Chapter 7 The Quaternary history of north Devon and west Somerset

Introduction

N. Stephens

The Quaternary deposits and associated landforms of north Devon and west Somerset have been investigated for over 150 years. Some of the most significant early contributions were made by Sedgwick and Murchison (1840), who studied the raised beach and associated deposits between Saunton and Baggy Point (Croyde Bay), and De la Beche (1839) who established the term 'head' for a variety of slope deposits developed under non-temperate freeze-thaw conditions. Maw (1864) identified and mapped the controversial Fremington Clay for which he proposed a glacial origin. Dewey (1910, 1913) considered the possible source of various erratic and striated pebbles and boulders and investigated the stratigraphical relationships of the local raised beach deposits and the Fremington Clay.

Since this early work, numerous examinations of Quaternary deposits in north Devon have been carried out (e.g. Mitchell, 1960, 1972; Stephens, 1961a, 1961b, 1966a, 1966b, 1970a, 1973, 1974, 1977; Churchill and Wymer, 1965; Wood, 1970, 1974; Kidson, 1971, 1977; Edmonds, 1972; Kidson and Wood, 1974; Gilbertson and Mottershead, 1975). Attention has also been given to a variety of landforms including hogback cliff profiles (E. Arber, 1911; Steers, 1946; M. Arber, 1949, 1974), dry valleys, including the Valley of Rocks (Simpson, 1953; Stephens, 1966a; Pearce, 1972; Mottershead, 1977c; Dalzell and Durrance, 1980), and the buried rock channel of the Taw–Torridge Estuary (McFarlane, 1955). Erratic-rich gravels on Lundy Island have been investigated (Mitchell, 1968) as well as the curious flint-bearing gravel at Orleigh Court near Bideford (Rogers and Simpson, 1937).

Numerous attempts have been made to date and correlate deposits in the region, but as yet there is little agreement on many aspects of its Quaternary history. However, it is generally agreed that the bulk of South-West England was not overrun by Pleistocene ice sheets. Fragmentary evidence for the encroachment of an ice sheet along the north coast, from the Isles of Scilly to north Devon, is, however, widely recorded, taking the form of giant erratics stranded on shore platforms (e.g. Saunton), postulated glacigenic gravels (Isles of Scilly, Trebetherick and Lundy Island) and possible outcrops of till (Fremington) (Stephens, 1973; *in* Mitchell *et al.,* 1973b). This has led to the proposition that the most extensive of the Pleistocene ice sheets reached its southernmost limit at or near the north Devon and Cornish coasts (Figure 2.3). Traditionally, this glacial event has been regarded as 'Wolstonian' in age (Mitchell, 1960, 1972; Stephens, 1966a, 1966b, 1970a; Mitchell and Orme, 1967; Kidson, 1977). However, recent intense scrutiny of the status of Wolstonian' deposits in Britain (e.g. Sumbler, 1983a, 1983b; Rose, 1987, 1988, 1989, 1991) has necessitated a radical revision of the concept of the Wolstonian. Best estimates now ascribe glaciation of the northern Isles of Scilly to the Late Devensian (Scourse, 1985a, 1987, 1991), refute evidence of glacial activity at Trebetherick (Kidson, 1977; Scourse, 1996c), and assign the Fremington Clay or Till of north Devon, albeit tentatively, to a glaciolacustrine event of Anglian age (Croot *et al.,* in prep.; Campbell *et al.,* in prep.). Evidence of an earlier glacial event comes from the Bristol district where marginal marine deposits, dated by amino-acid geochronology to Oxygen Isotope Stage 15 (Cromer Complex), are underlain by glacigenic sediments (Gilbertson and Hawkins, 1978a; Andrews *et al.,* 1984; Bowen, 1994b). An attribution of the glacial beds to Stage 16, a major ice-volume episode, is possible, and may also be appropriate for some of the large stranded erratics such as the Giant's Rock at Porthleven (Bowen, 1994b).

Large erratic boulders weighing up to *c.* 50 tons are found around the shores of Barnstaple Bay and Croyde Bay. Some authorities have linked them with similar erratic material recovered from the Fremington Clay (Kidson, 1977), but in reality the relationship is far from clear. Moreover, large erratic boulders are also found on the south coast of Cornwall (the Giant's Rock at Porthleven; Flett and Hill, 1912), along the English Channel coast as far east as Sussex and even in Brittany (Tricart, 1956).

The presence of glacier ice in the Bristol Channel has also been used to account for numerous dry valleys, channels and cols found in north Devon especially near Lynmouth and Hartland Point. Stephens (1966b, 1974) raised the possibility that these were cut by pre-Devensian, probably Wolstonian, meltwater. Others have interpreted them as remnants of dismembered fluvial valley systems formed by protracted coastal erosion and cliff retreat (Steers, 1946; Dalzell and Durrance, 1980).

Throughout the Peninsula there is widespread evidence of former periglacial activity. The development of large coastal 'terraces' of head deposits testifies to the mobility of slope deposits, including weathered residues and frost-shattered rock. These sediments bury ancient cliff notches, some of the marine-planated rock platforms and raised beach deposits, fossil sand dunes (the sandrock of the Croyde–Saunton coast; Stephens, 1966b, 1970a; Kidson, 1977) and some of the large erratic boulders. On the higher slopes the head deposits are generally thinner, and, where sections exist, display a more coarse-textured and blocky nature than at the foot of the coastal slopes, but there is considerable sedimentological variation.

Above about 175 to 200 m no genuine erratic material has been recorded from the mantle of head deposits, although detailed mapping is far from complete. Investigations of erratic limits and erratic-free areas have proved difficult, largely because of human activity (e.g. Madgett and Inglis, 1987). For example, quantities of Carboniferous Limestone from South Wales were off-loaded at local quays and beaches and then transported inland for spreading on cultivated fields. Such activity undoubtedly accounts for the presence of numerous small 'foreign' pebbles such as quartz and flint and some Palaeozoic rocks found in ploughed fields for several kilometres inland from the coast. The modern sandy shingle beaches are rich in quartz and flint pebbles together with erratic material, but the former inland extent of any ice from the Bristol Channel and Irish Sea is unknown.

Thus not only the extent of former glaciation, which most authorities have argued must be pre-Devensian, but the age of the Fremington Clay (till?) and its relationship to the arrival of the large erratic boulders, and the fitting of these events into a timetable which also encompasses deposition of the raised beaches and the various head deposits are far from clear. This is reflected by widely disparate views and correlation tables which have been published of the Pleistocene history of the area (e.g. Edmonds, 1972; Stephens, 1973; Kidson, 1977; Bowen *et al.,* 1985, 1986; Campbell *et al.,* in prep.).

The Holocene is represented inland principally by sand and silt deposits which make up the present floodplains of the Taw–Torridge rivers and their tributaries. Holocene gravel and boulder debris is associated with the steeply falling north coast rivers such as the East and West Lyn, which are deeply incised in the coastal plateau. On slopes, variable amounts of hillwash and colluvium can be observed and, on Exmoor, pollen-bearing peats provide evidence of Holocene climatic and environmental changes (Merryfield and Moore, 1974; Moore *et al.,* 1984). Coastal peat, organic clays and trees from the submerged forest testify to the pro gressive drowning of the coast by the Holocene sea.

The coastal deposits and the sequence of events at Westward Ho! have been described in detail by Rogers (1908), Churchill (1965), Churchill and Wymer (1965) and Balaam *et al.* (1987). Sea level is considered to have been 4–6 m below present some 6–7 ka BP, thus allowing peats and peaty muds to accumulate and trees to grow on what is now the modern foreshore. Radiocarbon dating of the peat places it at 6585 ± 130 BP and a Mesolithic kitchen midden was recorded from the same set of deposits. Holocene sea-level rise is also well documented from other parts of the Bristol Channel and the Somerset Levels (Kidson and Heyworth, 1973, 1976; Heyworth and Kidson, 1982; Chapter 2). At Stolford, a submerged peat with tree stumps and fallen trees is seen in much the same position as the Westward Ho! deposits (between MLWOT and MHWOT) and radiocarbon dates indicate a very similar timescale of events, culminating in the sea returning to approximately its present level.

Thus in north Devon and the Somerset Levels, and probably also for much, if not all, of the South-West, the Holocene transgression appears to have been a continuous process, implying crustal stability over a wide area (Kidson and Heyworth, 1973; Kidson, 1977). In Barnstaple Bay the last few thousand years have seen construction of the enormous shingle and cobble ridge which extends northwards from Westward Ho!; the south-western end of this structure is estimated to have moved inland at least 60–70 m in the last 150 years (Stuart and Hookway, 1954). Massive sand dune systems have also formed at Northam Burrows, Braunton Burrows, in Croyde Bay and Woolacombe Bay; these dunes mask parts of the foot of the coastal slope in each of these localities (Kidson *et al.,* 1989; Chisholm, 1996).

The evidence

Rock platforms

In north Devon, Quaternary deposits constitute a wedge of sediments up to 18–20 m thick and mask the mainly convex coastal slopes. These deposits overlie a series of marine-planated rock platforms which lie between *c.* –1.5 m to + 15 m OD. Cliffs cut in the Pleistocene sediments vary in height from *c.* 2 to 20 m and it is clear that the extensive rock platforms now visible were once buried and have been exhumed by recent Holocene marine erosion. Although there has been some trimming of the old platforms, the evidence indicates that the greater part of the exposed platforms are ancient features.

At Saunton the platform at 5 m OD is most prominent. However, Kidson (1971) has shown other platforms also occur, extending from a few metres below OD and the modern beach to + 8 m OD. In Croyde Bay a series of platforms can be observed between Middleborough House and Pencil Rock, the 8–10 m OD platform being the dominant feature. A higher platform at 12–16 m OD is seen near Freshwater Gut and Middleborough House, rising to 14–15 m OD at Pencil Rock. Although marine processes undoubtedly account for the erosion of the platforms, it is not clear whether this took place entirely under interglacial climatic conditions; some parts of the platforms may have been cut by the sea under periglacial conditions (Dawson, 1990).

At Westward Ho! several platforms are superbly exposed. The present tidal platform extends for some 200 m at low tide with a height range of 2–3 m OD; a lower rock surface at about — 1.05 m OD disappears northwards below the modern beach. The 2–3 m platform terminates in a near-vertical rock cliff above which the 8–9 m OD platform is seen. Isolated remnants of a platform at 5 m OD rise locally above the 2–3 m surface (Stephens, 1970a; Kidson, 1971, 1977; (Figure 7.9)). The generally ragged appearance of the wide 2–3 m platform gives way to more smoothed surfaces at the cliff-foot where wave action has constructed an impressive storm beach of sandstone pebbles and cobbles. These appear to have been derived from raised beach material lying on the 8–9 m platform. The seaward edge of the 8–9 m platform lies 3–4 m above the highest storm beach ridge and about 6 m above the back of the 2–3 m surface. The notch of the 8–9 m platform is estimated to be at about 13–14 m OD although it is completely hidden by a suite of superficial deposits.

Buried rock channels

McFarlane (1955) demonstrated a buried rock channel at the confluence of the Taw–Torridge rivers, lying at a depth of about – 24 m OD and buried by *c.* 30 m of sediment in the estuary. He considered that both rivers formerly graded to a level of – 24 m OD north of Appledore. Similar flat-bottomed buried channels elsewhere in South-West England may have formed when sea level was lower by up to 45 m, and the shoreline some 15 km off the present coast.

The age of the channels has not been determined, but they are likely to have been formed during a variety of Pleistocene cold stages when sea levels were low. Similar buried channels have been described elsewhere in South-West England by Codrington (1898), and comparable features have been traced and recorded in South Wales and the Severn Estuary (Anderson, 1968). The sediment content of the channels varies from till, sand and gravel to a variety of Holocene deposits, and much of the sedimentary infill has been reworked.

Erratics and glacigenic materials

large erratic boulders on the coasts of north Devon and Cornwall, on the English Channel coast as far east as Sussex and in Brittany, together with significant quantities of pebble-sized erratics and some other glacially derived sediments have long provided interesting problems for Quaternary researchers (Williams, 1837; Pengelly, 1867, 1873a; Hall, 1879b; Dewey, 1910; Taylor, 1956; M. Arber, 1964; Stephens, 1966b; Kidson, 1971; Edmonds, 1972; Madgett and Inglis, 1987; Hallégouët and van Vliet-Lanoë, 1989; Sims, 1996). Virtually all the large coastal erratics are found within a narrow range of height (0–10 m OD) and resting upon one of the several marine-planated rock platforms (Stephens, 1970a, 1974; Kidson, 1971, 1977). A few have allegedly been recorded at higher altitudes, as for example an epidiorite block on Baggy Point at + 80 m OD (Madgett and Madgett, 1974), but some erratic material may owe its position to anthropogenic activity. Madgett and Inglis (1987) have made a comprehensive survey of erratics, of all sizes, found between Baggy Point and Saunton, and Sims (1996) reviews the possible mechanisms for their emplacement.

The wide distribution of the large erratics has been accounted for by the movement of land-based ice masses (Mitchell, 1960; Kidson, 1971; Kellaway *et al.,* 1975) or floating icebergs and floes (Synge and Stephens, 1960; Stephens, 1970a, 1974; Bowen, 1994b). However, deposition of the large erratics has also been linked directly to the emplacement of the Fremington Clay (Kidson and Wood, 1974; Kidson, 1977) where the erratic suite is similar to that on the open coast at Croyde and Saunton. The rejection of the proposition (Kellaway *et al.,* 1975) that land-based ice could have advanced sufficiently far eastwards into the English Channel to deposit large erratics from south Cornwall to Sussex and in Brittany (Gibbard, 1988), suggests that, at least for these coasts, floating ice was probably involved. In north Devon and north Cornwall the problem is more difficult because there is good evidence for incursions of Irish Sea ice into the Bristol Channel during some stage or stages of the Early and Middle Pleistocene to deposit till and related sediments as far east as Somerset (Hawkins and Kellaway, 1971; Hawkins, 1977; Andrews *et al.,* 1984). Thus two mechanisms of deposition may be involved in the South-West Peninsula, although it is also possible that the wide geographical distribution of the large erratic boulders was accomplished during a single glacial event of pre-Devensian age.

Erratic emplacement by floating ice requires a delicate balance between sea level and climate to allow the stranding of ice-rafted material. If isostatic adjustments were also involved then a complex relationship between land and sea level must be envisaged for which, at present, there is little or no evidence during the Early and Middle Pleistocene. Oscillations of the position of the North Atlantic Polar Front have been postulated by Ruddiman and McIntyre (1981) during the Devensian. If similar movements occurred during earlier Pleistocene glacial events then climatic conditions may well have allowed substantial ice-floes to stream southwards to latitudes of the Bristol and English channels while sea level remained sufficiently high to allow the floes to be stranded on the lower of the rock platforms.

The Fremington Clay and related deposits

An important suite of Pleistocene deposits is known from a small area between Fremington and Barnstaple. The description and analysis of these deposits began in the mid-nineteenth century but their interpretation and dating remains difficult and contentious (Maw, 1864; Dewey, 1910; Taylor, 1956; Mitchell, 1960; M. Arber, 1964; Stephens, 1966b, 1970a, 1974; Wood, 1970, 1974; Edmonds, 1972; Kidson and Wood, 1974; Kidson, 1977). The Fremington Clay in fact comprises a complex and variable sequence of clays, silts, sands and stony clays overlying gravels (Stephens, 1966b, 1970a; Croot, 1987; Croot *et al.,* 1996). Up to 30 m of clay have been recorded and erratics, including some large examples, and striated stones are abundant in certain horizons (but see Brannam's Clay Pit). The sub-clay gravels exposed in the base of the clay pits, at Fremington Quay, Fremington Railway Cutting and at Lake Quarry provide further problems of interpretation and correlation (Figure 7.1).

Sections at Fremington Quay, the Railway Cutting, Penhill Point and Lake Quarry show gravels which have been considered to represent a raised beach (usually equated with that exposed in the Croyde–Saunton coastal section) resting on bedrock and overlain by erratic-bearing stony clays (Figure 7.1). Stratigraphical variation over several hundred metres of section, however, has made interpretation difficult and dating controversial (Dewey, 1913; Stephens, 1966b, 1970a, 1974; Wood, 1970, 1974; Kidson and Wood, 1974; Kidson, 1977; Croot *et al.,* in prep.; see Fremington Quay).

Several metres of sand and gravel cap the Bickington–Hele ridge which rises to 55 m OD and stands above the main body of the Fremington Clay (at 30 m OD). These deposits, which contain erratic stones, may represent ice-marginal or sub- ice sediments associated with the Fremington Clay, which until recently has been regarded as, at least in part, a till. Edmonds (1972) re-mapped this area and reaffirmed the presence of till, a view accepted by most authors but recently questioned by Croot (1987) and Croot *et al.* (1996) who have proposed a glaciolacustrine origin for the bulk of the Fremington Clay (see Brannam's Clay Pit). Edmonds also mapped river terraces in the lower Taw Valley and between Barnstaple and Swimbridge. These terraces were related to a series of events involving both deposition of the Fremington Clay and the raised beach of the outer coast, and were considered to have accumulated during the Wolstonian and Ipswichian stages.

Foundation trenches for a housing development in Croyde Village revealed a red-brown clay containing erratics and striated stones. This too may be related to the Fremington Clay and other stony clays exposed in low cliffs below modern sand dunes in Croyde Bay (Madgett and Inglis, 1987). Although a glacial origin has traditionally been proposed for the Fremington and Croyde clays, there is still considerable doubt concerning the precise origin and age of these deposits and estimates of both vary widely. Most authorities have invoked a land-based ice sheet of Wolstonian (Saalian) age to account for the deposits, but this now seems highly unlikely (see Chapter 2; Anglian and Saalian events). Some workers have suggested the possibility of a Devensian age for the Fremington Clay; Eyles and McCabe (1989) postulated that the deposits could have accumulated as a glaciomarine mud drape from a disintegrating, floating, Devensian Irish Sea ice sheet. Such a possibility was also given credence by Bowen *et al.* (1989) and Campbell and Bowen (1989), and also by Synge (1977, 1979, 1981, 1985) who has argued consistently for extensive floating Devensian ice off the south-east Irish and south-west Wales coasts. Although such dating of the Fremington' Clay fits neatly with Scourse's (1985a, 1986) proposal that land-based Devensian ice reached the Isles of Scilly, it runs counter to the view of Kidson (1977) and others that there is no evidence of a glacial event post-dating the raised beaches at Croyde, Saunton and Westward Ho! The most recent attempts to date the Fremington Clay using OSL techniques (Croot *et al.,* 1996; Gilbert, in prep.) have provided ambiguous results. An age greater than *c.* 400 ka BP, however, is indicated suggesting that the deposits are at least of Anglian age. Evidence from the Bristol district suggests that glacigenic sediments there may be as old as Oxygen Isotope Stage 16 (Gilbertson and Hawkins, 1978a; Andrews *et al.,* 1984; Bowen, 1994b). If a correlation can be proved between these deposits and the Fremington Clay, then the Stage 16 ice limit in South-West England (Figure 2.3) proposed by Bowen and Sykes (1988) may appear increasingly realistic.

Lundy Island

Further evidence for the former presence of glacier ice in north Devon occurs on Lundy Island (Mitchell, 1968). The island is composed mainly of Tertiary granite except for a small area in the extreme south-east where Upper Devonian slates (Upcott Slates) crop out. There are also numerous dykes of basic and acid rocks. Pebbles of sandstone, flint, chert and greywacke up to 10 cm diameter are widely scattered over a considerable area at the northern end of the plateau between *c.* 84 and 107 m OD, and occasional erratics are also found in head which mantles coastal slopes in the east. Ice-moulded bedrock, demonstrating possible evidence for a WNW to ESE direction of ice movement, is recorded on the west side of the island north of St James's Stone. In the north of the island, small, deep dry valleys slope eastwards and trench the coastal slope: these have been interpreted as glacial meltwater channels (Mitchell, 1968). Although the precise age of the Pleistocene sediments and landforms is unknown, the evidence appears to confirm the presence of an ice sheet in this vicinity to a minimum height of 115 m OD: both Anglian and Woistonian glacial events have been suggested (Mitchell, 1960, 1968, 1972).

The Doniford gravels

The Doniford gravels crop out for approximately 2 km along the Somerset coast near Watchet. According to Gilbertson and Mottershead (1975), they appear to have no direct connection with the glacial deposits and raised beaches of north Devon nor the glacial deposits reported from the Somerset Levels at Kenn (Gilbertson and Hawkins, 1978a) and in the Bristol area (Hawkins and Kellaway, 1971).

The Doniford gravels have a maximum thickness of about 5 m and consist mainly of slates, sandstones, grits and chert derived from the Devonian rocks of the Bredon Hills, with subordinate blocks of local Liassic shale. Both the gravels and the underlying shale bedrock are severely disturbed by periglacial structures which extend upwards into the lowest member of a series of pebble-bearing loams; no far-travelled erratics have been detected in either set of sediments.

The gravels contain remains of *Mammuthus primigenius* (Blumenbach) (woolly mammoth) and well-rolled Palaeolithic implements (hand-axes and flakes) of Acheulian typology (Wedlake, 1950; Wedlake and Wedlake, 1963) which might appear to raise the possibility of a pre-Devensian age. However, since the uppermost loam, which caps the gravel sequence, contains Mesolithic artefacts and because there is no marked discontinuity between the lower loams and the gravels, Gilbertson and Mottershead (1975) have assigned the bulk of the Doniford sequence to the Devensian, arguing that the gravels accumulated as a mixture of periglacial fluvial and slope deposits.

Raised beach, sand and bead deposits

Slope deposits of varying composition and thickness mantle most of the landscape of north Devon. They range from weathered clasts supported in a sandy-silt matrix to coarse, loosely packed angular rock fragments. At the foot of some coastal slopes the deposits form 'terraces' of considerable extent and thickness. The term 'head' has been universally adopted to describe the bulk of these deposits since it was first used by De la Beche (1839).

It is accepted that non-temperate freeze-thaw processes were responsible for the break up of the regolith and underlying bedrock and, together with some water-action, enormous quantities of material were moved downslope. The terraces of head are particularly well developed around Croyde Bay, at Saunton, Lee Bay and Westward Ho!, and in each case the head overlies extensive raised beach deposits (Figure 7.1). In Croyde Bay and at Saunton, cemented dune sands rest directly on raised beach sediments and these in turn are covered by head, which in places interdigitates with dune sand. At the base of the sections, and overlain by either raised beach deposits, cemented dune sand or head, are found some of the large erratic boulders; in every known case these are in contact with the bedrock of the shore platforms.

The head deposits are clearly younger than the raised beach sediments and the large erratic boulders. The cemented sands (sandrock) rest directly on the raised beach sediments, which are pebbly towards their base at Saunton but pass upwards into current-bedded (marine) sand. The latter then gives way, often imperceptibly, to cemented dune sand (Greenwood, 1972; Gilbert, 1996) which accumulated, at least in part, when periglacial processes began to produce the extensive head deposits, thus accounting for the interdigitation of the two very different sediments.

Attempts to recognize divisions within the head deposits (Stephens, 1966a, 1966b, 1970a) have been based on the presence of a coarse, angular and blocky layer up to 2 m thick — the Upper Head — which forms the upper surface of the head terrace. The terrace was considered to comprise a Lower Head, a relatively consolidated deposit with well-weathered clasts set in a matrix of sand- and silt-sized material, while the Upper Head consists mainly of angular rock fragments, little weathered and without a substantial matrix. Occasional ice-wedge casts and other infilled (with silty clay) cracks disturb the bedding of the Upper Head. However, such a division of the head deposits is not universally accepted and Kidson (1971, 1977) regards the head as a single, if very variable, sedimentary unit. Thus, Kidson would regard the head as the product of a major periglacial phase during the Devensian cold period while Stephens suggested that at least two separate periglacial phases are represented. Aeolian sand, which underlies and interdigitates with the head along the Croyde–Saunton coast (e.g. Greenwood, 1972; Gilbert, 1996), has been dated recently by Optically Stimulated Luminescence (OSL) techniques (Gilbert, 1996). The preliminary results show that the aeolian sediments were deposited during Oxygen Isotope Stage 4, around 70 ka BP, and that the considerable thicknesses of overlying head must be Devensian. Precise subdivision and dating of the head are still, however, tenuous. There is no evidence that the surface of the coastal terrace here, or at other localities, was fashioned by marine activity.

The raised beach deposits would therefore appear to represent an interglacial sea-level event, or events, before at least one, and possibly more than one, major periglacial phase. Exposures of raised beach deposits vary in height and it is only in Croyde Bay, at Pencil Rock on Baggy Point and at Middleborough House at about 10 to 14 m OD that notches in bedrock can be observed. Raised beach deposits are seen at lower levels towards Saunton but here the rock notch is obscured.

Attempts to resolve the age of the raised beach deposits between Croyde and Saunton have been made using amino-acid analyses of fossil marine shells (Andrews *et al.,* 1979; Davies, 1983; Bowen *et al.,* 1985). The results show that most of the raised beach deposits can probably be correlated with high relative sea levels during Oxygen Isotope Stage 7. However, the presence of some shells with amino-acid ratios typical of Stage 5e (Ipswichian) and Stage 9 provides major problems of stratigraphic interpretation: Bowen *et al.* (1985) have tentatively suggested that locally Stage 5e deposits may be banked against an older (Stage 7) raised beach deposit (see Croyde–Saunton Coast). Gilbert (1996) assigns the bulk of raised marine sediments at this locality to Stage 5e.

The raised cobble beach deposits at Westward Ho! have been ascribed both to the Ipswichian (e.g. Kidson, 1977) and to the Hoxnian (e.g. Stephens, 1970a, 1973). However, the deposit lacks shells and cannot therefore be dated by amino-acid techniques. Comparison based upon position, stratigraphy and height range in fact suggests that the raised beach deposit at Westward Ho! is possibly equivalent to the Croyde–Saunton raised beaches, although such evidence alone is insufficient to justify correlation. The raised beach deposit at Lee Bay (see the Valley of Rocks), sealed below massive head deposits, may also be related. Unfortunately, there is no section known in north Devon where two undoubted raised beach deposits of different ages occur in clear superposition. Only in South Wales, at Portland Bill and in the Isles of Scilly (Mitchell and Orme, 1967) have two superposed beaches of different age been identified, although in the latter locality Scourse (1986) interprets the higher (younger) deposit as having been derived by solifluction from the older (Chapter 8).

The evidence presented by Bowen *et al.* (1985, 1989) and Bowen and Sykes (1988) has been summarized admirably by Jones and Keen (1993). It appears that for the present, a number of permutations for the ages of the various outcrops of raised beach deposits in southern Britain are possible. If the Saunton and Croyde raised beach sediments are not Ipswichian (the Pennard Stage of Bowen *et al.* (1985)) but belong to some pre-Ipswichian event (the Unnamed Stage and/or the Minchin Hole Stage of Bowen *et al.* (1985)), then many questions still arise concerning the age of the overlying head deposits, the Fremington Clay and the raised beach sediments reported from Fremington Quay, Fremington Railway Cutting and at Penhill Point.

Attention must also be given to the substantial patches of well-rounded pebbles and cobbles exposed at low tide on the foreshore at Westward Ho! These deposits are exposed sporadically beneath a suite of Holocene sediments. The pebbles and cobbles vary in size, many exceeding 30 all in length. Most are embedded in a head deposit and stand on-end, and some appear to have suffered post-depositional fracturing, perhaps by freeze-thaw processes. Rough polygonal patterns are displayed by the upstanding cobbles, suggesting an exposure of relic patterned ground in material almost identical to that of the modern storm beach ridge and the 8–10 m OD raised beach deposit (see Westward Ho!).

The lower intertidal rock platforms (–1.5 m and/or 2–3 m OD levels of Kidson, 1971) must surely pass below these deposits. Dating and correlation, however, remain very difficult although it has been suggested tentatively that these foreshore deposits constitute a periglacially disturbed beach of different age from the 8–10 m OD raised beach deposit (Stephens, 1974). Such an explanation is rejected by Kidson (1974) as an unnecessary division of the same raised beach. However, it can be argued that these periglacially disturbed beach deposits were closely associated with the cutting of the 2–3 m OD rock platform and removal of some of the head deposits originally covering its surface. Although the sea is at present trimming this low platform it seems clear that it is a relic feature cut below the higher raised beach platform at 8–10 m OD. There remains, therefore, the possibility that two different phases of rock platform cutting and beach deposition are preserved at Westward Ho!

The relationship of the raised beach deposits to the Fremington Clay and related sand and gravel deposits also remains highly contentious. The raised beach sediments exposed at Fremington Quay, the Railway Cutting and at Penhill (resting on bedrock at 10 m OD) are considered by most authors to post-date the Fremington Clay and to represent an Ipswichian beach deposit (Kidson, 1971; Edmonds, 1972; Kidson and Wood, 1974; Wood, 1974; Kidson, 1977). However, alternative explanations of the stratigraphy at these sites have been proposed (see Fremington Quay) and the age and origin of a sub-Fremington Clay gravel remains crucial to establishing the relative age of the raised beach (Stephens, 1966b, 1974). Dewey (1913) considered that at Fremington Quay raised beach gravels were overlain by weathered stony clay containing erratics and striated pebbles, while Stephens (1966b) recorded contorted beach gravels overlain by till in the nearby Railway Cutting; whether or not these stony, erratic-bearing clays overlying the raised beach rest *in situ* or not requires further investigation.

It is thus of critical importance that the age of the raised beach deposits on the outer coast at Croyde and Saunton be determined, that there should be a fresh examination of the Westward Ho! beach deposits (both in cliff and foreshore exposures), and that a major effort be made to establish the precise stratigraphical relationships of various deposits in the Fremington area and their relationship to the sedimentary sequence on the outer coast. At present it is not possible to assign any of the beach deposits, the sandrock, the very large erratic boulders, the Fremington Clay and related sands and gravels at Bickington and Hele to a precise Quaternary timescale with any confidence.

Holocene deposits at Westward Ho!

The finest coastal exposures of Holocene deposits in north Devon crop out on the foreshore at Westward Ho! The sediments consist of peat and organic-rich clays with tree stumps and blue-grey clays. The sequence contains mammal remains and Mesolithic artefacts (I. Rogers, 1908; E.H. Rogers, 1946). Detailed excavation of the intertidal site was carried out by Churchill (1965), and Churchill and Wymer (1965) provided a radiocarbon date of 6585 130 BP (Q–672) for a fen peat overlying a Mesolithic kitchen midden. A comprehensive reassessment of the site's palaeoenvironmental and archaeological history is provided by Balaam *et al.* (1987).

The site is one of many localities in southern Britain where former land surfaces (the 'submerged forests') can be shown to have been transgressed by the rising Holocene sea. At the time of the formation of the peat at Westward Ho!, sea level is considered to have been 4–6 m below that at present, which is consistent with the evidence from the Somerset coast at Stolford and South Wales (Kidson, 1977). The Holocene deposits rest upon a sterile blue-grey clay which in turn overlies the well-rounded pebbles and cobbles of periglacially disturbed beach deposits and head (Stephens, 1966b, 1970a).

Dry valley systems in north Devon

Dry valleys, dry cols and related features are widely recorded in north Devon. These include the Valley of Rocks near Lynmouth, the Hartland and Damehole Point channels south of Hartland Point, and some dry valleys and 'through' valleys near Bideford and Newton Tracey.

Controversy surrounds the origin of the Valley of Rocks, the associated dry col at Lee Abbey and a series of flattened spurs at Duty Point, Crock Point and Woody Bay, extending in all some 5 km westwards along the high cuffed coast from the joint mouth of the East and West Lyn rivers. The Valley of Rocks is incised over 100 m below the northern edge of the Exmoor plateau and hangs 120 m above the sea. It is a dry valley trending east-west, cut in the sandstones and slates of the Devonian Lynton Beds. It appears to occupy an anomalous position in relation to the mainly north-flowing drainage off the Exmoor plateau, except for segments of the East Lyn river.

Stephens (1966a, 1966b) suggested that if large ice masses had once occupied the Bristol Channel, there was a distinct possibility that conditions would have favoured the development of ice-marginal meltwater channels between the ice and the northern edge of Exmoor and even, locally, sub-glacial channels. However, other mechanisms involving coastal retreat and river capture have been suggested (E. Arber, 1911; Steers, 1946; Mottershead, 1964, 1967, 1977c; Pearce, 1972, 1982; Dalzell and Durrance, 1980). Pearce (1972, 1982) outlined a series of possible drainage diversions involving the East and West Lyn rivers, and the Lee stream, which he argued resulted from the retreat of the cuffed coastline.

Mottershead (1977c) invoked coastal erosion to account for the diversion of the East and West Lyn rivers to their present outlet at Lynmouth and the consequent abandonment of the Valley of Rocks. Such an hypothesis does not, however, take into account the enormous thickness of superficial (mainly head) deposits obscuring the rock floor of the Valley of Rocks and the Lee Abbey col. Similarly, the projection of river profiles from the East Lyn River to fit the Valley of Rocks and the Lee Abbey col also ignores the fact that thick superficial deposits overlie the rock floor (Simpson, 1953; Stephens, 1966b).

Dalzell and Durrance (1980) confirmed the existence of considerable thicknesses of superficial material, including thick head deposits, in the Valley of Rocks and the Lee Abbey col. Rockhead was shown to fall steeply westward to Wringcliff Bay and, in the Lee Abbey col, stands well above any westward projection of its profile under the Valley of Rocks. In a carefully argued account they envisaged that the East and West Lyn rivers and the Lee stream formerly joined at Wringcliff Bay and then flowed westwards along the coast to Duty Point and Crock Point, where the flattened spurs represented remnants of the old valley floor. This extended river system was then dismembered by coastal erosion and substantial cliff retreat during the Ipswichian.

The well-argued case that marine erosion and considerable cliff retreat is the most likely agent responsible for the capture and diversion of the East and West Lyn drainage is attractive and reasonable. Indeed, examination of the East Lyn Valley indicates that if very rapid cliff retreat took place about 4 km east of Foreland Point, near Glenthorne and County Gate, to reach an elbow of the river at Southern Wood and Malmsmead, where the Badworthy Water joins the East Lyn, then another gently sloping dry valley might be created between Southern Wood and Leeford. The dry valley would be about 2 km long. The lower gorge section of the East Lyn Valley between Leeford and Barton Wood, where it is joined by the Farley Water, would also form part of the abandoned system but would not be completely dry because of the input from several small streams. The implication of such an hypothesis is that cliff retreat of about 1.5 km would be necessary through ground rising to over 300 m OD. If a similar explanation is accepted for the evolution of the Valley of Rocks then the rate of cliff retreat must have been exceptionally fast to have been completed during the Ipswichian, or even during the entire Pleistocene Period.

The presence today of long, subaerially and periglacially modified slopes above a limited development of vertical cliffs, to form the hogback cliffs (E. Arber, 1911; Steers, 1946; Stephens, 1990) suggests that marine erosion along the north Devon coast has in fact been relatively slow. Consequently, the efficiency of wave attack to bring about river capture of the kind proposed must be questioned, unless special geological conditions were present. These might include the presence of particularly weak strata immediately offshore and systems of fault lines along the northern edge of the Exmoor plateau. While little is known about the rate of marine erosion on hard rocks in southern Britain, there seems insufficient evidence from north Devon to indicate that cliff recession is taking place at a rapid rate. Furthermore, the existence of a raised beach deposit (Ipswichian or older?) deeply buried by head deposits in Lee Bay indicates that at least some of the existing crenulations in the coastline have been in existence for some considerable time.

Consequently, the possible role of meltwater associated with an ice mass pressing against the north Devon coast during a pre-Devensian glacial event cannot be completely dismissed. Although there is no unanimity of agreement as to which glacial event (Oxygen Isotope Stage 16, Anglian or later?) may have been involved, there can be no doubt as to the former existence of ice masses in the Bristol Channel between the Isles of Scilly, Somerset and the Bristol area (Jones and Keen (1993) provide a summary of the evidence.). Erratic pebbles have been recovered from all the modern and raised beaches in north Devon and there is some evidence provided by erratic material that ice extended to about 150–175 m OD on the western plateau behind Ilfracombe and Berrynarbour. Meltwater erosion may have occurred with or without the development of ice-dammed lakes and the channels could have operated with steep gradients and very variable directions of flow, both parallel to the coast and transverse towards the Bristol Channel, perhaps contributing to the breaching of the seaward rim of Hollerday Hill at Wringcliff Bay. The matter clearly requires further investigation.

A series of dry channels has also been identified at Hartland Quay, Damehole Point and Speke's Mill Mouth in north Devon (Steers, 1946; Stephens, 1966b, 1974). The wide flat-floored valleys 'hang' above the sea near Hartland Point and Damehole Point and effectively isolate the prominent St Catherine's Tor; they continue as flattened spurs at Hartland Quay and Speke's Mill Mouth, which are similar features to those at Duty Point and Crock Point. Accumulations of coarse blocky head up to 3 m thick emphasize the flat floors and their accordance of level at about 25–30 m OD. Some parts of the channels contain small streams which plunge by waterfalls to the sea, as for example on the north side of St Catherine's Tor.

Steers (1946) regarded these features as part of a system of small valleys which were dismembered by cliff retreat, drawing on the evidence of the prominent vertical cliff profiles seen along the coast from Hartland Point southwards. The explanation could be accepted without question if it were not for two factors. The first is the considerable disparity between the size of the channels and the very small streams now flowing in some parts of them, the discharges of which appear to do little more than cut modest 'gutters' in the head which occasionally reach rockhead. The second is the recorded presence of glacial erratics on Lundy Island (up to 107 m OD) some 30 km to the northwest, and of the general acceptance that ice reached this coast during the Early or Middle Pleistocene. Thus, it is suggested that meltwater associated with an ice-front may well have played a part in the formation of these channels.

There are also low-level dry valleys near Bideford, which have been described by Edmonds (1972) as possible drainage channels resulting from the incursion of Wolstonian ice into Bamstaple Bay and as far inland as Barnstaple and Fremington. Edmonds provided a possible sequence of events involving drainage diversions resulting from the blocking of the outlets of the Taw and Torridge rivers and their tributaries by ice occupying the estuary, the deposition of the Fremington Clay (till and lake clay) and a series of terraces as multiple ice advances and retreat took place (Figure 7.4). Among the valleys that may have been used, and enlarged, by meltwater, is the dry valley extending from the Torridge at Bideford to the coast at Cornborough, 1.2 km south of Westward Ho! The valley floor rises from about 10 m OD in Bideford to about 30 m OD at its western end in the Cornborough col and was formerly used by the railway line to Westward Ho!

Another 'through' valley which he identified extends from the east side of the Torridge at Bideford eastwards to the Taw Valley. The linked valleys are flat-floored and both contain tiny streams: the highest point of a possible glacial drainage channel is 55 m OD at Newton Tracey (Edmonds, 1972). Edmonds also envisaged another such channel extending from the Torridge Valley at Landcross, via the River Yeo valley to Yeo Vale and then north-west towards Ford and the coast.

The Orleigh Court flint-bearing gravels

A deposit of flinty gravels and sands covers some 0.75 km^2 on a low plateau above the valleys of the River Yeo and River Duntz at Orleigh Court, 4 km west-south-west of Bideford. The gravels rest on Carboniferous sandstones and were recorded by Vancouver (1808), De la Beche (1839) and Rogers and Simpson (1937). The deposit is estimated to be about 8 m thick and consists of:

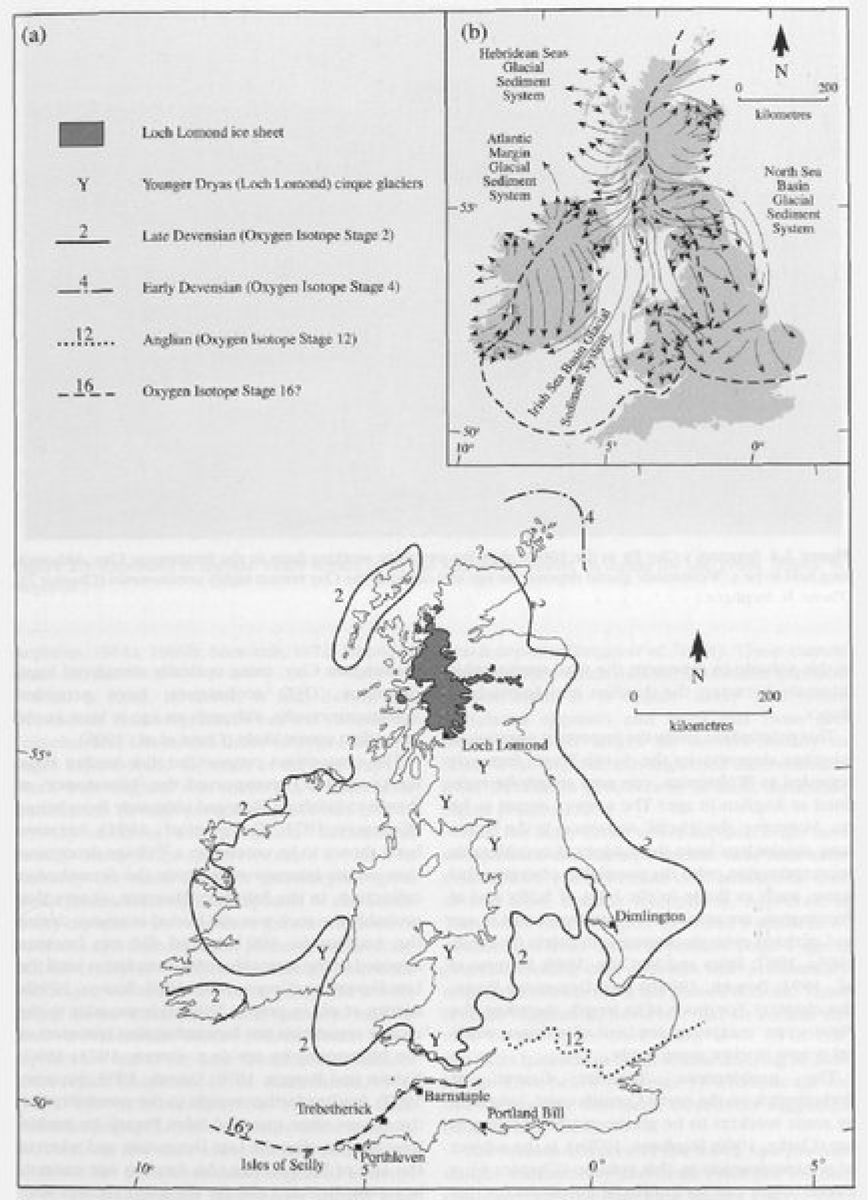
3. Upper gravels: flint-rich (flints up to 39 cm) with indurated ferruginous grit, much clay and silt

2. Lower gravels: relatively few flints, mostly small, with 'clean' sand

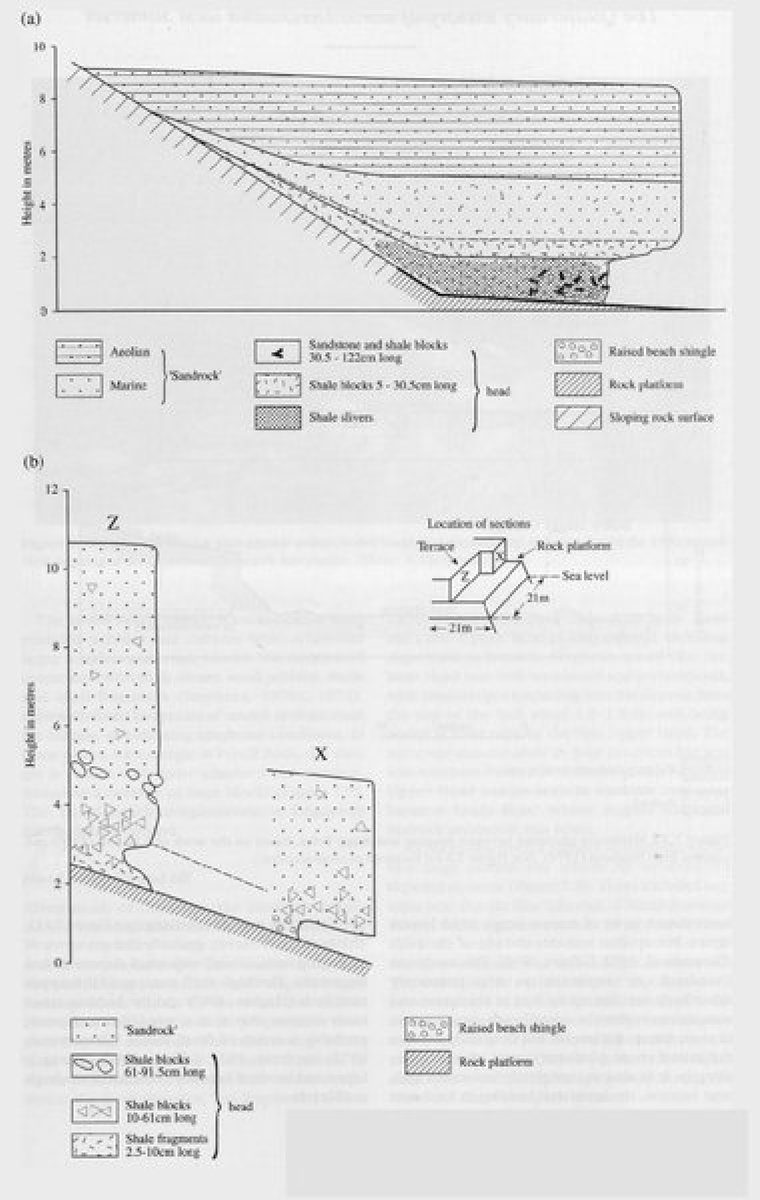
1. Yellow clay of unknown thickness

The most abundant flints are seen in ploughed fields over a rather smaller area of about 0.3 km^2 and there has clearly been downslope movement of the gravels off the plateau, which ranges in height from about 61–80 m OD. The deposits have been considered to represent a Pliocene outlier with affinities to the Lower and Upper Greensand and with fossils derived from the Upper Chalk (Chapter 3). However, the origin of the gravels is unknown. What does appear to be important is the lack of carriage of large flints to adjacent areas and the survival of about 8 m of sediments in an exposed position. There is no indication that the gravels represent a glacial deposit for no erratics or striated stones have been recovered, but it is suggested that the existence of the deposit may indicate that there has been no ice movement across this part of north Devon to reach a height of 80 m OD. This in no way precludes ice from having crossed Lundy Island (84–107 m OD), entered Barnstaple Bay to reach Fremington, and pressed against the north Devon coast.

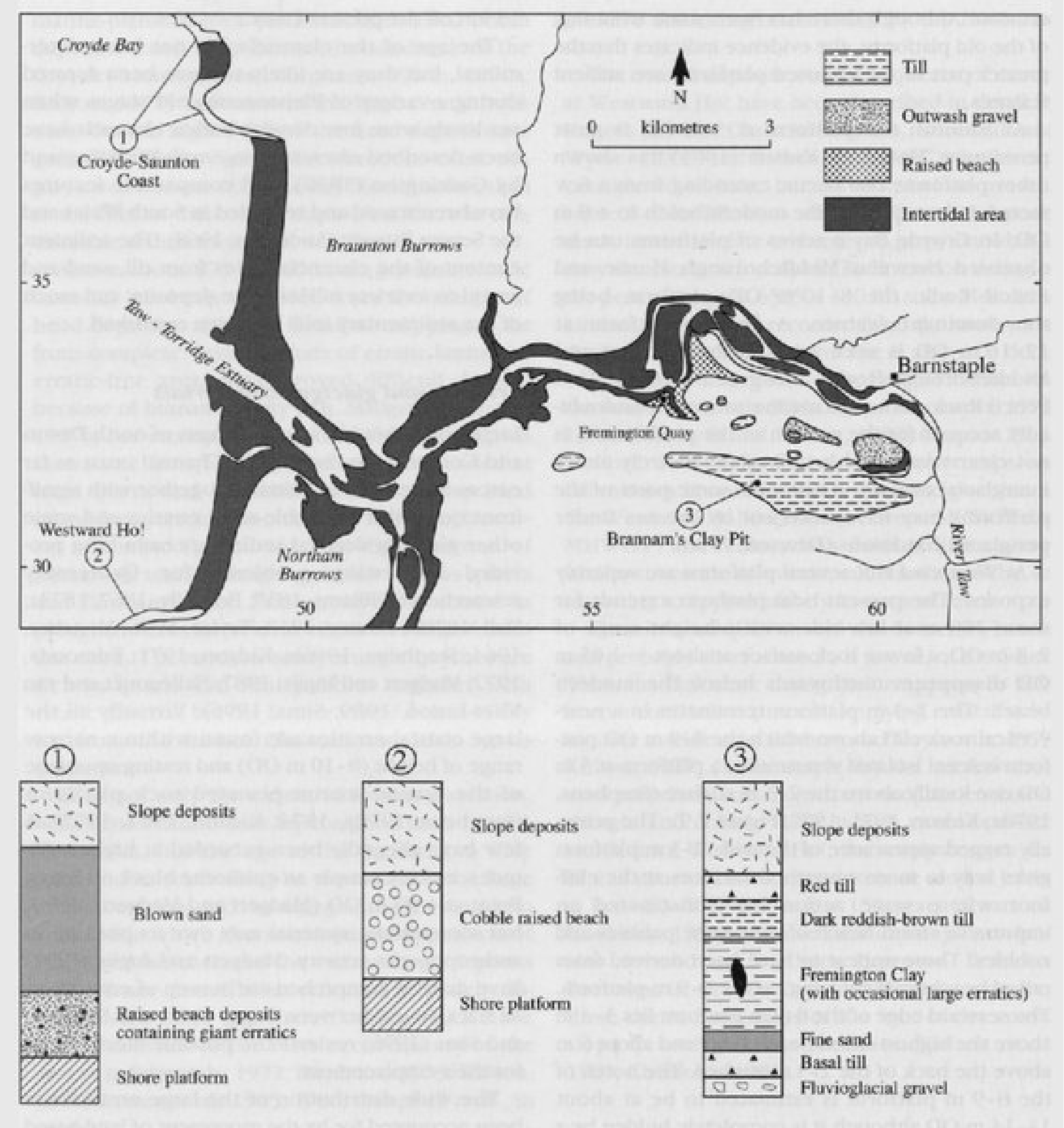
References



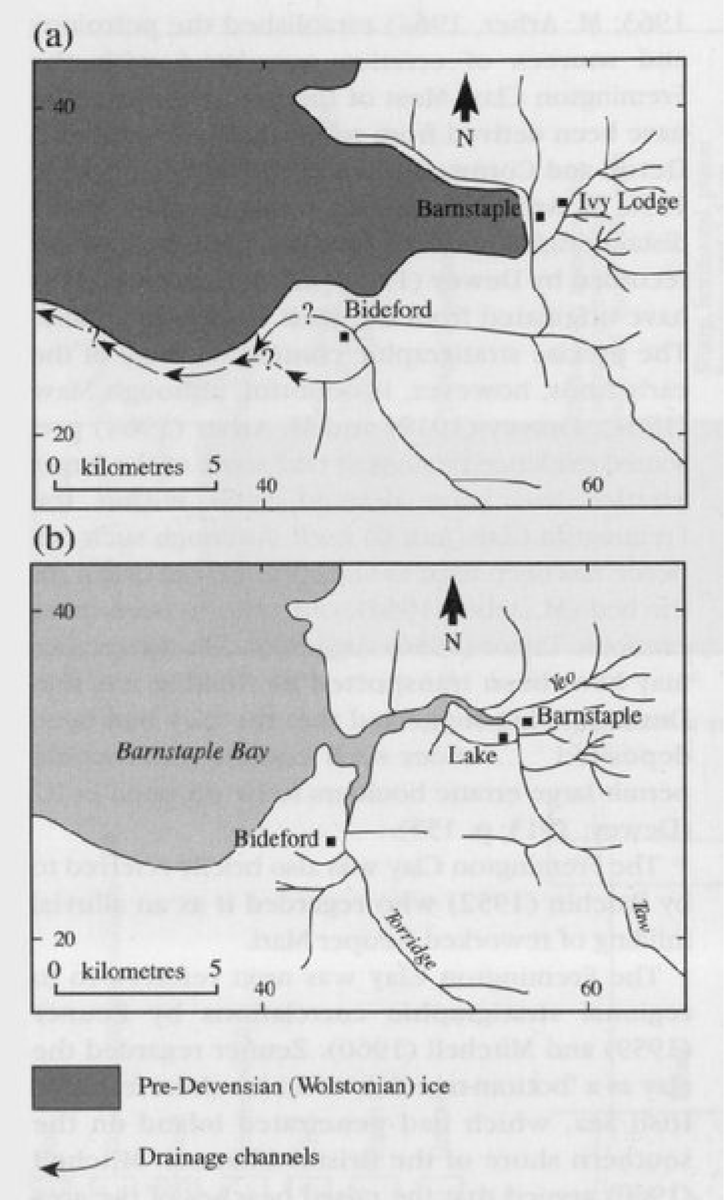
(Figure 2.3) (a) Reconstructed Pleistocene maximum ice limits after Bowen (1994a) and Gray and Coxon (1991). (b) British glacial sediment systems. After Charlesworth (1957), and Bowen (1991). (But also see (Figure 8.4).)



(Figure 7.9) The Quaternary succession at: (a) Pencil Rock; (b) East of Pencil Rock, based on the work of R.M. Eve (1970) and adapted from Stephens (1974).



(Figure 7.1) The distribution and proposed stratigraphical relationships of Quaternary deposits around the Taw–Torridge Estuary. (After Kidson and Heyworth, 1977.)



(Figure 7.4) A reconstruction of the proposed Wolstonian (Saalian) glaciation of the Barnstaple Bay area, after Edmonds (1972), illustrating: (a) The development of ice-marginal drainage at the height of glaciation; (b) Present-day drainage.