourse, 1991) revealed a unit (bed 1) of homogeneous coarse to medium light brown sand, separated from the overlying organic material by a layer of coarse cemented granitic head (bed 2) just a few centimetres thick (Figure 8.5). The sands are uncemented and appear to rest on solid granite. The contact between beds 1 and 2 is sharp and erosional.

Farther to the north-west, on the southern shore of Watermill Cove itself (SV 924123), a raised beach consisting of both rounded granite cobbles and sand is exposed at the same elevation. No raised beach cobbles are visible within the main exposure, but it is clear that the sand (bed 1) there forms part of the same exposure of raised beach.

The coarse granite head (bed 7) overlies the entire sequence. Most of the Devensian organic sites on Scilly (e.g. Carn Morval, Porth Askin, Porth Seal; Figure 8.1) have been severely disrupted by deposition of the overlying head. At Watermill Cove, however, only the uppermost parts of bed 6 have been deformed.

Interpretation

The sand unit (bed 1), along with the raised beach cobbles along the southern shore of Watermill Cove, form the stratotype of the Watermill Sands and Gravel (Scourse, 1991). This is the basal stratigraphic unit of the Quaternary succession on the islands, and is clearly of littoral origin. The sand has a dominant mode of 1.0ϕ on the coarse/medium sand boundary with moderate to good sorting. Though it resembles dune sand it lacks the high kurtosis characteristic of such sediments and may therefore be of backshore origin.

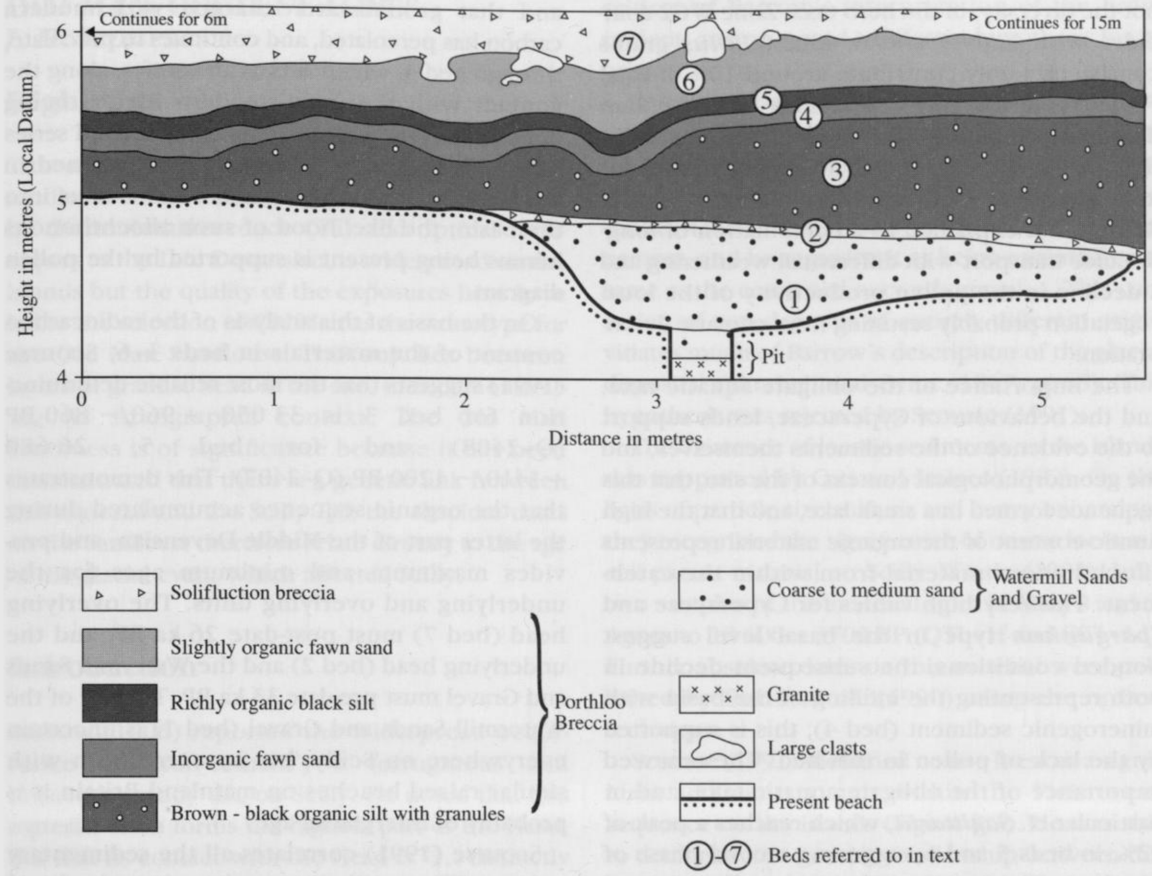

Figure 8.5 The Pleistocene sequence at Watermill Cove. (Adapted from Scourse 1991.)

The thin head (bed 2), like the more massive head (bed 7) above the organic sequence, is interpreted as a solifluction deposit which must have spread across the surface of the exposed beach. To the north-west of the organic sequence a prominent quartz-porphyry dyke (elvan) crosses the shore platform from south-west to north-east. Clasts derived from this dyke can be found in the main body of head (bed 7), indicating that the dominant direction of solifluction was from the east, north-east or north in response to the local slope morphology.

Solifluction is interpreted by Scourse (1991) to be the cause of the accumulation of the organic sequence at the site. Solifluction down the slopes of the neighbouring headlands would have ponded any small stream flowing down the valley into the Cove, forming a small lake or large pond into which the sediments accumulated. The organic content of beds 3–6 varies conversely with coarse minerogenic content; organic content reaches 10% in beds 3 and 5 coincident with minima in the coarse minerogenic fraction. The varying sediments of these beds are therefore interpreted to represent inwashings of coarse minerogenic sediment, probably associated with active solifluction within the catchment, contrasting with phases of quiescent organic sedimentation.

The lacustrine origin of the organic sequence is further supported by the occurrence of obligate aquatic taxa in the pollen spectra. These include *Sparganium* type, *Potamogeton*, cf. *Sagittaria*, and the algae *Botryococcus* and *Pediastrum*. These are all represented by quite high frequencies in beds 3 and 5.

The pollen diagram (Scourse, 1991; Fig. 14, p. 420) from beds 3–6 can be divided into two assemblage zones on the basis of changes in the frequency of *Pinus*. Zone WC1 is dominated by herb taxa, particularly Cyperaceae, Gramineae, *Solidago* type and Rubiaceae, and occurs within bed 3. *Pinus* values remain below 1% throughout zone WC1, but rise to a peak of 51% in WC2 with a concomitant decrease in the frequencies, though not the diversity, of the herb taxa. Zone WC2 coincides with beds 5 and 6. Intact *Pinus* grains consistently only contribute around 10% of total *Pinus*. As in the case of the Carn Morval pollen diagram (see above), which also contains a distinctive *Pinus* peak, this is not interpreted as an increase in the local representation of this tree. Rather, it is explained as a combination of long-distance transport with differential weathering and a decline in the pollen productivity of the local vegetation probably resulting from climatic deterioration.

The importance of the obligate aquatic taxa, and the behaviour of Cyperaceae, lends support to the evidence of the sediments themselves, and the geomorphological context of the site, that this sequence formed in a small lake, and that the high humic content of the organic material represents allochthonous material from within the catchment. The very high values for Cyperaceae and *Sparganium* type in the basal level suggest ponded conditions, the subsequent decline in both representing the infilling of the basin with minerogenic sediment (bed 4); this is supported by the lack of pollen in this bed. The renewed importance of the obligate aquatic taxa, and in particular cf. *Sagittaria*, which reaches a peak of 12%, in beds 5 and 6 suggests a second phase of ponding. The stratigraphy and pollen record therefore indicate two ponding episodes at Watermill Cove.

Page (1972) obtained two radiocarbon dates from the organic material corresponding to Scourse's (1991) beds 3–6; these were 21 200 + 900/− 600 BP (GaK-2471) and 22 200 + 400/− 400 BP (T-833). Scourse (1991) obtained a further eight dates from humic and humin fractions of beds 3 and 5; these were from samples taken up to 3 m back from the face of the section ('second series' samples) in addition to samples from only 0.75 m from the face ('first series' samples). Apart from the bed 5 second series determinations, the humic extract samples are younger than the humin residues, and the second series dates older than the first series. This pattern is very similar to the radiocarbon results from other similar organic sites on Scilly; the differences in radiocarbon content indicate that contamination by modern humus, probably transported by percolating groundwater from recent/modern soil, is a problem at the face and the base of the profile, but that this contamination is less of a problem higher in the sequence. It is probable that the thin head (bed 2) acts as an impermeable layer, and that groundwater charged with modern carbon has percolated, and continues to percolate, through bed 3, which acts as an aquifer, along the contact with the head, modern humus being deposited in the process. The older second series bed 5 humic extract date can be explained in terms of the inwashing of older mor humus into the basin; the likelihood of such allochthonous humus being present is supported by the pollen diagram.

On the basis of this analysis of the radiocarbon content of the materials in beds 3–6, Scourse (1991) suggests that the most reliable determination for bed 3 is 33 050 + 960/− 860 BP (Q-2408) and for bed 5, 26 680 + 1410/− 1200 BP (Q-2407). This demonstrates that the organic sequence accumulated during the latter part of the Middle Devensian, and provides maximum and minimum ages for the underlying and overlying units. The overlying head (bed 7) must post-date 26 ka BP, and the underlying head (bed 2) and the Watermill Sands and Gravel must pre-date 33 ka BP. The age of the Watermill Sands and Gravel (bed 1) is uncertain everywhere on Scilly, but by correlation with similar raised beaches on mainland Britain it is probably of interglacial age.

Scourse (1991) correlates all the sedimentary units at Watermill Cove, other than the basal raised beach, with the Porthloo Breccia (Figure 8.3). In the absence of the Old Man Sandloess at the site it is not possible to correlate beds 2–7 definitively with either the upper or lower Porthloo Breccia. However, the radiocarbon dates and pollen spectra are very similar to analogous sequences at other organic sites on Scilly where stratigraphic relationships can be established with the Old Man Sandloess (Carn Morval, Porth Askin) indicating that probably at least bed 2 and beds 3–6 can be correlated with the lower Porthloo Breccia.

Conclusion

Watermill Cove contains the best exposures on Scilly of raised beach sediments deposited in an interglacial temperate stage, before a glacier advanced as far as the northern islands around 19 ka BP. The site also contains excellent exposures of organic sediments deposited under cold tundra-like conditions between 33 ka and 26 ka BP. Pollen analysis of these sediments reveals an open grassland type vegetation with no trees.

OLD MAN, GUGH, ST AGNES

J. D. Scourse

Highlights

This site affords the finest exposures of aeolian sandloess on the Isles of Scilly. This material, dated by thermoluminescence (TL) and optical techniques to the Late Devensian, is widespread on the islands but the quality of the exposures here have led to the selection of Old Man as the stratotype for the Old Man Sandloess. This unit lies between layers of granitic head at the site, thus demonstrating its stratigraphic context. The Old Man Sandloess is of significance because it has been demonstrated that there is a genetic link between this material and the Scilly Till; the absolute dates on the Sandloess therefore relate directly to the age of the glacial event which affected Scilly.

Introduction

Barrow (1906) reported the widespread occurrence of 'iron-cement', a ferruginous and micaceous sandy silt, on Scilly. He noted that this material often forms the highest part of the Head, but that its contact with the Head is ' … distinctly sharp, suggesting a somewhat different origin from the latter' (Barrow, 1906; p. 20). He commented that 'The origin of this curious deposit is no means clear; it is distinctly micaceous and far finer in texture than normal blown sand, as well as of a totally different colour and composition' (Barrow, 1906; p. 21). He speculated that the deposit might be of aeolian origin derived from material released from frost action; 'The idea of invoking the aid of frost in the production of this material is based on its substantial identity both in composition, mode of occurrence, and geological age, with the matrix of an undoubted glacial deposit … ' (Barrow, 1906; p. 21). Barrow therefore hinted at a possible genetic relationship between the 'iron-cement' and the glacial material found on the northern islands.

Arkell (1943) commented that ' … in the Scilly Isles, where the main head is covered by loess identical with the *limon* of Brittany … ' (Arkell, 1943; p. 159) and later quotes W.B.R. King in a personal communication linking the loess of Brittany, Normandy, the Channel Islands and the Isles of Scilly. This was the first recognition that the 'iron-cement' described by Barrow was in fact loessic.

However, Mitchell and Orme (1967) did not recognize loessic sediments on the islands. They were critical of Barrow's interpretation of the 'iron-cement' and proposed a different hypothesis for its origin:

'In post-glacial time, soil-forming processes have developed a podsol profile on the Upper Head. The B-horizon is deeply coloured by iron and humus, and is sometimes cemented by silica and iron oxide. This material Barrow described as iron-cement, and he regarded it as being essentially the same as the cemented outwash gravel … This confusion of two deposits of entirely different origin vitiates much of Barrow's description of the glacial deposits' (Mitchell and Orme, 1967; p. 68). This hypothesis was rejected by Scourse (1991).

The existence of loessic sediments on the islands was supported by Catt and Staines (1982). On the basis of particle-size analysis and heavy mineralogy they recognized the significance of coarse loess as a soil parent material on Scilly. Wintle (1981) dated two samples of this material from St Mary's and St Agnes to 18 600 ± 3700 BP (QTL-1f and QTL-1d). Further absolute dates on this material were published by Smith *et al.* (1990) using the optical technique.

Scourse (1991) identified coarse loess as a significant sedimentary unit within the Pleistocene sequence on the islands (Figure 8.3). He was able to demonstrate a genetic relationship between this material and the Scilly Till on the basis of particle-size distributions, mineralogy, patterns of sedimentation, stratigraphy and absolute age. He defined the unit as the Old Man Sandloess from this site on Gugh, St Agnes, and noted a limited distribution of the material south of the ice limit across the northern islands (Figure 8.1). North of the ice limit the Sandloess has been mixed with glaciofluvial (Tregarthen Gravel) and glacial (Scilly Till) sediment, and soliflucted downslope as the Hell Bay Gravel (Figure 8.3).

The Old Man Sandloess is of stratigraphic significance because it provides evidence in support of the Late Devensian glaciation of the northern islands (Scourse, 1991). The absolute age of this unit, derived from the TL and optical methods, directly relates to the age of the glacial event because of the demonstrated genetic link between the Old Man Sandloess and the Scilly Till.

Description

The Old Man section is located on the north-east coast of Gugh (St Agnes; SV 893085); the name 'Old Man' is derived from a prominent standing stone positioned a few metres upslope. The section comprises:

3. Granitic head (0.2 m)
2. Light brown to ochre sandy silt (1.0 m)
1. Coarse granitic head (1.5 m)

The lower head contains occasional very well-rounded granite boulders, probably incorporated into the head from an underlying raised beach. There are good exposures of cobble-rich raised beach deposits underlying the head at other sites along the eastern coast of Gugh indicating that this is the probable source.

The sandy silt is moderately well sorted with a dominant mode in the coarse silt fraction, and a subdominant mode in the medium sand fraction; the grain-size distribution has a high kurtosis. The unit possesses a columnar structure and small pin-hole voids are visible in the sediment fabric.

Interpretation

The grain-size and structural characteristics of the sandy silt (bed 2) are characteristic features of *in situ* loess (Mellors, 1977). This material at Old Man is typical of the Scilly loesses in containing consistently more sand than clay (Catt and Staines, 1982; Scourse, 1991). It is too coarse to be defined as true loess, but too fine to be defined as coversand. The Old Man material is typical in having a dominant modal class either in the coarse silt or fine sand fraction, with total sand usually more than 25% and total clay less than 10%. In The Netherlands and Belgium, sediment with these characteristics is commonly distributed in a transitional belt between true loess and coversand, and is known as 'sandloess'. Comparable material on Scilly was thus defined as the Old Man Sandloess by Scourse (1991) from the type-site at Old Man.

Scourse (1991) defined four facies of the Old Man Sandloess on the basis of structural and grain-size criteria. The stratotype of the Old Man Sandloess is typical of facies A. This is interpreted as *in situ* material because it contains the columnar structure and pin-hole voids characteristic of *in situ* loess (Mellors, 1977). The other facies are interpreted to have been deposited through water (facies B), or reworked by fluvial (facies C) or soliflual (facies D) processes. All the facies described by Scourse (1991) represent stages along a continuum from *in situ* material to sandloess intermixed to such an extent with other material that its identity is only barely recognizable. Scourse (1991) further noted that the matrix of the soliflual Hell Bay Gravel is identical to the Old Man Sandloess, indicating that the Hell Bay Gravel comprises glacially derived material (Scilly Till, Tregarthen Gravel) thoroughly mixed with Old Man Sandloess and reworked downslope by solifluction. He noted that the Old Man Sandloess is confined to the area outside the ice limit (Figure 8.1).

Two samples of the Old Man Sandloess have been dated to 18 600 ± 3700 BP (QTL-1f, sample from St Mary's; QTL-1d, sample from St Agnes) using the TL method (Wintle, 1981). These dates therefore suggest that this material is of Late Devensian age. This interpretation has been partially supported by two optical dates of 20 ka ± 7 ka BP and 26 ka + 10 ka/− 9 ka BP (Smith *et al.*, 1990) from the same material. These dates are stratigraphically significant because Scourse (1991) has interpreted a genetic link between the glacigenic units of the northern Scillies (Scilly Till, Tregarthen Gravel) and the Old Man Sandloess. The relative coarseness of the Sandloess is interpreted as a function of proximity to glacially derived source material, and the mineralogy of the Scilly Till is sufficiently similar to the Sandloess to suggest a genetic relationship between the two units (Catt, 1986; Scourse, 1991). Aeolian loessic processes in association with the glacial advance therefore resulted in the contemporary deposition of the Old Man Sandloess in the southern Isles of Scilly with glacial deposition in the northern islands. The Late Devensian dates for deposition of the Old Man Sandloess can therefore be used to constrain the age of the glacial event.

At locations where the Old Man Sandloess is absent, it is not possible to discriminate between the upper and lower units of Porthloo Breccia (Figure 8.3). At sites such as Old Man, however, the Sandloess lies clearly between two units of granitic head. The dates on the Sandloess therefore also help to constrain phases of active solifluction in the the Isles of Scilly.

Conclusion

This site contains the best exposures on the Isles of Scilly of sandy silts deposited by wind action beyond the southern limit of an ice sheet which crossed the northern islands at about 19 ka BP. The silts were picked up from the outwash plain in front of the glacier by strong winds, and therefore contain the same minerals found in the glacial deposits in the northern islands. The silts have yielded absolute dates which help to constrain the age of the glaciation of the Isles of Scilly to the last major ice-sheet glaciation of the British Isles, the Late Devensian.

PENINNIS HEAD, ST MARY'S
J. D. Scourse

Highlights

This site contains some of the most spectacular granite landforms in the British Isles. These include the finest development on the Isles of Scilly of the 'castellated' or 'mammilated' tor forms which are characteristically found only outside the glacial limit which straddles the islands.

Introduction

Although the granite landforms of Peninnis Head (Figure 8.1) have been mentioned briefly by a number of authors (Barrow, 1906; Mitchell and Orme, 1967), they have never been the focus of a major individual study. Scourse (1986, 1987) discussed the general aspects of tor morphology on the islands and cited the examples at Peninnis Head as constituting some of the finest granite landforms in Britain. He (Scourse, 1986, 1987, 1991) further drew attention to the association between different tor forms and the glacial limit (Figures 8.1 and 8.6) which he, and others (Mitchell and Orme, 1967), were able to identify across the islands.

Description

Scourse (1986, 1987, 1991) mapped four tor forms on the Isles of Scilly (Figure 8.6). Peninnis Head (SV 911094) contains the largest concentration of forms A, B and C in the islands, and the finest individual examples of each form (Figure 8.7). Horizontal tors (form A) are characterized by extensive sub-horizontal discontinuities separating large granite slabs which typically touch at only a few points. These resemble 'pedestal' features locally called 'logan stones'. Elsewhere this particular tor form has been described as 'mammilated', 'castellated' or 'lamellar' (Waters, 1955). Vertical tors (form B) are characterized by vertical discontinuities with granitic rubble often filling the voids between granite slabs. Form C, hillslope tors, are a coastal variant of forms A and B.

Interpretation

Granite tors occur throughout the Isles of Scilly, but they are particularly well developed to the south of the ice limit which has been identified across the islands (Figure 8.1). South of this limit all tors can be classified as forms A, B or C, as described above, or resultant transitional or composite forms (Figure 8.6). These forms are well displayed on St Agnes, where ornate, individual, weathered granite slabs have been assigned popular local names, on Annet, the Western Rocks, St Mary's and the southern part of Tresco. However, the scale, concentration and extent of the features at Peninnis Head justify selection of this site to represent these landforms which typify the Scillonian landscape south of the ice limit.

Examples of tor form D (Figure 8.6) have only been identified north of the reconstructed ice limit. This form is smoothed and rounded, with all loose material removed. Alternatively, forms A, B and C are all ornate and contain a large proportion of loose or delicately shaped rock masses.

The distribution of the different tor varieties provides a key to understanding their evolution. The lower slopes of tor forms A, B and C at Peninnis Head, as elsewhere on the islands, are mantled by thick periglacial slope deposits or 'head' (Porthloo Breccia; Figure 8.3) which have been interpreted by most workers as being of soliflual origin (e.g. Scourse, 1987). This provides strong evidence that exhumation of the corestones of these tors took place under periglacial conditions during the Pleistocene. The radiometric dates on organic sediments from within the mantling Porthloo Breccia (Figure 8.3) provide valuable evidence on the timing and rate of tor exhumation during periglacial conditions of the late Middle and early Late Devensian.

Tors attributable to form D, however, are quite distinct in resembling roches moutonnées; a good example is provided by Round Island (Figures 8.1 and 8.6) in the northern Isles of Scilly. The clear association between these different landforms and the proposed ice limit suggests that the smoothed form D is a product of glacial erosion. Despite the fact that some authors have interpreted elaborate tor forms as occurring within former ice limits (Dahl, 1966; Sugden, 1968; Clapperton, 1970), Scourse (1987) points out that it is difficult to envisage how the more delicate tor forms, typified by those at Peninnis Head, could have survived being overridden by ice.

The origin of tors has long been a matter of

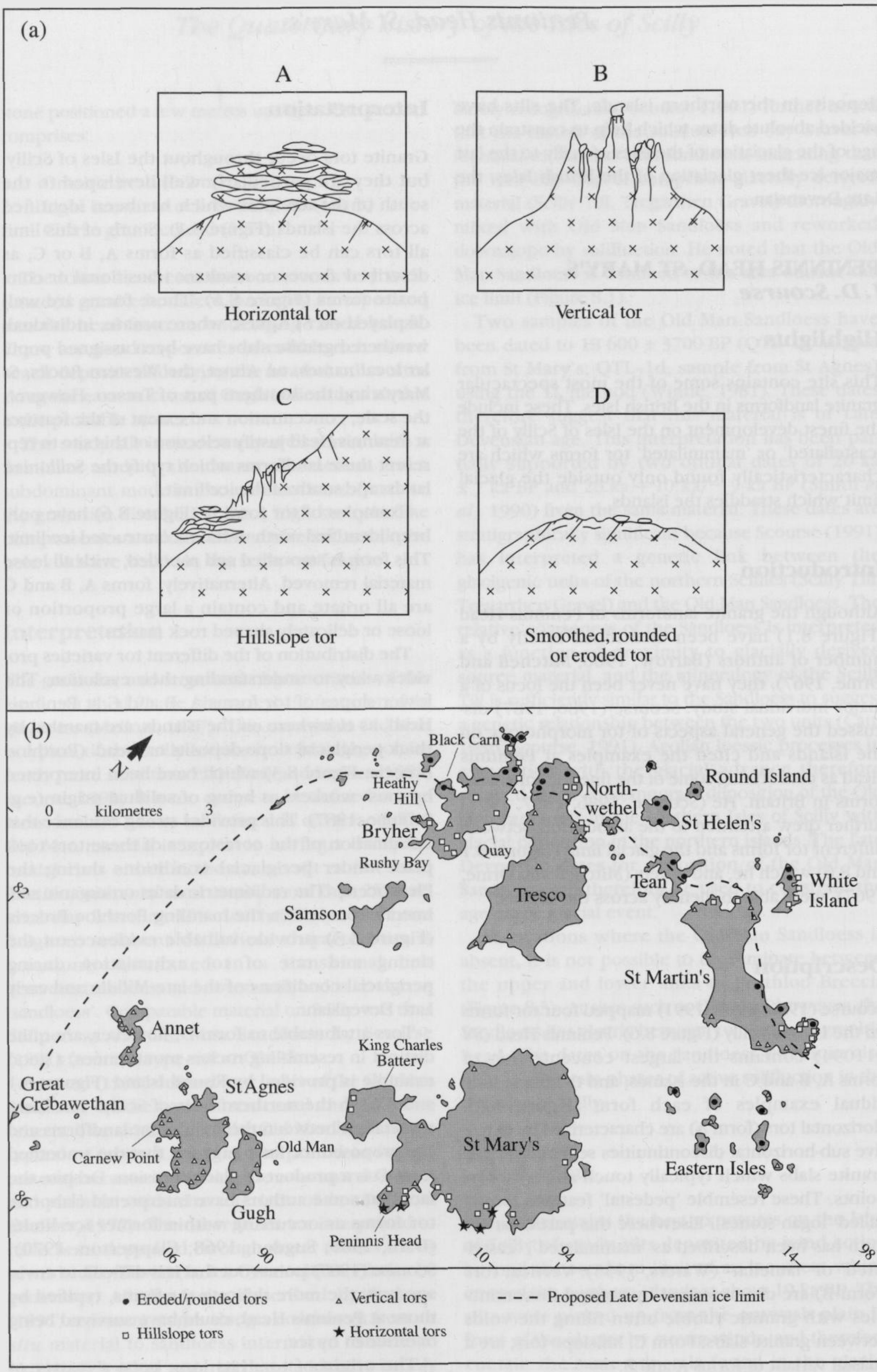

Figure 8.6 (a) Variations in tor morphology. (b) Their distribution across the Isles of Scilly. (Adapted from Scourse 1986.)

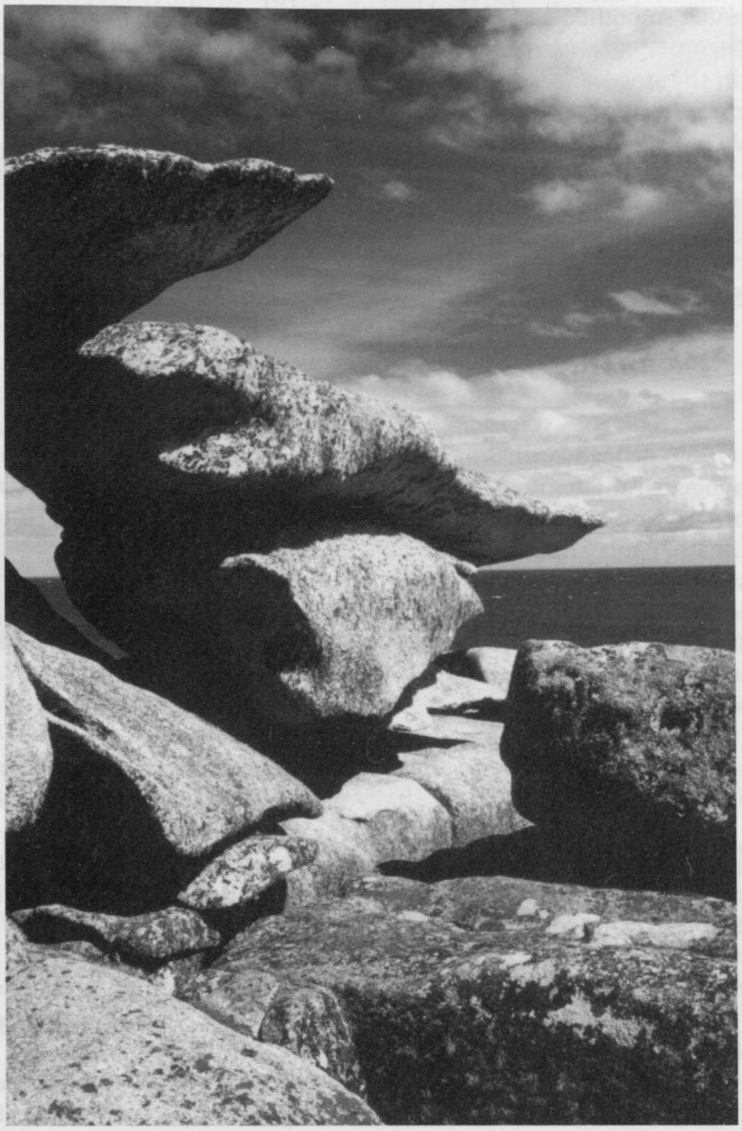

Figure 8.7 The spectacular development of horizontal tors (form (a); Figure 8.6) on the eastern side of Peninnis Head. (Photo: S. Campbell.)

considerable debate, and the various mechanisms and processes proposed are discussed more fully in Chapter 4. Some authors have invoked a two-stage process of tor formation involving deep chemical weathering during the Tertiary followed by exhumation of corestones by Pleistocene periglacial processes (Linton, 1955). Others have argued that Pleistocene periglacial activity alone was responsible for the tors (Palmer and Radley, 1961; Palmer and Nielson, 1962). The Scilly tors, and the Peninnis Head features in particular, therefore support the widely recognized implication of periglacial slope processes in tor exhumation. However, there is no evidence at Peninnis Head, or at any other tor site on Scilly, which might point to an earlier phase of deep chemical weathering during the Tertiary.

Conclusion

Peninnis Head contains the largest concentration, and the finest examples, of granite tors in the Isles of Scilly. The association of these features with dated slope deposits formed under cold climates elsewhere on Scilly provides unique evidence of the timing and conditions of their formation. The intricate and delicate tor forms at Peninnis Head contrast with the much smoothed and apparently ice-eroded tors which occur in association with glacial sediments in the northern Isles of Scilly. They therefore provide supporting evidence that the southern islands remained unglaciated during the proposed Late Devensian (*c.* 19 ka BP) glaciation of the northern islands.

PORTH SEAL, ST MARTIN'S
J. D. Scourse

Highlights

Mitchell and Orme (1967) defined Porth Seal as the type-site for the younger of the two raised beach deposits they identified on Scilly. Organic beds found within the head at this site have yielded pollen consistent with deposition under periglacial conditions, and the beds have been radiocarbon dated to the late Middle and early Late Devensian. These absolute dates are critical for establishing a chronology of Pleistocene events on Scilly.

Introduction

Mitchell and Orme (1967) recognized two distinct raised beach deposits on the Isles of Scilly. An erratic-free deposit, the Chad Girt Raised Beach, was assigned a Hoxnian age, while an erratic-rich deposit, the Porth Seal Raised Beach, was believed to post-date the proposed Gipping (= Wolstonian/Saalian) glaciation of the northern islands, and was accordingly assigned to the Eemian (= Ipswichian). Mitchell and Orme were unable to identify a site where both beach deposits could be seen unambiguously in stratigraphic superposition, although they believed that two separate raised beach deposits were present at Porth Seal (Mitchell and Orme, 1967; p. 73). However, the sequence at Porth Seal was subsequently depicted by Stephens (1970a; Figure 8.8), based on an unpublished field sketch made in 1965 by F.M. Synge, as showing two raised beach deposits separated by periglacial head (Figure 8.8; Section 3). The lower raised beach deposit was correlated with the 'erratic-free' Chad Girt Raised Beach, the upper being the 'erratic-rich' Porth Seal Raised Beach.

Bowen (1981) suggested that the Porth Seal Raised Beach was not marine in origin, but that instead it comprised soliflucted granite corestones. Scourse (1991) re-interpreted the upper beach as a soliflucted facies of the lower (= Chad Girt Raised Beach) (Figure 8.8). Similar stratigraphic relationships were also described at Northward Bight. He correlated this raised beach with the Watermill Sands and Gravel (Figure 8.3).

Description

Porth Seal (SV 918166) lies on the north-west coast of St Martin's (Figure 8.1), and the most complete sections occur on the south side of the bay. Scourse (1991) records the critical section described by Mitchell and Orme (1967) and Stephens (1970a), and demonstrates the stratigraphic relations between this sequence and organic materials at the site (Figures 8.8 and 8.9). Scourse's (1985a, 1991) composite sequence from Sections 1 and 2 (Figure 8.8) can be summarized thus:

9. Coarse, granitic solifluction breccia
8. Fawn granular sand
7. Organic silty sands with granite clasts and quartz granules
6. Coarse, white granular sand
5. Black, richly organic fine silt
4. Coarse, white granular sand
3. Soliflucted raised beach deposits (= Porth Seal Raised Beach of Mitchell and Orme (1967))
2. Solifluction breccia
1. Raised beach deposits (= Chad Girt Raised Beach of Mitchell and Orme (1967))

Matrix-supported, rounded, raised beach cobbles (bed 3) are exposed towards the western end of the described section overlying a unit of granitic blocky head (bed 2). A complex unit (beds 4–8), including organic materials, overlies these beach cobbles laterally to the east. This metre-thick deposit consists of several distinct, internally stratified, beds. The lowest (bed 4) consists of coarse white granitic sand and granules, and rests directly on the underlying (soliflucted) beach cobbles. This sand lenses out to the west such that the overlying bed of black, richly organic, fine silt (bed 5) also rests directly on the beach cobbles at its western limit. In places the matrix of the cobble deposit (bed 3) comprises this organic silt. Bed 6 is similar to bed 4, and is overlain by bed 7, a relatively thick deposit of internally variable, dark brown, organic silty sand with granite clasts and quartz granules. Beds 4–8 are overlain by up to 5 m of coarse granitic head (bed 9).

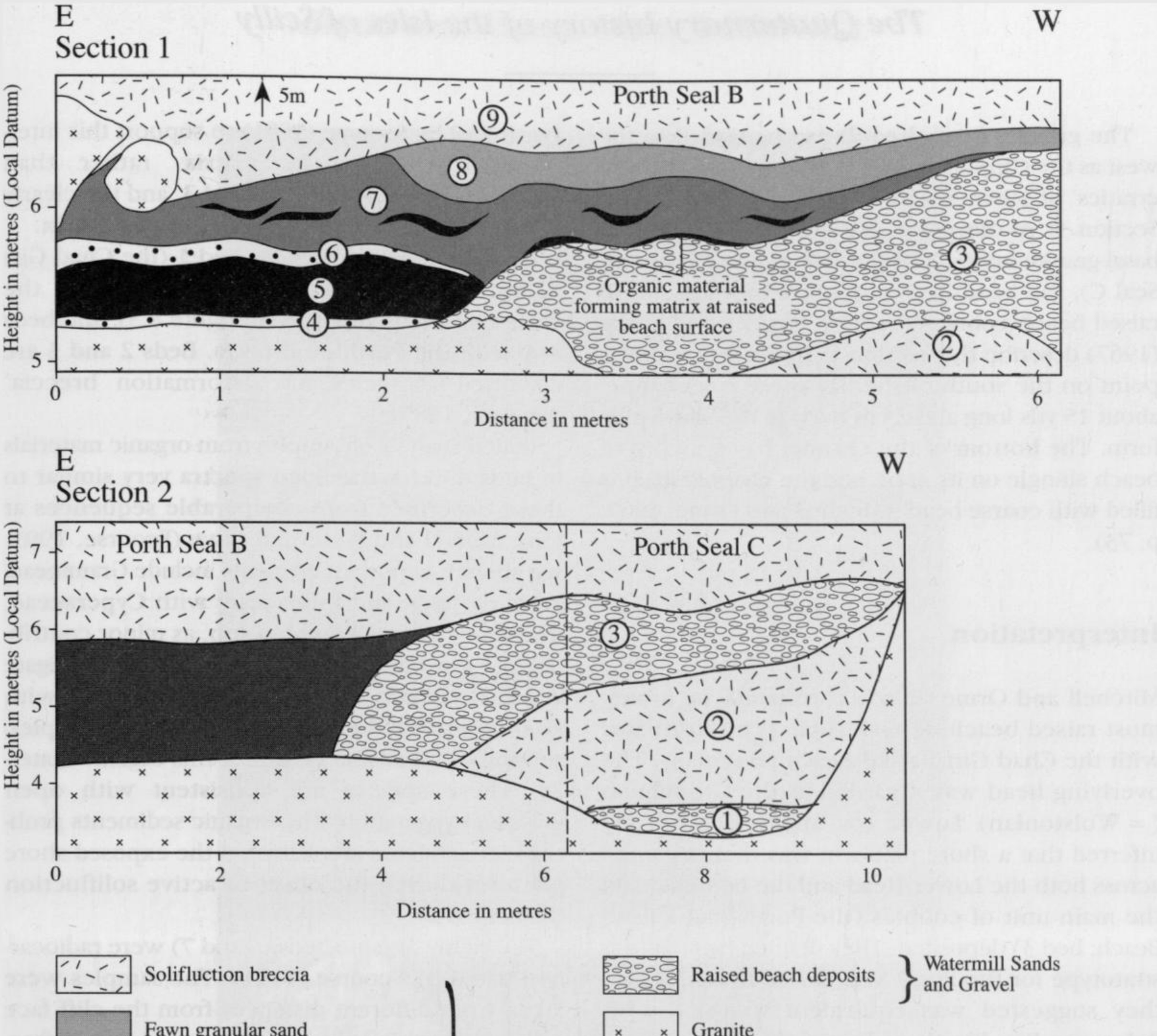

Figure 8.8 The Pleistocene sequence at Porth Seal: Sections 1 and 2 adapted from Scourse (1991); Section 3 is based on a field sketch made in 1965 by F.M. Synge and subsequently figured in Stephens (1970a) and Kidson (1977).

The granitic head (bed 2) can be traced to the west as the Gipping (= Wolstonian) 'head without erratics' of Mitchell and Orme (1967) (Figure 8.8; Section 3). At this point, in a small gully within the basal granite bedrock (Figure 8.8; Section 2 = Porth Seal C), the head is underlain by another unit of raised beach cobbles (bed 1). Mitchell and Orme (1967) describe this section as follows: ' ... at one point on the south of the bay there is a channel about 15 yds long and 2 yds deep in the shore-platform. The bottom of the channel has 6 inches of beach shingle on its floor, and the channel itself is filled with coarse head' (Mitchell and Orme, 1967; p. 73).

Interpretation

Mitchell and Orme (1967) correlated the lowermost raised beach deposit (bed 1) at Porth Seal with the Chad Girt Raised Beach (Hoxnian). The overlying head was regarded as the Gippingian (= Wolstonian) Lower (or Main) Head. They inferred that a shore platform was then trimmed across both the Lower Head and the bedrock, and the main unit of cobbles (the Porth Seal Raised Beach; bed 3) deposited. They defined bed 3 as the stratotype for the Porth Seal Raised Beach, which they suggested was equivalent to the Upper Belcroute Bay Beach of Jersey (Mourant, 1933, 1935) and of Eemian (= Ipswichian) age. They identified the head covering the Porth Seal Raised Beach as Upper Head of Weichselian (= Devensian) age.

Bowen (1981) suggested that the Porth Seal Raised Beach might not be a raised beach at all, but rather a body of soliflucted granite corestones. Scourse (1991) alternatively interpreted the Porth Seal Raised Beach as a soliflucted facies of the underlying (= Chad Girt) raised beach. Rather than the direct litho-chronostratigraphical interpretation offered by Mitchell and Orme (1967), he identified only one *in situ* raised beach deposit at Porth Seal, represented by bed 1 or the 'Chad Girt Raised Beach'. He suggested that the upper parts of this deposit have become entrained within the overlying solifluction flow and appear in section as an upper, younger, raised beach deposit (bed 3). Such tongues of incorporated beach material occur at many sites in South-West England where beach sediments have been overridden by solifluction lobes and sheets. These often appear in two-dimensional cliff sections as stratigraphically distinct raised beach units. Sedimentological criteria invoked at Porth Seal by Scourse (1991) to support this interpretation include the matrix- rather than clast-supported character of bed 3, and the clearly soliflual rather than littoral origin of this matrix.

Scourse (1991) correlates bed 1 (the Chad Girt Raised Beach of Mitchell and Orme) with the Watermill Sands and Gravel (Figure 8.3), and beds 4–9 with the Porthloo Breccia. Beds 2 and 3 are classified as facies Aa 'deformation breccia' (Scourse, 1987).

Pollen analysis of samples from organic materials in beds 4–8 have yielded spectra very similar to those described from comparable sequences at Carn Morval and Watermill Cove (Scourse, 1991; see above). Important elements include Gramineae, *Solidago* type and Rubiaceae, with Cyperaceae, *Achillea* type and *Plantago* spp. as minor contributors. A low but consistent presence of the obligate aquatic taxon *Sparganium* type, with *Potamogeton* and *Typha latifolia* in some samples, supports a lacustrine origin for this organic material. These spectra are consistent with open grassland vegetation. The organic sediments probably accumulated in a basin on the exposed shore platform during the onset of active solifluction (Figure 8.9).

The richly organic beds (5 and 7) were radiocarbon dated by Scourse (1991). The samples were taken from different distances from the cliff face and each sample split into humic and humin fractions to identify the extent and sources of contamination. Six radiocarbon determinations were obtained; the most reliable dates were interpreted by Scourse (1991) to be 34 500 + 885/− 800 BP (Q-2410) for bed 5 and 25 670 + 560/− 530 BP (Q-2409) for bed 7. These determinations therefore suggest that beds 4–8 were deposited during the late Middle and early Late Devensian, and that the underlying head and raised beach units (beds 1–3) pre-date the late Middle Devensian. It follows that the overlying head (bed 9) post-dates the early Late Devensian. These dates form part of a series of radiocarbon determinations from a network of organic sites within the Porthloo Breccia throughout Scilly which provide critical chronological data on the age of the identified sedimentary units (Figure 8.3).

Conclusion

Porth Seal is a critical site because it contains rare organic beds which can be dated by the radiocarbon method. Such dating has shown that these

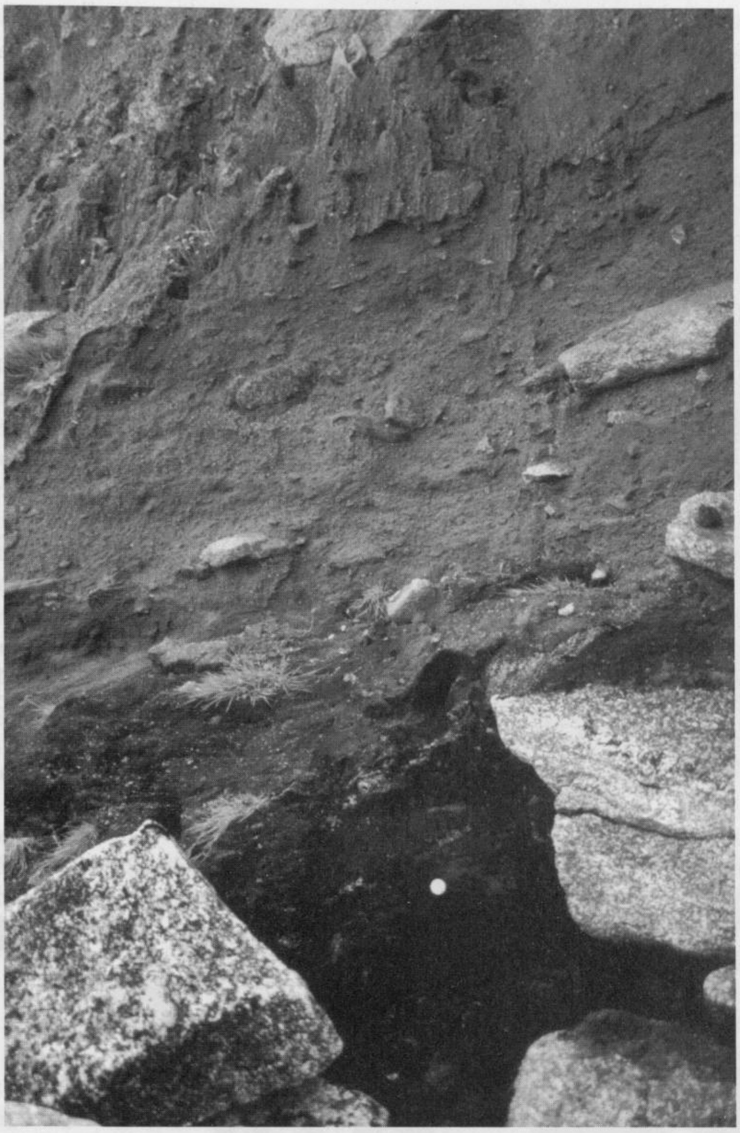

Figure 8.9 Richly organic sediments lying beneath periglacial head at Porth Seal, St Martin's. (Photo: J.D. Scourse.)

sediments were deposited between 25 ka and 35 ka BP. These dates help to constrain the ages of the underlying and overlying sediments. The organic beds also contain abundant fossil pollen grains and spores which indicate that between these dates Scilly was characterized by open grassland vegetation in a cold Arctic climate. Porth Seal is also important because it shows controversial evidence of possibly two interglacial highstands of sea level.

BREAD AND CHEESE COVE, ST MARTIN'S
J.D. Scourse

Highlights

This is the most important Quaternary site on the Isles of Scilly. It is crucial to the arguments concerning the evidence for, and age of, the Late Devensian glaciation of the northern islands. The

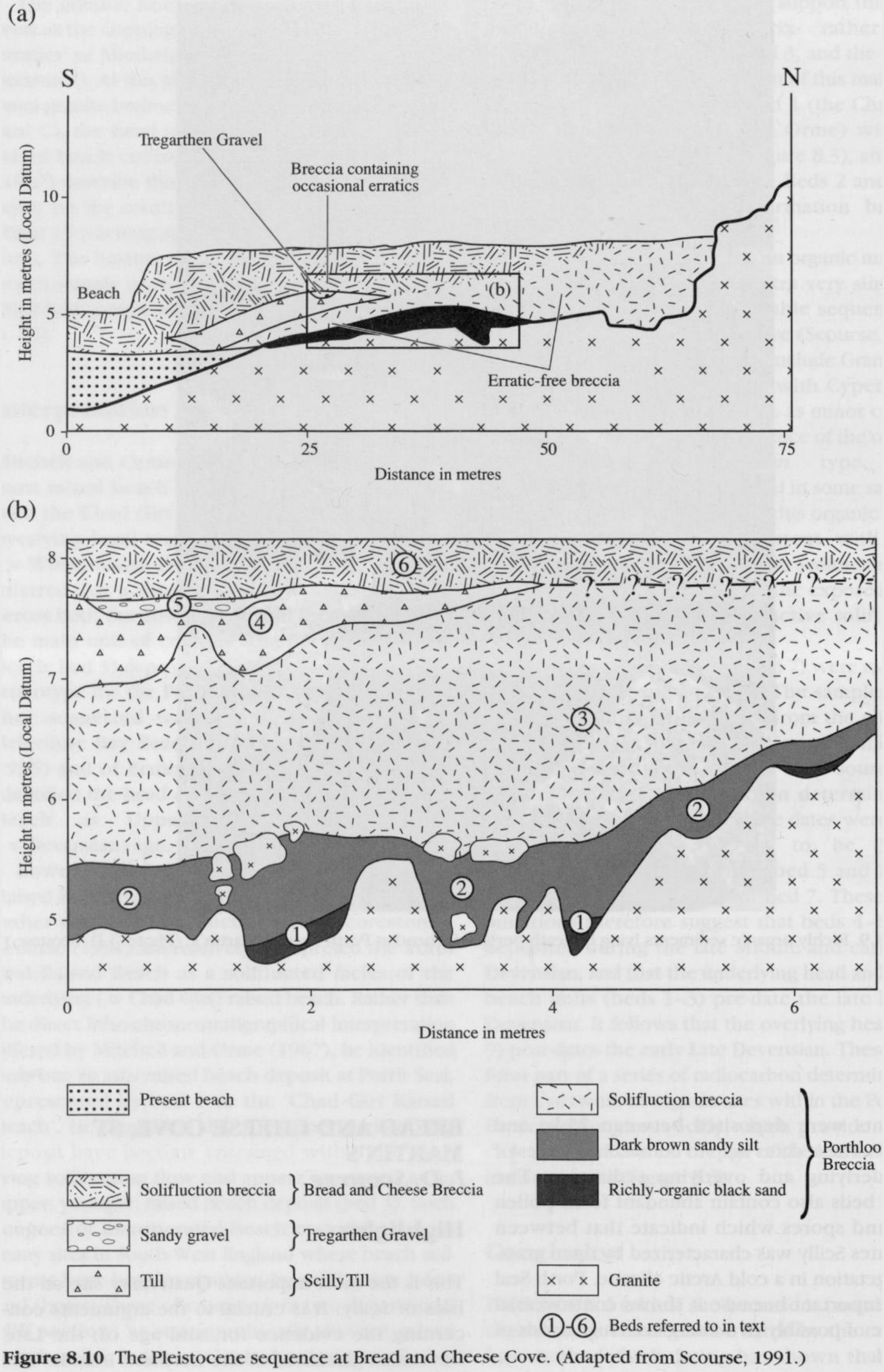

Figure 8.10 The Pleistocene sequence at Bread and Cheese Cove. (Adapted from Scourse, 1991.)

site contains the stratotypes of the Scilly Till and the Bread and Cheese Breccia.

Introduction

The significance of Bread and Cheese Cove was first recognized by Mitchell and Orme (1967) who described glacial sediments (presumed Wolstonian) cropping out in the low coastal cliffs at the cove. Scourse (1991) undertook a reinvestigation of the sedimentology of these 'glacial' deposits to establish their precise depositional origin and, in particular, whether post-depositional downslope movement had occurred. He also discovered brown humic organic beds underlying the supposed glacial sequence at the base of the cliffs. Pollen analyses of these organic deposits indicated open grassland vegetation consistent with deposition in a periglacial regime, and enabled correlation with other organic sequences in the islands – at Watermill Cove, Carn Morval, Porth Askin and Porth Seal (Figure 8.1) – all of which have been radiocarbon dated to the late Middle and early Late Devensian. Radiocarbon determinations on the organic sediments at Bread and Cheese Cove yielded Holocene ages (*c.* 10–7.5 ka BP) which are clearly incompatible with the lithostratigraphical and pollen evidence, and indicate sample contamination by younger carbon.

Description

Bread and Cheese Cove (SV 940159) lies on the northern coast of St Martin's (Figure 8.1). Mitchell and Orme (1967) recorded the presence of till and outwash gravel between the Lower (Main) Head and the Upper Head at this site. Their section is still readily observed, but Scourse (1991) was further able to identify the presence of organic sediments at the base of the section (Figure 8.10). A granite wave-cut platform rises towards the south-west and underlies a coarse granitic solifluction breccia (bed 3). At the base of the section there is a deposit of very coarse granite rubble and boulders, which extends outwards from the modern cliff across the granite platform. Forming the matrix between these boulders, and also a coherent unit towards the base of the section, is a humic horizon (bed 1), a dark brown sandy silt with quartz granules. Pits dug at the base of the section by Scourse (1991) revealed a richly organic black sand (bed 1) resting either on the granite boulders or the wave-cut platform. Bed 3 is overlain gradationally by bed 4, a clay-rich light brown diamicton containing abundant erratic clasts. Bed 4 forms a lens some 22 m in length with a maximum thickness of 2 m. At one point (Figure 8.10) the diamicton is overlain by a small lens of iron-cemented sandy gravel (bed 5), which also contains abundant erratic clasts. Both the diamicton and the gravel are overlain by up to 4 m of coarse, dominantly granitic, breccia (bed 6) which contains occasional erratic clasts. The section is capped by a number of large granite boulders.

Interpretation

On the basis of lithological characteristics and pollen assemblage zones, Scourse (1991) correlated beds 1–3 with the Porthloo Breccia and bed 5 with the Tregarthen Gravel (Figures 8.3 and 8.10). He defined (Scourse, 1991) bed 4 as the stratotype of the Scilly Till, and bed 6 as the stratotype of the Bread and Cheese Breccia.

Pollen spectra from the basal organic deposits (bed 1) are dominated by herb taxa, in particular Gramineae, *Solidago* type, Rubiaceae and *Ranunculus repens* type. Tree taxa are almost completely absent, as are plant macrofossils. There are no significant changes in the pollen stratigraphy through the sequence. This assemblage is typical of open grassland vegetation, and is very similar to the spectra from other comparable organic sequences on the Scillies, all radiocarbon dated to the late Middle or early Late Devensian.

The coarse breccia deposits (beds 3 and 6) were interpreted by Scourse (1987, 1991) as solifluction deposits laid down under periglacial conditions. There is no evidence for breccia deposition, and therefore of solifluction, between the granite platform and the organic sediments. The organic sediments fill cracks in the surface of the platform, and the interstices between granite boulders associated with the platform. These boulders probably represent an immature beach deposit, organic sedimentation having occurred directly on the surface of the beach. Many of the sand grains and granules found within the organic sediment are extremely well rounded, suggesting a beach origin. This interpretation is supported by the presence of unambiguous raised beach deposits (lithostratigraphically assigned to the Watermill Sands and Gravel) in a similar stratigraphic position beneath the Porthloo Breccia at many sites on the Isles of Scilly. The organic deposits are probably lacustrine, ponding having been effected by contemporaneous local solifluction. The sediments and pollen spectra indicate that beds 1–3 accumulated during periglacial climatic conditions.

The stratotype of the Scilly Till (bed 4) is dark yellowish-brown, drying to light yellowish-brown. It is largely non-calcareous, but mineralogical data (Catt, 1986) suggest that it is not heavily weathered, containing a number of easily weatherable minerals such as muscovite, glauconite, chlorite, biotite, augite, apatite, olivine and calcite. It contains abundant siliceous sponge spicules (Jenkins, 1986), but no calcareous microfossils or macrofossils. These data suggest a marine derivation with subsequent partial decalcification. The Scilly Till at this site is geochemically similar to other Late Devensian tills from the Irish Sea Basin (Burek and Cubitt, 1991).

The Scilly Till is extremely poorly sorted and crudely stratified with a number of sub-horizontal iron-stained sand partings up to 1 mm thick. The contained clasts are very freshly striated and faceted, and consist of a wide variety of lithologies, including Cretaceous flint, Variscan greywackes and quartzites, red sandstones and schistose metamorphic rocks, in addition to local granitic material (Hawkes, 1991). The till also contains small granules of a distinctive light green glauconitic micrite which is derived from the Miocene Jones Formation offshore to the north (Pantin and Evans, 1984).

Three features set the Scilly Till apart from the underlying Porthloo Breccia: the high clay content, low clast concentrations and the diverse erratic and mineralogical assemblage. The geochemistry, distinctive erratic and mineralogical assemblage, abundance of clay and silt and presence of sponge spicules are all consistent with derivation from the offshore area to the north of the Isles of Scilly.

A coarse lag of angular granite boulders occurs at the base of the Scilly Till at its contact with the Porthloo Breccia. The upper contact with the Bread and Cheese Breccia is clearly soliflucted.

Statistical (eigenvalue) analysis of clast macrofabric data shows that the central and upper parts of the Scilly Till are very similar to lodgement tills from both modern (Dowdeswell and Sharp, 1986) and fossil (Rose, 1974) contexts, and are quite different in fabric character from the overlying and underlying solifluction deposits (Porthloo Breccia and Bread and Cheese Breccia). However, the base of the deposit is more characteristic of remobilized or slumped till. Given that the Scilly Till may be largely of lodgement origin, the fabric data are consistent with ice flow from north-west to south-east (Scourse, 1991).

Scourse (1991) concludes that while it is impossible to interpret the precise depositional origin of the Scilly Till from this one small exposure, it is different in a number of fundamental characteristics from undoubted soliflucted till, as represented by the Hell Bay Gravel at other sites (Figure 8.3).

The grain-size and lithological content of the sandy gravel (bed 5) suggest clear affinities with the stratotype of the Tregarthen Gravel (Figure 8.3) at the Battery (Castle Down) site on Tresco (see below). This material is interpreted by Scourse (1991) as a glaciofluvial gravel deposited very close to the Scilly Till.

In its general characteristics the Bread and Cheese Breccia (bed 6) is very similar to the Porthloo Breccia, and is similarly interpreted as a periglacial solifluction deposit. However, it does contain occasional erratic clasts clearly derived from the underlying Scilly Till and Tregarthen Gravel. It cannot, therefore, be correlated with the Porthloo Breccia on lithological grounds, even though it was deposited in a similar environment. It has therefore been defined as a separate stratigraphic unit (Scourse, 1991).

The large granite boulders capping the section have been interpreted by Scourse (1987) as fossil 'ploughing blocks' (Tufnell, 1972). Large boulders lying on the surface of solifluction sheets and lobes have been extensively reported from contemporary periglacial environments where they have been termed 'ploughing blocks' because they move at velocities faster than the flow of the deposits on which they rest.

The Bread and Cheese Cove sequence is unique because it is the only site on the Isles of Scilly where dateable organic sediments occur beneath the glacigenically derived units of the Bread and Cheese Formation of the northern Scillies (Figure 8.3). Humic extract dates of 7880 ± 180 BP (Q-2369) and 7830 ± 110 BP (Q-2411), and a humin date of 9670 ± 65 BP (Q-2368), are however clearly aberrant, with values very much younger than ^{14}C and TL dates on related stratigraphical units elsewhere on the Scillies, and the occurrence of glacigenic and solifluction deposits overlying material yielding Holocene-equivalent radiocarbon determinations clearly suggests that the samples are wholly unreliable. Furthermore, these results are inconsistent with the pollen spectra from this same unit.

Scourse (1991) attributes these erroneous results to contamination by modern carbon derived from rootlet penetration and/or groundwater deposition of modern humus. In particular, the impermeable surface of the granite immediately beneath the organic deposit concentrates groundwater flows through the overlying permeable organic material. It is therefore probable that post-depositional concentration of groundwater-derived humus has occurred in this material. Scourse (1991) has demonstrated, through split humic/humin radiocarbon analyses of other similar organic sequences on the Isles of Scilly, that such hydrogeological contexts consistently produce erroneously young radiocarbon determinations.

Conclusion

Bread and Cheese Cove provides the most complete vertical succession of Pleistocene sediments on the Isles of Scilly. It also contains the most extensive exposure of glacial sediments on the Scillies, providing vital evidence for the glaciation of the northern islands. These sediments appear not to have moved since they were originally deposited, and provide evidence for the direction of movement of the glacier with which they are associated. The sequence also contains meltwater sediments associated with the ice, and slope deposits laid down in cold non-glacial climates both before and after the glacial event. The site is also unique because it is the only place on the Isles of Scilly where organic deposits rich in fossil pollen have been discovered beneath the glacial sediments. These organic deposits provide evidence of open grassland vegetation on the islands prior to the ice advance. From other sites on the Scillies it is known that this type of vegetation was present on the islands around 30 ka BP. This therefore provides evidence that the glaciation must have occurred after this time, during the Late Devensian.

CHAD GIRT, WHITE ISLAND, ST MARTIN'S

J. D. Scourse

Highlights

This site affords excellent exposures through a sequence of raised beach and overlying periglacial slope deposits containing reworked glacial sediments of Late Devensian age. The site is of historical importance because it was selected in the early twentieth century as the type-site for the Quaternary sequence of the Isles of Scilly.

Introduction

Barrow (1906) was the first worker to place the erratic pebbles found at a number of locations on the northern islands into a stratigraphic context. He used Chad Girt to exemplify and demonstrate this context, in addition to showing the stratigraphic relations between other Pleistocene deposits. The site was discussed by Mitchell and Orme (1967), who used it as the type-site for their 'Chad Girt' Raised Beach. The site was reinterpreted by Scourse (1991).

Description

Barrow (1906) defined four main stratigraphic units in the Isles of Scilly: raised beach, head, ironcement and a glacial deposit. Barrow recognized the conglomerate of an old beach, now raised above the level of the present beach, resting on a shore platform. He regarded the beach as once much more extensive but having been largely eroded away leaving the old platform exposed in many places. He applied the term 'head' to the '… accumulation of angular or subangular fragments of granite in an advanced state of decomposition' (Barrow, 1906; p. 17). This head had reoccupied the position of the eroded beach and, resting on the old platform, had a terrace-like contour imparted to it. He was able to divide the head in certain localities into two parts, an 'Upper' and a 'Lower' or 'Main' Head separated by a 'curious glacial deposit' (Barrow, 1906; p. 18).

Barrow cited the section at Chad Girt (SV 926174) on White Island, St Martin's, as fixing the stratigraphic position of these identified units. He described the Isles of Scilly as surrounding an 'interior-sea'; the northern coast of St Martin's, including White Island, forms part of this island rim. The north and east shore of White Island consists of a linking chain of granite tors forming a steeply cliffed coastline; the western slopes of these tors descend gradually to the beach-dune coastline on the sheltered western shore adjoining Porth Morran. The rugged cliffs of the east and north shore are bisected by some deep fissures in the solid granite and overlying Pleistocene sediments, trending north-west to south-east, typified by Underland Girt and Chad Girt. The deep embay-

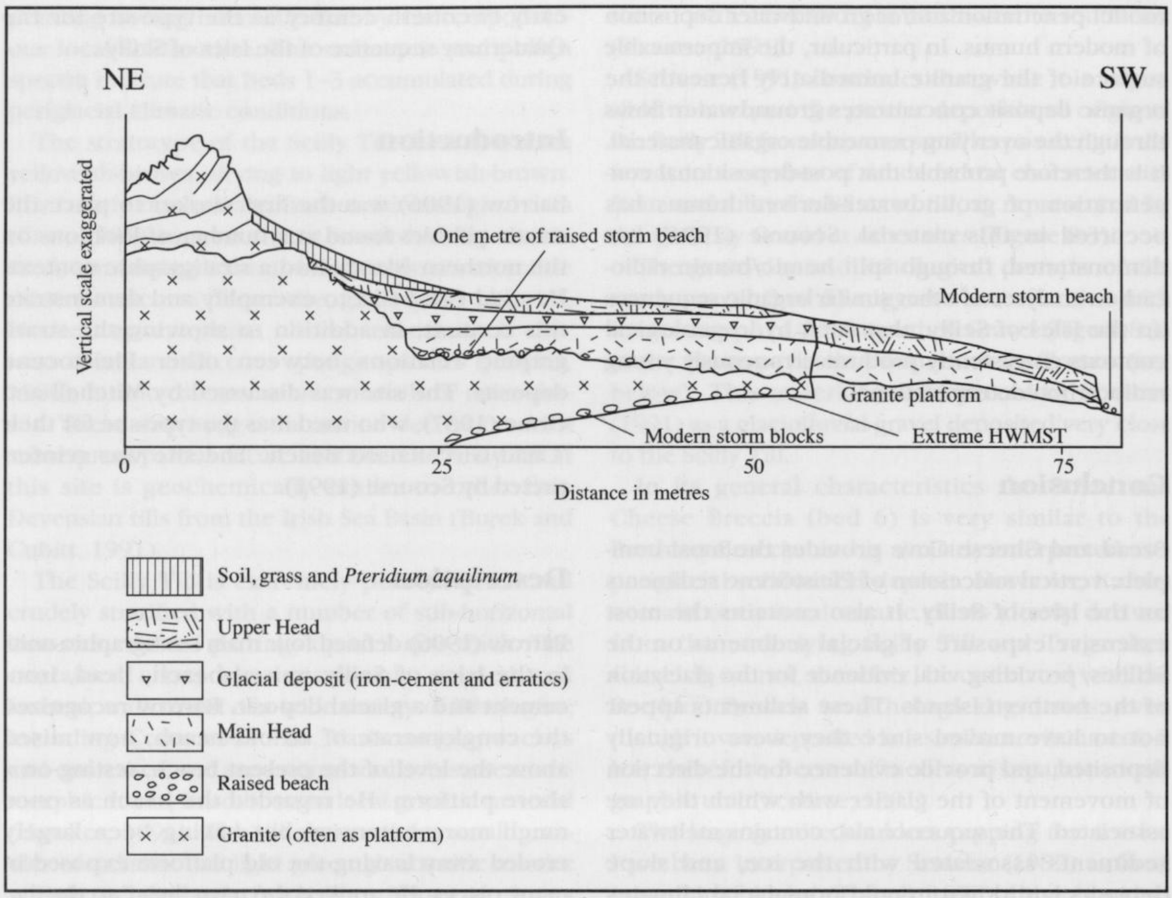

Figure 8.11 The Quaternary sequence at Chad Girt according to Barrow (1906). (Adapted from Scourse, 1986.)

ment of Chad Girt is separated by two parallel granite ridges.

The southern side of the Chad Girt fissure affords an excellent exposure of Pleistocene sediments resting on the solid granite. Here Barrow (1906; Figure 8.11) noted that the old beach rests on the bare granite and underlies the 'Main Head', '... a glacial deposit in turn reposing on the latter' (Barrow, 1906; p. 16). Barrow's (1906) sequence is still clearly exposed, and is little disputed; there have, however, been differences of interpretation.

Interpretation

Mitchell and Orme (1967) provided an excellent interpretation of the geomorphological evolution of the site. They recognized that the Chad Girt embayment did not exist when the shore platform was cut, and that the east side of White Island then formed a continuous north-south rock ridge. Higher sea levels eroded a shore platform on both sides of this ridge, and beach deposits were laid down on the sheltered, western, Porth Morran side. Marine erosion in the 'post-glacial' then attacked the ridge from the east, cutting through the rock ridge and into the shore platform and overlying deposits on its west side.

Although Barrow (1906) was explicit in his interpretations of the basal cobble deposit at Chad Girt as a raised beach, and was able to recognize that the Main and Upper Heads were derived from weathered granite and showed evidence of having moved downslope, he was less sure about the 'glacial deposit'; 'The origin of this curious deposit is by no means clear ... ' (Barrow, 1906; p. 21). He noted the high content of silica and iron oxide in the matrix, and the occurrence of lenticular patches of foreign stones within it. He argued that '... a considerable portion of them [the foreign stones] must have been derived from an older deposit, as many of them are too well rounded to leave any doubt that they were derived from some gravel and not directly from the parent rock'

(Barrow, 1906; p. 23). Whatever their precise origin, Barrow was quite certain that they had been transported to the islands by ice; 'That these stones have been brought into their present position by ice admits of little doubt' (Barrow, 1906; p. 27). He believed their curious distribution to be unintelligible except by invoking some other means of transport than water. Further, 'It is quite clear that they [the foreign stones] must have been carried by floe-ice' (Barrow, 1906; p. 27).

Mitchell and Orme (1967) interpreted the head deposits as the products of solifluction under periglacial conditions, and the glacial deposit as of glaciofluvial (meltwater) rather than strictly glacial origin. Whereas Barrow only identified a single raised beach on the islands, Mitchell and Orme recognized what they believed to be two stratigraphically distinct raised beach deposits, the lower being erratic-free, the upper erratic-rich. They identified the raised beach at Chad Girt as the stratotype for the lower, erratic-free, beach. Mitchell and Orme placed the meltwater sediments in the Gipping (= Wolstonian) glacial stage, the raised beach in the Hoxnian, thus assigning the Lower Head to the Wolstonian and the Upper Head to the 'Last Cold Period' (= Devensian).

Scourse (1991) concurred broadly with previous sedimentological interpretations of the raised beach and solifluction deposits, assigning these units to the Watermill Sands and Gravel (raised beach), Porthloo Breccia (Lower or Main Head) and Bread and Cheese Breccia (Upper Head). However, he differed from Mitchell and Orme (1967) on the age of the various units, and from Barrow (1906) and Mitchell and Orme on the interpretation of the glacial deposit.

The grain-size, lithology and mineralogy of the 'glacial deposit' at Chad Girt is identical to the Hell Bay Gravel (Figure 8.3). This is a solifluction deposit derived from the Old Man Sandloess, the Scilly Till and the Tregarthen Gravel, in which all these sediments were mixed and redistributed downslope. The very distinctive silt matrix of this deposit is derived largely from the Old Man Sandloess, an aeolian sandy silt deposited penecontemporaneously with the glacial event. This material is not therefore an *in situ* glacial or glaciofluvial sediment, but rather a periglacial slope deposit derived from sediments associated with the glaciation.

The Old Man Sandloess has been dated by TL on the southern islands to 18 600 ± 3700 BP (Wintle, 1981; Scourse, 1991), and the Porthloo Breccia, which underlies the Hell Bay Gravel, contains organic beds at other sites on Scilly which have been dated by radiocarbon methods to the late Middle and early Late Devensian. The age of the raised beach remains uncertain. Scourse (1991) therefore interprets most of the sediments at Chad Girt as considerably younger than the ages envisaged by Mitchell and Orme (1967).

Conclusion

The fine exposures of Pleistocene sediments at Chad Girt have been used as a reference section by a number of workers, and are therefore of historical significance. The site demonstrates evidence for a high sea-level event pre-dating periglacial conditions in the Devensian in which Late Devensian glacial deposits were moved downslope.

NORTHWARD BIGHT, ST MARTIN'S

J. D. Scourse

Highlights

This site shows controversial evidence for two raised beach deposits separated by periglacial head. Different interpretations of this sequence have important implications for the age and sequence of Quaternary events on the Isles of Scilly.

Introduction

In 1906 Barrow identified a single raised beach deposit at the base of the Pleistocene sequence on the Isles of Scilly. Mitchell and Orme (1967) proposed a more complicated sequence consisting of two raised beaches separated by periglacial and glacial sediments. They argued that the lower beach was typified by the exposure at Chad Girt (see above; Figure 8.1) and was typically erratic-free, whereas the upper beach, with a type-site at Porth Seal (see above; Figure 8.1), contained abundant erratic material derived from the underlying glacial sediments. In their 1967 study Mitchell and Orme were unable to identify a site where the two beaches could be observed strictly in stratigraphic succession, but subsequently Synge (*in* Stephens, 1970a; p. 294) described such a complete sequence from Porth Seal. The upper beach was reinterpreted by Bowen (1981) as a body of granite corestones, and by Scourse (1985a) as soliflucted beach sediment derived from the lower beach.

Mitchell (1986) identified Northward Bight as a second site where the two beaches could be observed in stratigraphic succession.

Description

Northward Bight (SV 944159) is the northernmost of two deep gullies trending south-west to north-east on the north-eastern side of St Martin's Head. Mitchell (1986) identified the following Pleistocene sequence, overlying bedrock, at this site:

4. Head with erratics
   Devensian
3. Unconsolidated beach with large cobbles
   Ipswichian
2. Head without erratics but with shattered beach cobbles
   Wolstonian
1. Consolidated beach with small cobbles
   Hoxnian

Interpretation

Mitchell (1986) correlated the upper unconsolidated beach deposit (bed 3) with the Porth Seal Raised Beach and the lower consolidated beach (bed 1) with the Chad Girt Raised Beach (Mitchell and Orme, 1967). He thus reinforced his belief that two raised beach deposits, of different ages, are present on the Isles of Scilly, assigning the earlier to a 'pre-glacial' Hoxnian sea-level event, and the later to a 'post-glacial' Ipswichian event. Such an interpretation therefore constrained the glaciation of the Isles of Scilly to the Wolstonian (Mitchell and Orme, 1967).

However, Scourse (1986) does not accept this interpretation. As in the case of Porth Seal (Scourse, 1991), he interprets the upper of the two 'beaches' at Northward Bight as beach material reworked by solifluction from the lower beach. Therefore, he recognises only one *in situ* raised beach deposit at this site. In discussion of the number of raised beach deposits present in the Pleistocene succession of the Isles of Scilly and Cornwall, Scourse (1987, 1991) points out that at nearly all sites where raised beach sediments have been overridden by solifluction lobes and sheets, 'tongues' of incorporated beach material can be observed in the overlying solifluction deposits. These can often appear as two stratigraphically distinct 'raised beach' units in section; in a facies model of solifluction deposits from this area he defines such incorporation of underlying materials as facies Aa 'deformation breccia' (Scourse, 1987).

Scourse (1986) assigns the basal raised beach deposit at Northward Bight (Mitchell's Chad Girt Raised Beach) to the Watermill Sands and Gravel Member of his lithostratigraphic classification (Figure 8.3), the 'head without foreign stones' and the 'Porth Seal beach' to the Porthloo Breccia, and the 'Head with foreign stones' to the Bread and Cheese Breccia. On the basis of radiocarbon dates from organic beds within the Porthloo Breccia at other sites on Scilly, he interprets the Porthloo Breccia as of late Middle or early Late Devensian age. The age of the Watermill Sands and Gravel he regards as uncertain.

Conclusion

Northward Bight contains a controversial sequence of deposits, the interpretation of which has considerable implications for the age of all the Pleistocene deposits of the Isles of Scilly. Mitchell (1986) identifies evidence of two high sea-level stands related to separate Pleistocene interglacials at this site, but Scourse (1986) denies that the upper beach is *in situ* and prefers a younger age for most of the succession.

BATTERY (CASTLE DOWN), TRESCO

J.D. Scourse

Highlights

This site contains the finest exposure on Scilly of Late Devensian meltwater sediments. Head deposits interbedded with the meltwater sediments demonstrate that solifluction was active on the slopes of the meltwater channels. Rounded granite tors on Castle Down have been interpreted as the products of glacial erosion.

Introduction

Pebbles of probable glacial derivation on the northern Isles of Scilly (Figure 8.1) have been known since the middle of the last century. Smith (1858) was the first to record these erratics, or 'foreign pebbles', making a collection of chalk-flints and greensand from Castle Down, Tresco. In reporting their occurrence to the Royal Geological Society of

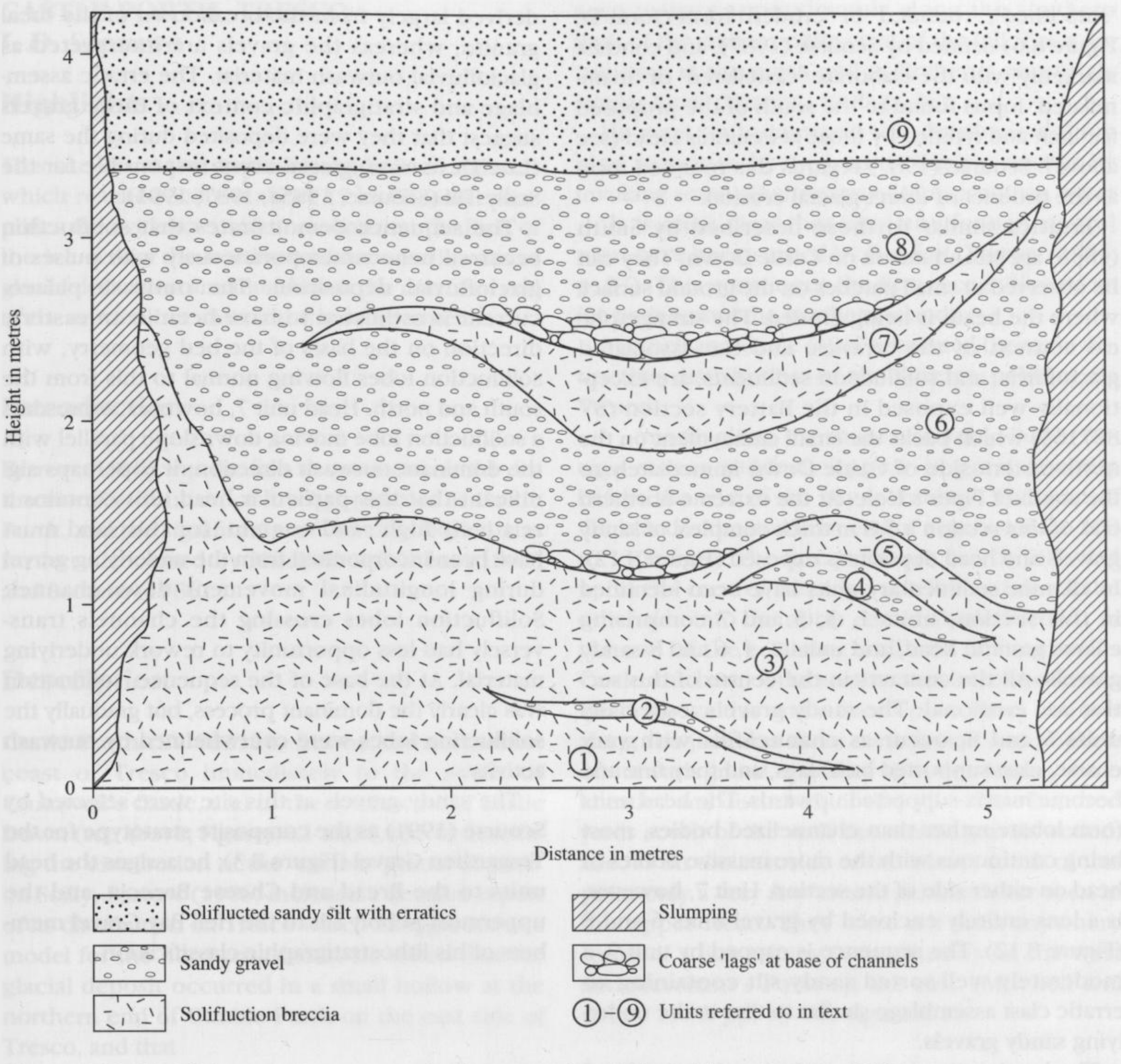

Figure 8.12 The Pleistocene Sequence at the Battery section. (Adapted from Scourse, 1986.)

Cornwall he commented that 'The flints and greenstones varied little in size ranging from that of a hen's egg to that of a blackbird – How they got to Scilly was a mystery which it was for gentlemen of more scientific knowledge than he professed to explain' (Bishop, 1967; p. 91). Such a gentleman proved to be Whitley (1882), who interpreted these foreign stones as glacial in origin.

More recently, Scourse (1991) described an important site of interbedded glaciofluvial and solifluction sediments from an embayment on the north-eastern side of Castle Down known as the Battery section.

Description

Castle Down is an expanse of undulating heath moorland forming the northern part of Tresco. Small eroded granite tors, locally called 'carns', in and around the moor rise to *c.* 40–45 m OD, and the coastal fringe of the moorland consists of granite headlands and small exposures of Pleistocene sediments in cliffs backing embayments and coves. The northern part of Castle Down lies to the north of the glacial limit identified across the northern islands by Mitchell and Orme (1967) and Scourse (1991) (Figure 8.1). The tors in this area are of the 'smoothed', 'rounded' or 'eroded' form (form D; Figure 8.6) defined by Scourse (1987), and contrast markedly with the elaborate 'castellated' or 'mammilated' forms found to the south of the proposed ice limit and typified by those at Peninnis Head (see above). Scourse (1987) regards this rounded form as the product of direct glacial erosion.

Erratics similar to those described by Smith (1858) are still abundant on Castle Down. They can be observed in small patches on the ground surface where the heath is being eroded. The stratigraphical context of the erratics, and the associated glaciofluvial and solifluction sediments, are exceptionally well exposed in the Battery section (SV 887165) which backs the small embayment on the north-eastern side of Castle Down immediately to the south of Piper's Hole. At the extreme northern end of this section a 5.8 m-thick complex of sandy gravels and head deposits is exposed (Figure 8.12). In all, nine sedimentary units have been identified in this section, units 1, 3, 5 and 7 comprising coarse granitic head, and units 2, 4, 6 and 8 sandy gravels. All the contacts in the centre of this section are erosional. The sandy gravels, especially units 6 and 8, occur as channel-fills with very coarse, clast-supported basal lags, and they fine and become matrix-supported upwards. The head units form lobate rather than channelized bodies, most being continuous with the more massive bodies of head on either side of the section. Unit 7, however, is a lens entirely enclosed by gravel units 6 and 8 (Figure 8.12). The sequence is capped by unit 9, a moderately well-sorted sandy silt containing an erratic clast assemblage similar to that in the underlying sandy gravels.

The head units are extremely poorly sorted and contrast with the well-sorted sandy gravels. However, the gravels are even more distinctive in containing a rich and diverse erratic assemblage that is strikingly similar to that obtained from the stratotype of the Scilly Till at Bread and Cheese Cove (Scourse, 1991). Unit 6 has also yielded a clast of green Miocene glauconitic micrite, a distinctive lithology which occurs in the Scilly Till and which is thought to be derived from the offshore Jones Formation (Pantin and Evans, 1984; Scourse, 1991). The head units contain more clasts than the sandy gravels.

Interpretation

The head units within the Battery section are interpreted as solifluction deposits comprising material derived largely from the breakdown of the local granite, whereas the gravels are interpreted as glaciofluvial outwash material. The erratic assemblage and stratigraphic context of these gravels suggest that they were deposited during the same (Late Devensian) glacial event responsible for the Scilly Till (Scourse, 1985a, 1987, 1991).

The sequence demonstrates that solifluction occurred penecontemporaneously with pulses of glaciofluvial deposition. The outwash palaeocurrent is estimated to have been in an easterly direction on the basis of the bed geometry, with solifluction lobes flowing normal to this from the south and north. Head unit 7, however, represents a solifluction lobe moving downslope parallel with the dominant outwash direction; it is perhaps significant that this particular head unit contains a relatively high sand content, for this sand must have been incorporated from the underlying gravel during longitudinal movement down-channel. Solifluction lobes crossing the channels transversely had less opportunity to rework underlying material. At the base of the sequence, solifluction was clearly the dominant process, but gradually the solifluction lobes were overwhelmed by outwash activity.

The sandy gravels at this site were selected by Scourse (1991) as the composite stratotype for the Tregarthen Gravel (Figure 8.3); he assigns the head units to the Bread and Cheese Breccia, and the uppermost pebbly silt to the Hell Bay Gravel members of his lithostratigraphic classification.

Conclusion

This site shows the best evidence on Scilly for the meltwater activity associated with the advance of a glacier to the northern islands at about 19 ka BP. Granite tors on Castle Down were eroded and smoothed by this glacial advance, and the Battery section demonstrates that the relatively rapid downslope movement of materials (solifluction), a common feature of Arctic environments, occurred at the same time as the meltwater deposits were accumulating. Castle Down is also of historical importance because pebbles transported to Scilly by glacier ice were first discovered here during the middle of the last century.

CASTLE PORTH, TRESCO
J. D. Scourse

Highlights

This site lies at the southernmost limit of a glacier which reached Scilly at about 19 ka BP, and exemplifies the evidence used to reconstruct the limit of the ice across the northern islands. Sediments of glacial derivation are abundant at the northern end of the section but absent at the southern end.

Introduction

Barrow (1906) was the first to comment on the distinctive distribution of foreign pebbles at Castle Porth, and the significance of this distribution was further elaborated by Mitchell and Orme (1967) and Scourse (1986).

Description

Castle Porth (SV 882160) lies on the north-west coast of Tresco immediately to the south of Cromwell's Castle, and to the south-west of Castle Down (see above; Figures 8.1 and 8.13). In describing the distribution of the 'curious glacial deposit' on Scilly, Barrow (1906) included a detailed report of its distribution on Tresco which he regarded as a model for the northern islands. He noted that the glacial deposit occurred in a small hollow at the northern end of Gimble Porth on the east side of Tresco, and that

'... this hollow is continued up the hill inland with a comparatively gentle slope. Up the whole of this slope the pebbles in considerable numbers can be traced to the crest of the ridge [Castle Down] ... and down the corresponding slope on the opposite side of the headland. Moreover on the crest of the ridge they may be traced to some little distance to the south. On the opposite, or western, side, owing to the exposed nature of the coastline, practically no Head is met with north of Cromwell's Castle, but immediately south of this is a small and more protected bay [Castle Porth] in which another patch of Head has escaped denudation. On top of this patch the foreign stones are abundant in the northern portion only of the outcrop; further south they cease just as suddenly as they did on the opposite side of the island [Gimble Porth]. If now the two points of cessation of this deposit on the two shore-lines be joined up their line of junction is seen to pass approximately along the southern limit of the stones on the crest of the hill. Their distribution at the north end of Bryher is on exactly similar lines' (Barrow, 1906; p. 26).

He went on to interpret this distribution of foreign stones to be ' ... unintelligible except by invoking some other means of transport than water ... It is quite clear that they [the foreign stones] must have been carried by floe-ice' (Barrow, 1906; p. 27). This constitutes the first recognition of an ice limit across the northern islands.

Mitchell and Orme (1967) reported the same distinctive distribution of the foreign pebbles on Tresco:

'... north along the shore of Gimble Porth, foreign stones suddenly appear in great quantity before the end of the bay is reached. This part of the island is the northern end of a granite ridge 100 to 130ft high. The foreign stones can be followed up to the crest of the ridge at 100ft and down the other side into the north end of Castle Porth ... at the end of the retaining wall east of Cromwell's Castle, the base of the section was in coarse Lower Head. Above this was a finer Upper Head, and just along the junction there were layers and pockets of outwash gravel, together with thin lenses, some kneaded and disturbed, of silty till ... One hundred yards south of the wall the erratic gravels ended, and, as on the east side of the island, south of this point only a very few erratic pebbles were seen in the Upper Head. They were not seen anywhere south of a line joining New Grimsby on the west and Merchant's Point on the east' (Mitchell and Orme, 1967; pp. 75–77; Figure 8.1).

Interpretation

The limit of erratic material which can observed so clearly in the section at Castle Porth has been interpreted by Barrow (1906), Mitchell and Orme (1967) and Scourse (1991) as recording the southern limit of ice on Scilly (Figure 8.1). Unlike some ice limits which are marked by morainic landforms, the maximum extent of ice on Scilly is simply delimited by the distribution of glacial or glacially derived sediment. This characteristic is exemplified by the Castle Porth site.

In terms of the stratigraphy proposed by Scourse (1991), the foreign pebbles at the northern end of Castle Porth occur within a matrix of sandy silt interpreted as a soliflucted mixture of sandloess, outwash gravel and till, formally defined as the Hell Bay Gravel. This conflicts with Mitchell and Orme's

Figure 8.13 Quaternary sediments exposed in coastal cliffs at Castle Porth, Tresco. The Hell Bay Gravel at the northern end of the exposure (left) is rich in erratics, whereas erratics are absent at the southern end (right) of the section. (Photo: S. Campbell.)

(1967) suggestion that the section contains 'silty till'.

The Hell Bay Gravel occurs above a granitic head devoid of erratic material, correlated by Scourse with the Porthloo Breccia. It is overlain by another unit of granitic head which contains a proportion of erratic material incorporated from the underlying Hell Bay Gravel; this is the Bread and Cheese Breccia. At the southern end of the section the Hell Bay Gravel is absent, and here the upper unit of granitic head (the 'Upper Head' of Mitchell and Orme) rests directly on the lower unit (their 'Lower Head'). Lithologically this upper unit is indistinguishable from the lower unit, hence Scourse's classification of the entire sequence here as Porthloo Breccia. This demonstrates two points: first, that the Bread and Cheese Breccia is confined to the area north of the ice limit and second, that at sites in the 'southern' Scillies where the Old Man Sandloess is absent, for example, the southern end of Castle Porth, the upper Porthloo Breccia rests directly on the lower Porthloo Breccia and is indistinguishable from it. All the sedimentary units at Castle Porth are therefore of soliflual origin and the basis for their differentiation lies in the lithological composition of the source material.

Conclusion

Castle Porth helps to establish the southern limit of a glacier which reached Scilly at *c.* 19 ka BP. Although this limit is recorded at a number of other sites on Scilly, it is most clearly demonstrated here. Sediments deposited by the glacier can be observed at the northern end of this site but are absent at its southern end. Since deposition, these glacial sediments have been moved downslope by gravity flows in an Arctic climate.

HIGHER MOORS, ST MARY'S

J. D. Scourse

Highlights

This site provides the most complete record of Holocene vegetational history on the Isles of Scilly.

Pollen and radiocarbon evidence indicates the existence of Holocene forest prior to clearance associated with the spread of agricultural activity during the Neolithic and Bronze Age.

Introduction

The Isles of Scilly are currently devoid of indigenous woodland, but the extremely mild climate of the islands has encouraged the development of a diverse flora and led to the success of many introduced species, some arboreal and many subtropical in character (Lousley, 1971). There would therefore appear to be no natural physical constraint on the development of indigenous woodland, raising the possibility that the islands were wooded prior to their settlement by humans.

Early descriptions of the occurrence of oak trunks at submerged forest localities first suggested the former existence of woodland around the islands (Scaife, 1986). These finds were supported by numerous records of stumps, mostly of *Quercus*, having been removed from the ground on St Mary's, St Martin's and Tresco, those on the latter island having been recorded by Augustus Smith during the last century (Scaife, 1986).

The first pollen-analytical evidence that the vegetation of St Mary's had formerly been dominated by deciduous woodland was provided by Dimbleby (1977) from analyses of a soil profile at Innisidgen (SV 919128). Though it was not possible to date this profile directly, it demonstrated that *Quercus* and *Corylus* had been present in open-canopy woodland with a Gramineae and *Pteridium* ground flora.

Palynological data from soil profiles at a number of archaeological sites have provided clear evidence of post-forest clearance agriculture (Butcher, 1970, 1971, 1972, 1974; Dimbleby *et al.*, 1981; Evans, 1984). These profiles, of various ages postdating the Neolithic, all provide evidence of very open vegetation with some indicating cereal cultivation.

In order to provide a more continuous record of Holocene vegetational change, Scaife (1980, 1981, 1984) investigated the only two remaining areas of peat accumulation on the islands, Higher Moors and Lower Moors on St Mary's. The cores from Higher Moors have yielded pollen and radiocarbon data which provide a reference stratigraphy against which the more isolated soil pollen profiles from archaeological sites can be compared; these data also support the hypothesis of former Holocene deciduous woodland cleared as a result of prehistoric agricultural activity.

Description

Higher Moors is a topogenous mire forming part of Porth Hellick Nature Reserve which extends inland from Porth Hellick (SV 925107) to Holy Vale (SV 921115). The present vegetation consists of a mosaic of wetland species ranging from *Salix caprea* and *S. viminilis* carr associated with the sedge *Carex paniculata*, to mesotrophic sedge and *Phragmites* fen (Scaife, 1984); however, the mire has been extensively disturbed by peat cutting (Lousley, 1971), land drainage and, more recently, by extraction of groundwater for public supply, and these activities have significantly altered the hydrology of the site with resultant impacts on the vegetation (Scaife, 1984). Extensive augering through the length of the mire indicated the thickest peats in the area close to Holy Vale. Here, black highly humified detritus and monocotyledonous peat reaches a maximum thickness of 76 cm, abruptly overlying white bleached sand of very low organic content. Samples for pollen analysis and radiocarbon dating were taken from open sections cut through the peat (Scaife, 1984). Five pollen zones (HM1–5) were recognized by Scaife (1984; Figure 8.14).

HM1: 76–70 cm. Arboreal and shrub pollen dominate this zone with *Quercus*, *Betula*, *Corylus* and *Salix* dominant, and *Pinus*, *Ulmus* and *Alnus* subdominant. Herbaceous frequencies are low and mainly represented by Cyperaceae and other mire taxa.

HM2: 70–62 cm. This zone is characterized by a reduction in arboreal pollen and increases in herbaceous taxa. Although *Corylus* and *Salix* remain important, *Betula* and *Quercus* decline, and *Calluna* increases. Herb taxa, chiefly Gramineae and Cyperaceae, dominate the zone. There are significant records of cereals, weeds and ruderals.

HM3: 62–50 cm. Significant increases in *Betula* and later *Quercus* dominate this zone with concomitant decreases in herbaceous taxa.

HM4: 50–4 cm. An abrupt decrease in arboreal and shrub frequencies occurs in this zone coinciding with increases in Gramineae, Cyperaceae and ruderal taxa. Pollen of Umbelliferae, *Pteridium* and ericaceous taxa also increase in this zone.

HM5: 4–0 cm. This zone reflects the uppermost level of the peat profile. It contains slightly higher frequencies of arboreal pollen than HM4 alongside

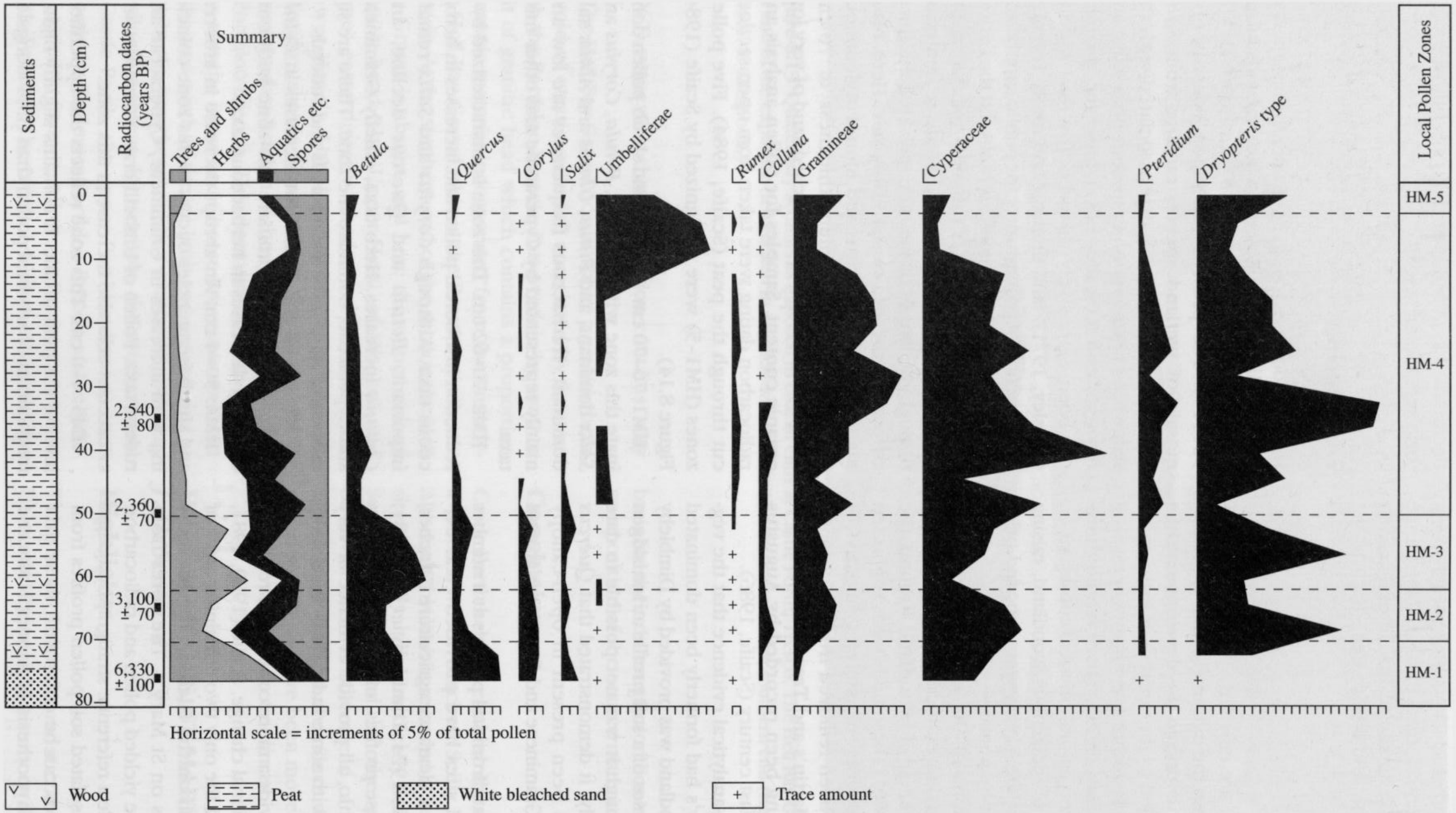

Figure 8.14 Selected pollen data and radiocarbon dates for a peat profile at Higher Moors, St Mary's. (Adapted from Scaife, 1984.)

Pittosporum and some other introduced exotic taxa.

Four 2 cm-thick samples of the peat were submitted for radiocarbon assay and the uncalibrated results are shown in Figure 8.14.

Interpretation

Although there is clearly a problem with the radiocarbon determinations (Figure 8.14), with an inversion towards the top of the profile, Scaife (1984) attributes this to humification effects, and accepts the lowermost date, from the base of the profile at 75 cm, as reliable. This therefore indicates the presence of forest, at least in this part of St Mary's, during the middle Holocene. Scaife (1984) interprets the pollen record as indicating open *Quercus* woodland allowing a *Corylus* understorey to flower freely. He correlates this forested phase with the undated soil profile from Innisidgen (Dimbleby, 1977) which provided the first pollen evidence for the former presence of woodland during the Holocene on the islands.

A decline in arboreal pollen and increases in herb taxa occur above 68 cm (HM2), including evidence of cereal cultivation, followed above 62 cm (HM3) by forest regeneration with increases in *Betula* and *Corylus*. Problems with the radiocarbon assays in this section of the profile hinder attempts to correlate this evidence of clearance and subsequent forest regeneration with specific archaeological events or periods. However, Scaife (1986) suggests that the clearance phase may be Neolithic with regeneration occurring in the late Neolithic or early Bronze Age. The major phase of forest clearance at 50 cm (HM4) probably dates to the middle Bronze Age and is consistent with the widespread archaeological evidence (Scaife, 1986).

Conclusion

The peat bog at Higher Moors has provided evidence that the Isles of Scilly were at least partly covered by deciduous forest at around 6 ka BP. This indigenous forest was then partly cleared by Neolithic humans, and finally disappeared as a result of ground clearance associated with agricultural activity during the Bronze Age. Higher Moors is the most important site providing evidence of the changing vegetation on Scilly since the end of the last ice age.