Quaternary of South-West England

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Chapter 10

The Quaternary history of the Avon Valley and Bristol district

INTRODUCTION
C. O. Hunt

The sites described in this chapter were selected to document the glaciation and subsequent landscape development of the Bristol district and Avon Valley (Figure 10.1). This region contains important and unique evidence for a very early glaciation. Especially important are the glacial deposits of the Kenn Formation and associated landforms, distributed widely throughout the area, and the ?Stage 15 interglacial deposits of the Yew Tree Formation, which overlies the Kenn Formation of the Kenn lowlands. The Avon Valley contains a potentially important terrace sequence post-dating the glacial deposits, and important cold-stage aeolian and colluvial sediments are preserved at Holly Lane, Clevedon.

The Pleistocene record of the Bristol district and Avon Valley has considerable importance, but, with a few notable exceptions, has been relatively neglected in recent years. There is a rich history of research, spanning nearly two centuries. In the early years of the nineteenth century, many of the major elements of the Pleistocene geology of the region were described and interpreted by a variety of notable geologists. Much of this work still holds good today. Thus, Smith (1815) identified the alluvial origin of the Avon Levels and the presence of buried valleys under the alluvium, Conybeare and Phillips (1822) recorded erratic material on the hilltops around Bath, and Buckland (1823) recorded mammal remains from a number of cave sites in his *Reliquiae Diluvianae*.

Later, Weston (1850) described fossiliferous terrace gravels and erratic-rich plateau deposits near Bath, and Trimmer (1853) identified glacial erratics at Court Hill. Both argued that the erratics had been introduced during the 'deluge'. Considerable early attention was focussed on vertebrate localities in the Bath and Bristol districts (Dawkins, 1865; Moore, 1870). The first detailed synthetic work on the Quaternary deposits of the region was the Geological Survey Memoir of Woodward (1876). Prestwich (1890) later re-described the high-level gravels in the Bath area.

In the early years of the twentieth century, Harmer (1907) proposed that the river network of the Bristol district had resulted from glacial diversions of drainage. Although his suggestion was contested or ignored by authors such as Varney (1921), Davies and Fry (1929), Palmer (1931) and Trueman (1938), who favoured a solely fluvial origin for the network unhindered by glacial activity, recent work has tended to support his views. The terrace stratigraphy of the Bristol Avon was revised by Davies and Fry (1929) and Palmer (1931), who both proposed a tripartite terrace sequence with low, 50 foot and 100 foot terraces.

The investigation of periglacial deposits in Avon started with the discovery of the Clevedon bone cave in the Holly Lane 'gravel' quarry (Davies, 1907; Hinton, 1907a; Reynolds, 1907). Greenly (1922) recognized the cold-climate aeolian origin of the loamy sand units at Holly Lane, a conclusion supported by Palmer and Hinton (1929), Palmer (1934) and Vink (1949). Palmer (1934) conducted studies of a number of cold-climate breccia and blown-sand sites, including Holly Lane and the important section at Brean Down (Chapter 9), and demonstrated a southerly origin for the sands on mineralogical grounds.

Modern interest in the glacial geology of the region was stimulated by Mitchell's (1960) influential review, which provoked much debate concerning the limits and timing of glaciation, the possible existence and age of proglacial lakes and the occurrence, nature and stratigraphic position of the local interglacial marine deposits (e.g. Stephens, 1970a, 1970b, 1973; Hawkins and Kellaway, 1971, 1973; Kellaway, 1971; Kidson, 1971, 1977; Kidson and Haynes, 1972; Mitchell, 1972; Kidson *et al.*, 1974; Kellaway *et al.*, 1975).

Eventually, a growing body of stratigraphical and palaeoenvironmental research was to lead to a broad consensus on two major issues. First, that much of Avon had been glaciated during the Wolstonian (Gilbertson, 1974; Kidson, 1977; Gilbertson and Hawkins, 1978a, 1978b) and second that Somerset had not been glaciated (Kidson, 1977; Hunt *et al.*, 1984; Hunt, 1987). The Burtle Beds were shown to be estuarine interglacial deposits with freshwater intercalations (Kidson *et al.*, 1978; Gilbertson, 1979; Hunt and Clark, 1983), with the balance of evidence pointing toward an Ipswichian age. Similar sediments, post-dating the glacial deposits, were described from Kenn and were also thought to be Ipswichian in age (Gilbertson, 1974; Gilbertson and Hawkins, 1978a; Hunt, 1981). Post-Ipswichian periglacial deposits were described at Holly Lane and elsewhere in Avon and north Somerset (Gilbertson, 1974; Gilbertson and Hawkins, 1974, 1983). Some deposits, for instance the gravels on Bleadon Hill (Findlay *et al.*, 1972), remained more enigmatic, however.

The application of amino-acid geochronological techniques has since led to the reassessment of the

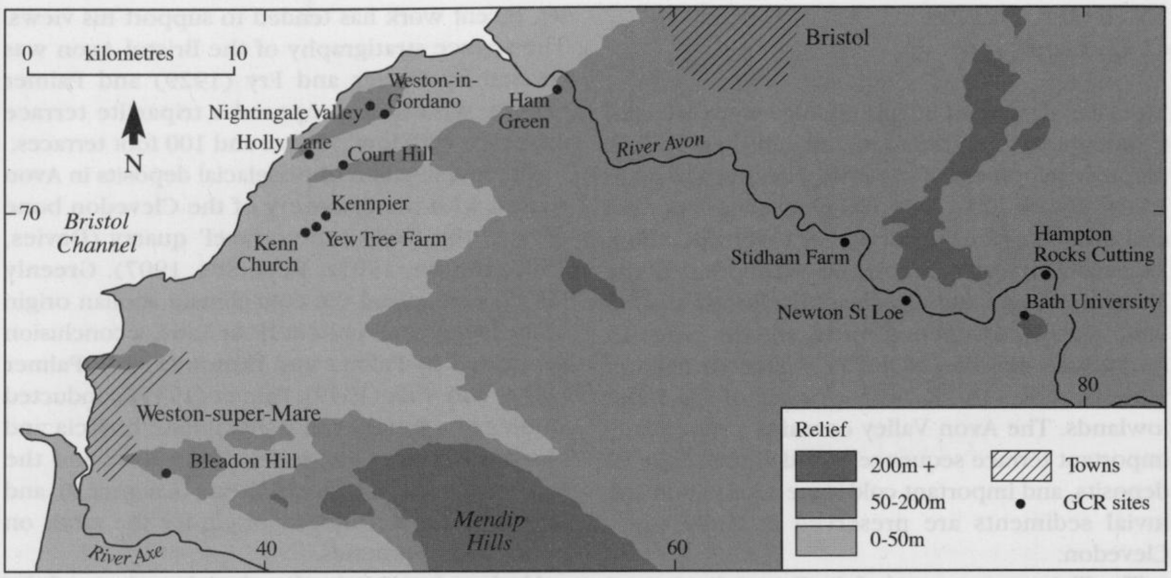

Figure 10.1 The Avon Valley and Bristol district, showing GCR sites described in this chapter.

Pleistocene sequence in the Bristol area and to the recognition that the glaciation of the region was of considerable antiquity. It has also become clear that marine interglacial deposits overlying the glacigenic sediments are of considerable complexity. Andrews *et al.* (1984) presented amino-acid ratios of *c.* 0.2 from estuarine interglacial deposits at Kenn Church and New Blind Yeo Drain, which they interpreted as Ipswichian; ratios of *c.* 0.38 for the upper estuarine deposits at Yew Tree Farm and Kennpier which overlay supposedly Wolstonian glacigenic deposits, were interpreted as equivalent in age to deposits at Purfleet in the Thames Estuary. Bowen *et al.* (1989) correlate these sites with later 'Cromer-complex' sites such as Waverley Wood and Oxygen Isotope Stage 15. The Kenn Church deposits have most recently been referred to Stage 7 (Campbell *et al.*, in prep.).

A number of important conclusions have emerged from the most recent work. First, many of the earlier ascriptions of sites to the Ipswichian Interglacial seem unfounded. Second, the great antiquity of the glaciation of Avon, pre-dating the Kennpier and Yew Tree Farm interglacial deposits and thus ?Stage 15, is also apparent. This glacial episode would appear to be substantially older than the Anglian glaciation of eastern England, which post-dates Stage 13.

Important themes in the Pleistocene of the Avon Valley and Bristol district

Several important themes emerge from the scientific framework outlined above, and were central to the process of site selection outlined in the introduction to Chapter 9. The themes are as follows.

1. Evidence for the age and limits of early glaciation

Sites in Somerset and Avon are of critical national importance since it is here that possible pre-Anglian glacial deposits and landforms are preserved in stratigraphic relationship with fossiliferous, and therefore datable, interglacial sediments. One group of sites was selected to demonstrate glacial deposits and landforms – the col-gully and glacial outwash at Court Hill, the till and glaciofluvial deposits at Nightingale Valley, and the tills and glaciofluvial gravels at Kennpier. A second group of sites provides additional evidence for glacial morphology and limits: glacial erratics contained in karstic fissures on the plateau of Bathampton Down at Bath University; recycled glacial erratics in fluvial gravels at Hampton Rocks Cutting in the Avon Valley, at Newton St Loe, Stidham Farm and Ham Green; ?glaciofluvial gravels at Bleadon Hill on Mendip; possible glacial deposits below the Burtle Beds at Greylake No. 2 Quarry in King's Sedgemoor (Chapter 9); and the erratic-free deposits at Langport Railway Cutting, 6 km farther south, which probably lay just beyond the glacial limit (Chapter 9). A further important group of sites provides dating evidence or the potential for dating Pleistocene events. At Kennpier, a channel incised into the Kennpier till contains interglacial deposits which have yielded amino-acid ratios indicative of an Oxygen Isotope ?Stage 15 age. At Weston-in-Gordano, till-like material lies stratified within interglacial marine deposits which may have formed during three separate high sea-level stands, thus providing further geochronological potential. The terrace stratigraphy of the Bristol Avon offers another potential dating tool since, in the nineteenth century, the Avon gravels were described as richly fossiliferous. Representatives of each of the main stratigraphic units were therefore selected – the plateau glacial deposits at Bath University, the 100' terrace at Ham Green, the 50' terrace at Stidham Farm, Saltford, and the low terraces at Newton St Loe and Hampton Rocks Cutting.

2. Evidence for high Pleistocene sea levels

Avon and Somerset offer an unparalleled sequence of marine interglacial and interstadial deposits and, wherever possible, GCR sites have been chosen to provide evidence for the high sea-level events. The sites are Kennpier (Stage 15), Kenn Church (Stage 7), and Weston-in-Gordano (undated but with three marine interglacial sequences interbedded with till-like material). Complementary sites are Swallow Cliff (Stage 5e or 7), Greylake No. 2 Quarry (Stages 7 and 5e) and Low Ham (Stage 5a) (Chapter 9).

3. Post-glaciation landscape development and river terrace stratigraphy

With the exception of the glacial and marine sequences, the fundamental evidence for establishing the Pleistocene stratigraphy of Somerset and Avon is provided by river terrace gravels. GCR sites were therefore selected to demonstrate the critical elements of this regional terrace stratigraphy. In the Bristol Avon Valley, Hampton Rocks Cutting, Newton St Loe, Stidham Farm and Ham Green were selected to represent the principal stratigraphic units. Complex deposits at Weston-in-Gordano show a long history of sea-level change and landscape development following the glaciation of the area. In the same area, more recent landscape development under a periglacial regime is documented at Holly Lane.

4. Temperate-stage palaeobiology

Somerset and Avon have one of the most complete and richly fossiliferous sequences of marine interglacial and interstadial deposits in Britain. Two sites are of particular significance. The ?Stage 15 interglacial deposits at Kennpier and Yew Tree Farm are unique, with their rich fossil mollusc faunas, pollen and dinoflagellate cysts. Also important are the marine mollusc sites at Kenn Church (Stage 7) and Weston-in-Gordano (?Stage 7 and/or earlier stages).

5. Cold-stage sedimentation and palaeobiology

Subsequent to the Kenn glaciation, Avon and Somerset lay beyond the Pleistocene ice sheets. Although cold-stage sedimentation was widespread, good examples of pre-Devensian sediments are very rare. Fine examples of cold-stage river terrace gravels are seen in the Avon Valley at Hampton Rocks Cutting, Newton St Loe, Stidham Farm, Saltford, and Ham Green. Also important are the 'coversands' of the Avon coastlands, which pass laterally into thick colluvial and aeolian sequences found below steep slopes, for instance at Holly Lane, Clevedon.

(A) GLACIATION OF THE BRISTOL DISTRICT

This section describes sites selected to illustrate the pattern of the ancient glaciation of coastal Somerset and Avon and the Avon Valley. Till and erratic-rich outwash gravels are preserved in the Kenn lowlands at Kennpier and Yew Tree Farm. Sites such as Court Hill and Nightingale Valley show excellent examples of glaciofluvial deposits and flow tills, and show that the ice sheet downwasted against the Carboniferous Limestone massifs of the Failland Ridge and Clevedon Down. The Bleadon Hill site contains enigmatic deposits which may be glaciofluvial in origin and, if so, documents the incursion of a substantial ice sheet into Sedgemoor. Whereas the basal diamicton at Greylake (Chapter 9) may provide evidence for the maximum extent of glacial deposits in Sedgemoor, Langport Railway Cutting, 6 km to the south, is erratic-free (Chapter 9).

This section also documents sites which provide evidence for the age of the glacial episode, or which have significant potential for providing chronological control. This evidence derives from the fossil content of deposits at these sites. The palaeochannel-fills at Kennpier and Yew Tree Farm, which overlie the glacial deposits, have provided important aminostratigraphic evidence. The evidence at Weston-in-Gordano remains undated, but the complex stratigraphic sequence here, which includes evidence for three marine transgressions, offers the possibility of further geochronometric dating. These sites also offer important temperate-stage palaeobiological evidence, and evidence of former high sea levels. This is augmented by the Stage 7 marine deposits at Kenn Church. Morphostratigraphical evidence for dating the glacial episode is contained in the terrace sequence of the Avon Valley, which is described in the second section of this chapter.

COURT HILL

C. O. Hunt

Highlights

Although much of the Quaternary fill of the 'col-gully' at Court Hill was removed during construction of the M5 motorway, the site still provides secure and spectacular evidence for the glaciation of the Avon coastlands. It is the only well-documented example of this type of glacial landform in South-West England.

Introduction

At Court Hill, a col-gully cut in Carboniferous Limestone of the Failland Ridge contains up to 24 m of glacigenic sediments. These comprise unstratified tills, stratified boulder beds, gravels, sands and glaciolacustrine deltaic deposits.

Gravels with a component of quartzite and other erratic lithologies were first recorded at Court Hill by Trimmer (1853). Prestwich (1890) suggested that these gravels might be linked with the Westleton Beds of East Anglia, and argued that they might be a continuation of the drifts on the hills around Bath. In the early 1970s, a cutting for the M5 motorway was excavated through the deposits at Court Hill. The geotechnical investigations and the cutting itself revealed 24 m of sands, gravels and diamictons lying in a channel cut through the Failland Ridge (Hawkins and Kellaway, 1971; Gilbertson, 1974; Gilbertson and Hawkins, 1978b). The deposits included a number of clasts of lithologies erratic to the Failland Ridge, including Greensand chert, and some Cretaceous foraminifera. Gilbertson and Hawkins (1978b) interpreted the feature as a 'col-gully', of glacial origin. Campbell *et al.* (in prep.) assigned the glacigenic deposits to the Kenn Formation, which elsewhere in Avon and north Somerset pre-dates an interglacial of 'Cromer-complex', probably Oxygen Isotope Stage 15, age.

Description

A full geomorphological and stratigraphical description of the site was given by Gilbertson and Hawkins (1978b), from whose account the following is largely taken.

The deposits at Court Hill (ST 473723) lie in a channel some 24 m deep, excavated in the Carboniferous Black Rock Limestone of the Failland Ridge. The base of the channel falls and the channel widens from south to north. The fill of the feature varies laterally, with predominantly boulder-, cobble- and gravel-sized material to the south, passing into predominantly sand-sized material to the north (Figure 10.2). The following sedimentary facies can be distinguished.

5. The whole site is overlain unconformably by a veneer of red silty sand usually less than 0.5 m thick.
4. Unconformably overlying the main part of the sequence are lenticular red-brown diamicton and gravel bodies up to 3 m thick. The matrix of the diamicton is a sandy silt, with constituent boulders up to 0.5 m in diameter. Most of the large clasts are Carboniferous Limestone, but other lithologies, including Pennant Sandstone, Carboniferous chert, Triassic sandstone, Mercia Mudstone, Old Red Sandstone, Greensand chert and flint, are present.
3. On the south side, the main part of the fill comprises beds between 0.5 to 2.0 m thick of imbricated, well-sorted, often openwork well-rounded gravels, cobbles and boulders, which dip northwards at *c.* 37°. The beds exhibit both normal and inverse grading. The deposits contain a similar range of rock types to facies 4. The silty sand to gritty sand matrix of the clast-supported beds is indurated with

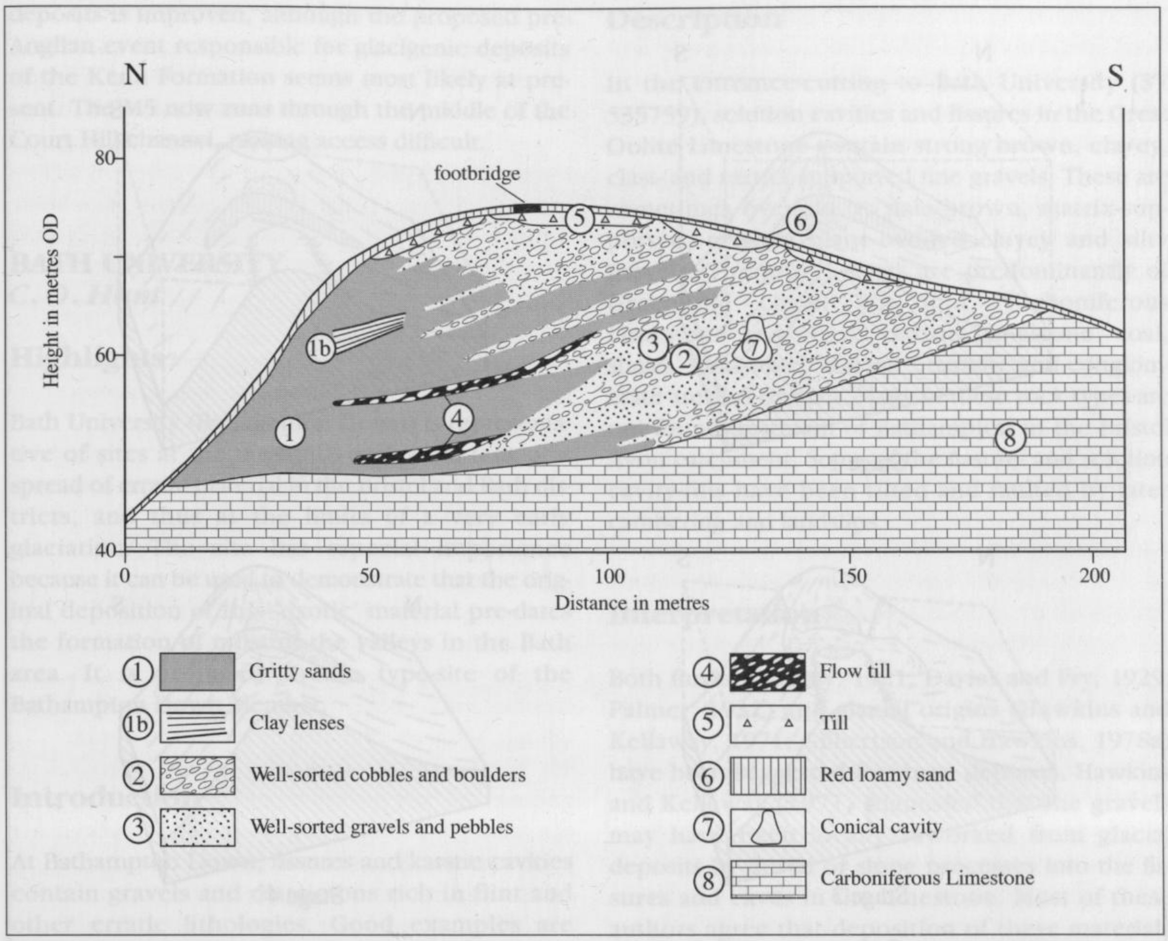

Figure 10.2 Schematic cross-section through Quaternary sediments in the 'col-gully' at Court Hill. (Adapted from Gilbertson and Hawkins, 1978b.)

calcium carbonate while openwork deposits are usually carbonate-cemented at point contact. A number of conical cavities, 2–3 m deep, 1 m wide at the top and 3–4 m wide at the base, occur within this facies.

2. The gravels and boulder beds interdigitate with uncemented, cross-bedded, coarse gritty sands with occasional very thin clay/silt partings. Gilbertson and Hawkins (1978b) suggest that this cross-bedding is of a deltaic type. Beds in the sands are 0.5–3.0 m thick and the cross-sets all dip northwards at 10–20°. A few Jurassic and Cretaceous foraminifera were found in the sands.

1. The sands are interbedded with occasional lenticular bodies of diamicton up to 0.75 m thick. The diamicton is poorly bedded and comprises cobbles and boulders in a sandy silt matrix. Most of the boulders are of Carboniferous Limestone, but other lithologies, similar to those in facies 3 and 4, are also present.

Interpretation

A number of valley-fills of Triassic dolomitic conglomerate are known in the Bristol District (Kellaway and Welch, 1948). The presence of erratic materials, notably the Greensand chert and flint and the Cretaceous foraminifera, however, precludes the fill of the Court Hill channel being dolomitic conglomerate.

Gilbertson and Hawkins (1978b) regard the Court Hill channel as a glacial 'col-gully', cut by meltwaters of a downwasting ice sheet and infilled with glaciofluvial gravels (facies 3), rare flow tills (facies 1) and deltaic sands (facies 2). Further

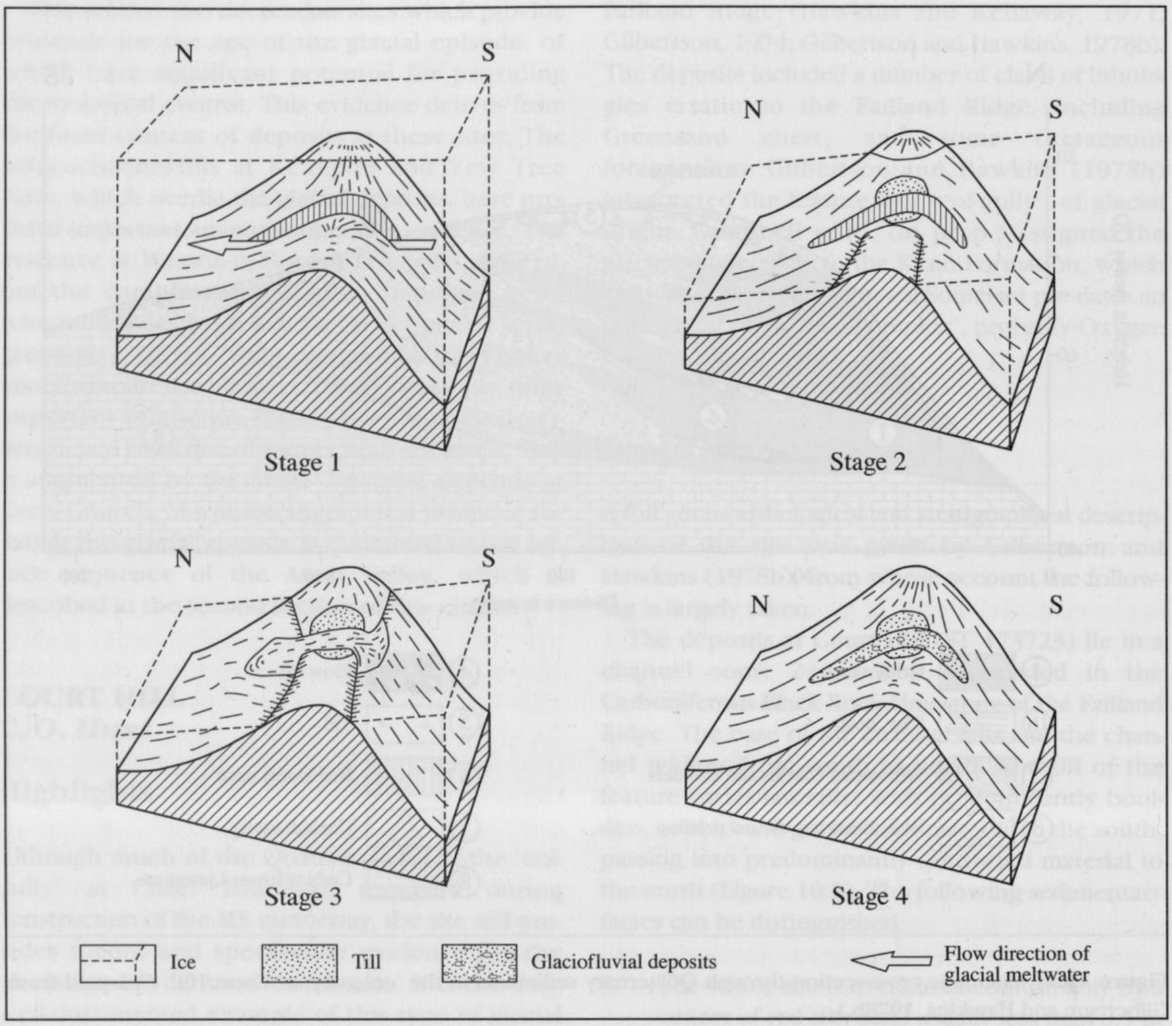

Figure 10.3 A four-stage model to explain the formation of the Court Hill 'col-gully'. (Adapted from Gilbertson and Hawkins, 1978b.)

patches of till (facies 4) overlie these deposits. The silty sand (facies 5) overlying the sequence was interpreted as an aeolian coversand. In their interpretation, the ice sheet, of proposed Wolstonian or Anglian age, is supposed to have been thicker in the Kenn lowlands, to the south of the Failland Ridge, than it was in the Vale of Gordano to the north, where an ice-marginal lake formed. The meltwaters which cut the 'col-gully' are believed to have flowed northwards into this lake (Figure 10.3).

Conclusion

Court Hill provides spectacular and unambiguous evidence for the glaciation of the Avon coastlands and, in particular, provides important evidence for the configuration of the ice masses located in the Vale of Gordano and the Kenn lowlands. The 'col-gully' contains an impressive infill of Quaternary sediments which includes till, glaciofluvial and glaciolacustrine deltaic deposits. The age of the glacial episode(s) responsible for the landforms and deposits is unproven, although the proposed pre-Anglian event responsible for glacigenic deposits of the Kenn Formation seems most likely at present. The M5 now runs through the middle of the Court Hill channel, making access difficult.

BATH UNIVERSITY
C. O. Hunt

Highlights

Bath University (Bathampton Down) is representative of sites at the far south-eastern extent of a spread of erratic material in the Bristol and Bath districts, and thus at the limits of a very early glaciation. The site has especial importance because it can be used to demonstrate that the original deposition of this 'exotic' material pre-dates the formation of most of the valleys in the Bath area. It is proposed as the type-site of the Bathampton Down Member.

Introduction

At Bathampton Down, fissures and karstic cavities contain gravels and diamictons rich in flint and other erratic lithologies. Good examples are exposed in the road cutting at the entrance to Bath University.

Buckland and Conybeare (1824) described transported chalk flints on the summits of the hills south and east of Bath. 'High-level' gravels in the Bath district were then described by Weston (1850), who attributed them to the 'deluge'. Prestwich (1890) attributed them to deposition by an eastward-flowing proto-Thames. Most of the subsequent writers (Varney, 1921; Davies and Fry, 1929; Palmer, 1931) regarded them as fluvial, deposited by a river system draining into the Solent. Later workers (Hawkins and Kellaway, 1971; Gilbertson and Hawkins, 1978a) have regarded them as of glacial origin. The gravels on Bathampton Down were described in general terms by Varney (1921), Davies and Fry (1929) and Palmer (1931), and in more detail by Hawkins and Kellaway (1971). The site is proposed as the type-locality of the Bathampton Down Member by Campbell *et al.* (in prep.), who correlated the deposits with the glacial deposits of the Kenn lowlands which are thought to pre-date Oxygen Isotope Stage 15.

Description

In the entrance-cutting to Bath University (ST 535759), solution cavities and fissures in the Great Oolite Limestone contain strong brown, clayey, clast- and matrix-supported fine gravels. These are sometimes overlain by pale brown, matrix-supported, crudely plane-bedded clayey and silty gravels. The gravel clasts are predominantly of Greensand chert, but flint, Carboniferous Limestone and chert, Oolitic Limestone, coal, shales, sandstone, 'bunter' quartzite and conglomerate are also present. Many of these rock types are not found upstream of Bathampton in the Bristol Avon catchment. Some of the fissure- and solution cavity-fills have been tilted and faulted by later cambering and landslips.

Interpretation

Both fluvial (Varney, 1921; Davies and Fry, 1929; Palmer, 1931) and glacial origins (Hawkins and Kellaway, 1971; Gilbertson and Hawkins, 1978a) have been suggested for these deposits. Hawkins and Kellaway (1971) suggested that the gravels may have been locally reworked from glacial deposits by fluvial or slope processes into the fissures and caves in the limestone. Most of these authors agree that deposition of these materials probably pre-dates the cutting of the valley system in the Bath area. The age of the glaciation which laid down these materials is not apparent from this site, but it has been argued to be the same as that which laid down the glacial deposits underlying interglacial sediments at Yew Tree Farm and Kennpier in the Avon Levels (Gilbertson and Hawkins, 1978a). Recent work (Andrews *et al.*, 1984; Bowen *et al.*, 1989) suggests that these interglacial deposits are of considerable antiquity and can be correlated with Oxygen Isotope Stage 15. Thus, the glacial deposits at Bathampton Down would appear to pre-date the Anglian and could date from before 600 ka BP.

Conclusion

The 'high-level' gravels of Bathampton Down are part of the evidence for a very early glaciation of the British Isles, although they have also been regarded as ancient fluvial deposits. This site lies towards the far south-eastern extent of a spread of 'exotic' material in the Bristol and Bath districts and

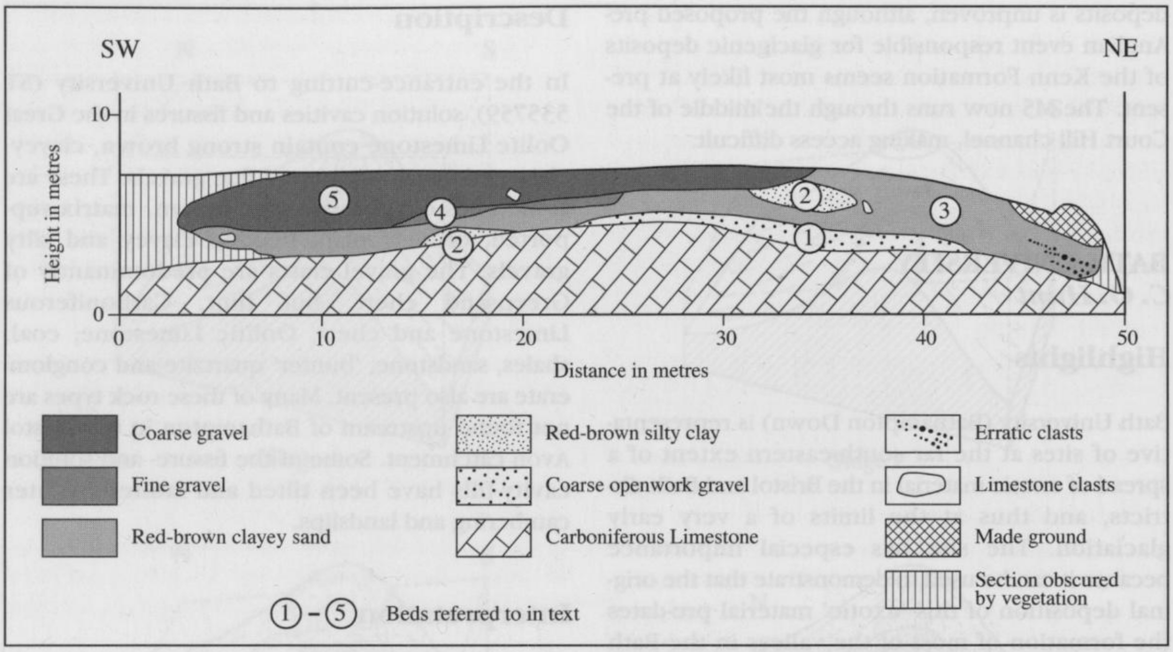

Figure 10.4 The Pleistocene sequence at Nightingale Valley, adapted from Hunt (in prep.).

is thus important for establishing the limits of a very early glaciation. Bath University GCR site is also important because it shows that most of the valleys in the Bath area were cut after this glacial event.

NIGHTINGALE VALLEY
C. O. Hunt

Highlights

Nightingale Valley contains unequivocal *in situ* glacial material and thus provides clear evidence for a glacial incursion in the Avon coastlands and the overriding of the Portishead–Clevedon ridge by ice from the Bristol Channel.

Introduction

Portishead Down is part of the Clevedon–Portishead ridge, a Carboniferous Limestone horst which separates the Vale of Gordano from the Bristol Channel. Near the summit of Portishead Down, overlooking the Vale of Gordano at above 85 m OD, up to 4 m of glacigenic deposits are exposed at the top of the old Black Rocks Quarry towards the head of Nightingale Valley. The deposits include boulders, imbricated coarse gravels, sands and silty clays. Some of these deposits have a substantial erratic content.

The earliest mention of drift deposits on the coastal ridge between Clevedon and Portishead was the observation that on Walton Down '… the rabbits have thrown up a quantity of fine flint gravel. 250–270-ft. O.D.' (Davies and Fry, 1929; p. 164). These authors suggested a fluvial origin for the gravels as part of their Avon 'High Terrace'. Hawkins and Kellaway (1971) record that the site was visited by a British Association field excursion from the Bristol Meeting in 1955, when opinion on the 'cannon-shot' gravels was divided between glacial and marine Tertiary origins. Deposits at the site were mapped by Welch (1955) and considered to be of glacial origin by Hawkins and Kellaway (1971). The site has recently been re-described by Hunt (in prep.).

Description

Eroded remnants of glacial deposits cap the limestone plateau of Portishead Down. *In situ* deposits lie above *c.* 85 m at Nightingale Valley GCR site (ST 450752) and are well exposed at the south-eastern side of the site, at the top of the abandoned Black Rocks Quarry. The deposits overlie an erosion surface cut across sharply dipping Carboniferous Limestone. In general, this surface has a smoothly undulating relief of 2–3 m, though localized steep-sided depressions occur over fault-planes in the limestone below.

The deposits are up to 4 m thick and extremely variable in lithology. They show a complex stratigraphy (Figure 10.4), and can be summarized as follows (maximum bed thicknesses in parentheses).

5. The section is capped by extremely coarse, mostly angular, clast- and matrix-supported gravel. Clasts with B-axes between 0.05 and 0.1 m are very common. The largest limestone clast had a B-axis of 0.2 m and the largest erratic, a well-rounded brown quartzite clast, had a B-axis of 0.09 m. The matrix of the gravels varies between whitish-brown angular fine gravels and whitish-brown gritty sands. The gravels are imbricated, with A-axes typically orientated towards 140°. (2.6 m)
4. Fine gravel, imbricated and clast-supported, with a reddish-brown sandy clay matrix. About 61% of this gravel is made up of angular Carboniferous Limestone clasts; most of the rest are erratics including, in descending order of abundance, flint, sandstone, vein calcite, quartzite, vein quartz, siltstone, basalt, haematite (vein-fill) and coal. (0.6 m)
3. Reddish-brown slightly clayey sand with rare rounded quartzite and flint pebbles. At the north-east extremity of the exposure, occasional lines of well-rounded pebbles, mostly of quartzite, flint and brown sandstone lie towards the base of the unit. The largest clast exposed was of limestone and had an A-axis of 0.72 m and a B-axis of 0.3 m, but limestone clasts are comparatively rare in this bed. (3 m)
2. Reddish-brown silty clay with occasional quartzite and flint pebbles. A sample from near the base of this bed yielded a sparse assemblage of palynomorphs of Carboniferous, Mesozoic and Quaternary age. (0.6 m)
1. Extremely coarse openwork gravels. The typical clast has a B-axis of around 0.05–0.1 m and the gravels consist almost exclusively of angular fragments of the local Carboniferous Limestone. (1 m)

Interpretation

The clast size, erratic content and stratigraphy of the deposits are inconsistent with a marine or fluvial origin, but are consistent with a glacial origin. The gravels and sands (beds 5, 4, 3 and 1) are most probably glaciofluvial in origin, though the reddish-brown silty clay (bed 2) may be a flow till. The presence of glaciofluvial deposits on the summit of Portishead Down and their south-eastward imbrication is not completely consistent with the suggestion (Hawkins, 1977) that glacial incursion was from the west. Neither is it fully consistent with Hawkins' (1977) suggestion that the Nightingale Valley to the south-east of the site originated as a glacial meltwater channel. Most of Nightingale Valley in fact drains south-westwards and therefore is unlikely to have been cut by meltwaters flowing south-eastwards. It is perhaps more probable that Nightingale Valley was cut by subaerial processes, probably in much the same way that the chalk combes were excavated under periglacial conditions (Kerney, 1963).

Some of the clast lithologies, such as the red sandstones, the brown sandstones and the coal, are erratic on Portishead Down but may be derived from nearby outcrops of Devonian, Triassic and Carboniferous age in the Bristol Coalfield, or possibly from the South Wales Coalfield. Other lithologies, principally the flint and the quartzites, are probably derived from farther afield, though the durability of these rocks and the roundness of the clasts is suggestive of an extremely long transportational history prior to their incorporation into the drift. A slightly disconcerting feature is the absence of Greensand chert, which is a common erratic lithology in glacial deposits elsewhere in Avon. The presence of erratic palynomorphs, including Rhaetic and Quaternary marine taxa, can be taken as evidence for the derivation of these sediments from the Bristol Channel.

Conclusion

The site is an important component in a network of sites which contains clear evidence for the glaciation of the Avon coastlands. Nightingale Valley is important because it contains evidence for the advance of ice inland from the Bristol Channel. The deposits are well preserved and rich in rocks that can only have been transported to the summit of Portishead Down by a glacier. The age of the glacial episode is unproven and the subject of considerable controversy. Nightingale Valley therefore has considerable potential for future research into the glacial history of the Avon coastlands.

BLEADON HILL
C. O. Hunt

Highlights

The enigmatic deposits on Bleadon Hill may be a Mesozoic sea beach deposit, Pleistocene shoreline materials, proglacial lake-shore sediments or glaciofluvial gravel. If either of the latter two possibilities is the case, this site provides evidence for a glacial invasion of at least part of Sedgemoor and is therefore of great significance for understanding the limits of Pleistocene glaciation in South-West England. Bleadon Hill has been proposed as the type-section of the Bleadon Member.

Introduction

Bleadon Hill lies on the southern flank of the Mendip Hills and its controversial deposits are unrelated to an obvious source, such as a valley or cave resurgence. Clasts are derived predominantly from the local Carboniferous Limestone, but the deposit contains rare Lower Jurassic foraminifera.

The site was found and described by Findlay *et al.* (1972) and re-described in the Geological Survey Memoir (Whittaker and Green, 1983). The following description is largely taken from their work. The site is proposed as the type-section of the Bleadon Member by Campbell *et al.* (in prep.), who accepted a glacial origin for the deposit.

Description

A body of sand and gravel lies at 82 m OD on the south side of Bleadon Hill at ST 350573. At its western end, the deposit lies upon a bench-like feature and against a near-vertical face cut in the Carboniferous Limestone, but most of the deposit lies upon siltstones of the Mercia Mudstone Formation.

At the south-east corner of the deposit, in an old gravel working, Findlay *et al.* (1972) recorded the following stratigraphy, with beds dipping at 35° to the north-east and all beds point-contact cemented. The base of the deposit was not seen. Not all bed maximum thicknesses were recorded by Findlay *et al.* (1972): those missing from their report were obtained during re-examination for the GCR, where possible, and are shown in parentheses.

5. Clast-supported, cobbly openwork gravel. The clasts are subrounded and up to 0.15 m in diameter. All clasts are of Carboniferous Limestone. (0.6 m)
4. Clast-supported, fine openwork gravel with occasional cobbles. The clasts are subrounded and most are between 5 and 20 mm, though the cobbles are up to 0.08 m. Most clasts are of Carboniferous Limestone, with some 'yellowish calcareous rock' and rare quartz and calcite. (1.2 m)
3. Clast-supported, cobbly openwork gravel. The clasts are subrounded and mostly 0.05–0.1 m in diameter, but with some up to 0.23 m in diameter. The transition to the underlying bed is irregular. (1.6 m)
2. Clast-supported, openwork very coarse gravel, cobbles and boulders. The clasts are up to 0.3 m in diameter. (*c.* 2 m)
1. Clast-supported fine and medium gravels. (> 2 m)

Findlay *et al.* (1972) recorded the following section at the eastern end of the site in an excavated pit:

4. Clast-supported, cobbly carbonate-cemented gravel. The clasts are subrounded and up to 0.15 m in diameter. They are all composed of Carboniferous Limestone. (0.6 m)
3. Reddish-brown, pebbly sandy silt. (1.2 m)
2. Pale brown carbonate-cemented sand.
1. Pale brown, 'laminated' and ripple-marked unconsolidated sand containing rare Liassic (probably Sinemurian) foraminifera. The bedding in the sands dips at 37° to the south. The base of the deposit was not seen.

Interpretation

Findlay *et al.* (1972) suggested a variety of origins for the deposits including a sea beach of either Mesozoic or Pleistocene age, a proglacial lacustrine beach deposit or a glaciofluvial gravel. Since it is now apparent that, in the Severn coastlands, sea levels have persistently returned only to levels close to or at most a few metres above present levels throughout the Middle and Upper Pleistocene (Andrews *et al.*, 1984), the presence of a Pleistocene shoreline deposit at 82 m OD at Bleadon Hill is considered unlikely. There is no evidence to disprove any of the other suggestions of Findlay *et al.* (1972), though the lack of demonstrably glacially transported erratic material could be taken as an indication that a glacial origin is unlikely. On the other hand, cementation of the deposit is never more than rather light point-contact; heavier cement might reasonably be expected from a deposit of Jurassic age.

Conclusion

The origin of the Bleadon Hill deposit is uncertain, but suggested possibilities include Mesozoic and Pleistocene sea beach deposits, a proglacial lake-shore deposit or a glaciofluvial gravel. This site thus potentially preserves evidence for a glacial invasion of at least part of Sedgemoor and therefore may be of great significance for the understanding of the limits of Pleistocene glaciation in South-West England. Its research potential is largely unrealized.

KENNPIER

C. O. Hunt

Highlights

Kennpier is of national importance because here the fossiliferous temperate-stage channel-fill and estuarine deposits of the Yew Tree Formation overlie the Kennpier and Nightingale members of the Kenn Formation. The latter comprises materials which have been interpreted as glacial outwash and till. Amino-acid ratios derived from fossil molluscs in the Yew Tree Formation suggest correlation with Oxygen Isotope Stage 15, and thus a pre-Anglian age for the underlying glacial deposits. Evidence for pre-Anglian glacial episodes is virtually unknown elsewhere in the British Isles. The site is the type-section of the Kenn Formation and of the Kennpier and Nightingale members.

Introduction

At Kennpier, exposures in deep drainage ditches and a borehole have shown a complex stratigraphy, with coversands of the Brean Member overlying estuarine sands of the Kenn Church Member and a richly fossiliferous channel-fill of the Yew Tree Formation. The latter can be correlated aminostratigraphically with Oxygen Isotope Stage 15. The channel-fill is incised into glacigenic diamictons and gravels of the Kenn Formation.

Pleistocene gravels have been known in the Kenn area since the work of Woodward (1876) and Greenly (1921). Gilbertson (1974) and Gilbertson and Hawkins (1978a) described the stratigraphy of Quaternary deposits at Kennpier Footbridge. These authors also carried out detailed studies on the freshwater, estuarine and terrestrial molluscs from the site, and Beck (*in* Gilbertson and Hawkins, 1978a) described six very small pollen assemblages. They regarded the palaeobiology of the site as indicative of the late stages of an interglacial, probably the Ipswichian. Hunt (1981) described the stratigraphy and palynology of a borehole through the channel-fill. The pollen was comparable with Ipswichian II–III assemblages. The organic-walled microplankton included both marine and freshwater forms, suggesting estuarine conditions. Andrews *et al*. (1984) presented amino-acid ratios on *Corbicula* shells from the Yew Tree Formation at Kennpier Footbridge. These are suggestive of an age of around 400 to 600 ka BP and may therefore indicate a pre-Anglian age for the underlying glacial deposits. This age was supported by Bowen *et al*. (1989) and accepted by Campbell *et al*. (in prep.). Andrews *et al*. (1984) also obtained an amino-acid ratio of 0.2 on *Macoma* from the Kenn Church Member at this site. Kennpier is designated the type-section of the Kenn Formation and of the Kennpier and Nightingale members (Campbell *et al*., in prep.).

Description

The stratigraphic relationships at Kennpier are shown in Figure 10.5. Gilbertson (1974) recorded the following section at ST 427698, overlying Mercia Mudstones. Maximum bed thicknesses are shown in parentheses.

6. Grey estuarine silts of Holocene age. The bed has a sharp boundary with bed 5. (1.7 m)
5. Red silty fine sands (Brean Member). These overlie and are juxtaposed with beds 2, 3 and 4 in a series of involutions. (1.0 m)
4. Pockets of pebbly shelly sands (Kenn Church Member), for instance at ST 425708, containing marine molluscs and overlying beds 1 and 2. (0.5 m)
3. Greenish-grey, shelly silty sands (Yew Tree Formation), lying in a channel 30 m wide and of variable depth incised into bed 2. (2.0 m)
2. Pale brown to red silty and sandy diamictons (Kennpier Member), with striated boulders up to 1 m in diameter and weighing over 1 tonne. (1.7 m)
1. Grey-brown, poorly bedded cobbly gravels (Nightingale Member). (4.0 m)

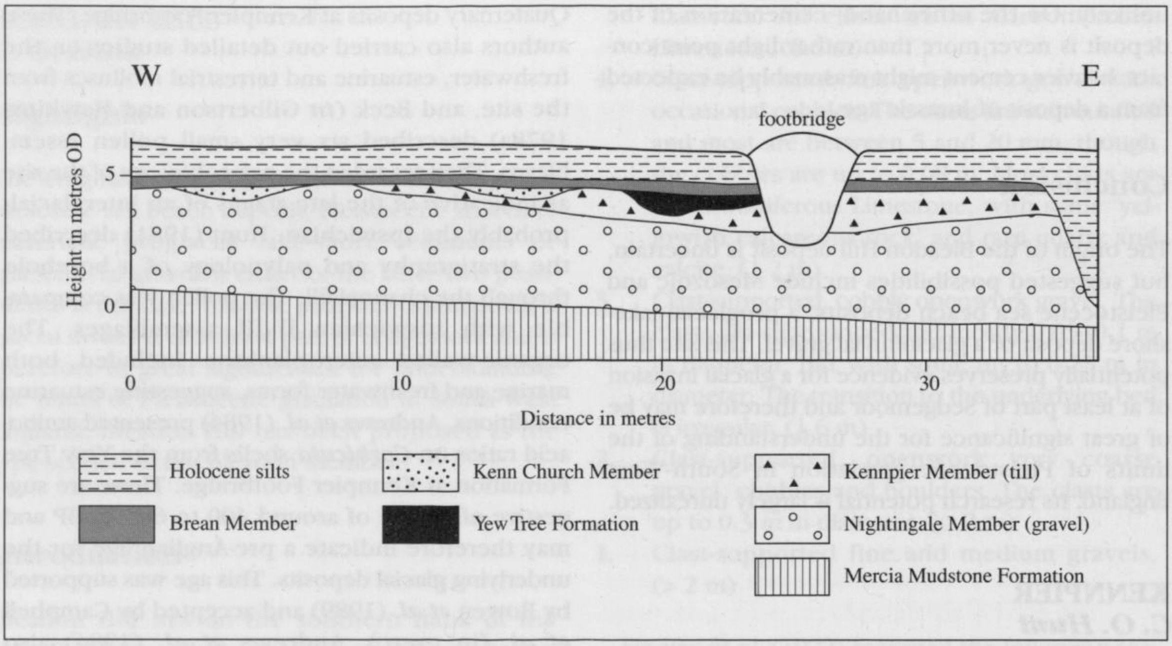

Figure 10.5 The Quaternary sequence at Kennpier. (Adapted from Andrews *et al.*, 1984.)

The Kenn gravels (bed 1) and Kennpier till (bed 2) contain numerous non-local rock types, and occasional very large striated clasts. The Yew Tree Formation channel-fill (bed 3) contains a diverse mollusc assemblage, with 30 taxa recorded (Gilbertson and Hawkins, 1978a; Table 10.1). The fauna is dominated by the opercula of *B. tentaculata*, with some *Agrolimax* spp. and *V. piscinalis*. Other taxa are comparatively rare. Estuarine molluscs are present but decrease in abundance up-section. The pollen assemblage (Hunt, 1981) contains abundant tree pollen, including *Pinus*, *Quercus*, *Alnus*, coryloid, *Carpinus*, *Betula*, *Picea* and *Tilia*, together with pollen of herbs, marsh plants and aquatics, and cryptogam spores. The algal microfossil assemblage (Hunt, 1981) is species-poor and includes the marine dinoflagellate cysts *Operculodinium centrocarpum*, *Achomosphaera andalousiense* (= *Spiniferites septentrionalis*; Figure 10.6), the prasinophyte *Cymatiosphaera* sp. and spores of the zygnemataceous alga *Spirogyra* sp. Molluscs from the Yew Tree Formation at Kennpier have yielded amino-acid ratios of 0.385 and 0.405 (Andrews *et al.*, 1984).

In the pebbly shelly sand pockets of the Kenn Church Member (bed 4), restricted molluscan faunas are dominated by *M. balthica* and *Littorina* spp. Freshwater species are occasionally present. Fossil material from this bed yielded an amino-acid ratio of 0.2 (Andrews *et al.*, 1984).

Interpretation

The stratigraphy and palaeobiology of the site have been interpreted by Gilbertson (1974), Gilbertson and Hawkins (1978a) and Hunt (1981). Andrews *et al.* (1984) reassessed the stratigraphical significance of the Yew Tree Formation and their model has been accepted by later workers.

The grey silts (bed 6) at the top of the section were laid down during the later Holocene (Gilbertson and Hawkins, 1978a; Butler, 1987). The red silty sands of the Brean Member (bed 5) were interpreted by Gilbertson and Hawkins (1978a) as coversands of aeolian origin. The pockets of pebbly shelly sand of the Kenn Church Member (bed 4) are most likely of estuarine origin. This bed can be correlated aminostratigraphically with Oxygen Isotope Stage 7 (Andrews *et al.*, 1984; Campbell *et al.*, in prep.).

In the Yew Tree Formation (bed 3), several of the mollusc taxa, especially *B. marginata* and *C. fluminalis*, require interglacial conditions. Declining counts of thermophilous taxa in the higher levels of the deposit led Gilbertson and Hawkins (1978a) to suggest that the sediments

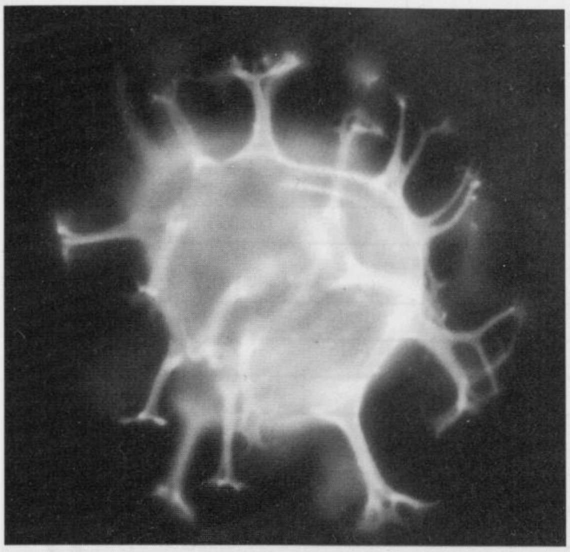

Figure 10.6 The commonest marine dinoflagellate cyst in the Kennpier interglacial deposit (bed 3) – *Achomosphaera andalousiense* Jan du Chene – seen at a magnification of *c.* × 1000 by UV fluorescence microscopy. (Photo: S.A.V. Hall.)

were laid down during an episode of deteriorating climate. The Yew Tree Formation at Kennpier was regarded as of fluvial origin, because most of the Mollusca are freshwater taxa, with the most abundant environmental group being taxa typical of moving water such as *B. tentaculata* and *V. piscinalis*. They suggested that the estuarine taxa in the channel-fill were recycled from nearby estuarine gravels. This interpretation was challenged by Hunt (1981) who described palynological evidence – high counts for Chenopodiaceae – and the presence of marine microfossils as evidence for marine influence: a depositional environment in the backwaters of an estuary was suggested. High counts for Poaceae and herbaceous taxa point to a relatively 'open' coastland environment, but the presence of a variety of broad-leaved tree species is evidence for interglacial conditions (Figure 10.7). Similarly 'open' environments have been noted from other coastal interglacial sites, for instance at Morston (Gale *et al.*, 1988). Marine taxa and broad-leaved tree species decrease in importance up-section, suggesting lessening marine influence and an opening of the landscape through time. The palynological evidence is thus consistent with the molluscan evidence for deteriorating climate and suggests that the Yew Tree Formation at Kennpier was laid down as climate started to deteriorate towards the end of an interglacial. The amino-acid ratios may indicate correlation with Oxygen Isotope Stage 15 (Bowen *et al.*, 1989), though Bowen (pers. comm., 1995), while accepting this correlation, suggested that ratios on *Corbicula* should be treated with some caution.

The Nightingale Member (bed 1) was regarded as glacial outwash and the Kennpier Member (bed 2) as till by Gilbertson and Hawkins (1978a). They correlated these deposits with the high-level drifts in the Bath area, on the Failland Ridge and at Court Hill and argued that together these provided evidence for a glacial incursion into the Avon coastlands. This interpretation was accepted by Campbell *et al.* (in prep.).

Conclusion

Kennpier is a key site for studies of the Pleistocene stratigraphy and palaeobiology of the British Isles. The sequence here contains a temperate-stage channel-fill, estuarine deposits also indicative of temperate conditions, gravels which have been interpreted as glacial outwash and diamictons that have been interpreted as glacial till. In the temperate-stage deposits of the Yew Tree Formation, molluscs, pollen, dinoflagellate cysts and foraminifera suggest interglacial conditions. Two amino-acid ratios have been determined from molluscs in this bed, which ostensibly suggest correlation with the Purfleet interglacial deposits in the Thames Estuary and Oxygen Isotope Stage 15. (This date would seem to be at conflict with Purfleet's position in the post-Anglian course of the Thames, which the river only assumed in Stage 11 (Bridgland, 1994).) The fossil remains from the Yew Tree Formation at Kennpier Footbridge offer considerable potential for future investigation, since the palaeobiology of the temperate stage which they reflect is as yet very poorly known. Further research potential is offered by the 'temperate' estuarine deposits of the Kenn Church Member. The interglacial deposits at Kennpier Footbridge rest on diamictons of the Kenn Formation suggested by Gilbertson and Hawkins (1978a) to be of glacial origin. These represent an ancient glacial episode which is very poorly known elsewhere in the British Isles.

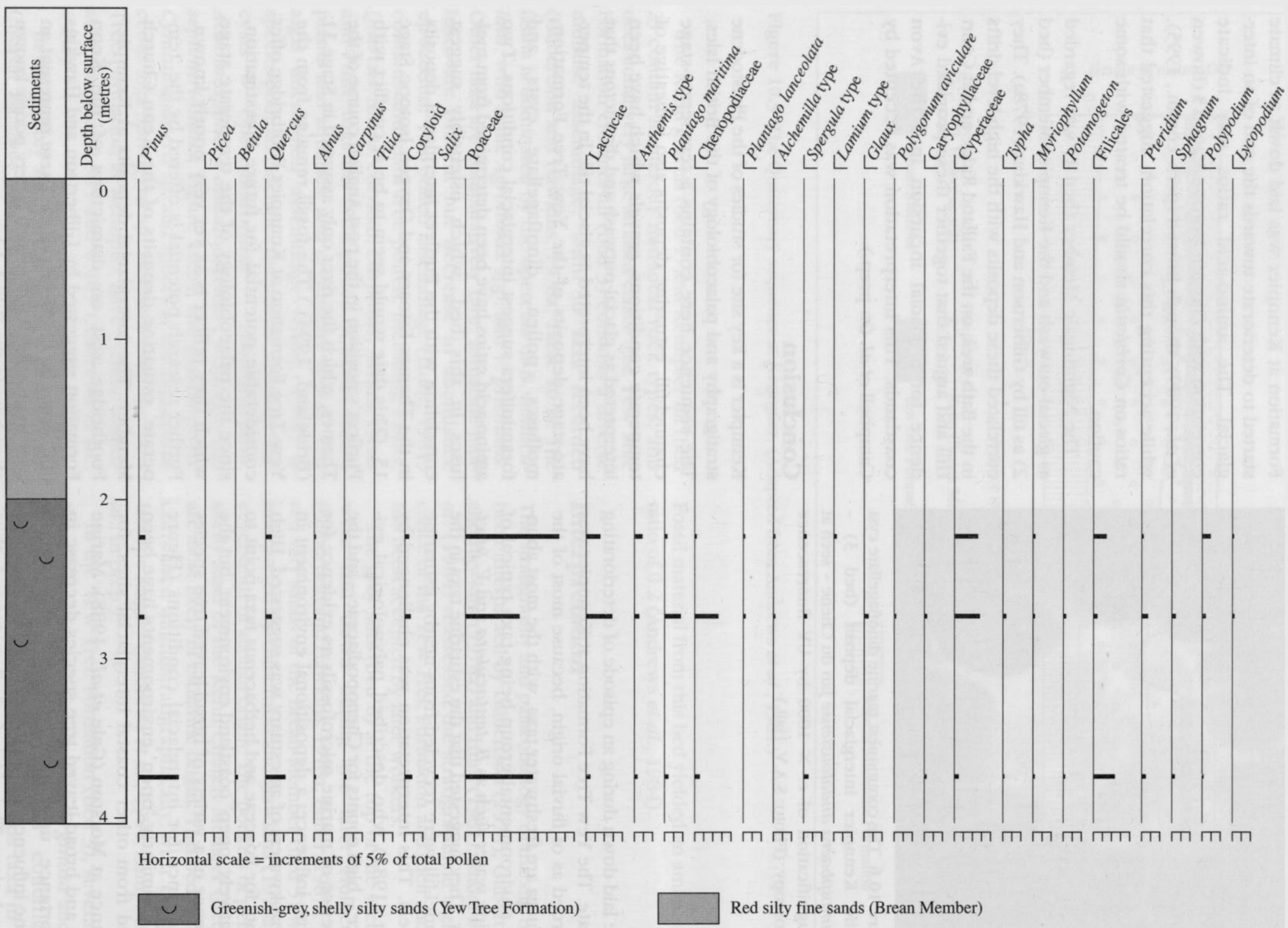

Figure 10.7 Pollen diagram for Kennpier. (Adapted from Hunt, 1981.)

Table 10.1 Fossil molluscs from three profiles through the interglacial channel-fill at Kennpier Footbridge (after Gilbertson and Hawkins, 1978a)

Species	***Profiles***		
	KPA	***KPB***	***KPD***
Marine			
Littorina littorea (Linné)	3	–	1
Littorina saxatilis (Olivi)	1	–	–
Littorina littoralis (Linné)	5	1	–
Littorina spp.	13	1	2
Retusa sp.	–	–	1
Nucella lapillus (Linné)	3	–	–
Ostrea sp.	1	–	2
Cerastoderma spp.	2	–	frags
Macoma balthica (Linné)	36	1	16
Land and freshwater			
Valvata piscinalis (Müller)	127	72	423
Belgrandia marginata (Michaud)	14	–	13
Bithynia tentaculata (Linné) shells	3	–	4
Bithynia tentaculata (Linné) opercula	1092	3579	5619
Lymnaea peregra (Müller)	12	–	65
Anisus leucostoma Müller	–	–	1
Gyraulus laevis Alder	4	–	1
Armiger crista (Linné)	1	–	1
Planorbis spp.	–	–	1
Ancylus fluviatilis Müller	2	–	–
Trichia hispida (Linné)	–	–	15
Zonitoides nitidus (Müller)	–	–	1
Agrolimax cf. *agrestis* (Linné)	70	70	128
Agrolimax cf. *reticulatus* (Müller)	30	43	35
Agrolimax cf. *laevis* (Müller)	6	–	22
Agrolimax spp.	65	56	162
Corbicula fluminalis (Müller)	–	20	24
Pisidium amnicum (Müller)	4	6	7
Pisidium obtusale (Lamarck)	–	–	1
Pisidium subtruncatum Malm	5	–	1
Pisidium henslowanum (Sheppard)	1	–	–
Pisidium nitidum Jenyns	5	–	1
Pisidium moitessierianum Paladilhe	–	–	1
Pisidium spp.	13	4	13
Total	1560	3854	6564

YEW TREE FARM

C. O. Hunt

Highlights

Yew Tree Farm, Avon, is of considerable significance for its diverse non-marine mollusc faunas dating from Oxygen Isotope Stage 15. The interglacial deposits here overlie glacial outwash deposited during a pre-Anglian glaciation, giving the site considerable stratigraphic significance. It is proposed as the type-site of the Yew Tree Formation.

Introduction

At Yew Tree Farm, estuarine silts of Holocene age overlie fine red silty sands. These in turn overlie gravels and then richly fossiliferous interglacial deposits which lie on coarse cobbly gravels.

Pleistocene gravels have been known in the Kenn area since the work of Woodward (1876) and Greenly (1921). Gilbertson and Hawkins (1978a) described the stratigraphy of the Quaternary deposits at Yew Tree Farm. They also carried out detailed studies on the freshwater and terrestrial molluscs from the site, and described three very small pollen assemblages. They regarded the palaeobiology of the site as indicative of the late stages of an interglacial, probably the Ipswichian. Hunt (1981) described a pollen and organic-walled microplankton assemblage from the site. The pollen was comparable with Ipswichian II–III assemblages. The organic-walled microplankton included both marine and freshwater forms, suggesting estuarine conditions. Andrews *et al.* (1984) and Bowen *et al.* (1989) presented amino-acid ratios derived from *Corbicula* shells from Yew Tree Farm. These are suggestive of an age of 400 to 600 ka BP. The site is proposed as the type-locality of the Yew Tree Formation by Campbell *et al.* (in prep.).

Description

At Yew Tree Farm (ST 42256927), Gilbertson and Hawkins (1978a) recorded the following sequence (maximum bed thicknesses in parentheses).

5. Grey estuarine silts of Holocene age. (0.6 m)
4. Fine red silty sands – Brean Member. (0.5 m)
3. Silty, sandy and cobbly gravels. (1.06 m)
2. Pale-grey, laminated and cross-bedded shelly sandy silt – Yew Tree Formation. (0.3 m)
1. Coarse cobbly gravels containing erratics – Nightingale Member.

A chalk clast from the Kenn gravels (bed 1) yielded foraminifera identified by Dr A. Bahafzallah as *Valvulinaria californica* Cushman, *Gyroidina umbilicata* d'Orbigny and *Atoxoophriagmium subsphaerica* (Marie) (Gilbertson, pers. comm., 1995). These taxa are only present onshore in the British Isles in the highest units of the Chalk of Northern Ireland.

The Yew Tree Formation (bed 2) contains a diverse mollusc assemblage, with over 40 taxa recorded (Gilbertson and Hawkins, 1978a; Table 10.2). The fauna is dominated by *V. piscinalis* and *B. tentaculata* with some *L. peregra*, *G. laevis*, *B. marginata*, *A. crista* and *Pisidium* spp. Other taxa are comparatively rare. Estuarine foraminifera are present in the deposit (Gilbertson and Hawkins, 1978a). The pollen assemblage (Hunt, 1981) contains abundant tree pollen, including *Quercus*, *Alnus*, coryloid, *Pinus*, *Betula*, and *Tilia*, together with pollen of herbs, marsh plants and aquatics, and cryptogam spores. The algal microfossil assemblage (Hunt, 1981) is species-poor and dominated by the marine dinoflagellate cyst *Achomosphaera andalousiense* Jan du Chene (= *Spiniferites septentrionalis*) with smaller numbers of *Operculodinium centrocarpum* (Deflandre and Cookson). Molluscs from the interglacial deposit have yielded amino-acid ratios of 0.378 (Andrews *et al.*, 1984; Bowen *et al.*, 1989).

Interpretation

The stratigraphy and palaeobiology of the site have been interpreted by Gilbertson and Hawkins (1978a) and Hunt (1981). Andrews *et al.* (1984), Bowen *et al.* (1989) and Campbell *et al.* (in prep.) have reassessed the stratigraphical significance of the site.

The grey silts (bed 5) at the top of the section were laid down in estuarine conditions in the later Holocene (cf. Butler, 1987). The red silty sands (bed 4) underlying the estuarine silts were interpreted by Gilbertson and Hawkins (1978a) as coversands of aeolian origin. The underlying gravels (bed 3) were regarded by them as cold-climate fluvial deposits. They demonstrate the occurrence of cold-stage fluvial activity at the site after the Yew Tree interglacial.

In the Yew Tree Formation (bed 2), several of the mollusc taxa, including *B. marginata*, *C. fluminalis*, *Anisus vorticulus* (Troschel), *Hippentis complanata* (Linné) and *A. lacustris*, require interglacial conditions, with July temperatures perhaps 2°C warmer than today. The interglacial deposit was regarded as of fluvial origin by Gilbertson and Hawkins (1978a), since most of the Mollusca are freshwater taxa, with the most abundant environmental group being taxa typical of moving water such as *B. tentaculata* and *V. piscinalis*. They recorded possible traces of salinity stress in the molluscan assemblages, but no characteristically estuarine or marine species.

From the same bed, Hunt (1981) described palynological evidence for an interglacial climate, with abundant pollen of broad-leaved trees (29%, including 19% *Quercus*), and some marine influence, indicated by the abundant pollen of Chenopodiaceae and *Plantago maritima* and the presence of marine dinoflagellate cysts. The interglacial deposit may have been laid down in a coastal lagoon or in the backwaters of an estuary. The amino-acid ratio is suggestive of Oxygen Isotope Stage 15 and an age of 400 to 600 ka BP

(Andrews *et al.*, 1984; Bowen *et al.*, 1989), although Bowen (pers. comm., 1995) urges caution in interpreting ratios derived from *Corbicula*.

The presence of erratics such as the chalk clast, a non-durable lithology most probably derived from Northern Ireland, is strongly suggestive of a Celtic Sea glacial origin for the Kenn gravels (bed 1). These were regarded as glacial outwash deposits of a sandur plain by Gilbertson and Hawkins (1978a) and this interpretation was accepted by Campbell *et al.* (in prep.).

Conclusion

Yew Tree Farm is an important site for the Pleistocene palaeobiology and stratigraphy of the British Isles. The deposits here preserve a temperate-stage river channel-fill and a complex of cold-stage sediments. In the temperate-stage deposits, molluscs, pollen, dinoflagellate cysts and foraminifera suggest interglacial conditions and a depositional environment at the margins of marine influence. A number of amino-acid ratios have been determined from molluscs in these deposits. These suggest correlation with Oxygen Isotope Stage 15. The fossil remains from the channel-fill at Yew Tree Farm are diverse and abundant and offer great potential for future investigation, since the palaeobiology of the temperate stage which they reflect is as yet very poorly known. The interglacial deposits at Yew Tree Farm and its correlative site at Kennpier, rest on gravels suggested by Gilbertson and Hawkins (1978a) to be of glaciofluvial origin. If, as seems very probable, these gravels are glacigenic, then they must represent an extremely ancient glacial episode, which is very poorly known elsewhere in the British Isles.

KENN CHURCH
C. O. Hunt

Highlights

Kenn Church is an excellent representative of the later transgressive marine deposits in the Kenn area. It contains fossiliferous sands overlying glaciofluvial gravels, and shows a transition from brackish to fully marine conditions with the transgression reaching 14–21 m OD. It is proposed as the type-site of the Kenn Church Member.

Table 10.2 Fossil molluscs from the interglacial deposit at Yew Tree Farm (after Gilbertson and Hawkins, 1978a)

Species	*Number*
Valvata cristata Müller	12
Valvata piscinalis (Müller)	3324
Belgrandia marginata (Michaud)	970
Bithynia tentaculata (Linné) shells	1039
Bithynia tentaculata (Linné) opercula	1755
Carychium minimum Müller	2
Lymnaea truncatula (Müller)	192
Lymnaea palustris (Müller)	1
Lymnaea peregra (Müller)	886
Planorbis planorbis (Linné)	25
Anisus vorticulus Troschel	147
Anisus leucostoma Müller	141
Gyraulus laevis Alder	1613
Armiger crista (Linné)	615
Planorbis spp.	3
Hippentis complanata (Linné)	21
Acroloxus lacustris (Linné)	8
Oxyloma cf. *pfeifferi* Rossmässler	6
Cochlicopa lubrica (Müller)	2
Pupilla muscorum (Linné)	2
Vallonia costata (Müller)	4
Vallonia pulchella (Müller)	6
Vallonia spp.	1
Cepaea nemoralis (Linné)	1
Trichia hispida (Linné)	3
Punctum pygmaeum Draparnaud	1
Zonitoides nitidus (Müller)	4
Agrolimax cf. *agrestis* (Linné)	6
Agrolimax spp.	42
Sphaerium corneum (Linné)	1
Corbicula fluminalis (Müller)	72
Pisidium amnicum (Müller)	44
Pisidium casertanum (Poli)	7
Pisidium obtusale (Lamarck)	10
Pisidium milium Held	56
Pisidium subtruncatum Malm	138
Pisidium henslowanum (Sheppard)	24
Pisidium nitidum Jenyns	270
Pisidium pulchellum Jenyns	2
Pisidium moitessierianum Paladilhe	3
Pisidium spp.	190
Total	11 649

Introduction

At Kenn Church, interglacial estuarine deposits occupy a channel incised into the glacigenic Kenn gravels. The sequence is overlain by aeolian coversands.

Pleistocene gravels have been known in the Kenn area since the work of Ussher (*in* Woodward, 1876), who described gravels at Kenn and Kennpier and sandy soil over gravels at Yatton. They also noted that ' ... small pebbles and large subangular and angular pieces of Carboniferous Limestone, and a few of sandstone, occur in greyish-brown soil ... ' near Kenn (Woodward, 1876; p. 154). Greenly (1921) described poorly sorted sediments from Yatton and wrote ' ... the formation recalls true boulder clays, but the extreme rarity of striated stones, the feebleness of the striations, and the almost total absence of erratics, forbid us to regard it as such.' (Greenly, 1921; p. 147).

Five feet of sand and gravel with pockets of coarse quartz sand containing *M. balthica* were reported from a degraded pit at St John's Church, Kenn (Welch, 1955). Welch described further gravels with *Macoma* elsewhere in the neighbourhood of Kenn. The gravel lithologies included flint, Greensand chert, quartz and Jurassic rocks. These deposits were equated with the Burtle Beds of King's Sedgemoor, a conclusion endorsed by ApSimon and Donovan (1956) and Kidson (1970). These latter authors also correlated the Kenn gravels with the marine deposits at Weston-in-Gordano and favoured an Ipswichian age for the marine incursion. Tills with striated boulders and coarse gravels overlain by marine and freshwater sands and gravels were briefly described by Hawkins and Kellaway (1971).

Gilbertson (1974) and Gilbertson and Hawkins (1978a) described the stratigraphy of the deposits at Kenn Church in a detailed survey of Pleistocene deposits in the Kenn area. These authors described coversands overlying interglacial deposits which in turn rested on coarse, unfossiliferous cold-stage gravels. Molluscan studies showed an initial brackish-water environment, with marine influence becoming stronger upwards. Amino-acid ratios were determined from a variety of fossil molluscs from the interglacial deposit at Kenn Church by Andrews *et al.* (1984). Most ratios were around 0.2, and were interpreted by these authors as indicating an Ipswichian age. The site was recently proposed as the type-locality of the Kenn Church Member by Campbell *et al.* (in prep.), who suggested assignment of the unit to Oxygen Isotope Stage 7.

Description

The following description is taken from Gilbertson (1974) and Gilbertson and Hawkins (1978a) and the fossil mollusc fauna is listed in Table 10.3. The Pleistocene deposits at Kenn form a low 'island' amidst the Holocene alluvium of the Avon Levels, rising to around 8.2 m OD (Gilbertson, 1974). They overlie Triassic mudrocks of the Mercia Mudstone Formation and are in places over 6 m thick. At Kenn Church (ST 41596890), a channel containing interglacial estuarine deposits is incised into the Kenn gravels. The channel appears to follow a slight rise to the south of the village to ST 412686 where shelly gravel with abundant *M. balthica* was found in 1969 (Gilbertson, 1974). The sequence can be summarized as follows (maximum bed thicknesses in parentheses).

9. Tarmac – made ground. (0.15 m)
8. Pale grey-brown cobbly sand – made ground. (0.38 m)
7. Pale red sand with cobbles – Brean Member. (0.21 m)
6. Dark grey sand – Kenn Church Member. (0.01 m)
5. Reddish-brown shelly sands with occasional well-rounded pebbles – Kenn Church Member. This bed contains a 'raft' of pebbly reddish clayey silt. (0.62 m)
4. Yellow shelly sand – Kenn Church Member. (0.69 m)
3. Yellow fine shelly sand, coarsening upwards – Kenn Church Member. (0.45 m)
2. Pale brown shelly sand – Kenn Church Member. (0.08 m)
1. Coarse, poorly sorted cobbly gravels, base unseen – Nightingale Member. (> 0.15 m)

Amino-acid racemization assays were carried out on a variety of shells from Kenn Church by Andrews *et al.* (1984). Assays on *Macoma* gave ratios of 0.197 ± 0.02? and 0.2 ± 0.02?, on *Corbicula* 0.21 ± 0.03, on *Patella* 0.104 ± 0.005 and on *Littorina* 0.215 ± 0.02.

Interpretation

The stratigraphy and palaeobiology of the site were first interpreted by Gilbertson (1974) and Gilbertson and Hawkins (1978a). Andrews *et al.* (1984) have reassessed the stratigraphical significance of the site in view of their aminostratigraphic results and this is reviewed here, in the light of further research.

The basal Kenn gravels (bed 1) were regarded as sandur deposits by Gilbertson (1974) and

Table 10.3 Molluscs from the interglacial deposit at Kenn Church (after Gilbertson, 1974; Gilbertson and Hawkins, 1978a)

Sample	***A***	***B***	***C***	***D***	***E***	***G***	***J***	***O***
Sample depth (m)	2.7	2.2	1.7	1.5	1.2	0.8	unstratified	
Marine/estuarine taxa								
Patella vulgata Linné						2		
Gibbula sp.							1	
Littorina littorea (Linné)	1						2	
Littorina saxatilis (Olivi)	2						1	
Littorina littoralis (Linné)	1				1	1		
Littorina sp.	2f	f	2f	1f		f	f	f
Nucella lapillus (Linné)							1	2
Ocenebra erinacea (Linné)						1	1	
Buccinum undatum (Linné)							1	3
Nassarius reticulatus (Linné)							1	
Cerastoderma spp.	3f	8f	1f	f		f	f	1f
Macoma balthica (Linné)	7f	16f	23f	2f		6f	90f	50f
Brackish-water taxa								
Hydrobia ventrosa Montagu	163	125	16	2		1		
Hydrobia ulvae (Pennant)	103	75	19	4		2	1	
Freshwater taxa								
Valvata piscinalis (Müller)	6	2						
Belgrandia marginata (Michaud)	1							
Bithynia tentaculata (Linné)	3							
Lymnaea peregra (Müller)	20	14	5					
Planorbis planorbis (Linné)	1	2						
Anisus vorticulus Troschel	2							
Gyraulus laevis (Alder)	11	15	1					
Corbicula fluminalis (Müller)						2		
Pisidium subtruncatum Malm	1							
Pisidium nitidum Jenyns	1							
Pisidium moitessierianum Paladilhe	1							
Pisidium spp.	2	2						
Terrestrial taxa								
Vallonia pulchella (Müller)	1							
Vallonia enniensis (Gredler)		1						
Trichia striolata Pfeiffer	1							
Helicella virgata (Da Costa)						1		
Discus rotundatus (Müller)						1		

Gilbertson and Hawkins (1978a). The sands of the interglacial Kenn Church Member (beds 2–6) contain fossil mollusc assemblages which enable detailed palaeoenvironmental reconstruction (Gilbertson, 1974; Gilbertson and Hawkins, 1978a). A fully interglacial but rather continental environment, with July temperatures perhaps 2°C warmer than present, is suggested by the presence of the thermophilous *C. fluminalis*, *O. erinacea*, *B. marginata*, *Vallonia enniensis* (Gredler) and *A. vorticulus* (Gilbertson, 1974). The basal sands of the Kenn Church Member contain abundant brackish-water taxa, some marine and some freshwater species, probably reflecting a brackish-water environment with input from a clear freshwater stream. The freshwater taxa decrease rapidly upwards through the deposits, and *H. ulvae* becomes increasingly important at the expense of the less salt-tolerant *H. ventrosa* before both decline rapidly as marine taxa become dominant. Gilbertson (1974) computed a maximum mean sea level of 14–21 m OD for the height of the transgression.

The red cobbly sands of the Brean Member (bed 7), overlying the interglacial deposit, are most likely the result of cold-climate sedimentation, probably having formed as niveo-aeolian coversands with an admixture of cobbles introduced by cryoturbation and solifluction (Gilbertson, 1974; Gilbertson and Hawkins, 1978a).

The aminostratigraphic data, with most ratios of *c.* 0.2, suggest comparison with Oxygen Isotope Stage 7 or older. The initial correlation of these sites with the Ipswichian interglacial is unlikely, as Ipswichian sites are characterized by ratios of about 0.1. (Bowen *et al.*, 1989; Campbell *et al.*, in prep.). Comparison with the Group 4 ratios of Mottershead *et al.* (1987) suggests an age of around 200 ka BP for deposits characterized by amino-acid ratios of *c.* 0.2. The presence of *Corbicula* also points to a pre-Stage 5 age, since Keen (1990) and Bridgland (1994) have argued that this species is not present in Britain after Stage 7.

Conclusion

Kenn Church GCR site is important as a representative of the later interglacial marine transgressive deposits in the Kenn area. Detailed studies of its molluscan fauna have showed the progression of a marine transgression to 14–21 m OD in a warm continental climate, probably around 200 ka BP. The Kenn Church interglacial deposits occupy a channel incised into glaciofluvial gravels and are overlain by niveo-aeolian coversands.

WESTON-IN-GORDANO
C. O. Hunt

Highlights

Weston-in-Gordano is important because it contains a complex of fossiliferous marine and non-marine interglacial deposits which post-date, and thus offer a minimum age for, the glaciation of the valley. The site is of considerable importance for reconstructing ancient sea levels because it contains evidence for as many as three interglacial marine transgressions. The site is the type-locality of the Weston Member.

Introduction

Weston-in-Gordano contains slope deposits overlying a complex of marine and freshwater interglacial deposits, interbedded with stony clays of possible glacial origin and lying against the steep face of the limestone massif of Portishead Down. The site lies almost immediately downslope of the glacigenic sediments of Nightingale Valley (this chapter).

The site was found by ApSimon and Donovan (1956), who recorded marine gravels and sands with *M. balthica*, overlain by stony clays, further marine gravels with *Macoma*, then subtidal sands, all overlain by cryoturbated sandy breccias of subaerial origin (Figure 10.8). The highest marine deposit was at 13.6 m OD. The gravels contained fragments of Old Red Sandstone, Carboniferous Limestone, Triassic breccias, flint and Greensand chert.

Spoil from the 1982 excavations for drains at a new police headquarters, yielded fine gravel and grey silts with the interglacial freshwater mollusc *C. fluminalis* (Hunt, in prep.). In 1992, two auger holes were drilled to relocate the freshwater interglacial deposits and establish their relationship with the published stratigraphy (Hunt, in prep.). Colluvial breccias and silts were found to overlie laminated silts, sands and gravel of probable intertidal origin. These in turn overlay laminated sands with freshwater molluscs, most probably the lateral equivalents of the silts with *Corbicula*, and then gravels with occasional marine shells similar to those described by ApSimon and Donovan (1956). The site was proposed as the type-locality of the Weston Member by Campbell *et al.* (in prep.), who assigned its marine and freshwater interglacial deposits to Oxygen Isotope Stage 7 and earlier.

Description

At Woodside, near Weston-in-Gordano (ST 456754), complex Quaternary deposits underlie a gentle slope beneath the steep Carboniferous Limestone of Portishead Down and above the Holocene alluvium and peats of Clapton Moor. The stratigraphy of the site is most complete on the north-west side of the B3124 and is taken here from the work of ApSimon and Donovan (1956) and Hunt (in prep.). Junctions between beds are sharp unless otherwise stated and maximum bed thicknesses are given in parentheses (Figure 10.8).

12. Reddish-brown sandy clayey silt with occasional Carboniferous Limestone fragments. This bed has a transitional junction with bed 11. (0.6 m)
11. Reddish-brown breccia of angular

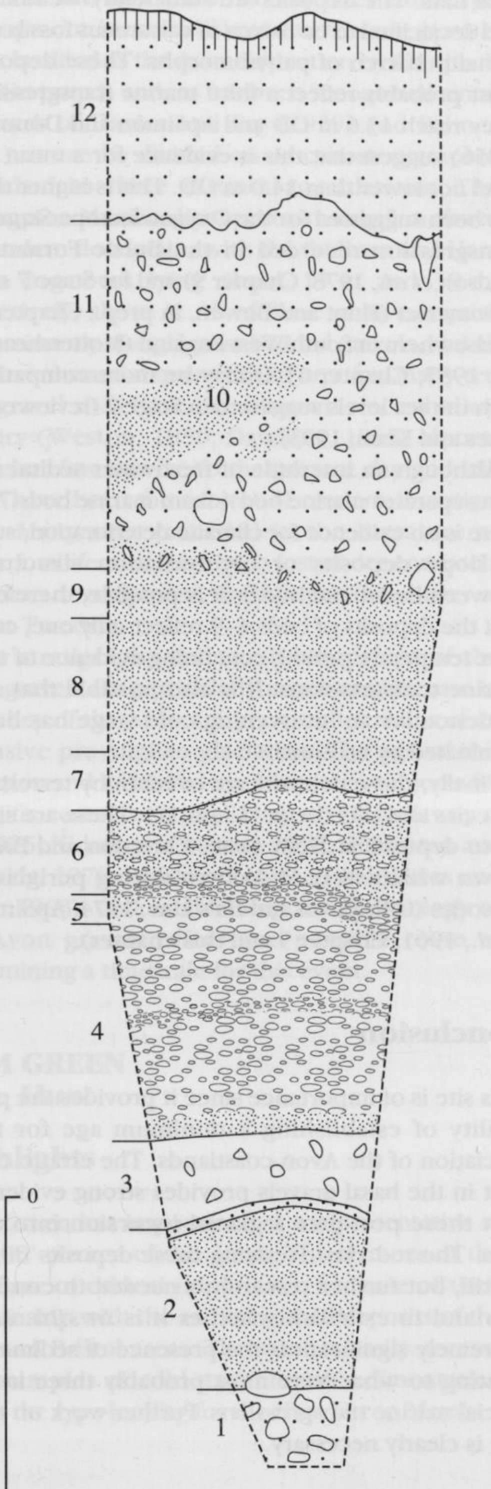

Figure 10.8 The Quaternary sequence at Weston-in-Gordano. (Adapted from ApSimon and Donovan, 1956.)

Carboniferous Limestone, dark red sandstone and green-grey and pink marl fragments in a matrix of sandy clayey silt. (0.25 m)

10. Dark red, slightly silty coarse sand. (0.05 m)
9. Dark reddish-brown, mottled black, laminated clayey silts and occasional sands, passing gradually into bed 8. (0.15 m)
8. Yellow-brown clayey silts with occasional manganese nodules at the top, passing gradually into bed 7. (0.95 m)
7. Yellow-brown laminated coarse silt and very fine sand. (0.4 m)
6. Yellow-brown fine gravel, rich in flint. (0.05 m)
5. Reddish-grey fine silty sand with *L. peregra*, *Trichia* cf. *hispida* and freshwater mollusc fragments. (0.10 m)
4. Strong brown coarse gravel with a matrix of very coarse sand. The gravel is point-contact cemented with calcite. Clasts include flint and Greensand chert, Jurassic micrite, oolitic limestone, ironstone, oysters and belemnites, Carboniferous Limestone, coal, Coal Measures and Old Red sandstones. The bed contains occasional shells of *M. balthica* and *Littorina* sp. (0.95 m)
3. Red clay with a few pebbles. (0.2 m)
2. Grey, mottled red and black coarse sand, patchily cemented at the top. (0.5 m)
1. Sands and gravels with angular fragments of Carboniferous Limestone. Clasts include flint, Old Red Sandstone and Triassic rocks. Occasional shells of *M. balthica* are present. (0.2 m)

Palynological analysis of a coal clast from bed 4 yielded a small, very weathered assemblage including species of *Lycospora*, *Florinites*, *Triquitrites*, *Crassispora*, *Densosporites* and *Dictyotriletes*. These indicate a Westphalian age. A very small mud lens in this bed yielded single specimens of the marine dinoflagellate cysts *A. andalousiense* and *Bitectatodinium tepikense*, a foram cast and grains of Cyperaceae and Poaceae. Analyses of samples from beds 5 and 7 were largely unsuccessful, only two grains of Poaceae and one Filicales spore being found in bed 7.

Interpretation

The basal gravels (bed 1) contain a variety of erratics and thus are likely to post-date a glaciation of the Avon coastlands. The presence of *M. balthica* indicates that this is a marine deposit. ApSimon and Donovan (1956) suggest that this is an 'upper' beach deposit and note that it reaches 11.2 m OD, consistent with a mean sea level of 4.5–6.0 m OD. The overlying sands (bed 2) probably also have a marine origin, having been laid down below High Water of Mean Ordinary Tides (ApSimon and Donovan, 1956). It reaches 11.77 m OD and may indicate a sea level of over 8 m OD.

The red clay (bed 3) was suggested by ApSimon and Donovan (1956) to be derived by weathering from local Triassic rocks, but the presence of flint in this bed is inconsistent with such an origin. It may be a very weathered slope deposit containing erratics from the underlying marine gravel, or it could be till, or partially derived from till, since it is apparently similar to the tills on Portishead Down, though whether it lies *in situ* is not established. Because erratics are present in the underlying (probably marine) deposits, two hypotheses are tenable. First, there may have been two glaciations in the Vale of Gordano, separated by an interglacial marine incursion. Second, and perhaps more likely, there was one glaciation, pre-dating the lower marine deposits, and this bed was soliflucted to its present position after sea level fell following deposition of the basal gravel and sand.

The roundness of the gravels overlying the red clay (bed 4) and the presence of *M. balthica* and *Littorina* sp. and perhaps *B. undatum* (ApSimon and Donovan, 1956) and marine dinoflagellate cysts is consistent with a shallow-marine origin, possibly as upper beach deposits. This gravel reached 12.6 m OD (ApSimon and Donovan, 1956), consistent with a mean sea level of 6.0–7.5 m OD. The presence of a substantial component of Mesozoic rocks in this gravel most probably implies an input of erratic material, possibly from the erratic-rich drifts on nearby Portishead Down (Nightingale Valley; this chapter).

Overlying what is probably the eroded surface of bed 4 are sands and silts with freshwater shells (bed 5). This unit is the probable source of the *Corbicula* shells seen in the temporary excavation. *C. fluminalis* is regarded as a species of clean running water, while *L. peregra* is a generalist species. *T. hispida* is typically found in damp herbaceous vegetation. *Corbicula* has not been found in sites of demonstrable last interglacial age (Bridgland, 1994), and it is therefore likely that this horizon dates from Oxygen Isotope Stage 7 or earlier (Campbell *et al.*, in prep.).

Overlying these sediments are sandy silts (beds 7–9) which were most probably laid down on intertidal flats. The deposits are sufficiently weathered and decalcified to be barren of calcareous fossils and virtually barren of palynomorphs. These deposits most probably reflect a third marine transgression. They reach 13.6 m OD and ApSimon and Donovan (1956) suggest that this is evidence for a mean sea level not lower than 14.0 m OD. This is higher than has been suggested for the Oxygen Isotope Stage 5e transgression recorded in the Burtle Formation (Kidson *et al.*, 1978; Chapter 9) and for Stage 7 sites in Somerset (Hunt and Bowen, in prep.; Chapter 9) or elsewhere in South-West England (Mottershead *et al.*, 1987; Chapter 6). It may be more compatible with the sea levels suggested in Stage 9 (reviewed in Jones and Keen, 1993).

Although an interlude of freshwater sedimentation separates marine bed 4 from marine beds 7–9, there is no evidence for climatic deterioration, such as slope deposits or cryoturbation structures between bed 4 and bed 9. It is possible, therefore, that the deposits of beds 4–9 reflect only one, complex temperate period, containing evidence of two marine transgressions. It is also possible that any evidence for an intervening cold stage has been eliminated by erosion.

Finally, these deposits are overlain by terrestrial breccias and silts (beds 11 and 12). These are similar to deposits at Holly Lane, Clevedon and Brean Down which were laid down during periglacial episodes (Gilbertson and Hawkins, 1974; ApSimon *et al.*, 1961; Chapter 9 and this chapter).

Conclusion

This site is of importance since it provides the possibility of establishing a minimum age for the glaciation of the Avon coastlands. The erratic content in the basal gravels provides strong evidence that these post-date a glacial incursion into the area. The red clay overlying these deposits might be till, but further research is needed to confirm this and to establish whether it is *in situ*. Also extremely significant is the presence of sediments relating to what were most probably three interglacial marine transgressions. Further work on this site is clearly necessary.

(B) RIVER TERRACES AND LANDSCAPE DEVELOPMENT

This section describes a series of sites chosen to conserve representative examples of the terrace gravels of the River Avon and of later landscape development in Avon. The Avon terrace gravels were classified as the Avon Formation by Campbell *et al.* (in prep.), and, as has been recognized since the work of Davies and Fry (1929) and Palmer (1931), it can be divided on morphostratigraphic grounds into three distinct aggradations. The Bathampton Member lies approximately 3 m above the modern floodplain, with the Stidham and Ham Green members lying about 15 m and 30 m, respectively, above it. All of these units comprise predominantly trough cross-bedded gravels, and all contain substantial quantities of erratics. Many terrace gravel sites have been known since the last century (Weston, 1850; Dawkins, 1865; Moore, 1870) but few survive to the present day and still fewer have been the subject of modern investigations. Many sites recorded in the literature as 'richly fossiliferous' have been lost under encroaching urban development, for instance the cluster of sites at Twerton.

The stratigraphy and age relationships of the Avon gravels are particularly important because in the valley of the Avon are preserved remains of an extensive pre-Anglian glaciation. The age of this glaciation and its limits have long been subjects for scientific controversy (Kellaway, 1971; Kellaway *et al.*, 1975; Kidson and Bowen, 1976; Gilbertson and Hawkins, 1978a; Andrews *et al.*, 1984; Jones and Keen, 1993), and establishing the chronology of the Avon gravels offers one possible route to determining a timescale for this event.

HAM GREEN
C. O. Hunt

Highlights

Ham Green has importance as a representative of the 100' terrace of the Avon. The terraces of the Avon are of critical importance because of their relationship with the ancient glacial deposits of the Bath and Bristol areas. The site has easily accessible examples of cold-stage fluvial sedimentation and is the type-locality for the Ham Green Member.

Introduction

At Ham Green, a clear terrace surface at 30–31 m OD at the mouth of the Avon Gorge is underlain by fine, massively bedded and imbricated sandy gravels containing a significant proportion of erratics. This site was selected for the GCR as representative of the 'high terrace' of the Bristol Avon.

The site was first described by Davies and Fry (1929) as part of their 100' terrace. They described a 'considerable tract' of gravel, mostly of lithologies derived from the Jurassic, but with the surface gravels rich in Greensand chert and quartzite pebbles. They recorded 'several feet' of gravel in temporary roadside excavations at Bristol Road, Ham Green, and in the nearby railway cutting. Hawkins and Tratman (1977) suggested that the terraces of the Avon west of Bristol may be degraded estuarine terraces or relic glacigenic deposits. The site was re-investigated in 1984 during the compilation of the Geological Conservation Review. Massively bedded gravels were found which provide evidence for cold-stage sedimentation by a precursor of the Bristol Avon. Like other localities in the 'high' terrace of the Avon, a substantial erratic content was noted. The site was proposed as the type-locality of the Ham Green Member by Campbell *et al.* (in prep.). They tentatively attributed the deposits to some part of Oxygen Isotope Stages 10–12, on geomorphological grounds.

Description

At Ham Green, a broad terrace surface lies about 30–31 m above the Avon, to the south and east of the Hospital. Up to 1.2 m of gravels are exposed in the railway cutting near ST 539768, at 31 m OD. The sequence can be summarized as follows (maximum bed thicknesses in parentheses).

4. Dark brown stony loam soil. (0.2 m)
3. Strong brown, massively bedded, stony silty clay, with some large clasts orientated with their A-axes vertical. Clast lithologies include flint, Carboniferous and Greensand chert and quartzites. (0.6 m)
2. Strong brown, massively bedded, clast-supported, imbricated silty gravel. The gravel clasts mostly have B-axes in the size range 10–15 mm. They are predominantly of brown (?Carboniferous) sandstones (24%), Jurassic limestones (oolitic and micritic) and flint (39%), with rarer Carboniferous and Greensand chert (9%), quartzite (5.5%), Carboniferous Limestone (10%), and other lithologies including Triassic mudstone, siltstones, sandstones and vein materials. The quartzite clasts are rounded, the flint and

chert clasts predominantly angular and the other clast lithologies are subrounded to rounded. The clast imbrication direction suggests deposition by a current flowing from the south-east (146°). (0.3 m)

1. Strong brown, imbricated very coarse gravels. The clasts have B-axes up to 80 mm. The gravel rests on a gently undulating erosion surface cut in Triassic mudstones and marly limestones. (0.1 m)

During the compilation of the GCR, a temporary exposure was seen in a sewer trench outside the main entrance to Ham Green Hospital at ST 53307563. The trench exposed 0.4 m of made ground overlying 1.2 m of strong, brown to red-brown, massively bedded, matrix-supported, cobbly sandy gravel. The cobble-sized clasts were mostly of flint and white and grey quartzite, but smaller gravel clasts included Greensand chert, red and yellow sandstone and ironstone.

Interpretation

The Ham Green site lies on a prominent 'flat' in the landscape at the mouth of the Clifton Gorge of the River Avon. Underlying this 'flat' is a sequence of deposits which can be interpreted as follows.

Gilbertson and Hawkins (1978a) have described silty deposits similar to bed 2 from a number of sites in Avon. They regard these deposits as cover-sands of predominantly aeolian origin. The stones may have been incorporated into the bed from below by cryoturbation. The high clay content and the presence of only siliceous clasts in the bed are consistent with prolonged exposure to pedogenic processes.

In bed 3, the size, roundness, sorting and imbrication of the gravels are consistent with a fluvial origin. Palaeocurrent data indicate deposition by an ancient precursor of the modern Avon. The coarseness of the sediment and the lack of Quaternary fossils is perhaps suggestive of aggradation under 'cold-stage' conditions, as suggested for terrace gravels elsewhere in southern England (Briggs and Gilbertson, 1980). Bed 1 is most probably a basal lag deposit.

The geomorphology and sedimentology of the site are thus consistent with the deposits being an early fluvial gravel of the Avon, rather than of glacial or estuarine origin, as suggested by Hawkins and Tratman (1977). The altitude of the deposit points to its considerable antiquity, while the presence of rock types such as flint and Greensand chert, which have no outcrop in the catchment of the Avon, suggests that the site post-dates glaciation of the area.

In particular, the high altitude of the Ham Green Member points to its considerable antiquity. On altitudinal grounds, it must pre-date the Bathampton Member and Stidham Member in the Avon Valley. The Bathampton Member dates from Oxygen Isotope Stage 6 or earlier (this chapter) and the Stidham Member is thus likely to date from Stage 8 or earlier. Considering the significant down-cutting separating the Stidham and Ham Green members, the latter is thus likely to date from Stage 10 or 12, or quite possibly from an earlier stage. Its maximum age is constrained by the age of the Kenn Formation glacial deposits, which pre-date Oxygen Isotope Stage 15 (this chapter).

Conclusion

An extensive area of the high (100') terrace of the Avon occurs at Ham Green, downstream from the Clifton Gorge. The site is one of a set which conserves the critical geomorphological and stratigraphical elements of the terraces of the Bath Avon. This terrace sequence is important because of its relationship with the ancient glacial deposits of the Bath and Bristol areas. The site provides easily accessible examples of cold-stage fluvial sedimentation.

NEWTON ST LOE

C. O. Hunt

Highlights

Newton St Loe provides the last surviving example of fossiliferous gravels among the low terraces of the Avon. It is a key site for establishing the stratigraphy and history of the Avon terraces and has wider stratigraphic significance in helping to establish a relative timescale for the ancient glaciation of the Avon coastlands and Bath area.

Introduction

The Avon Valley was famous in the nineteenth century for its fossiliferous Pleistocene gravels. Newton St Loe is the last surviving fossiliferous gravel site; all others downstream from Bath have been built over and lost. At Newton St Loe, thin trough cross-bedded gravels of the Bathampton Member have been exposed in road and railway cuttings.

Owen (1846), Dawkins (1866) and Moore (1870) recorded bones of mammoth and horse from thin gravels here. The site was also mentioned by Woodward (1876) and Winwood (1889), but no modern work was done until the site was revisited during the compilation of the GCR.

Description

A terrace surface approximately 10 m above the Avon can be seen at Newton St Loe. Thin decalcified gravels are exposed in shallow roadside exposures at ST 715664, near the northern edge of the deposit. North of the A4, at ST 71306555, the following section was recorded from a temporary exposure made by road workers (maximum bed thicknesses in parentheses).

3. Dark brown, pebbly loam soil. (0.2 m)
2. Strong brown, matrix-supported, silty clayey fine gravel, with many vertical stones. The clasts are all of insoluble lithologies, including Greensand chert, flint, Carboniferous chert, quartzite and brown sandstone. (0.6 m)
1. Strong brown, clast- and matrix-supported clayey gravel. The gravel is decalcified but shows some traces of trough cross-bedding. Only insoluble lithologies such as flint, Greensand and Carboniferous chert, quartzite, ironstone and brown and yellow sandstone are present. The matrix was probably once sandy, but is now very clay-rich. The bedding appears to be disrupted locally by involutions. The gravels rest on a gently undulating surface cut in Mercia Mudstones. (0.3 m)

Interpretation

The trough cross-bedding seen in bed 1 is consistent with the gravels having been laid down by a braided river, a fluvial style usually associated in the British Isles with cold-stage sedimentation (Briggs and Gilbertson, 1980). The gravels were subsequently weathered and decalcified, probably during episodes of temperate climate, and cryoturbated, most probably under stadial conditions. The altitudinal relationships of the gravels suggest attribution to the Bathampton Member, which probably accumulated during Oxygen Isotope Stage 6 (this chapter). The fossil remains found at Newton St Loe during the last century must, at face value, reflect a relatively open but not stadial environment, probably one with herbaceous rather than forest vegetation. There is, however, a reasonable probability that the bones are derived and therefore do not reflect conditions during the aggradation of the gravels.

Conclusion

At Newton St Loe, terrace gravels of a low terrace of the river Avon are exposed in road and railway cuttings. The gravels yielded a restricted mammal fauna of elephant and horse in the nineteenth century. Such fossils might be taken as indicative of an open but not necessarily cold environment, perhaps characterized by a herbaceous flora. However, it is quite likely that the bones were derived from older deposits and that they do not reflect environmental conditions at the time of gravel deposition. The exposures show typical features associated with cold-stage fluvial deposition and have been deeply weathered. Newton St Loe forms a key element in a network of sites which can be used to reconstruct the protracted history of the Bath Avon.

STIDHAM FARM
C. O. Hunt

Highlights

Stidham Farm, Saltford, is important as a representative of the middle (50') terrace of the Avon. The site has good examples of cold-stage fluvial sedimentation and is the type-locality of the Stidham Member.

Introduction

At Stidham Farm, the 15 m terrace of the River Avon is underlain by trough cross-bedded gravels of the Stidham Member. The gravels contain abundant clast types not found in the Avon catchment or found only at outcrop downstream. They thus provide important evidence for a glacial advance into the Avon Valley from the west.

The site was first described by Moore (1870), who noted that mammoth remains had been found there and that the gravels were rich in material derived from the Lias (the local bedrock) and the Coal Measures. It was re-described in some detail (as Steedham Farm) by Woodward (1876), who described gravels to the north-east of Stidham Farm and noted their wide range of clast lithologies. He observed that the gravels he described were one of two patches in the area around Stidham Farm. Winwood (1889) listed the site as containing mammoth remains.

Davies and Fry (1929) briefly described gravels from the other outlier, to the west of the farm. The site was mentioned by Palmer (1931), who assigned it to his 50' terrace, but gave no further details. It was revisited in 1984 during the compilation of the Geological Conservation Review and subsequently designated the type-locality of the Stidham Member by Campbell *et al.* (in prep.). The deposits were attributed, on geomorphological grounds, to Oxygen Isotope Stage 8.

Description

Survey of degraded sections at ST 674684, on the margins of the old gravel excavations described by Davies and Fry (1929), gives a sequence that is essentially similar to those described by Woodward (1876) and Davies and Fry (1929). A similar though thinner sequence was seen nearby in the edge of the old railway cutting (maximum bed thicknesses in parentheses).

3. Dark yellow-brown, stony clayey silt, disturbed in its upper part by ploughing and containing occasional sherds of nineteenth century pottery. The clasts include brown and red sandstone, flint, Greensand chert and quartzite. (0.3 m)
2. Yellow-brown, planar trough cross-bedded and massively bedded, clast-supported sandy gravel, with occasional scour-fills of coarse sand. The clasts are predominantly Jurassic limestones (micritic and oolitic), with some Carboniferous Limestone, brown and red sandstone, flint, Greensand chert and quartzite. Fossils derived from the Carboniferous Limestone, Lower Lias, Upper Lias and Greensand were reported by Davies and Fry (1929). A sample taken from one of the scour-fills yielded no fossil material. (1.2 m)
1. Yellow-brown, imbricated, very coarse, silty sandy gravel, with some cobbles and small boulders of micritic (Lias) limestone. The gravels lie on an undulating erosion surface cut in Lias mudstones. (0.3 m)

Interpretation

Bed 3 is most probably the result of soil formation on, and plough disturbance of, the underlying gravels. Any limestone pebbles present in this bed have probably been removed by weathering. Bed 2 has the hallmarks of braided sandy gravel, typically laid down in the British Pleistocene during stadial phases (Briggs and Gilbertson, 1980). Bed 1 is a 'lag' deposit, consisting of large clasts moved a minimal distance by the river during an erosional phase, when all smaller material was carried farther downstream. This bed is the probable source of the mammoth bones found during the nineteenth century. These may have been *in situ*, but in this context are very likely to have been recycled. The deposits at Stidham Farm, therefore make up a typical cold-stage fluvial aggradation. The virtual absence of fossil material from the site is consistent with this interpretation, although the facies present at the site would generally have been unsuitable for the deposition of molluscs (Briggs *et al.*, 1990), since the sediments are coarse-grained and were most probably laid down near the channel centre. Like most Avon Valley gravel localities, erratic lithologies such as flint, Greensand chert and Carboniferous limestones and sandstones are common. They provide important evidence for a previous glacial advance into the Avon catchment from the west.

Conclusion

Gravels of the Stidham Member, underlying the middle (15 m) terrace of the Avon, are preserved at Stidham Farm, Saltford. The site has importance as one of a set safeguarding representatives of the terrace stratigraphy of the Bath Avon. These terrace deposits have critical importance because of their relationship with the ancient glacial deposits of the Bath and Bristol areas. Deposits at the site provide impressive examples of cold-stage fluvial sedimentation and contain a wide variety of erratics.

HAMPTON ROCKS CUTTING
C. O. Hunt

Highlights

Hampton Rocks Cutting was one of the first Pleistocene sites described from Somerset and Avon. It provides fine exposures through the low terrace of the Bath Avon and is nationally important for its calcretes – soil carbonate induration features. It is the type-site for the Bathampton Member and Bathampton Palaeosol of the Avon Valley Formation.

Introduction

Hampton Rocks railway cutting is one of a series of sites chosen to conserve representative examples of the terrace gravels of the Bath Avon. Hampton Rocks Cutting GCR site (ST 778667) is important for a number of reasons. It was selected as the best-available area of river gravels from the lowest (and therefore probably youngest) river terrace of the Avon. It has historical importance as one of the first sites described from Somerset and Avon, and it demonstrates good examples of cold-stage fluvial and aeolian sedimentation as well as a cold-stage fossil mollusc assemblage. There are fragmentary mammal remains. More significant, however, are the calcretes, which are extremely rare in the British Quaternary record. At Hampton Rocks Cutting, these are especially well developed and well preserved.

The site was initially described by Weston (1850), who recorded horizontal beds of fine gravel and coarse sand, with clast lithologies including flint, Greensand, oolitic limestone, Carboniferous Limestone, Millstone Grit and Old Red Sandstone. The section was re-described by Woodward (1876), who noted 3 feet of reddish-brown clay overlying 'an irregular bed of sand and small gravel' about 6 feet thick. The site was revisited in 1984 in the course of the GCR and again in 1990, and the stratigraphy, sedimentology, clast lithology and palaeontology of the gravels re-described (Hunt, 1990b). The site was nominated as the type-locality of the Bathampton Member (gravels) and the Bathampton Palaeosol (calcreted soil) by Campbell *et al.* (in prep.). The gravels of the Bathampton Member were attributed to Oxygen Isotope Stage 6 and the Bathampton Palaeosol to Stage 5e.

Description

The Bathampton Member is a terrace deposit of the River Avon. The deposits lie at *c.* 30–35 m OD, some 3 m above the floodplain, and are thus part of Davies and Fry's (1929) 'Lower Terrace'. The description given below follows Hunt (1990b), but also includes new data (maximum bed thicknesses in parentheses).

6. Dark brown, silty sandy clay soil with occasional pebbles and extremely rare 'blue and white' (19th–20th century) potsherds and modern sheep bones. (0.2 m)
5. Strong brown, slightly clayey, fine sandy silt with occasional stones, some vertical. This bed has a sharp but somewhat involuted boundary with bed 4. (0.35 m)
4. Pale brown, imbricated, clast-supported, medium trough cross-bedded gravels. The bedding is disturbed at the top, probably by cryoturbation, and irregular masses up to 0.6 m across of calcrete (pedogenic calcium carbonate induration) have formed, often emphasizing and respecting the disturbed bedding and sometimes appearing to have the shape of the roots of substantial trees. The transition to the underlying bed occurs over a distance of 0.05 m. (0.55 m)
3. Pale brown, trough cross-bedded fine gravels and coarse sand, with channel-fills of pale brown, plane-bedded, sandy silty clays with occasional pebbles and extremely rare mollusc remains. (0.30 m)
2. Pale brown, mottled strong brown, trough cross-bedded sandy gravel and gravelly sand, with occasional openwork lenses, generally fining upwards. Trough cross-beds are 0.05–0.10 m deep, 2 to > 3 m wide. Maximum clast size in the bed is 0.25 m diameter. (2.0 m)
1. Brown, mottled black, sandy fine gravel, fining upwards, and strongly manganese indurated. Contains occasional very large clasts, mostly Jurassic limestones, up to 0.35 m, at base of horizon and often partially embedded in the bedrock. This bed has a sharp but very irregular junction with Fuller's Earth bedrock. (0.10 m)

The gravels of beds 1 and 2 are relatively well sorted and show a strong imbrication. The clast orientation data are heavily dominated by eastward dips. The clasts comprise two main groups of materials. The most numerically important includes oolitic and micritic limestones, Jurassic fossils, phosphate, flint, beef, Greensand and Greensand chert. All these lithologies have parent outcrops upstream of Bathampton. The other lithologies either have outcrops downstream in the Bristol district (yellow and red sandstones of the Carboniferous and Devonian or Permo-Triassic, Carboniferous Limestone, Bunter Quartzite, and possibly the igneous rocks) or farther afield (metamorphosed siltstones and mudrock probably originating from the Midlands or Wales). Others, such as limonite, are untraceable.

The palaeochannel-fills of bed 3 are laterally very discontinuous. They contain rare *P. muscorum*, *Succinea* cf. *oblonga*, *Trichia* cf. *hispida* and *Pisidium* sp. Fragments of elephant or mammoth tusk ivory and unidentifiable mammal bone were found evenly distributed in the gravels.

The upper parts of the gravel (bed 4) are somewhat involuted, with many vertical stones. Irregular masses of calcrete are present at the top of the gravels. These seem to have formed after the involutions had formed. These deposits are overlain by homogeneous sandy silts (bed 5), which in some places are disturbed by ploughing.

Interpretation

The stratigraphy can be interpreted in the following way. The trough cross-bedded gravels (bed 2) are the product of deposition by a braided (multichannel) stream. Such streams are typical of environments with little vegetation cover and a seasonal precipitation pattern, such as deserts and arctic-alpine areas (Briggs and Gilbertson, 1980). This environmental diagnosis is supported by the molluscan data. The few fossils recovered are typical of cold-stage mollusc assemblages in the British Isles (Kerney, 1976b; Jones and Keen, 1993). The molluscs present have well-known environmental tolerances at the present day and the environment at the time of deposition can therefore be deduced. *P. muscorum* prefers dry, exposed habitats, while *Succinea oblonga* (Draparnaud) inhabits wet muddy places. *T. hispida* is a generalist with a particular liking for wet grassy places. Members of the genus *Pisidium* are all aquatic. A dry landscape, with little vegetation except near watercourses is suggested. The climate was probably arid and rather cold. The terraces of the Bath Avon are famous for their mammal remains, but the 'Low Terrace' is regarded as virtually devoid of them (Davies and Fry, 1929). There is a high probability that the durable fragments found during the GCR re-survey are recycled and therefore of little palaeoenvironmental significance. Their presence, however, raises the interesting possibility that other, larger fragments of greater significance may be preserved elsewhere in the deposit.

Clast orientations in the gravels are consistent with deposition by a westward-flowing river. The clast lithological data suggest the input of erratic material into the catchment, probably by the ice sheet which laid down the glacial deposits now found at Bath University and elsewhere in Avon (this chapter; Hawkins and Kellaway, 1971; Gilbertson, 1974).

The upper part of the deposit was disrupted by frost action, which led to the formation of involutions and to the stones being turned into an upright position (bed 4). Subsequently, the masses of calcrete formed, most probably around the roots of trees, judging by the morphology of the calcrete bodies. Calcrete does not form at the present day in the British Isles, but is forming in the Mediterranean basin, suggesting a warm, relatively arid climate when this calcrete formed. The last time it was sufficiently warm for calcrete formation in this country was during Oxygen Isotope Stage 5e. Following this episode, the climate deteriorated and wind-blown 'coversands' were laid down. These have been altered significantly by later pedogenic processes to give rise to bed 5.

Conclusion

Hampton Rocks Cutting is important for a number of reasons. It provides an excellent example of the low terrace of the Bath Avon and therefore has stratigraphical significance. It contains a good example of cold-stage river sedimentation, dating from the last part of the Middle Pleistocene. It contains non-local pebbles which can only have been brought into the area by glacial action and thus provides compelling evidence for a former glaciation of the Bath area. Its greatest importance is for its calcretes, extremely unusual soil carbonate induration features probably dating from the last interglacial, Oxygen Isotope Stage 5e.

HOLLY LANE

C. O. Hunt

Highlights

Holly Lane, Clevedon, provides important evidence for landscape evolution in Avon during the Devensian. The site is an important locality for Devensian mammal, bird and mollusc remains and is also notable for its periglacial breccias and aeolian deposits.

Introduction

At Holly Lane, up to 21 m of breccias, sands and silts are banked against an ancient cliff. The sequence consists of a basal talus cone, overlain by sandy loams, breccias, very coarse breccias, sandy loams, breccias, sandy loams and then a final thin breccia. Several beds in this sequence have yielded important mammalian fossils and sparse mollusc assemblages indicative of cold-stage conditions.

The breccias and sands at Holly Lane were first exposed by quarrying in 1905. Initially, interest centred around a small, richly fossiliferous cave, which, with the breccias immediately outside it, yielded over 2000 bones (Greenly, 1922). Davies (1907) demonstrated that the cave was unconnected to a karstic conduit system and unrelated to the structure of the Carboniferous Limestone bedrock. Two sedimentary horizons were identified in the cave: a 'dull red stony loam' about 0.45 m thick, overlain by 1.5 m of the lower breccias (Davies, 1907; Greenly, 1922). Outside the cave, Davies (1907) described a sequence of lower 'gravel' (breccia), clay, middle 'gravel', sand, and upper 'gravel'. The mammal fauna was identified by Hinton (1907a, 1907b, 1910) and Reynolds (1907) and included horse, bear, wolf, fox, ?Arctic fox, ?rabbit, voles and ?lemming. Bird fossils were also present. The fauna included 24 species, notably eagle, buzzard, heron, gull and cormorant. Four fish vertebrae and a mollusc fauna comprising *T. hispida* and *Succinea putris* (Linné) were found in the cave. *T. hispida*, *Hellicella (Cernuella) virgata* (Da Costa), *Helix aspersa* Müller, *P. muscorum* and *S. putris* were found in the breccias outside the cave (Greenly, 1922), though Kerney (1966), Gilbertson (1974) and Gilbertson and Hawkins (1974) have suggested that *Helix* and *Helicella* were contaminants. Gilbertson (1974) quotes a personal communication from W.A.E. Ussher in 1970, who recalled that a local doctor had unsuccessfully tried to save human remains in the cave when excavation started.

Interest later turned to the breccias and sands at Holly Lane. Greenly (1922) provided a description of these deposits. A basal sandy breccia was overlain by a very coarse breccia. This was sharply overlain by a sandy loam, then a slightly stony loamy sand with abundant *T. hispida* and *P. muscorum* and then an upper sandy breccia. The beds dipped as much as 32° and were banked up against a steep, or even undercut, cliff in the Carboniferous Limestone. The maximum recorded thickness of the sequence was about 21 m. The clasts in the breccias were all derived from the local outcrop of Carboniferous Limestone, but mineralogical analyses of the sandy loam and loamy sand showed the presence of far-travelled minerals. The mineralogy of the sands was comparable with that of sands in South Wales. These were suggested, therefore, to be the parent deposits from which the sands at Holly Lane were derived by the action of wind.

The deposits were discussed again by Hinton (1926), Palmer and Hinton (1929), Palmer (1931, 1934), Kennard and Woodward (1934) and Vink (1949). Hinton (1926) dealt with the vole remains from the site, identifying five taxa. Palmer and Hinton (1929) described mineralogical analyses of the sandy matrix of the breccias and of the sandy loam and loamy sand which showed a common composition and thus probably origin. They described a fauna of voles, horse, wolf, bear and ?Arctic fox, most probably from the lower breccias, and a polished bone point of indeterminate type. Palmer (1931, 1934) integrated the site within a local stratigraphical scheme and suggested that the deposits overlay the '50 foot' shore platform. Palmer (1934) compared mineralogical analyses from Holly Lane with analyses from other sites in the Bristol district. The far-travelled minerals in these deposits were thought to have been derived from the south or south-west. Kennard and Woodward (1934) described mollusc faunas from the cave, lower breccia, 'aeolian sands', 'upper coarse gravel' and 'subsoil'. The faunas from the subsoil and the upper breccia and some components of the fauna from the lower breccia were regarded by Kerney (1966), Gilbertson (1974) and Gilbertson and Hawkins (1974) as intrusive. The probably *in situ* components of the fauna are, in the middle sands, *T. hispida* and *P. muscorum* and in the lower breccias *T. hispida*, *P. muscorum*, *V. costata* and *Lymnaea stagnalis* (Linné). Vink (1949) carried out sedimentological analyses of the sands at Holly Lane. They were comparable with

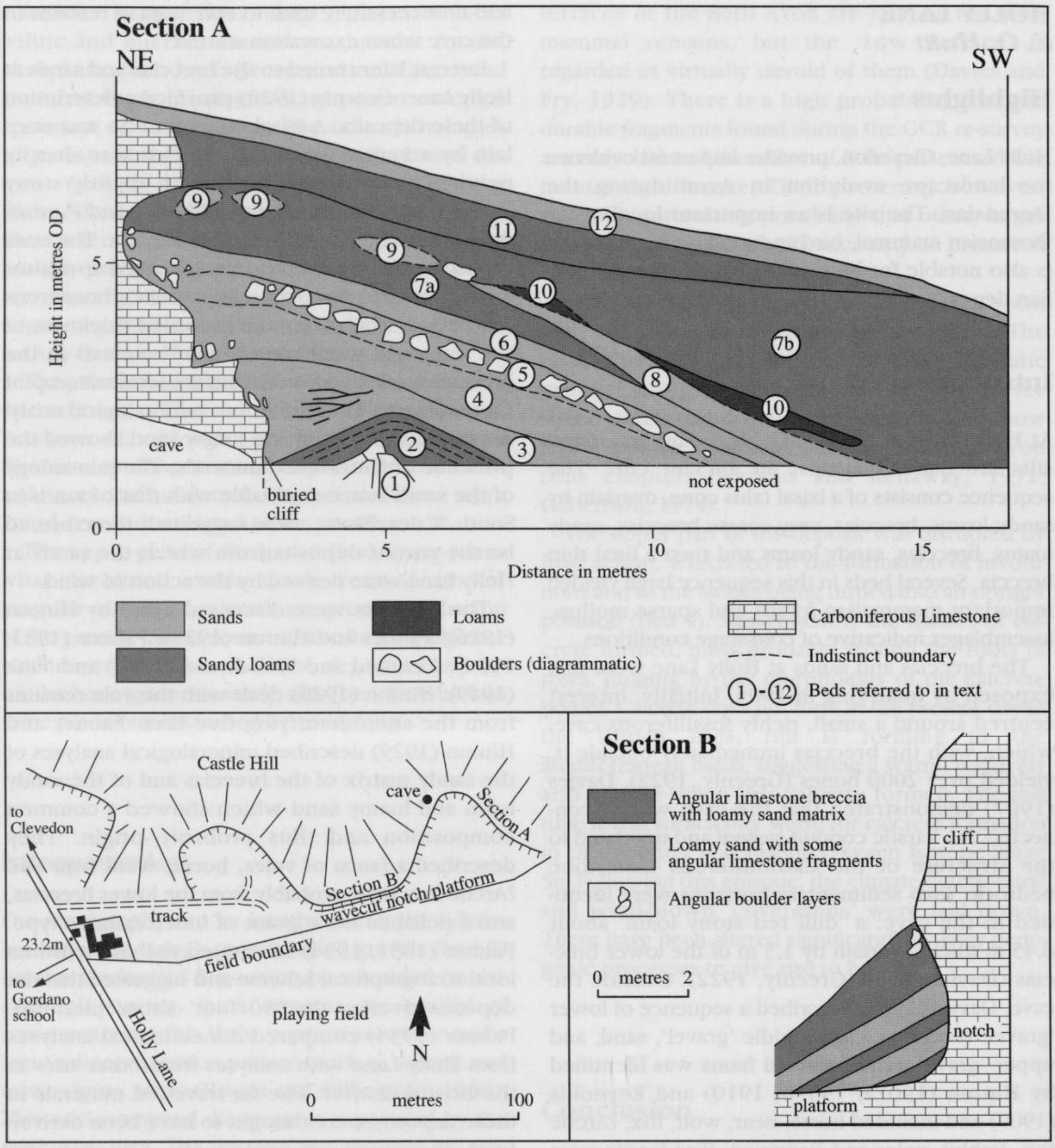

Figure 10.9 The Quaternary sequence at Holly Lane, Clevedon. (Adapted from Gilbertson and Hawkins, 1974.)

the periglacial coversands of the Low Countries.

Gilbertson (1974) and Gilbertson and Hawkins (1974) re-described the sections at Holly Lane and reviewed previous work on the site. They described two sections and recognized a complex stratigraphy, with a basal talus cone, overlain by sandy loams, breccias, very coarse breccias, sandy loams, breccias, sandy loams and then a final thin breccia. The middle sandy loam was equivalent to the middle aeolian sand bed of Greenly (1922), Palmer and Hinton (1929) and Palmer (1931, 1934). They suggested that the breccias had accumulated during phases of frost-shattering and that the sandy loams were niveo-aeolian coversands, and they compared the sequence with stratified slope-waste deposits elsewhere. These authors reassessed early accounts of the terrestrial molluscs from the site. They obtained occasional specimens of *P. muscorum* from the middle and lower sandy loams and one specimen of *Succinea* sp. from the lower sandy loam.

Description

At Holly Lane (ST 419727), a thick breccia and sandy loam sequence has been exposed by quarrying (Figure 10.9). The description by Gilbertson (1974) and Gilbertson and Hawkins (1974) is followed here (maximum bed thicknesses in parentheses).

12. Black topsoil developed on breccia, with angular blocks in a sandy matrix. The bed has a sharp boundary with bed 11. (0.5 m)
11. Reddish-brown sandy loam with a few small angular clasts. The bed has a sharp boundary with bed 10. (1.0 m)
10. Breccia containing many angular blocks in a reddish-brown loam matrix, with clasts up to 0.25 m. The deposit is poorly bedded and has an indistinct boundary with bed 9. (4.30 m)
9. Reddish-brown silty sand with occasional angular clasts. It occurs in discontinuous lenses and has an indistinct boundary with bed 8. (0.30 m)
8. Breccia containing angular boulders in a reddish-brown blocky sandy matrix. This occurs in discontinuous pockets and has an indistinct boundary with bed 7. (0.50 m)
7. Breccia containing angular blocks in a reddish-brown sandy loam matrix, and clasts up to 0.3 m. The bed thickens downslope and has a distinct boundary with bed 6. (0.20 m)
6. Breccia containing angular blocks and boulders in a reddish-brown sandy matrix, and clasts up to 0.4 m. Occasional lines of finer clasts are present and the deposit is poorly bedded and coarsens upward. It has a sharp boundary with bed 5. (1.50 m)
5. Reddish-brown loamy sand with occasional tabular clasts up to 0.04 m, lying parallel to the dip of the bed. It contains occasional *P. muscorum* and some foraminifera. It has a sharp boundary with bed 4. (0.40 m)
4. Breccia containing angular boulders and smaller clasts in a reddish-brown sandy matrix. It has an indistinct boundary with bed 3. (0.45 m)
3. Breccia containing angular blocks in a reddish-brown sandy matrix. Clasts average 0.02–0.04 m, and the deposit coarsens upwards. It contains occasional boulders and has a sharp boundary with bed 2. (1.10 m)
2. Reddish-brown, very silty loamy sand with occasional angular clasts up to 0.01 m, becoming more frequent upwards. Occasional *P. muscorum*, very rare *Succinea* sp. and other molluscs, and some foraminifera are present. This deposit buries the dome of bed 1 and is banked against the limestone cliff at an angle of 30°. It has a sharp junction with bed 1. (> 2.0 m)
1. Breccia containing angular blocks in a red sandy matrix. Clasts average 0.25 m, and occasional boulders are present. It is poorly bedded and forms a low cone-shaped structure. It lies on a fissured rock surface, possibly bedrock. (1.1 m)

Interpretation

No palaeosols or weathering horizons have been found at Holly Lane, so it is probable that the whole sequence dates from the Devensian (Gilbertson and Hawkins, 1974). The alternating breccias and sandy loams at Holly Lane provide evidence for aeolian, perhaps niveo-aeolian, activity and intermittent frost-shattering. Gilbertson and Hawkins (1974) argued that the breccias reflected cold moist phases, while the sandy loams and loamy sands were laid down in cold arid periods.

The biological evidence in the lower beds is for open, relatively exposed landscapes, with molluscs such as *P. muscorum* and *T. hispida* typical of open, perhaps discontinuous herbaceous vegetation. The presence of moisture-loving taxa like *Succinea* in the lower loam is consistent with a locally very damp environment and conflicts with Gilbertson and Hawkins' (1974) suggestion that the sandy loams indicate aridity, unless the shells were brought to Holly Lane from marshy environments nearby. The mammal and bird faunas, which were probably recovered mostly from beds 1–3 and their lateral equivalents are arguably indicative of a cold steppe environment. The decrease upward in the diversity and incidence of faunal remains may perhaps be taken as evidence for a gradual climatic deterioration.

Conclusion

The deposits at Holly Lane, Clevedon, provide evidence for a complex sequence of environmental change and landscape evolution during the Devensian cold stage. They have yielded important mammal, bird and mollusc faunas characteristic of this period, together with sedimentary evidence for aeolian activity and intermittent frost-shattering.