Quaternary of South-West England

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JOINT NATURE CONSERVATION COMMITTEE

CHAPMAN & HALL

Chapter 9

The Quaternary history of the Somerset lowland, Mendip Hills and adjacent areas

INTRODUCTION
C. O. Hunt

The sites described in this chapter were selected to document the extra-glacial development of the Somerset lowland, Mendip Hills and adjacent areas (Figure 9.1). This region has considerable potential significance, because it contains important and unique evidence for extra-glacial Quaternary environments. Especially important are the interglacial marine deposits of the Burtle Formation, the interstadial marginal marine Low Ham Member and the massive cold-stage gravel aggradations, possibly interstadial deposits and archaeological material of the Broom Gravel Pits in the Axe Valley. The northern and western parts of the region also contain extremely important examples of cold-stage periglacial, colluvial, aeolian and fan-gravel sedimentation and warm-stage palaeosol development.

The Pleistocene record of Somerset has great potential importance, but has been relatively neglected in comparison with regions such as East Anglia. Some of the leading nineteenth century earth scientists worked on aspects of the Pleistocene of the region. For instance, Buckland (1823) recorded mammal remains from a number of cave sites in his *Reliquiae Diluvianae* and Buckland and Conybeare (1824) identified the marine origin of the interglacial Burtle Beds of King's Sedgemoor. Later in the nineteenth century, raised beaches near Weston-super-Mare were described by Sanders (1841) and Ravis (1869). The first detailed synthetic work on the Quaternary deposits of the region was the Geological Survey Memoir of Woodward (1876). Prestwich included a number of sites in Somerset and Avon in his monumental reviews, providing faunal lists and proposing an interglacial age for the raised beaches and Burtle Beds (Prestwich, 1892).

Head, alluvial fan gravels and 'cold-stage' terrace gravels are an extremely important component of the Pleistocene deposits in this region, but until modern geochronometric methods are applied to them they will remain virtually impossible to date with any confidence. Occasional records of gravel and head deposits were made during the nineteenth century, and many of these are summarized in the early Geological Survey Memoirs. Thus, Woodward (1876) described a number of terrace-gravel and fan-gravel sites around Mendip. Ussher (1906) mapped and described 'old washes and talus fans' and 'terrace gravels' in the Isle Valley and Chard Gap and later mapped 'loamy gravel and head' in the Quantocks and Tone Valley (Ussher, 1908). At several localities, these deposits were associated with reindeer remains and, at Doniford, with mammoth (Ussher, 1908). The great hand-axe sites of the Axe Valley were first noted by D'Urban (1878) and these terrace sites were briefly described by J.F.N. Green (1943). Similar deposits were later mapped as 'spreads of head and gravel' in the upper Parrett, Yeo, and Cam valleys by Wilson *et al.* (1958). Palmer (1934) conducted studies of a number of cold-climate breccia and blown-sand sites, including Holly Lane (Chapter 10) and the important section at Brean Down, and demonstrated a southerly origin for the sands on mineralogical grounds. The first detailed account of the periglacial deposits of Brean Down was not made, however, until the work of ApSimon *et al.* (1961).

After the work of Woodward (1876), Prestwich (1892) and Ussher (1908), interest in the marine interglacial deposits of the Somerset lowlands waned. Research resumed with Bulleid and Jackson's (1937, 1941) detailed accounts of the Burtle Beds of King's Sedgemoor. This was followed by the work of ApSimon and Donovan (1956), who described marine Pleistocene deposits in the Vale of Gordano. The marine interglacial deposits became a source of major controversy, as morphometric work and then the first radiocarbon dates on the raised beach at Middle Hope suggested correlation with the Upton Warren Interstadial (Donovan, 1962; Wood *in* Callow and Hassall, 1969), though this was later rejected by Kidson (1970).

The influential reviews by Mitchell (1960, 1972) 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 interglacial marine deposits. Thus Kellaway (1971), Hawkins and Kellaway (1971, 1973), and Kellaway *et al.* (1975) suggested that most of South-West England had been overrun by ice sheets during an early glaciation. Convincing evidence of glaciation in the Bristol area was provided by Hawkins and Kellaway (1971) and these authors contended that the Burtle Beds of lowland Somerset were glacial outwash deposits. Stephens (1970a, 1970b, 1973) suggested an alternative, with limited glaciation in the coastlands of Somerset damming an enormous proglacial lake in lowland Somerset, which eventually discharged into the Axe Valley through the Chard Gap. These suggestions were vigorously disputed

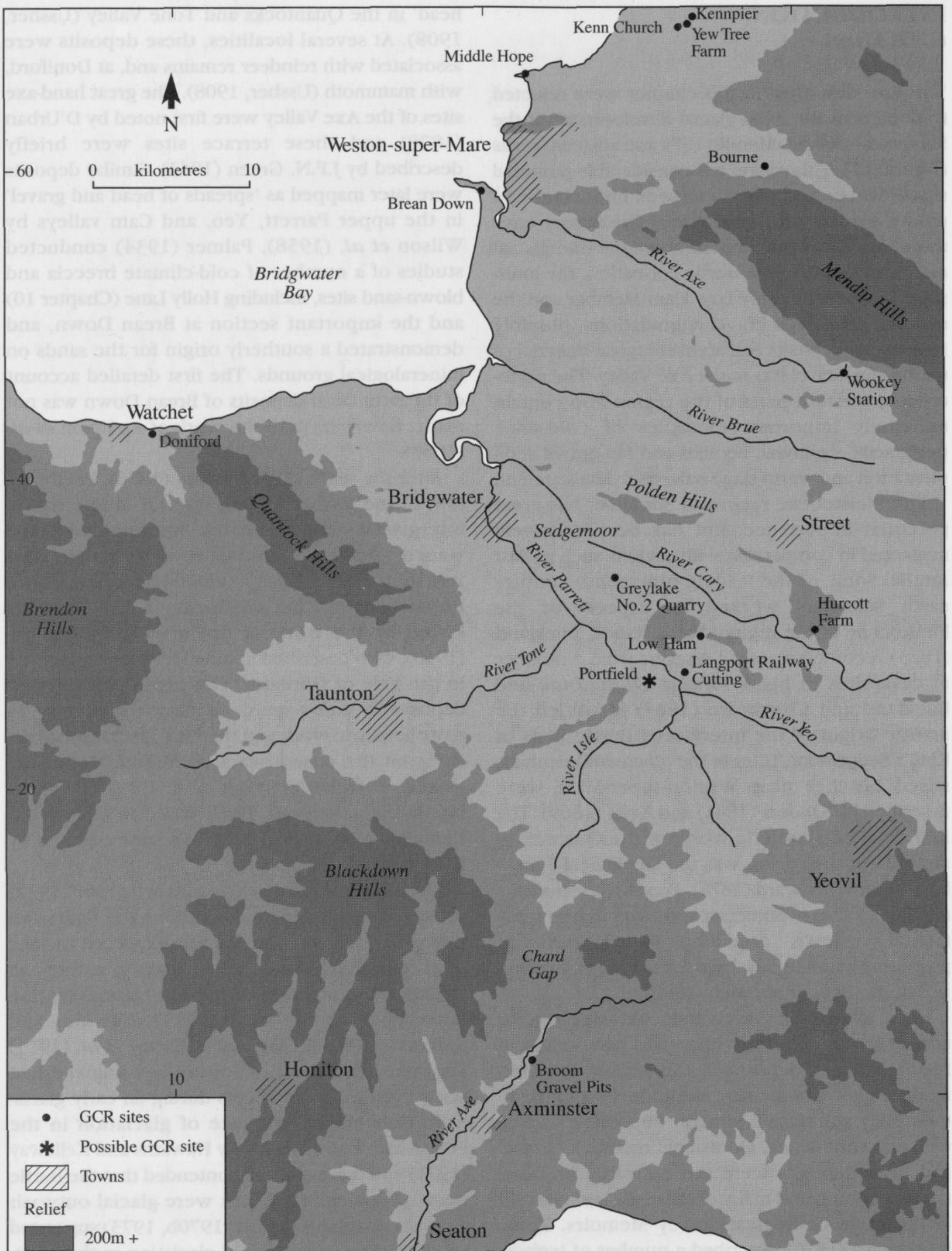

Figure 9.1 The Mendips and Somerset lowland, showing GCR sites described in this chapter, and selected GCR sites described in Chapters 7 and 10.

by Kidson (1971), Kidson and Haynes (1972), Kidson *et al.* (1974) and Kidson (1977) who produced compelling evidence to show that the Burtle Beds were of interglacial marine origin, and C.P. Green (1974b) who showed that the gravels of the Axe Valley were locally derived. More recently, Hunt *et al.* (1984) showed that no unequivocally erratic material could be found in southern Somerset.

Eventually, the emergence of robust stratigraphical and palaeoenvironmental evidence led to a broad consensus: that the Burtle Beds of King's Sedgemoor are estuarine interglacial deposits with freshwater intercalations (Kidson *et al.*, 1978; Gilbertson, 1979; Hunt and Clarke, 1983), with the balance of evidence pointing toward an Ipswichian age. The raised beach at Swallow Cliff, Middle Hope (Gilbertson, 1974; Gilbertson and Hawkins, 1977; Briggs *et al.*, 1991), periglacial deposits at Holly Lane and elsewhere in Avon and north Somerset (Gilbertson, 1974; Gilbertson and Hawkins, 1974, 1983), the valley-fill deposits at Doniford (Gilbertson and Mottershead, 1975) and fan sediments in Mendip (Findlay, 1977; Pounder and Macklin, 1985; Macklin and Hunt, 1988) were also re-described.

Recently, the development and application of aminostratigraphy have led to the recognition of the extreme complexity of the Pleistocene sequence in Avon and Somerset and have prompted the re-examination of a number of key sites. The first application of the method in the region was by Andrews *et al.* (1979) who determined ratios from the Burtle Beds at Greylake and the Middle Hope raised beach, together with other sites in South-West England and South Wales. The Greylake No. 2 Quarry deposits were shown to be only marginally older than the Middle Hope raised beach deposits, although *Patella* shells from both produced ratios in the region of 0.11. The work of Davies (1983) suggested that the Middle Hope raised beach deposits were substantially older, and she attributed them to Group 3 of her classification (mean ratios of 0.2). This problem has not yet been fully resolved, though the latest views (Bowen, pers. comm., 1996) lean towards a last interglacial (Oxygen Isotope Stage 5e) age. Hunt *et al.* (1984) provided ratios on *Corbicula* of 0.18 from the Chadbrick Gravels and 0.18 and 0.26 from *in situ* assemblages from the Burtle Beds at Greylake No. 1 Quarry (Gilbertson, 1979). These ratios were interpreted as suggesting an Ipswichian age for the Chadbrick Gravels and some components of the Burtle Beds.

The important reassessment of the aminostratigraphy of British non-marine deposits by Bowen *et al.* (1989) renders many of the early aminostratigraphic interpretations in Somerset and Avon obsolete (Hunt, 1990a). Given that very few assays have been made and that correlations based on small numbers of ratios may not be trustworthy, it would nevertheless appear that an extremely complex picture of sea-level change is preserved in the sequences in Avon and Somerset. These changes can be related, albeit tentatively, to the global oxygen isotope stratigraphy (Campbell *et al.*, in prep.; Figure 9.2).

Important themes in the Pleistocene of the Somerset lowland, Mendip Hills and adjoining areas

Several important themes emerge from the scientific background outlined above. These have guided site selection, which was carried out in consultation with other relevant specialists. In several cases, there is only one site where a certain facet or feature of Quaternary history can be demonstrated clearly; where several closely comparable sites were available, secondary factors, such as other features of earth-science interest, vulnerability to development and ease of access were considered. The themes are:

1. Evidence for high Pleistocene sea levels

Somerset and Avon offer an exceptional sequence of marine interglacial and interstadial deposits. GCR sites were chosen to provide the best evidence for these high sea-level events, wherever possible. The sites are Swallow Cliff (Oxygen Isotope Stage 5e or 7), Portfield (Stage 7), Greylake No. 2 Quarry (Stages 7 and 5e) and Low Ham (Stage 5a). Low Ham is particularly important as the only site in the UK where high relative sea levels during a Devensian (i.e. post-Stage 5e) interstadial can be demonstrated. Complementary sites in the Bristol area (Chapter 10) include Kennpier (? Stage 15), Kenn Church (Stage 7) and Weston-in-Gordano (undated but with three marine interglacial sequences interbedded with ?till).

2. Terrace stratigraphy

Excluding the glacial and marine sequences, the fundamental framework for establishing a Pleistocene stratigraphy in Somerset and Avon is

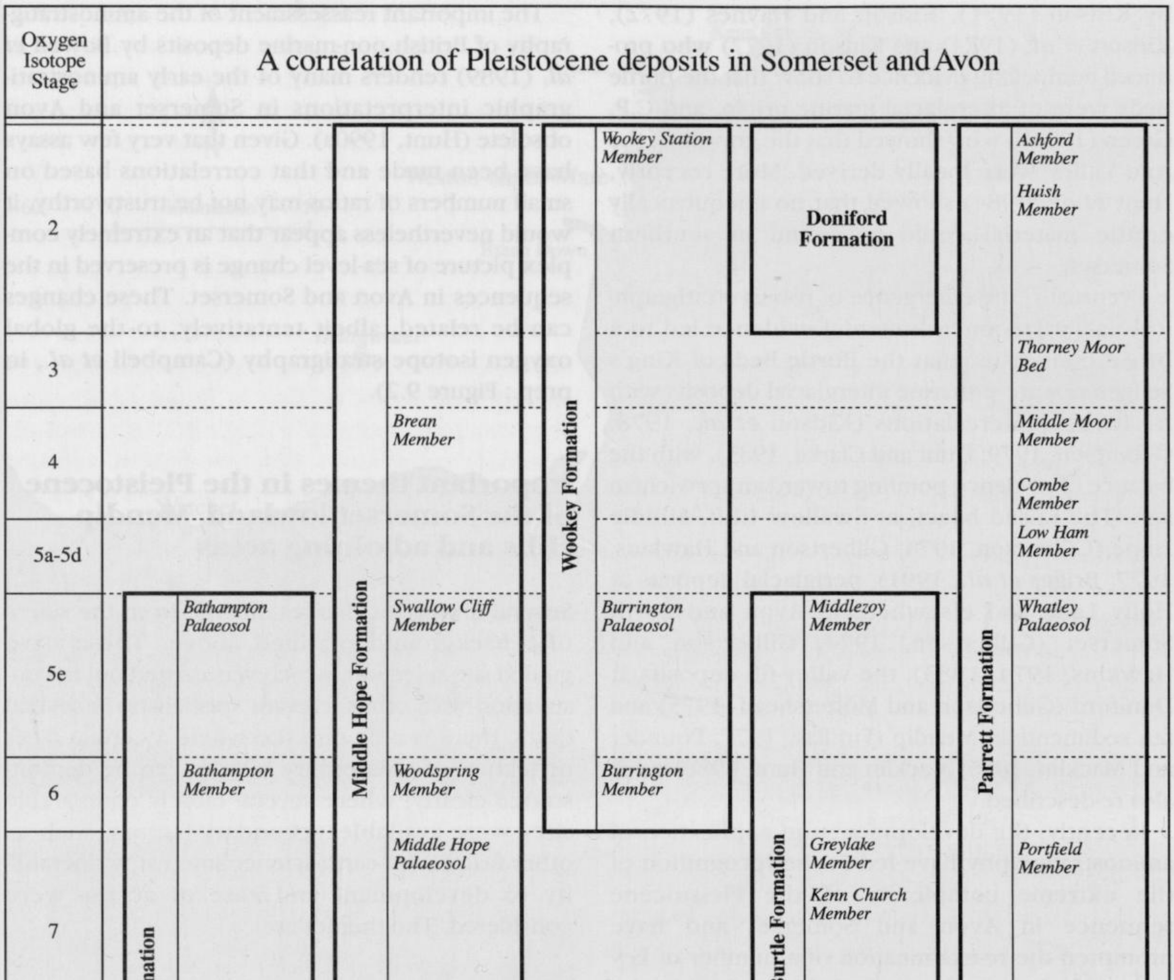

Figure 9.2 A correlation of Pleistocene deposits in the Somerset lowland, Mendips, Bristol district and Avon Valley. (Adapted from Campbell *et al.*, in prep.)

provided by river terrace gravels. Key terrace sites were selected for the GCR to demonstrate the main elements and regional variations in terrace stratigraphy. In southern Somerset, key sites in the Parrett-Cary catchment are the interglacial (Stages 9 and 7) sites at Hurcott Farm and Portfield, the cold-stage (Stage 8) site at Langport Railway Cutting and the interstadial site (Stage 5a) at Low Ham.

3. Temperate-stage palaeobiology

Somerset and Avon have one of the most complete and richly fossiliferous sequences of marine interglacial and interstadial deposits in the British Isles. There are also some important non-marine palaeobiological sites. One site is of particular significance. The Stage 5a marginal marine interstadial site at Low Ham, with its mollusc and ostracod faunas, plant macrofossils and pollen is unique in north-western Europe. Important regional marine mollusc sites include Greylake No. 1 Quarry (Stage 9 and late Stage 7), Swallow Cliff (Stage 5e or 7) and Greylake No. 2 Quarry (Stage 5e). The Greylake sites have yielded regionally important mammal faunas and freshwater mollusc assemblages. The Stage 9 site at Hurcott Farm and the Stage 7 site at Portfield contain regionally important freshwater mollusc fossils and some pollen.

4. Cold-stage sedimentation and palaeobiology

Subsequent to the Kenn glaciation, Avon and Somerset lay beyond the glacial limits. Cold-stage sedimentation was ubiquitous, but good examples, particularly pre-Devensian ones, are very rare. Sub-groups of sites were chosen to demonstrate this aspect of Pleistocene history. Two sites represent fan sedimentation around Mendip. Wookey Station provides an excellent example of fan sedimentation, a rare mollusc fauna and pollen dating from the coldest part of the Late Devensian. The Bourne sequence demonstrates at least two earlier periods of fan aggradation, separated by an interglacial palaeosol which is virtually unique in the region. Brean Down is important for periglacial aeolian and slope sediments and Early to Mid-Devensian vertebrates and land molluscs. At Swallow Cliff, Middle Hope, the raised beach deposits overlie rare Stage 6 or 8 slope deposits which contain land molluscs. Cold-stage river terrace gravels make up a further important group of sites. Outstanding among these is the cliff section at Doniford (Chapter 7), which exposes a considerable proportion, in cross-section, of a cold-stage valley-fill. Langport Railway Cutting provides an excellent sequence, of proposed Stage 8 age, with land mollusc faunas.

(A) SITES RELATING TO THE EXTRA-GLACIAL DEVELOPMENT OF THE SOMERSET LOWLAND AND ADJACENT AREAS

In this section, sites are documented which illustrate the Quaternary development of the Somerset lowland and adjacent areas. Two main themes are apparent: marine incursions into the Somerset Levels, and landscape development through the evolution of drainage nets and incision of valleys around the margins of the lowland, particularly in the Parrett catchment to the south of Sedgemoor.

There is still considerable scope for investigations of the marine record in the Somerset lowland, since the complexity of the sequences at localities such as Greylake may have been underestimated by previous workers. Nevertheless, marine and marginal marine sediments attributed to Oxygen Isotope Stage 7 (the Greylake and Kenn Church members at Greylake No. 2 Quarry and Kenn Church, respectively), Stage 5e (the Middlezoy Member at Greylake No. 2 Quarry), and Stage 5a (the Low Ham Member at Low Ham) have been identified and are documented here. The altitude reached by these marine transgressions can be determined; for Stage 7 at Portfield, for Stage 5e at Greylake No. 2 Quarry, and for Stage 5a at Low Ham. These sites are all richly fossiliferous and those at Greylake and Kenn Church provide important evidence for interglacial shallow-marine mollusc communities in South-West England.

A further set of sites documents landscape development around the margins of the Somerset lowland. Key stratigraphic sites in the terrace 'staircase' of the Parrett catchment include the ?Stage 9 site at Hurcott Farm, the Stage 8 site at Langport Railway Cutting, the Stage 7 site at Portfield and the Stage 5a site at Low Ham. Hurcott Farm, Portfield and Low Ham have been dated by aminostratigraphy and thus provide important chronological control in an otherwise undateable sequence. The vastly important site at Broom is perhaps the richest Palaeolithic site in the South-West, and provides important information on the evolution of the Axe Valley in east Devon. The selected GCR sites are all important for the light they throw on the palaeobiology of inland South-West England during the Middle and Late Pleistocene.

LANGPORT RAILWAY CUTTING
C. O. Hunt

Highlights

Langport Railway Cutting provides a good example of 'cold-stage' fluvial sedimentation, correlated with Oxygen Isotope Stage 8, and interglacial soil development seen in a rare permanent exposure. The site is located at the Langport Gap, a key locality in southern Somerset where the presence within a small area of several important fluvial and marine formations enables morphostratigraphical relationships to be elucidated. This is the type-site of the Chadbrick Member.

Introduction

Langport Railway Cutting contains well-exposed 'cold-stage' river gravels overlain by a well-developed palaeosol. The site is representative of the oldest gravel aggradation in southern Somerset, which can be traced upstream into the headwaters of the rivers Isle and Parrett. The gravels are probably best correlated with Oxygen Isotope Stage 8.

The site was first recorded by Woodward (1905) in his survey of railway cuttings between Langport and Castle Cary, but was not described. Subsequently, Hughes (1980) gave a very brief description of the site and attributed it to a 'fluvio-estuarine' facies of the interglacial marine Burtle Beds. More recently, Hunt (1987; in press) re-described the site, carrying out geomorphological, clast lithological, sedimentological and palaeontological studies. He established that deposition was from a multi-channel river flowing through a sparsely vegetated landscape. The site evidence was attributed to an unspecified cold stage prior to the last interglacial. Subseqently, Campbell *et al.* (in prep.) used Langport Railway Cutting as the type-section for the Chadbrick Member which is correlated with Oxygen Isotope Stage 8.

Description

Langport Railway Cutting (ST 426272) is excavated in a broad terrace-like feature to the north-east of Langport. The feature is separated from the present course of the River Parrett by a low hill known as Whatley and lies some 14 m above the level of the present floodplain. The terrace surface is underlain by gravels which lie on a gently undulating erosion surface cut in Rhaetic shales. The gravels can be divided into three units (maximum bed thicknesses in parentheses):

3. Gravels, once probably sandy but now significantly clay-enriched and lacking in limestone clasts. The original trough cross-bedding is disrupted and many large clasts are orientated vertically. The upper part of the unit is generally bleached while the lower part is slightly reddened, but this pattern has been somewhat disturbed by involutions. A few very decalcified specimens of *Cepaea* sp. were present in the lower part of this unit. (1.4 m)
2. Gravels and sands infilling a channel, 0.9 m deep and over 10 m wide, incised into bed 1. The infill comprises a basal, imbricated clast-supported gravel passing into trough cross-bedded yellow-buff sands and sandy gravels. Clast orientation in the imbricated unit suggests a palaeocurrent direction of 332°. Most gravel clasts are lightly point-contact cemented with calcite, but some sand beds, particularly towards the top of the unit, are heavily cemented ('plugged'). A restricted molluscan fauna, including *Pisidium* sp., *Succinea* cf. *oblonga*, *Trichia* cf. *hispida*, *Pupilla muscorum* Linné, Limacidae and helicid fragments, was found in this unit, together with fragments of the case of the aquatic larvae of *Caddis* sp. and fragments of insect exoskeleton attributable to the Trichoptera. (0.9 m)
1. Pale brown, trough cross-bedded coarse sands and matrix-supported sandy gravels. The trough cross-beds are of the order of 0.1–0.3 m deep and 1.0–3.0 m across. A rather restricted molluscan fauna, including *Succinea* cf. *oblonga*, *P. muscorum*, *Vertigo* sp., Limacidae and helicid fragments, was found in this unit. Clast lithological analysis showed that these gravels comprise lithologies derived from the Mesozoic and Tertiary rocks upstream. The dominant lithotypes are grey micrites derived from the limestone beds in the Rhaetic and Lias, oolitic and bioclastic limestones from the Middle Jurassic formations, and flint and chert from the Chalk and Greensand. (1.2 m)

Interpretation

The sands and gravels of the Langport terrace and many of the other terrace deposits of Somerset can be exemplified by the site at Langport Railway Cutting. The trough cross-stratification of the lower unit (bed 1) is consistent with deposition from a multi-channel river with a highly peaked or even ephemeral discharge regime and an abundant sediment supply. Modern analogues are widely known from high altitudes, high latitudes and arid and semi-arid areas (Doeglas, 1962; Williams and Rust, 1969; Bull, 1972; Miall, 1977). The palaeontological evidence from bed 1 is consistent with this type of depositional regime. The absence of aquatic molluscs in this unit probably reflects the ephemeral nature of the river, particularly the short duration of flows. *P. muscorum* is a species typical of exposed arid environments (Kerney and Cameron, 1979), though it is thought to have been tolerant of damp places during the Pleistocene (Kerney, 1963; Kerney *et al.*, 1964). The other taxa were most probably living in damp, partially vegetated areas on the floodplain.

The imbricated gravels at the base of the middle unit (bed 2) are probably related to the scouring of the channel. The scour-and-fill structures in the sands and gravels overlying the imbricated gravels may be the result of the movement of sand waves in one channel, or may reflect deposition from a number of smaller braided channels. The fauna from bed 2 includes remains of the aquatic larvae of *Caddis* sp. and Trichoptera and the aquatic bivalve mollusc *Pisidium* sp.. It is therefore probable that flows were less ephemeral than they were during deposition of bed 1, or that standing water occupied a pool here after the recession of seasonal floods. The other molluscs are taxa of damp herbaceous vegetation (*Trichia* cf. *hispida*), wet terrestrial environments (*Succinea* cf. *oblonga*), generalists (Helicidae, Limacidae) or xerophiles (*P. muscorum*).

The remaining traces of trough cross-bedding in the upper unit (bed 3) are again consistent with deposition from a multi-channel stream. *Cepaea* is a thermophilous, generalist terrestrial mollusc genus, but other smaller taxa were most probably destroyed by decalcification. The leached and reddened upper horizons and especially the presence of plugged calcretes are consistent with weathering under a warm arid climate, probably during the last interglacial. However, most evidence shows that the last interglacial was characterized by a 'continental warm summer' rather than 'arid' climate (Jones and Keen, 1993). The disruption of soil horizons and bedding and the reorientation of stones probably took place under periglacial conditions during the Devensian.

Langport Railway Cutting is one of the key sites in the argument about the possible glaciation of southern Somerset, as suggested by Gilbertson and Hawkins (1978a, 1978b), or a more widespread glaciation of southern England, as argued by Kellaway (1971) and Kellaway *et al.* (1975), or the development of a proglacial lake in southern Somerset as hypothesized by Stephens (1966b, 1970b, 1973). A possible glacial erratic was recorded some 7 km north at Greylake (Kidson *et al.*, 1978; Gilbertson, pers. comm., 1982), but Langport Railway Cutting contains only clasts derived from within the Parrett catchment and therefore probably lay beyond any possible glacial or glaciolacustrine limits.

Conclusion

Langport Railway Cutting was selected as a good example of 'cold-stage' fluvial sedimentation seen in a rare permanent exposure. The site has well-preserved scour-and-fill stratification typical of deposition from a braided river and well-preserved, if sparse, molluscan assemblages. It is also unusual among British 'cold-stage' sites for having yielded remains of the larvae of aquatic insects. The upper part of the sequence shows good examples of post-depositional modification by periglacial and pedogenic processes including the rather unusual process of calcrete formation during the last interglacial. The site has stratigraphical significance: it is part of the oldest (and only pre-Ipswichian) terrace of the River Parrett and is located at the Langport Gap, a key locality in southern Somerset where the presence within a small area of several important fluvial and marine formations enables their morphostratigraphical relationships to be elucidated. The site also helps to establish the limits of glaciation in southern Somerset; it contains only rock types derived from within the Parrett catchment and therefore probably lay beyond any possible glacial or glaciolacustrine limits.

GREYLAKE (NO. 2 QUARRY)
C. O. Hunt

Highlights

This classic locality is the type-site for the Burtle Formation – a complex of shallow marine shelly sands, gravels and clays probably dating from more

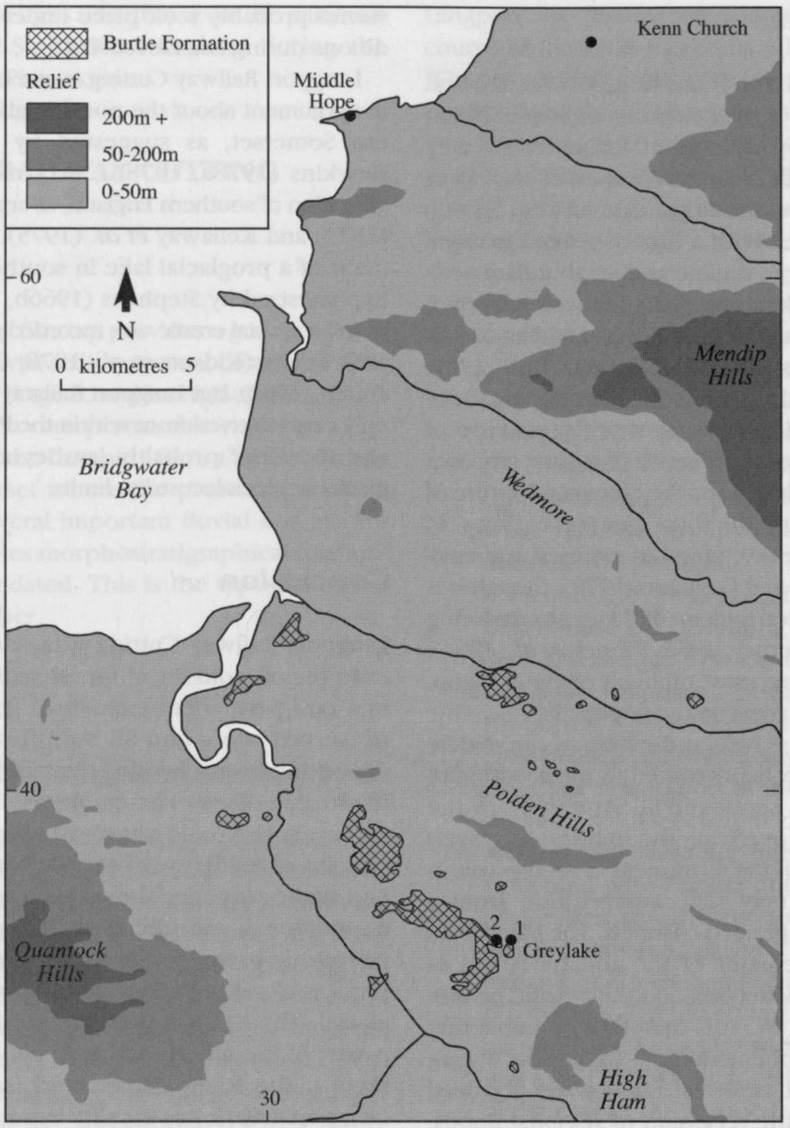

Figure 9.3 The Burtle Formation of the Somerset lowland. (Adapted from Kidson *et al.*, 1978 and Hunt, 1987.)

than one interglacial. The old Greylake No. 2 Quarry is the best known and most studied Burtle Beds locality, and has yielded rich fossil mollusc, foraminifer and ostracod assemblages as well as mammal bones. At least two phases of interglacial marine sedimentation can be demonstrated, with the marine beds separated by a well-developed calcreted palaeosol. The site may mark the southernmost limit of the Kenn glaciation in Somerset.

Introduction

The name 'Burtle Beds' was coined by Buckland and Conybeare (1824) for shelly sands and sandy gravels which form 'batches' – the local name for areas raised above the alluvial deposits of the Somerset Levels (Figure 9.3). They described the distribution of the shelly sands around King's Sedgemoor and suggested a littoral marine origin. Later, in a number of rather inexact reports (e.g. Poole, 1864), shelly sands were described from the lower part of the Parrett Valley but no precise locality details were given. Ussher (*in* Woodward, 1876) noted shelly marine sand at a number of localities near Middlezoy and Westonzoyland. The presence of marine sand in the Greylake pits was first noted by Ussher (1914), but detailed description of the site awaited the work of Bulleid and Jackson (1937), who described shelly sands and gravels from the uppermost 5 m of the sequence, down to the water-table. They listed a fossil mammal fauna of *Dama* cf. *dama*, *Cervus elaphus* Linné and *Bos primigenius* Bojanus and a diverse marine mollusc fauna. Two valves of *Corbicula fluminalis* (Müller), a freshwater bivalve now extinct in Europe, were found in the marine deposits.

In the early 1970s, Kellaway and his co-workers (Kellaway, 1971; Kellaway *et al.*, 1975) suggested that the Burtle Beds were outwash deposits associated with a glacial incursion into southern England. Kidson and colleagues reinvestigated the Burtle Beds and vigorously restated their marine interglacial origin (Kidson and Haynes, 1972; Kidson *et al.*, 1974; Kidson and Heyworth, 1976; Kidson, 1977; Kidson *et al.*, 1978; Hughes, 1980). Kidson *et al.* (1978) gave a definitive description of the beds visible in Greylake No. 2 Quarry in the mid-1970s (Figure 9.4). These workers conducted an intensive investigation of the stratigraphy, sedimentology, molluscs, foraminifers, ostracods, plant macrofossils and pollen. They demonstrated a sequence of basal non-marine deposits overlain by a silt-clay intertidal mudflat unit in turn overlain by the marine Burtle sands and gravels, and interpreted the evidence as showing the progress of a marine transgression to a mean sea level about 12 m higher than today's.

Amino-acid racemization ratios derived from *P. vulgata* and *Macoma balthica* (Linné) from Greylake No. 2 Quarry were given by Andrews *et al.* (1979), who assigned the site to their amino-acid Group 2, which they regarded as of last interglacial age. More recently, Hunt *et al.* (1984) obtained ratios on *Corbicula* from Greylake No. 1 Quarry, less than 400 m from this site. These ratios, in the light of subsequent research, suggest that these shells, and thus probably the deposits at Greylake No. 1 Quarry, date from Oxygen Isotope Stages 9 and 7, whereas at least part of the sequence at Greylake No. 2 Quarry is more recent, dating from Stage 5e.

During reinvestigation of the site for the GCR, a series of boreholes was drilled to the west of the old quarry. These proved a sequence of fine silts overlying shelly sands and then a strongly calcreted gravelly palaeosol overlying further marine sands. Recently, Campbell *et al.* (in prep.) classified the lower sands as the Greylake Member of the Burtle Formation, and correlated them with Oxygen Isotope Stage 7; the upper marine sand unit is termed the Middlezoy Member and is correlated with Stage 5e.

Description

The deposits at Greylake No. 2 Quarry (ST 385336) extend to around 9 m OD and thus stand 2–3 m above the local Holocene deposits. The sequence in the old quarry (following Bulleid and Jackson (1937) and Kidson *et al.* (1978)), and confirmed by the GCR boreholes to the west, can be summarized thus (maximum bed thicknesses in parentheses):

16. Olive-grey silts, containing freshwater molluscs and large specimens of *Cepaea* and other land snails, on which is developed a modern soil profile. (1.4 m)
15. Reddish-brown sandy silts on which is developed a modern soil profile. Bed 15 passes gradually into bed 14. (1.0 m)
14. Pale yellow-brown fine-medium sand, cross-bedded, with heavily but irregularly carbonate-cemented horizons, and sometimes weathered and reddened towards the top. Contains occasional to abundant shells of *M. balthica* and *Hydrobia* spp. (2.0 m)

13b. Pale yellow-brown, sandy shelly gravel with abundant *H. ulvae*, some *Hydrobia ventrosa* (Montagu) and a few *Phytia myosotis* (Draparnaud), *Littorina* spp., *M. edulis*, *O. edulis*, *Retusa* sp. and *Patella* sp. *C. fluminalis* and bones of *B. primigenius*, *Dama* cf. *dama* and *C. elaphus* were reported from this horizon by Bulleid and Jackson (1937). This bed may pass laterally into bed 13a. (0.3 m)

13a. Strong brown, mottled dark red, very stony clay passing down into a coarse sandy gravel strongly cemented with pedogenic calcium carbonate (a plugged calcrete horizon). (0.3 m)

12. Pale yellow fine sand, plane-bedded, with *Hydrobia ?ulvae*. (0.4 m)
11. Pale yellow-brown gravel with rare *M. balthica*, *C. edule*, *M. edulis*, *Littorina neritoides* (Linné), *Helicella itala* (Linné), *Acroloxus lacustris* (Linné) and *Armiger crista* (Linné). (0.1 m)
10. Pale yellow fine sand, plane-bedded, with *H. ulvae*, some *H. ventrosa*, *M. balthica*, *Littorina* spp. and *Patella* sp. (0.9 m)
9. Blue-grey clay with sedge and grass stems in growth position, seeds of Chenopodiaceae and one seed of *Betula pendula*, and abundant *H. ulvae* and *H. ventrosa*. Foraminifer and ostracod biocoenoses suggestive of estuarine mudflats are present. (0.4 m)

8. Blue-grey, silty fine sand with a few *H. ulvae* and *H. ventrosa*. The foraminifers and ostracods are consistent with deposition on estuarine mudflats, with some inwashed outer estuarine and marine taxa. (0.4 m)
7. Blue-grey clay with sedge and grass stems in growth position, seeds of Chenopodiaceae, and extremely abundant *H. ventrosa*, very abundant *H. ulvae*, rare *P. myosotis* and *Cerastoderma* sp. Foraminifer and ostracod biocoenoses suggestive of estuarine mudflats are present. (0.1 m)
6. Blue-grey, silty fine sand with abundant *H. ventrosa* and some *H. ulvae*. The foraminifers and ostracods are consistent with deposition on estuarine mudflats, with some inwashed outer estuarine and marine taxa. (0.6 m)
5. Blue-grey silt with very abundant *H. ventrosa*, abundant *H. ulvae*, rare *Lymnaea peregra* (Müller), a planorbid and foraminifers and ostracods consistent with deposition on estuarine mudflats, with some inwashed outer estuarine and marine taxa. (0.5 m)
4. Grey-brown silt passing downwards into fine sandy silt, with wood fragments, probably roots, replaced by iron oxides. (0.6 m)
3. Grey-brown gravel with frost-cracked pebbles. (0.3 m)
2. Grey-brown sandy clay. (0.2 m)
1. Grey-brown diamicton with a clayey matrix. Clasts include chalk and frost-cracked pebbles. (> 0.4 m, base unseen)

The upper part of the sequence described here is very similar to the descriptions and photograph of Greylake No. 1 Quarry given by Bulleid and Jackson (1937). Of particular interest is their description of 'earthy gravel' (beds 13a and 13b above, and their units iii and vi at Greylake No. 1 Quarry). Their plate XXVII shows the 'earthy gravel' as irregular weathering horizons cutting across the marine beds. Bed 11 or 13 seems to have been associated with a sandy channel fill from which M.P. Kerney recovered large amounts of freshwater mollusc remains (Gilbertson, 1984).

Interpretation

At least six major sedimentary units are present at Greylake No. 2 Quarry. The interpretation of several of these units is equivocal, with the present state of knowledge, and there is considerable scope for further research. The oldest unit is most probably beds 1–4 in the old quarry, which are deposits of fluvial, periglacial or possibly glacial origin capped by what is probably a palaeosol which contains evidence of forest growth. The presence of a chalk clast within the basal diamict is possibly suggestive of glacial transport, since chalk clasts were quickly lost downstream from the Chalk outcrop in southernmost Somerset as the result of normal cold-stage and warm-stage fluvial transport (Hunt, 1987). If this is the case, then Greylake is the southernmost locality in Somerset where glacigenic deposits, most probably referrable to the Kenn Formation, have been identified.

The second unit at Greylake No. 2 Quarry is the body of silts, clays, fine silty sands, fine gravels and shelly sands (beds 5–12). Beds 5–9 contain molluscs, ostracods, foraminifers and plant macrofossils all of which indicate deposition on estuarine tidal mudflats and among reed communities near High Water Spring Tides with salinity values around 15‰. Sedimentation appears to have kept abreast of sea-level rise during deposition of these beds (Kidson *et al.*, 1978). The fine sands of beds 10 and 12 are dominated by the molluscs *H. ulvae* and *M. balthica* and were therefore most probably laid down below Mean High Water Neaps (Kidson *et al.*, 1978) and quite probably near the low tide mark (Hughes, 1980). The ostracod assemblages are a thanatocoenosis with a good proportion of fully marine species, but the foraminifera are consistent with deposition in shifting sand shoals near or below low tide mark (Kidson *et al.*, 1978). The gravel (bed 11) interbedded with these sands includes the freshwater taxa *A. lacustris* and *A. crista*, and also *H. itala*, which is a sand dune species in this country. Kidson *et al.* (1978) suggest that this assemblage is consistent with deposition in the vicinity of a small stream passing through sand dunes at the back of a beach. The channel itself may have been visible in the mid 1970s but was never adequately recorded. This unit is capped by the cemented palaeosol (bed 13a), which is regarded as partially reworked by tidal action in the area documented by Kidson *et al.* (1978). Here, it is listed above as bed 13b. The deposits of beds 5–12, the Greylake Member, can probably be referred to Oxygen Isotope Stage 7 (Campbell *et al.*, in prep.).

In this account, it is assumed that the marine sequence recorded in the old quarry reflects more than one marine transgressive cycle, contrary to the interpretation of Kidson *et al.* (1978). The third unit comprises the classic Burtle sands and gravels of the Middlezoy Member. The basal bed (13b) is a

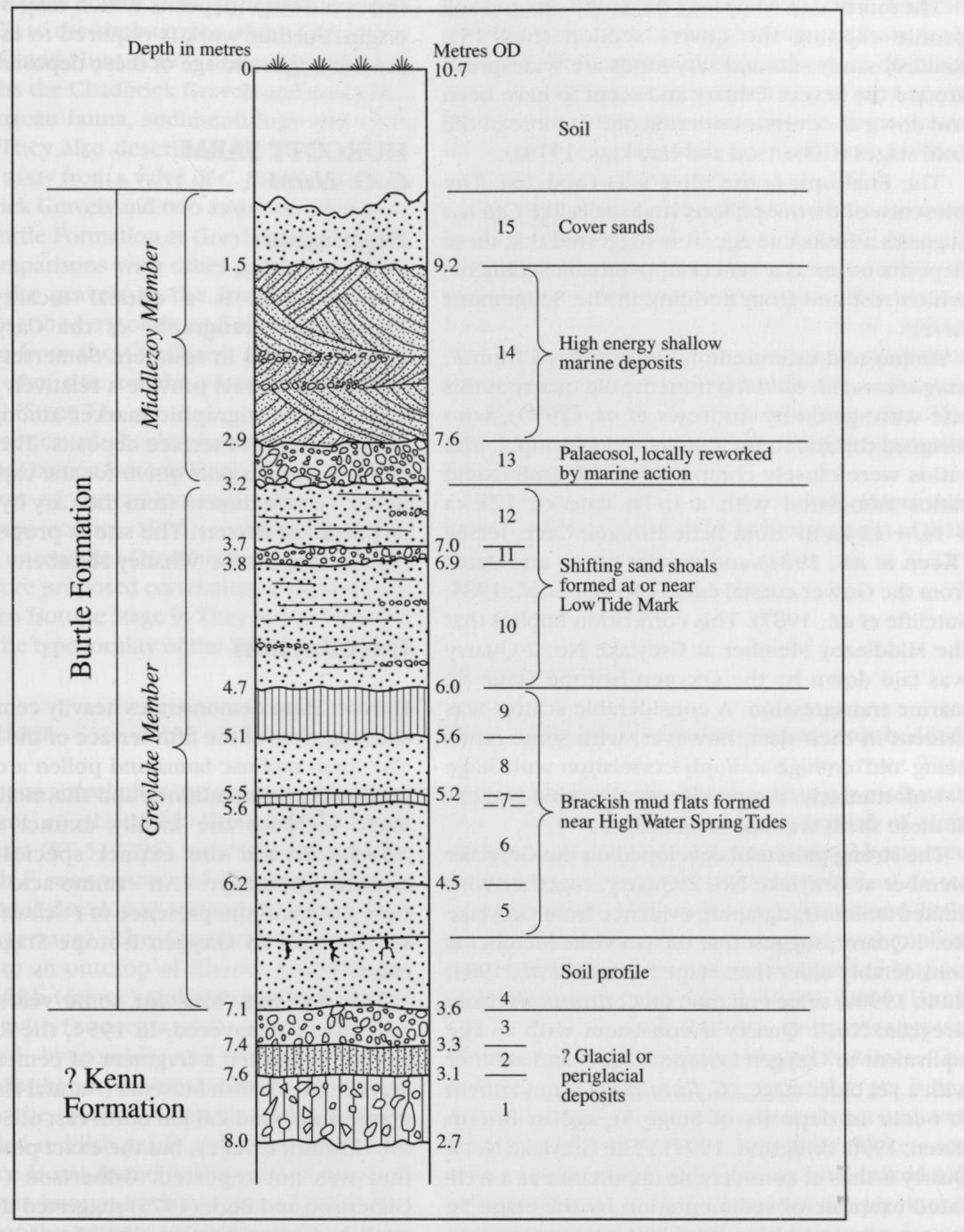

Figure 9.4 An interpretation of the Quaternary sequence at Greylake No. 2 Quarry, adapted from Hughes (1980). Beds 1–15 are described in more detail in the text.

lag deposit containing fossil molluscs, such as *C. fluminalis*, recycled from the Greylake Member. The mammal bones from this horizon – *C. elaphus*, *B. primigenius* and *Dama* cf. *dama* – are a warm-stage assemblage, but not ecologically very specific. The sands and gravels above this level contain mollusc, foraminifer and ostracod assemblages. These and the mollusc assemblage in bed 13b are all consistent with deposition around Low Water Neap Tides. Kidson *et al.* (1978) computed a Mean Sea Level 12 m above the modern MSL and a high tide level of around 18 m OD for the peak of the marine incursion, which is equated here with Oxygen Isotope Stage 5e.

The fourth unit comprises the sandy silts and soil profile capping the quarry section (bed 15). Reddish sandy silts and silty sands are widespread around the Severn Estuary and seem to have been laid down as coversands during one or more of the cold stages (Gilbertson and Hawkins, 1978a).

The final unit is the olive silts (bed 16). The presence of thermophilous land snails like *Cepaea* suggests a Holocene age. It is suggested that these deposits occur as a veneer of overbank sediments which resulted from flooding in the Sedgemoor Levels.

Amino-acid racemization ratios derived from *P. vulgata* and *M. balthica* from the old quarry at this site were given by Andrews *et al*. (1979), who assigned the site to their amino-acid Group 2. The ratios were closely comparable with amino-acid ratios associated with a U/Th date of 121 ka + 14/− 12 ka BP from Belle Hougue Cave, Jersey (Keen *et al*., 1981) and similar ratios and dates from the Gower coastal caves (Bowen *et al*., 1985; Sutcliffe *et al*., 1987). This correlation implies that the Middlezoy Member at Greylake No. 2 Quarry was laid down by the Oxygen Isotope Stage 5e marine transgression. A considerable scatter was evident in their data, however, with some ratios being 'old' enough to imply correlation with Stage 7. Unfortunately, the precise stratigraphic context of these shells was not recorded.

The strong palaeosol developed on the Greylake Member at Greylake No. 2 Quarry, together with limited aminostratigraphic evidence from Greylake No. 1 Quarry, suggest that the Greylake Member is considerably older than Stage 5 (Hunt *et al*., 1984; Hunt, 1990a) since one ratio on *C. fluminalis* from Greylake No. 1 Quarry is consistent with an age equivalent to Oxygen Isotope Stage 7 and another with a yet older stage. (*C. fluminalis* is not known to occur in deposits of Stage 5e age in Britain (Keen, 1990; Bridgland, 1994).) The Greylake No. 2 Quarry is thus of considerable importance as a well-dated example of sedimentation by the Stage 5e transgression overlying an older transgressive unit.

Conclusion

Greylake No. 2 Quarry is important because it provides a well-dated, very fossiliferous sequence laid down during the Oxygen Isotope Stage 5e marine transgression. These deposits contain a classic interglacial estuarine fauna and microfauna. The interglacial deposits overlie a palaeosol and a second, older, interglacial marine sand unit and then cold-stage deposits which may be of glacial origin. Further work is required to establish the precise origin and age of these deposits.

HURCOTT FARM

C. O. Hunt

Highlights

Hurcott Farm is a critical locality for the Pleistocene stratigraphy of the Cary and Yeo drainage basins in southern Somerset. Here, the Chadbrick Gravels provide a relatively unambiguous aminostratigraphic marker among a largely undateable set of terrace deposits. They also provide a *terminus post quem* for the capture of the upper Yeo catchment from the Cary by a tributary of the River Parrett. The site is proposed as the type-locality for the Whatley Member.

Introduction

Hurcott Farm demonstrates heavily cemented very shelly gravels of the fifth terrace of the River Cary. The fossil mollusc fauna and pollen are indicative of interglacial conditions and the mollusc assemblage includes the locally extinct species *C. fluminalis* and the extinct species *Pisidium clessini* Neumayr. An amino-acid ratio on *Corbicula* and the presence of *P. clessini* are consistent with an Oxygen Isotope Stage 9 age or older.

The site was 'lost' for some years and only recently rediscovered. In 1954, the Reverend J. Fowler presented a fragment of cemented shelly gravel to the British Museum (Natural History). The gravel was found 2.8 km north-east of Somerton in the Chadbrick Valley, but the exact position of the find was not reported. Gilbertson (1974) and Gilbertson and Beck (1975) suggested that the fragment had come from an area of terrace gravels of the River Cary mapped by the Geological Survey near Hurcott Farm. They identified a number of molluscs, including *Valvata piscinalis* (Müller), *L. peregra*, *Planorbis* sp., *Hygromia (Trichia)* cf. *hispida*, *C. fluminalis*, *Pisidium henslowanum* (Sheppard), *Pisidium nitidum* (Jenyns) and *Pisidium* sp. They interpreted the assemblage as indicating fluvial interglacial conditions.

The shelly gravels were relocated in 1982 (Hunt *et al*., 1984; Hunt, 1987), lying on the valley side some 6 m lower than the terrace gravels mapped by the Geological Survey. The latter were referred (Hunt, 1987) to the sixth terrace of the Cary. Hunt *et al.* (1984) and Hunt (1987) named the fifth terrace deposits the Chadbrick Gravels and described their molluscan fauna, sedimentology and clast lithology. They also described the results of an amino-acid assay from a valve of *C. fluminalis* from the Chadbrick Gravels and two assays on *Corbicula* from the Burtle Formation at Greylake and, on the basis of comparisons with other published ratios, attributed the gravels to the Ipswichian. Hunt (1990a) described a pollen and algal microfossil assemblage from the Chadbrick Gravels and re-attributed the site to the 'Stanton Harcourt Interglacial' (Stage 7).

The presence of *P. clessini*, which became extinct after Oxygen Isotope Stage 9 (Keen, 1992), and a re-run of the amino-acid ratio to 0.225 (Bowen, pers. comm., 1996), make earlier interpretations untenable. Campbell *et al.* (in prep.) have therefore proposed correlation of the deposits with Oxygen Isotope Stage 9. They also designated the site as the type-locality of the Whatley Member.

Description

Six Pleistocene gravel units are present in the Cary Valley (Hunt *et al.*, 1984; Hunt, 1987). Near Hurcott Farm (ST 512296), coarse poorly sorted gravels with *P. muscorum* and *Trichia* cf. *hispida* underlie a well-developed terrace surface at 43 m OD (sixth terrace). The Chadbrick Gravels are cemented to an outcrop of Rhaetic limestone at 37 m OD (fifth terrace) and overlain by 0.5 m of silty sands with fragments of *P. muscorum*, succineids and hygromids and 0.5 m of stony colluvium. Farther downslope at 29 m OD are fragments of the fourth terrace, underlain by plane-bedded reddish sands and fine gravels. The third terrace is not found in this part of the Cary Valley, but is known both upstream and downstream. Near the present valley floor, the second terrace surface at 14 m OD is underlain by coarse, poorly sorted unfossiliferous gravels. Woodward (1905) described further coarse gravels underlying the Cary floodplain alluvium in foundation trenches for the Somerton railway viaduct. These can be traced upstream into the first terrace of the Cary.

The Chadbrick Gravels lie on a gently undulating surface cut into Rhaetic limestones. One unit of clast-supported, imbricated, epsilon cross-bedded shelly cemented gravel is present, truncated by erosion and overlain by uncemented silty sands and stony silts. The gravels are well sorted, with an average clast size around 5.0 mm, and are well rounded. The cement is very uneven in development, consisting of irregular areas of grey-green micrite, which weathers rusty brown, interspersed with areas of sparry calcite. Voids are present under some large clasts (Hunt *et al.*, 1984).

The fossil mollusc fauna (Table 9.1) is dominated by *V. piscinalis* (35.5%), with lesser *L. peregra* (16.5%), *Bithynia tentaculata* (Linné) (9.6%), *C. fluminalis* (7.3%) and other species. The extinct bivalve *P. clessini* is present (Hunt *et al.*, 1984). The pollen assemblage is marked by abundant *Alnus* (24.7%) and Cyperaceae (20.5%), and a variety of broad-leaved tree and wetland species. The algal microfossils *Pediastrum* and *Spirogyra* are present (Hunt, 1990a).

An amino-acid assay on a valve of *C. fluminalis* gave a D-*alloisoleucine* to L-*isoleucine* ratio of 0.18 (Hunt *et al.*, 1984). This was re-run at 0.225 (Campbell *et al.*, in prep.).

Interpretation

The Chadbrick Gravels are epsilon cross-bedded, indicating deposition in a meandering river. They contain a diverse, temperate freshwater molluscan fauna, with a group of species typical of slow moving, calcareous, eutrophic mud-bottomed rivers and a group of species typical of faster moving water with sandy substrates and little aquatic vegetation. This is consistent with molluscan assemblages from rivers characterized by pool and riffle sequences (Hunt *et al.*, 1984; Hunt, 1987). The terrestrial molluscs are species typical of woodland and damp sheltered habitats. The pollen assemblage is of interglacial type, being dominated by broad-leaved arboreal taxa and wetland species. It probably reflects alder thickets and sedge marsh close to the river and mixed-oak woodland beyond. The presence of the planktonic *Pediastrum* and the benthonic *Spirogyra* is consistent with deposition in a fluvial environment (Hunt, 1990a).

The original amino-acid ratio is broadly comparable with ratios from the Stanton Harcourt Stage 7 interglacial deposits (Bowen *et al.*, 1989; Hunt, 1990a), but the re-run ratio is more compatible with ratios indicative of an Oxygen Isotope Stage 9 age (Bowen, pers. comm., 1996), as is the presence of *P. clessini*, which became extinct after Stage 9 (Keen, 1992). The high tree pollen percentages are also similar to those from other Stage 9 sites,

Table 9.1 Fossil molluscs from the Chadbrick Gravel

Species	*Number*	*Percentage*
Valvata cristata (Müller)	1	0.4
Valvata piscinalis (Müller)	88	35.5
Bithynia tentaculata (Linné)	24	9.6
Physa fontinalis (Linné)	1	0.4
Lymnaea stagnalis (Linné)	1	0.4
Lymnaea peregra (Müller)	41	16.5
Planorbis spp.	2	0.8
Gyraulus laevis (Alder)	7	2.8
Ancylus fluviatilis (Müller)	1	0.4
Unio sp.	3	1.2
Corbicula fluminalis (Müller)	18	7.3
?*Sphaerium* sp.	1	0.4
Pisidium amnicum (Müller)	9	3.6
Pisidium clessini Neumayr	5	2.0
Pisidium henslowanum (Sheppard)	5	2.0
Pisidium nitidum Jenyns	1	0.4
Pisidium subtruncatum Malm	4	1.6
Pisidium spp.	22	8.9
Oxyloma cf. *pfeifferi*	5	2.0
Cochlicopa cf. *lubrica*	1	0.4
Vallonia cf. *pulchella*	1	0.4
Discus rotundatus (Müller)	1	0.4
?*Helicella* sp.	1	0.4
Trichia cf. *hispida*	6	2.4
Total	**248**	

whereas most Stage 7 sites have relatively low tree pollen percentages. Capture of the former headwaters of the Cary by the Yeo, a tributary of the Parrett, occurred after aggradation of the second terrace of the Cary (Hunt, 1987).

Conclusion

The Chadbrick Gravels at Hurcott Farm have yielded important interglacial molluscan and pollen assemblages. A re-run of an amino-acid assay on a valve of *C. fluminalis* yielded a ratio of 0.225, comparable with ratios from sites attributed to Oxygen Isotope Stage 9. There is support for this ascription from the molluscan and palynological data. Hurcott Farm is a critical locality for the Pleistocene stratigraphy of the Cary and Yeo drainage basins in southern Somerset, where the Chadbrick Gravels provide a relatively unambiguous aminostratigraphic marker among a largely undateable set of terrace deposits. They help to determine when the upper Yeo catchment was captured from the Cary by a tributary of the River Parrett. Non-marine interglacial deposits are unusual in South-West England, making Hurcott Farm's aminostratigraphically correlated interglacial molluscan and pollen assemblages of considerable importance to reconstructions of Pleistocene history.

PORTFIELD
C. O. Hunt

Highlights

Portfield is a key site in the terrace stratigraphy of the Parrett catchment because amino-acid ratios on molluscs from the site provide rare chronological control in a largely undated set of terraces. The site is also important for its interglacial, non-marine fossil mollusc fauna. It is the type-locality for the Portfield Member of the Parrett Formation.

Introduction

Portfield is the only surviving locality of the fifth terrace of the Parrett/Isle system. The site is complex. A basal weathered diamicton is overlain by silts which contain freshwater and terrestrial fossil molluscs of interglacial affinity. The silt unit extends to 12.5 m OD and is overlain by over 6 m of gravelly sands which contain a sparse and restricted mollusc fauna. These are succeeded by stony diamictons. Amino-acid ratios derived from shells in the interglacial silts suggest an Oxygen Isotope Stage 7 age.

Quaternary gravelly sands were briefly reported from Portfield by Hughes (1980), who equated them with the interglacial marine Burtle Formation of the Somerset Levels. The site was reinvestigated by Hunt (1987) and Hunt and Bowen (in prep.) who drilled a number of boreholes, conducted mollusc analyses and amino-acid geochronometric assays and attributed the interglacial deposits to Oxygen Isotope Stage 7. Campbell *et al.* (in prep.) accepted this correlation, and named the interglacial deposits the Portfield Member.

Description

Near Portfield, the former existence of deposits of the fifth terrace of the Parrett/Isle system can be seen from 'flats' in the landscape underlain by extensive spreads of shallow gravel-based soil

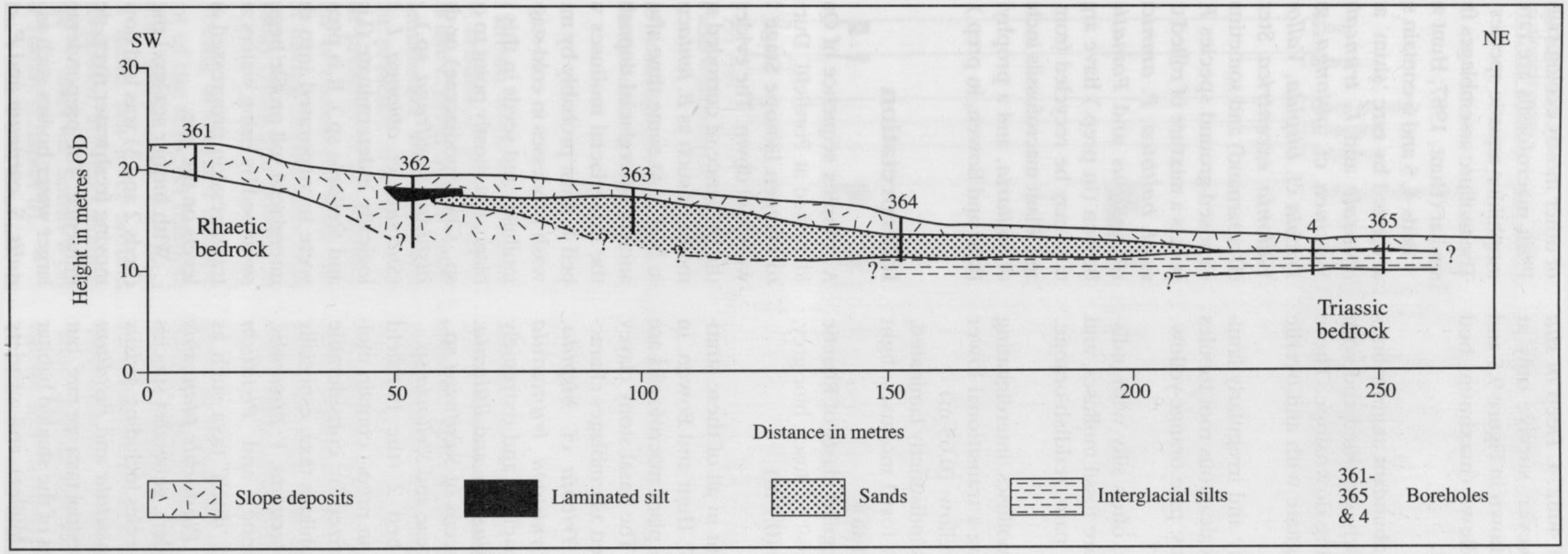

Figure 9.5 A cross-section of the Pleistocene deposits at Portfield. (Adapted from Hunt, 1987.)

between ST 409260 and ST 408274. Deep *in situ* Pleistocene deposits, however, survive only at Portfield. The sequence is shown in Figure 9.5 and can be summarized as follows (maximum bed thicknesses in parentheses):

6. Sandy silty clays with abundant angular limestone fragments, crudely stratified and with clast long-axes pointing downslope. These slope deposits interdigitate with and overlie beds 5 and 4. (2.0 m)
5. Sandy silts, indistinctly and irregularly laminated, with abundant calcareous root tubules and rare fossil molluscs; pale orange-yellow. (0.5 m)
4. Fine to medium sands, often silty with indistinct lamination and rare fossil molluscs, and sometimes gravelly; pale reddish-orange. (6.5 m)
3. Fine sands with fossil molluscs, interdigitating with bed 2, and having a transitional lower junction with it; pale yellow. (0.65 m)
2. Clayey silts, sometimes indistinctly laminated, with rare to abundant fossil molluscs; light green to blue-grey. (1.1 m)
1. Stiff clayey silt with angular clasts of Rhaetic limestone, with rare fossil molluscs; blue-grey, mottled strong brown. (0.7 m)

Fossil molluscs are present in all of these stratigraphical units (Hunt, 1987; Hunt and Bowen, in prep.; Figure 9.6) and a few plant macrofossils are also present in some units. The basal stony clayey silts (bed 1) contain restricted assemblages characterized by taxa such as *Trichia* cf. *hispida*, *Succinea* cf. *oblonga*, *Lymnaea truncatula* (Müller), *Helicella* sp., Limacidae and extremely corroded fragments of *Pisidium* sp. and *Bithynia*. Plant macrofossils include seeds of *Saxifraga* sp., Polygonaceae, Chenopodiaceae and *Stellaria* sp.

The laminated silts of bed 2 (the Portfield Member of Campbell *et al.*, in prep.) contain mollusc assemblages characterized by considerable numbers of aquatic thermophilous taxa, especially 'river' species such as *B. tentaculata*, *V. piscinalis*, *Sphaerium corneum* (Linné) and *Pisidium amnicum* (Linné) but also 'ditch' taxa such as *Valvata cristata* (Müller), *Planorbis planorbis* (Linné), *Gyraulus laevis* (Alder), generalist species like *L. peregra*, and 'slum' species including *Anisus leucostoma* (Millet), *L. truncatula* and *Pisidium obtusale* (Lamarck). The terrestrial taxa are rare, but include occasional specimens of the shaded habitat species *Discus rotundatus* (Müller), and a variety of other mostly ecologically indeterminate species. Plant macrofossils are rare, but include the thermophilous aquatic species *Zannichellia palustris*. The mollusc assemblages from bed 3 are essentially similar (Hunt, 1987; Hunt and Bowen, in prep.).

Beds 4, 5 and 6 contain sparse assemblages characterized by rare 'slum' aquatic taxa, such as *P. obtusale* and *L. truncatula*, the marsh taxon *Succinea* cf. *oblonga*, grassland taxa such as *Trichia* cf. *hispida*, *Vallonia pulchella* (Müller), *Vallonia excentrica* Sterki, *Vertigo pygmaea* (Draparnaud) and sometimes large numbers of the exposed-ground species *P. muscorum*. Also present is a mixture of rolled thermophilous taxa such as *M. balthica*, *P. amnicum*, *Viviparus* sp., *D. rotundatus* and *Pomatias elegans*. Hunt and Bowen (in prep.) have argued that the grassland taxa may be recycled from soil profiles of Stage 7 age. Plant macrofossils include *Carex* nutlets, seeds of *Stellaria*, and a prophyll of *Salix* (Hunt, 1987; Hunt and Bowen, in prep.).

Interpretation

A complex sequence of Quaternary events can be identified at Portfield. During an interglacial prior to Oxygen Isotope Stage 7, interglacial deposits were laid down. The evidence for these deposits is the presence of corroded specimens of freshwater molluscs such as *B. tentaculata* and *Pisidium* spp. in bed 1. At some time after the deposition of this ancient interglacial deposit, it was destroyed and the interglacial molluscs were incorporated into bed 1, most probably by mudflow, solifluction and wash processes in cold-stage conditions. The other molluscs and seeds in this unit are a mixed assemblage, but mostly point to open exposed (*Helicella* sp., Chenopodiaceae) or damp grassy (*Trichia* cf. *hispida*, *Saxifraga* sp.), or marshy conditions (*Succinea* cf. *oblonga*, *L. truncatula*) or are ecologically indeterminate (Limacidae, Polygonaceae and *Stellaria* sp.). It is presumed that these fossils were incorporated into the deposit as an early-interglacial soil profile began to form and was then swamped by rising waters as the interglacial marine transgression progressed and caused rising water levels on the site.

With further sea-level rise, the Portfield Member (beds 2 and 3) was laid down by a perennial, slow-moving freshwater river, perhaps under weak tidal influence. The preponderance of species typical of larger water bodies such as *B. tentaculata*, *V. piscinalis*, *S. corneum* and *P. amnicum* points to this

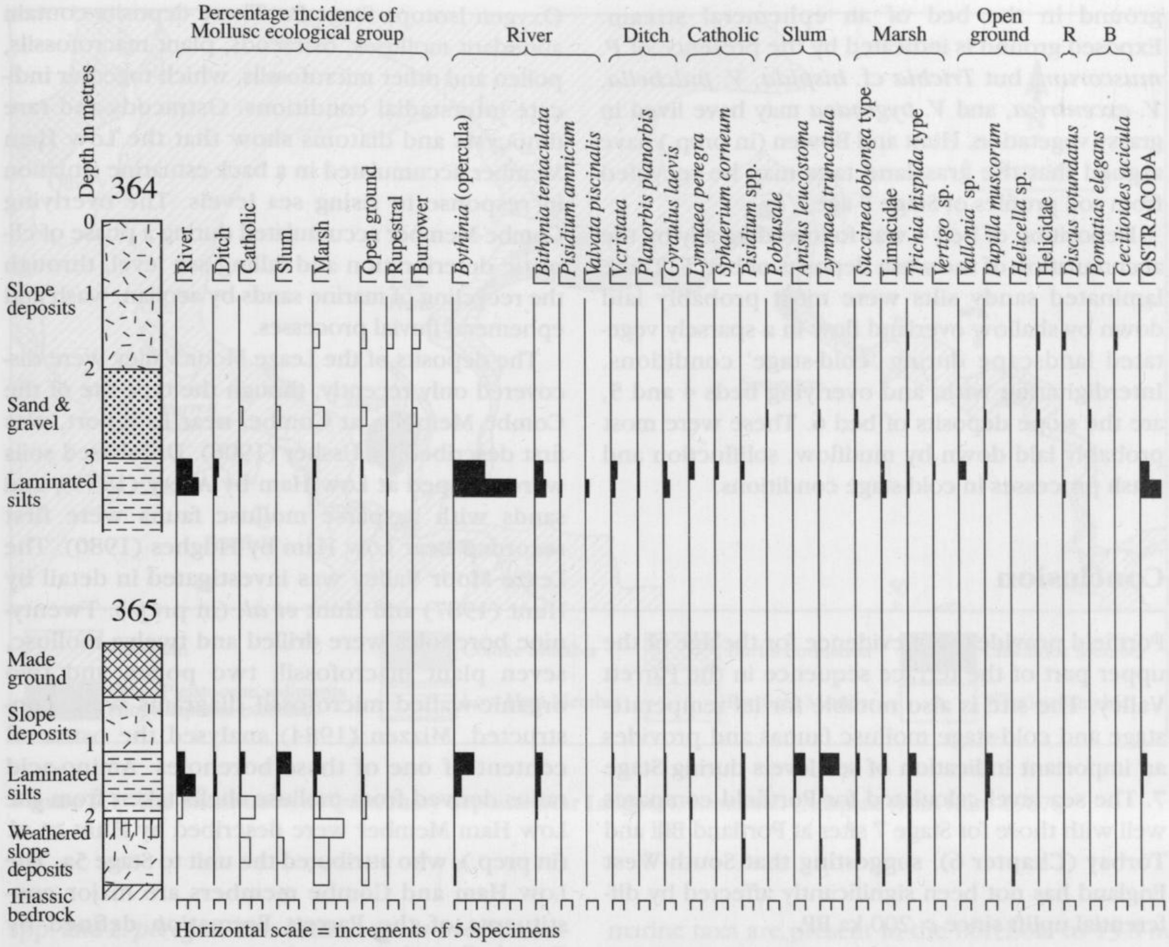

Figure 9.6 The molluscan biostratigraphy of Pleistocene deposits at Portfield, adapted from Hunt (1987). Numbers 364 and 365 refer to boreholes shown in Figure 9.5.

being more than a small stream, while the presence of 'ditch' taxa such as *V. cristata*, *P. planorbis*, *G. laevis*, generalist species like *L. peregra*, and 'slum' species including *A. leucostoma*, *L. truncatula* and *P. obtusale* indicates the presence of a variety of submerged habitats. The presence of *D. rotundatus* and *B. tentaculata* is consistent with the climate at this time not having been cooler than southern Scandinavia today (Hunt and Bowen, in prep.). The amino-acid ratios are compatible with the Portfield Member being of Oxygen Isotope Stage 7 age. Assessment of the sea-level relationships of the silts, after allowances for tidal funnelling, suggests a mean sea level around 4.5–7.5 m OD (Hunt and Bowen, in prep.), comparable with other Stage 7 sites in South-West England at Portland and Torbay (Chapter 6).

The deposition of beds 2 and 3 was followed by climate deterioration and sea-level fall. The latter led to the exposure and deflation of substantial areas of interglacial marine sands of the Burtle Formation in Sedgemoor. The deflated sand then accumulated against the Langport-Curry Rivel escarpment, behind the Portfield site. At the same time, exposed soils on the escarpment were subject to erosion. The aeolian sands and eroded soil were then redeposited at the foot of the escarpment as bed 4. Sedimentary structures in this unit point to deposition in a multi-channel ephemeral stream. The molluscs and plant macrofossils in bed 4 may be partly recycled, especially the rolled thermophilous taxa such as *M. balthica*, *P. amnicum*, *Viviparus* sp., *D. rotundatus* and *P. elegans*. The 'slum' aquatic and marsh taxa, *P. obtusale*, *L. truncatula* and *Succinea* cf. *oblonga*, are the type of assemblage that might colonize pools and wet ground in the bed of an ephemeral stream. Exposed ground is indicated by the presence of *P. muscorum*, but *Trichia* cf. *hispida*, *V. pulchella*, *V. excentrica*, and *V. pygmaea* may have lived in grassy vegetation. Hunt and Bowen (in prep.) have argued that the grassland taxa may be recycled from soil profiles of Stage 7 age.

Deposition of bed 4 was followed locally by the accumulation of the wash deposits of bed 5. These laminated sandy silts were most probably laid down by shallow overland flow in a sparsely vegetated landscape during 'cold-stage' conditions. Interdigitating with, and overlying beds 4 and 5, are the slope deposits of bed 6. These were most probably laid down by mudflow, solifluction and wash processes in cold-stage conditions.

Conclusion

Portfield provides vital evidence for the age of the upper part of the terrace sequence in the Parrett Valley. The site is also notable for its temperate-stage and cold-stage mollusc faunas and provides an important indication of sea levels during Stage 7. The sea level calculated for Portfield compares well with those for Stage 7 sites at Portland Bill and Torbay (Chapter 6), suggesting that South-West England has not been significantly affected by differential uplift since *c.* 200 ka BP.

LOW HAM

C. O. Hunt

Highlights

Low Ham is of national importance as the only locality where high sea levels during a Devensian interstadial can be demonstrated. The site contains the best Stage 5a interstadial pollen, mollusc and ostracod assemblages in South-West England and is the type-site of the Low Ham Member of the Parrett Formation.

Introduction

A thick drift sequence – the Low Ham Member and the Combe Member – can be found in the Leaze Moor Valley, which cuts through the Langport-Somerton escarpment in southern Somerset (Figure 9.7). The Low Ham Member consists of sands, silts, clays and peats, dated by aminostratigraphy to Oxygen Isotope Stage 5a. These deposits contain abundant molluscs, ostracods, plant macrofossils, pollen and other microfossils, which together indicate interstadial conditions. Ostracods and rare dinocysts and diatoms show that the Low Ham Member accumulated in a back-estuarine situation in response to rising sea levels. The overlying Combe Member accumulated during a phase of climatic deterioration and falling sea level, through the recycling of marine sands by aeolian, wash and ephemeral fluvial processes.

The deposits of the Leaze Moor Valley were discovered only recently, though the type-site of the Combe Member, at Combe, near Langport, was first described by Ussher (1908). Drift-based soils were mapped at Low Ham by Avery (1955), and sands with a sparse mollusc fauna were first recorded near Low Ham by Hughes (1980). The Leaze Moor Valley was investigated in detail by Hunt (1987) and Hunt *et al.* (in prep.). Twenty-nine boreholes were drilled and twelve mollusc, seven plant macrofossil, two pollen and two organic-walled microfossil diagrams were constructed. Mizzen (1984) analysed the ostracod content of one of these boreholes. Amino-acid ratios derived from mollusc shells taken from the Low Ham Member were described by Hunt *et al.* (in prep.), who attributed the unit to Stage 5a. The Low Ham and Combe members are major constituents of the Parrett Formation defined by Campbell *et al.* (in prep.).

Description

The Low Ham beds underlie 'terraces' standing up to 4 m above Holocene alluvium in the valleys between Langport and Somerton (Hunt, 1987). At Low Ham GCR site (ST 43902900), the terrace surface lies at 19 m OD. Underlying the terrace surfaces are thick stony diamictons, then sandy gravels and laminated silts of the Combe Member with a sparse mollusc fauna characterized by *P. muscorum*, *Succinea* cf. *oblonga* and occasional *Columella edentula* (Draparnaud) (Figure 9.8).

These deposits pass down conformably into the Low Ham Member, the first unit being dark brown laminated sedge peats and thin grey silts with *Succinea* cf. *oblonga* and *P. muscorum*. These overlie dark brown highly organic detritus muds, with abundant seeds of *Zannichellia palustris*, *Potamogeton* stones and *Hippuris* nodes and stones. The mollusc fauna of this unit includes *Succinea* cf. *oblonga*, *A. leucostoma*, *Pisidium*

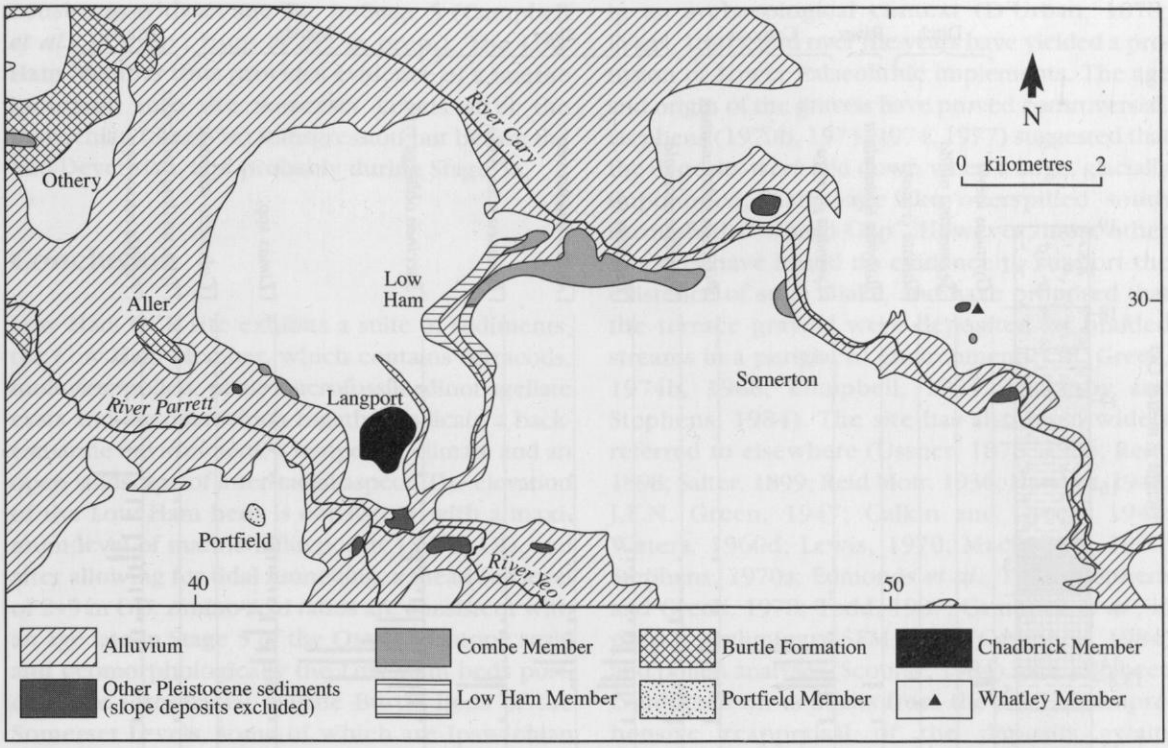

Figure 9.7 The distribution of Quaternary deposits near Langport, Somerset. (Adapted from Hunt 1987.)

spp. and *L. peregra*. The detritus muds overlie compacted mid-grey silts with *G. laevis*, *B. tentaculata*, *V. cristata*, *A. leucostoma*, *Pisidium* spp., *L. peregra* and *Succinea* cf. *oblonga*. These silts pass down into sparsely fossiliferous, pale blue-grey silty sands with *G. laevis*, *B. tentaculata*, *V. cristata*, *Pisidium* spp., and *L. peregra* and then unfossiliferous coarse red sands (Figure 9.8). Farther to the north along the Low Ham Valley, more diverse aquatic mollusc assemblages, including *Belgrandia marginata* (Michaud), were recorded (Hunt, 1987). Pollen assemblages from the detritus muds and grey silts are dominated by sedge, grass and herbs, with rare pine, birch, spruce, alder, willow and hazel. Assemblages from the laminated sedge peats and silts are of lower diversity and lack the tree and shrub species. Ostracod assemblages from the detritus muds are rich, often containing around 80 species. Occasional specimens of the salinity tolerant *Cyprideis torosa* (Jones) and a number of obligate halophilous taxa are present (Whatley *in* Hunt, 1987; Hunt *et al.*, in prep.). Also present are rare specimens of the marine dinoflagellate cysts *Operculodinium centrocarpum* and *Spiniferites* cf. *ramosus* and very rare marine diatoms. These marine taxa are present in the borehole to 13.8 m OD.

Radiocarbon assays of the Low Ham Member yielded ages of >40 300 (SRR-2450) and > 41 ka BP (SRR-2451). Amino-acid racemization assays on molluscs from the Low Ham Member are technically very difficult because of the small size of most mollusc specimens, but ratios indicate that the most probable correlation is with Oxygen Isotope Stage 5a (Bowen, pers. comm., 1996; Campbell *et al.*, in prep.; Hunt *et al.*, in prep.). However, Keen (pers. comm., 1997) notes that *B. marginata* has not been recorded in deposits younger than Stage 5e.

Interpretation

The Combe Member (beds 1 and 2) contains *P. muscorum*, *Succinea* cf. *oblonga* and *C. edentula*, an assemblage typical of 'cold-stage' terrestrial sedimentation in open exposed landscapes. The diamictons, sandy gravels and silts of these deposits are consistent with deposition by a variety of mass movement and wash processes and thus with generally poorly vegetated stadial conditions.

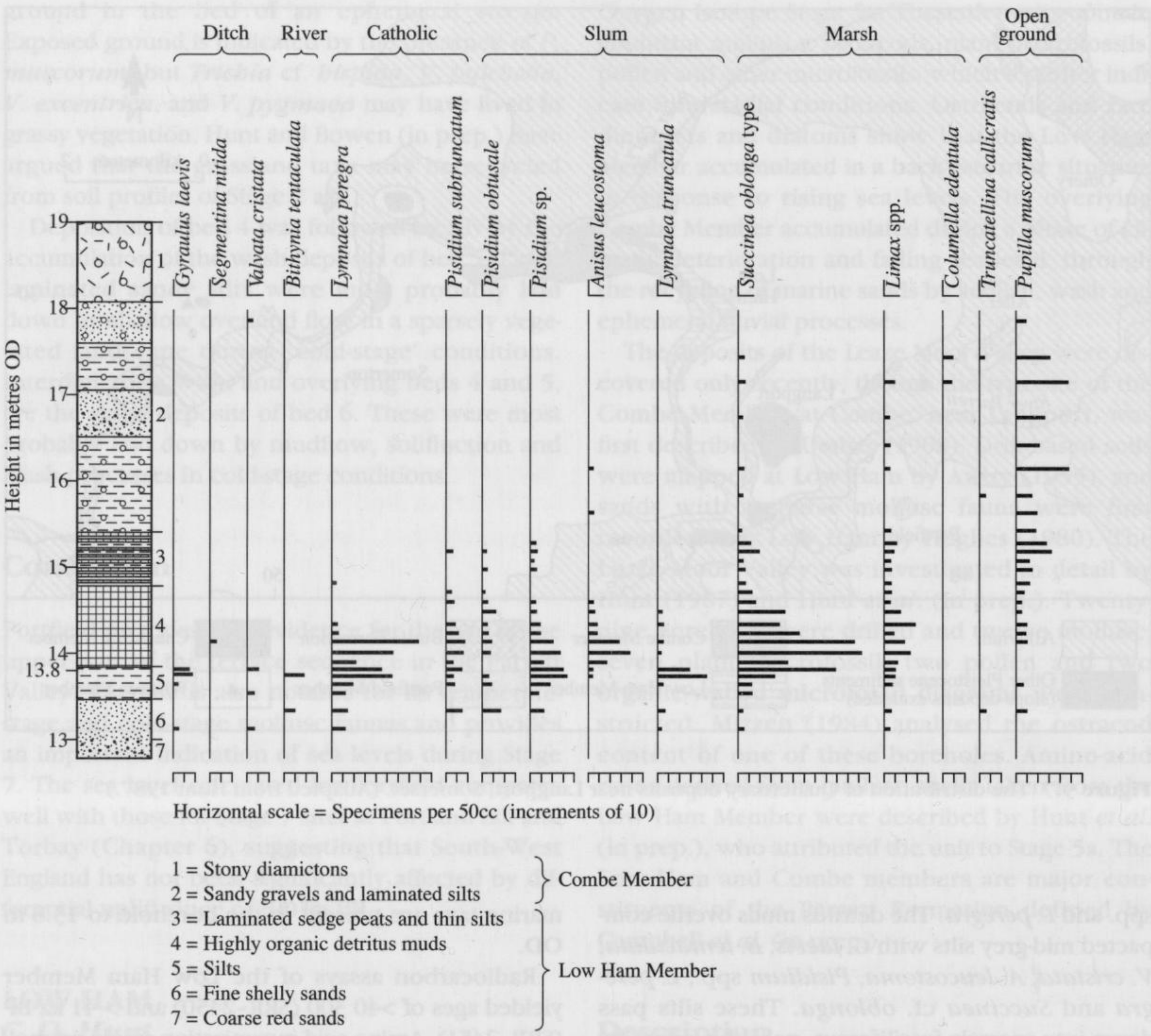

Figure 9.8 The molluscan biostratigraphy of Pleistocene deposits at Low Ham. (Adapted from Hunt 1987.)

The Low Ham Member at this site has the characteristics of a channel-fill succession, with basal moving-water sands passing up into quiet-water detritus muds and then marsh peats. The succession of molluscan species also indicates a transition from a basal assemblage consisting largely of taxa typical of moving water with some weeds, such as *B. tentaculata* and *V. cristata*, to assemblages typical of rather poor quality stagnant water, typified by *A. leucostoma* and *L. peregra* in the detritus muds, and then into marshy conditions with occasional standing water characterized by *Succinea* cf. *oblonga*, occasional *Pisidium* spp. and terrestrial molluscs.

Although no brackish-water molluscs are present, the ostracods, dinoflagellate cysts and diatoms point to marine influence up to 13.8 m OD. The tidal range in the Bristol Channel is very large as the result of tidal funnelling and, assuming similar tidal ranges in the past, a mean sea level of 2–5 m OD is probable.

The age of the Low Ham Member is still open to question. The facies of the pollen and terrestrial mollusc assemblages are consistent with interstadial rather than interglacial conditions, though the presence of *B. marginata* at some localities is incompatible with later Devensian interstadials. The most compelling biostratigraphic comparisons are with the Wretton Interstadial of Norfolk (Hunt, 1987). The radiocarbon assays indicate only an age greater than 41 ka BP, while the amino-acid ratios are broadly consistent with an age late in Stage 5 (Campbell *et al.*, in prep.; Hunt *et al.*, in prep.). The Low Ham Member thus provides evidence of a marine incursion into the Somerset Levels after the Ipswichian (Stage 5e) transgression but before the Mid-Devensian, and probably during Stage 5a.

Conclusion

Low Ham GCR site exhibits a suite of sediments, the Low Ham Member, which contains ostracods, molluscs, pollen, plant macrofossils, dinoflagellate cysts and diatoms which together indicate a back-estuarine environment, a temperate climate and an open landscape of interstadial aspect. The elevation of the Low Ham beds is consistent with a maximum level of marine influence at 13.8 m OD, and after allowing for tidal funnelling, a mean sea level of 2–5 m OD. Amino-acid ratios are consistent with an age late in Stage 5 of the Oxygen Isotope scale and geomorphologically the Low Ham beds post-date the interglacial marine Burtle Beds of the Somerset Levels, some of which are Ipswichian (although some are certainly older). The site is therefore of national importance as the only location where high sea levels subsequent to the Ipswichian Interglacial (Oxygen Isotope Stage 5e) and prior to the Holocene marine transgression can be demonstrated clearly.

BROOM GRAVEL PITS

S. Campbell, N. Stephens, C. P. Green and R. A. Shakesby

Highlights

A site of exceptional interest to geomorphologists and archaeologists alike, Broom Gravel Pits expose a thick sequence of terrace deposits once attributed to waters spilling from glacially impounded 'Lake Maw'. However, the terrace sequence is now widely believed to have been deposited by braided streams in a periglacial environment. Broom is also notable for being the richest source of Lower Palaeolithic artefacts yet known from South-West England.

Introduction

The Axe Valley terrace gravels have a protracted history of investigation. They first attracted interest in an archaeological context (D'Urban, 1878; Evans, 1897), and over the years have yielded a profusion of Lower Palaeolithic implements. The age and origin of the gravels have proved controversial. Stephens (1970b, 1973, 1974, 1977) suggested that the deposits were laid down when a large, glacially impounded, Saalian-age lake 'overspilled' south through the 'Chard Gap'. However, most other workers have found no evidence to support the existence of such a lake, and have proposed that the terrace gravels were deposited by braided streams in a periglacial environment (C.P. Green, 1974b, 1988; Campbell, 1984; Shakesby and Stephens, 1984). The site has also been widely referred to elsewhere (Ussher, 1878, 1906; Reid, 1898; Salter, 1899; Reid Moir, 1936; Hawkes, 1943; J.F.N. Green, 1947; Calkin and Green, 1949; Waters, 1960d; Lewis, 1970; Macfadyen, 1970; Stephens, 1970a; Edmonds *et al.*, 1975; Stephens and Green, 1978; Todd, 1987; Campbell *et al.*, in prep.). Preliminary SEM work (Campbell, 1984) and pollen analyses (Scourse, 1984) have also been conducted on deposits from the site. A comprehensive reappraisal of the deposits awaits publication (C.P. Green *et al.*, in prep.).

Description

Regional setting

The relationship of Broom GCR site to the 'Chard Gap' and other important topographic features is shown in Figure 9.9. Stephens (1977) has asserted that the Chard Gap is the largest and lowest (at 83–90 m OD) of a number of major breaks in the watershed between the Somerset Levels (and Bristol Channel) and the English Channel. Today, the headwaters of the north-flowing Isle are located within the gap; the Axe rises in the high ground to the north of Beaminster and flows past the southern end of the gap in a south-west direction. In east Devon and south Somerset, Cretaceous rocks (Chalk and Greensand) form multiple escarpments of varying height; less resistant Jurassic and Keuper clays and marls are exposed in the bottom of incised valleys (Ussher, 1906; J.F.N. Green, 1941; Gregory, 1969; Waters, 1971; Shakesby and Stephens, 1984). Structural and lithological variations have controlled dissection and erosion, giving rise to a 'cuesta' landscape (Stephens, 1977) with quite prominent west- and north-west-facing escarpments. Stephens (1970b) has also argued that the trench-like form of the Chard Gap is unlike

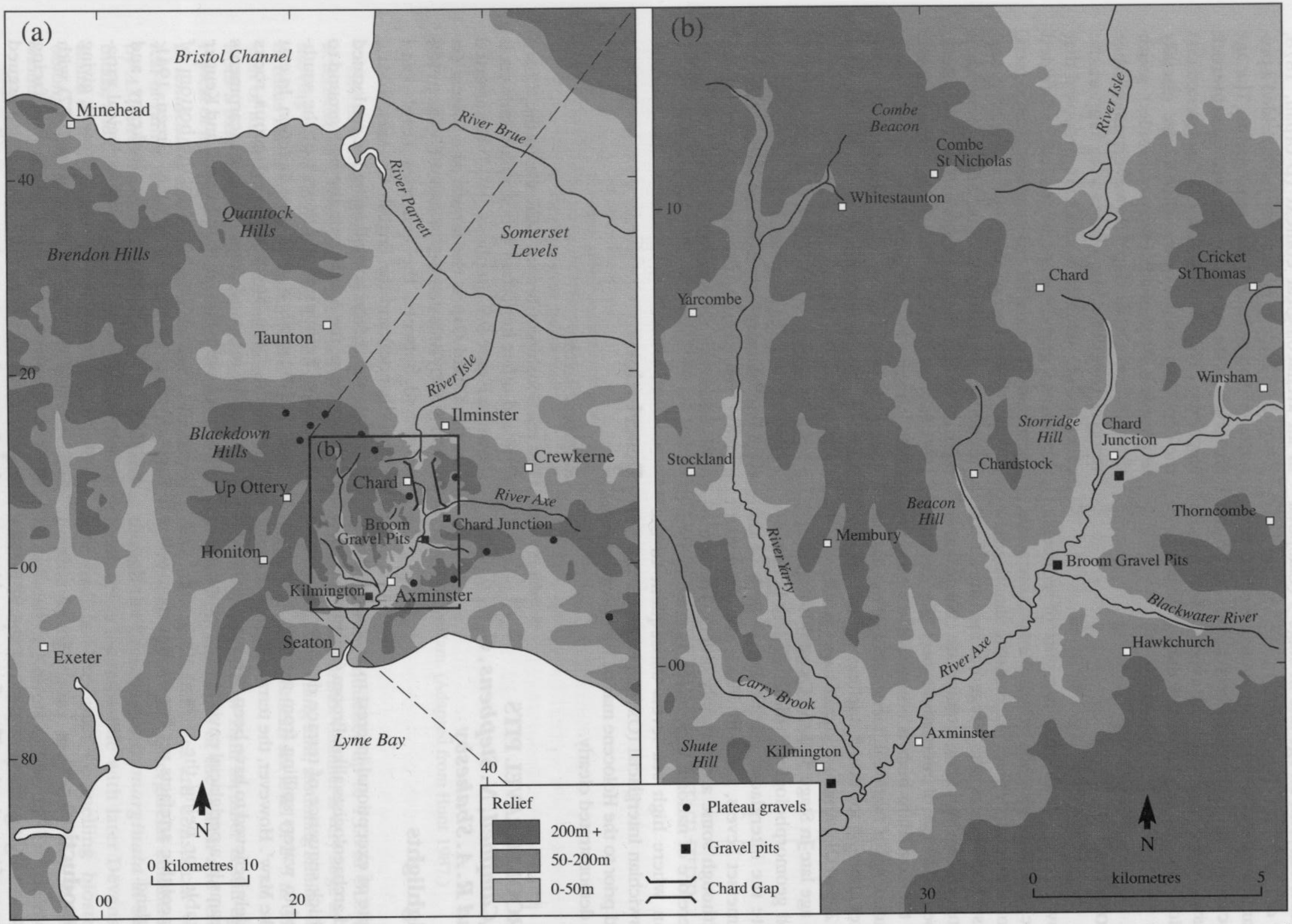

Figure 9.9 (a) The topographic setting of the Axe Valley and the distribution of plateau-gravel sites. (b) The principal exposures of the Axe Valley terrace gravels. (Adapted from Stephens, 1977 and Green *et al.*, in prep.)

any nearby watershed col except for that near Crewkerne, the Hewlish Gap, with a floor at *c.* 100–120 m OD. Local topography is therefore characterized by a series of comparatively flat-topped hills and low plateaux, although most of the Axe Valley lacks steep slopes. Between Chard Junction and Kilmington, the modern River Axe meanders across a broad floodplain; its main tributary, the Yarty, occupies a narrower, more confined valley (Shakesby and Stephens, 1984). Stephens (1974) identified five main types of superficial deposit in the local area:

1. Alluvium: mostly confined to existing river floodplains.
2. Valley gravels (described in more detail below): forming extensive outcrops on low ground to the north of the Chard Gap and also present, in small patches, within the gap and forming a major terrace in the lower Axe Valley (Figure 9.10). In places, a fine-grained 'brickearth' crops out on the surface of the terrace. The terrace surface itself declines in height seawards from *c.* 70 m OD at Chard Junction, to *c.* 65 m OD at Broom and finally to *c.* 30 m OD at Seaton on the coast (Stephens, 1973; Figure 9.10).
3. Head: this consists generally of locally derived material from various geological outcrops.
4. 'Clay-with-flints' and '-chert': this is composed largely of argillaceous material believed to have been derived from Tertiary strata, and mixed with flints and chert from Cretaceous beds. The material forms a discontinuous capping of irregular thickness on the plateau-like interfluves east and west of Chard and the lower Axe Valley (see Beer Quarry; Chapter 3).
5. Interfluve and plateau gravels: these are found in patches on both sides of the Axe Valley north of Axminster (Figure 9.9). Both Ussher (1906) and Waters (1960d) described the gravels as occurring on widely separated interfluves between *c.* 200 and 315 m; Reid (1898) interpreted them as river gravels, although Waters claimed the presence of ' ... unmistakable beach cobbles of flint' (Waters, 1960d; p. 92). The material varies from subangular to well-rounded pebbles in a sandy matrix, with chert, flint, quartz, tourmalinized rocks, greywacke, a miscellany of Palaeozoic rock types, and a few chatter-marked flint cobbles (Stephens, 1974, 1977). C.P. Green (1974b) analysed the lithological composition of these gravels which he regarded as Tertiary in age.

The Axe Valley gravels

Extensive Pleistocene terrace gravels border the River Axe and its tributaries, including the Blackwater and Yarty, lying above their modern floodplains (Figure 9.10). They form a major lithostratigraphic unit (the Axe Valley Formation) divisible into the Broom, Pratt's Pit, Chard Junction and Kilmington members (Campbell *et al.*, in prep.). The terrace 'gravels' are generally poorly sorted, comprising clasts from gravel to boulder grade. They are crudely bedded, occasionally exhibit imbrication and contain lenses of laminated sands; more continuous beds of clay, silt and sand are present locally. The gravels comprise mostly flint and chert (69–96%), but quartz (0–35%) and other pebbles derived from Palaeozoic rocks (0–12%) are present (C.P. Green, 1974b). Occasionally, the gravels contain distinctive 'blocks' or 'rafts' of laminated sand. Their upper layers are frequently disturbed by involutions.

The principal descriptions of the terrace gravels have been based on three sites: Chard Junction (ST 342044); Kilmington 'New' Pit (ST 277976) and Broom Gravel Pits (ST 326020; see below). At Chard Junction, over 11 m of terrace gravels, comprising mainly clasts of flint and chert, are exposed (Figure 9.11). The gravels are overlain by a loamy silt or 'brickearth' and the upper 1.5–2.0 m of the gravel are cryoturbated (Shakesby and Stephens, 1984). Kilmington New Pit shows at least 3 m of poorly sorted, crudely bedded terrace gravels with discontinuous lenses of silt and sand (Shakesby and Stephens, 1984). Chard Junction is currently the most substantial working, sections at many of the other pits having become somewhat degraded and overgrown. Nonetheless, the most recent stratigraphic descriptions of the terrace gravels are based on an extensive series of excavations carried out at Broom Gravel Pits between 1978 and 1981 by Stephens and colleagues (Campbell, 1984; Scourse, 1984; Shakesby and Stephens, 1984; C.P. Green *et al.*, in prep.). The Broom Gravel Pits have proved not only the most prolific source of Palaeolithic implements from the Axe Valley, but are, to date, stratigraphically the most informative – hence their selection for the GCR.

Broom Gravel Pits

The GCR site comprises two disused gravel pits on the east side of the River Axe between Wadbrook

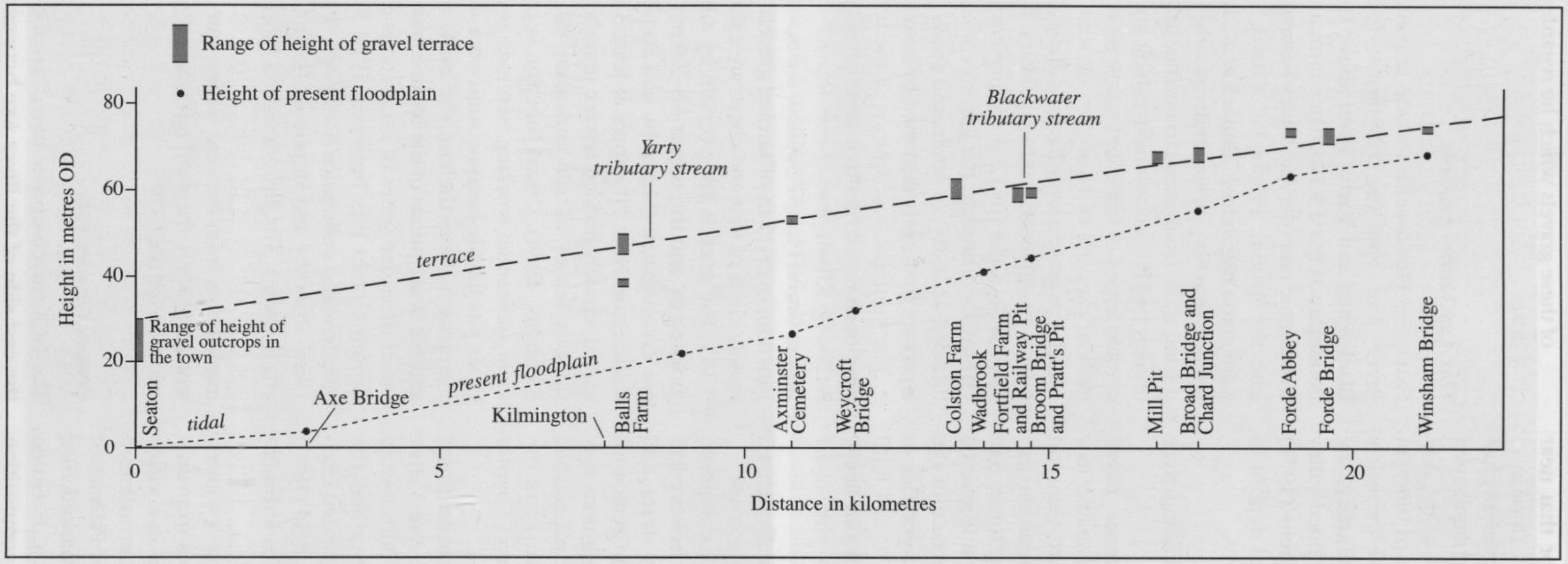

Figure 9.10 The long-profile of the modern River Axe, and the height-range and distribution of the principal terrace gravel outcrops. (Adapted from Green *et al.*, in prep.)

Figure 9.11 Extensive exposures at Chard Junction through the Axe Valley terrace gravels in 1985. (Photo: S. Campbell.)

Cross and Broom Crossing (Figure 9.12): 1. Pratt's New Pit (ST 328023); and 2. the Ballast or Railway Pit (ST 326020). A further disused pit, Pratt's Old Pit (ST 328024), occurs to the north of Holditch Lane (Figure 9.12; C.P. Green, 1988). These pits occur in a marked terrace which rises locally to *c.* 60 m OD.

Reid Moir (1936) gave the following composite stratigraphy for Broom (maximum bed thicknesses in parentheses):

4. Surface soil
3. Tumbled coarse gravels with partings of sandy clay and clayey matrix (derived implements) (7.6 m)
2. Stratified gravel with clayey and sandy seams, some black bands (fresh, unrolled implements) (2.4 m)
1. Unstratified sand and gravel (5.2 m)

The abandoned faces of the nineteenth century workings in the Ballast Pit at Broom reveal *c.* 13–15 m of chert-rich gravels disturbed by cryoturbation structures in their uppermost two metres. These gravels are overlain by a discontinuous stony silt ('brickearth'). Recent excavations at the base of the disused faces have shown that the 'chert' gravels overlie a laterally persistent layer of pollen-bearing (Scourse, 1984), manganese- and iron-stained clay, silt and sand up to 0.5 m thick (Figure 9.12d; Shakesby and Stephens, 1984; Campbell *et al.*, in prep.). These in turn overlie flint-rich gravel which extends below *c.* 45 m OD to an unknown depth (Scourse, 1984; Stephens and Shakesby, 1984; C.P. Green, 1988).

A fresh cut in Pratt's New Pit, made in 1975, revealed a similar succession comprising 6–10 m of crudely stratified gravels overlying laminated sands and clays (Stephens, 1977). The Pleistocene sequence here extends below *c.* 46 m OD to an unknown depth.

Pratt's Old Pit, north of Holditch Lane, has been reclaimed and grassed over, and is not therefore included within the GCR site. The best descriptions of the sequence here are those gleaned by C.P. Green (1988) from the notebooks of the late Charles Bean. The sequence consisted of *c.* 16 m of terrace gravels separated by up to 2 m of clay, sandy clay and loam (the Upper Gravel, Middle Beds and Lower Gravel of Green (1988)). The red

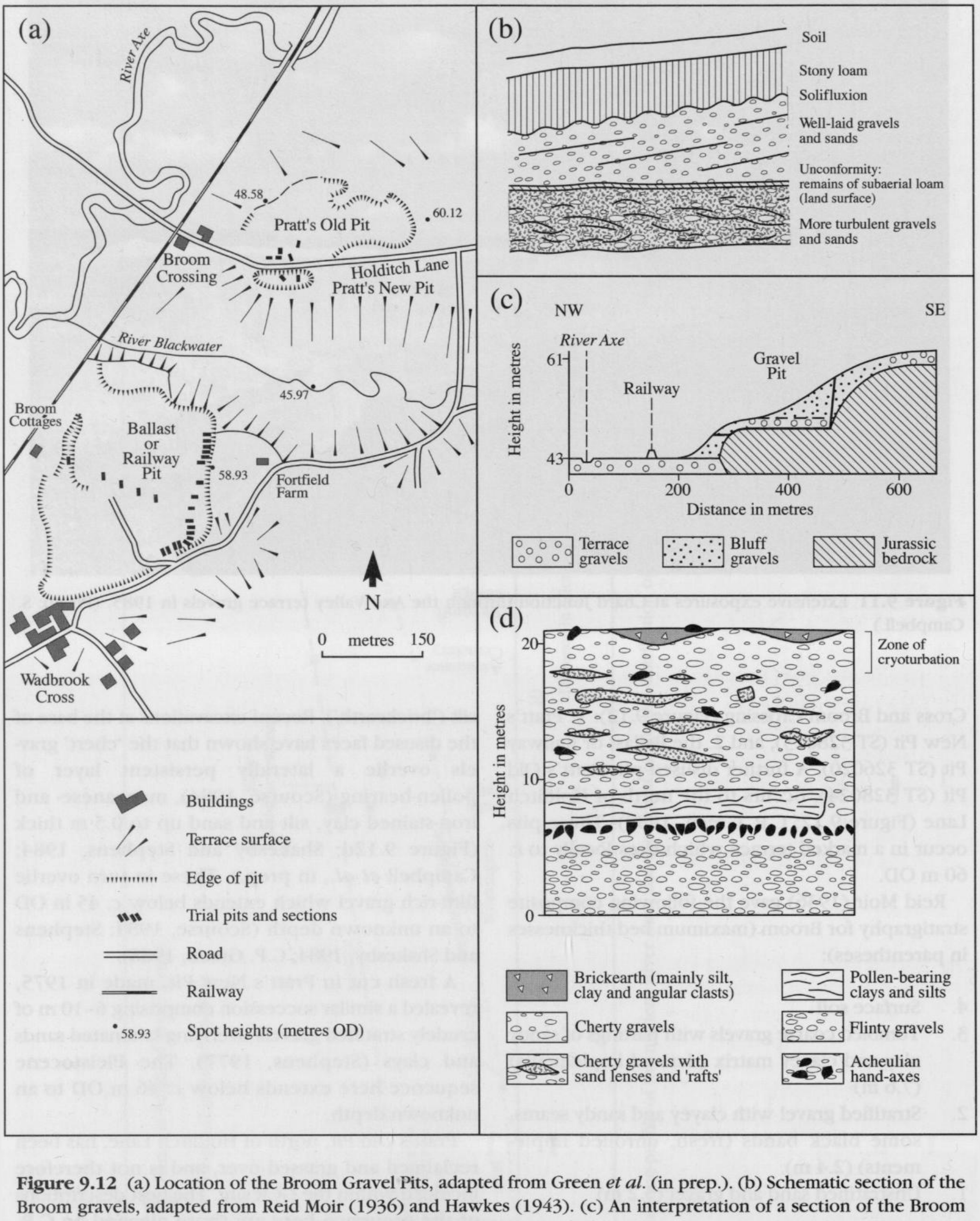

Figure 9.12 (a) Location of the Broom Gravel Pits, adapted from Green *et al.* (in prep.). (b) Schematic section of the Broom gravels, adapted from Reid Moir (1936) and Hawkes (1943). (c) An interpretation of a section of the Broom gravels, adapted from J.F.N. Green (1947) and Calkin and Green (1949). (d) A schematic composite section of the Broom gravels, adapted from Shakesby and Stephens (1984).

Upper Gravel appears to have reached a thickness of *c.* 9 m and contained lenses of sand and loam. The Middle Beds were described as brown and containing scattered stones and, notably, red- and black-stained gravel. They lay at levels between *c.* 45–50 m OD and their boundary with the Lower Gravel was sharp. The pale-grey to white Lower Gravel (> 5 m) contained smaller clasts than the Upper Gravel and was better stratified, exhibiting shallow cross-beds (C.P. Green, 1988).

Although full results of recent excavations at Broom Gravel Pits (C.P. Green *et al.*, in prep.) are not yet available, it appears that the broad threefold sequence described at each of the major disused pits is part of a laterally continuous succession (Campbell *et al.*, in prep.). Whether this pattern holds more widely elsewhere in the Axe Valley is unknown.

Palaeolithic artefacts

Numerous Lower Palaeolithic artefacts have been recovered from a wide range of locations in the Axe Valley, from Chard to Seaton. The main concentrations of material have been found at Chard Junction, Kilmington and Broom. Of these, Broom has undoubtedly been the most prolific: over a century of gravel working has yielded some 1800 hand-axes (Stephens, 1977; C.P. Green, 1988), although virtually none of these has a clearly defined stratigraphical or archaeological context (Todd, 1987; C.P. Green, 1988). Many, including the 900 or so collected by Charles Bean, probably originated from Pratt's Old Pit, north of Holditch Lane, and there are strong indications that most originated from the 'Middle Beds' at Broom in particular. Many fine hand-axes are preserved in the Exeter, Salisbury, Brighton and British museums (Macfadyen, 1970; Todd, 1987). Less impressive implements and flakes have fared less well, frequently being ignored or discarded (Rosenfeld, 1969; Todd, 1987). Most of the implements from Broom are made of green-brown Upper Greensand chert, although a few are made from chalk-flint (Hawkes, 1943; Macfadyen, 1970). Some are sharp-edged (unrolled), others waterworn (rolled), but in both cases an ovate type (more properly termed chordate, namely asymmetrical ovate) predominates (D'Urban, 1878; Evans, 1897; Stephens, 1974; C.P. Green, 1988). They vary considerably in size, from *c.* 6–23 cm in length (Macfadyen, 1970). Roe (1968a, 1968b, 1981) described the industry as 'finely worked', and confirmed the view of earlier workers that ovates, including twisted forms, predominate (60%); nearly 40%, however, are pointed forms, the remainder being narrow cleavers, several of which appear to have been sharpened by the tranchet blow (Roe, 1981). This confirms Charles Bean's analysis which shows that ovate forms are dominant (C.P. Green, 1988). The industry as a whole is classified as part of Roe's 'Intermediate Group IV' of British hand-axe industries. Whereas 34 out of the 37 other sites used in this classification fall very clearly into either 'pointed' or 'ovate' hand-axe traditions, the mixed assemblage found at Broom does not. The unknown stratigraphic provenance of most of the Broom finds leaves the interesting possibility that several industries are present. Nonetheless, most authorities seem to agree that the hand-axes are of Early–Middle Acheulian Culture (e.g. Roe, 1968a, 1968b, 1981; Wymer, 1968, 1970, 1977). Stephens (1974) added that since the industry included triangular hand-axes and twisted ovates, it was therefore probably comparable to the Acheulian at Swanscombe (but see Roe, 1981; Bridgland, 1994). On this basis, the manufacture of artefacts at Broom has been seen as broadly contemporaneous with the Hoxnian and Wolstonian (Saalian) stages (Stephens, 1970b, 1973, 1974, 1977).

Interpretation

At the outset, it should be pointed out that no first-hand detailed account of the Broom Gravel Pits has ever been published. Many of the early accounts, particularly those of the 1930s and 1940s, gleaned their evidence from meagre earlier-published accounts rather than from detailed field observation. Some had a tendency to 'force' the field evidence into preconceived stratigraphic schemes based on localities far from Broom and probably wrong even for those localities. Many of these accounts are either very slight, second-hand, or both, and tend to reflect interpretative traditions that have now been largely discarded. The best account is undoubtedly that of Charles Bean, recorded in his notebooks and summarized by C.P. Green (1988). His observations have been fully borne out by excavations undertaken in the late 1970s/early 1980s and reported in preliminary form by Shakesby and Stephens (1984).

D'Urban (1878) recorded that many chert palaeoliths had been found in the Ballast Pit during 1878, and that some had even been picked up from the gravel spread along the adjacent railway line;

none, however, had a known stratigraphic provenance. The hand-axes were considered to resemble closely those illustrated by Evans (1872) from Hoxne in East Anglia. D'Urban's remarks about the deposits from which the palaeoliths had come were brief. He noted that sections, up to *c.* 12–15 m high, through cherty gravel and clay occurred in the Ballast Pit; this material was believed to have been derived from the Greensand which caps the local hills (D'Urban, 1878). The earliest finds and descriptions of implements from the site were subsequently documented by Evans (1897).

The Ballast Pit was also referred to briefly by Salter (1899) who noted that the location and composition of the Axe Valley gravels showed that they had been emplaced 'by a strong current or stream from the north', and he regarded the Ballast Pit deposits as being made up of the debris from the 'high- and low-level plateau drifts' (cf. C.P. Green, 1974b). He observed that roughly shaped chert implements were abundant, being found largely in the 'bottom layers' of the pit.

Likewise, Jukes-Browne (1904a) regarded the valley gravels as having been formed by the 'action of rain and rivers during the excavation of the valleys to their present depth in the Pleistocene'. He thus considered them to have been derived from flint- and chert-rich clays (Eocene) found on the higher slopes and plateaux of the neighbourhood (Jukes-Browne, 1904a).

Between 1932 and 1941, Palaeolithic artefacts, including over 900 hand-axes, were recovered from the terrace deposits at Broom (the Holditch Lane Pits) by amateur archaeologist, Charles Bean. His detailed records, presented for the first time by C.P. Green (1988), show that most of the archaeological material originated from a complex bed (the Middle Beds), about 2 m in thickness, lying between two major gravel units (C.P. Green, 1988). Also from this early period of investigation comes an account of the site's stratigraphy by Reid Moir (1936) (see site description), and two further reviews of the archaeological material that had, by that time, been recovered (Gray, 1927; Smith, 1931).

Reid Moir (1936) described three gravel layers which he interpreted as a single aggradation. The mostly unstratified gravels (bed 3) were believed to have been formed by a mixture of periglacial solifluction and river processes. The stratified gravels (bed 2), on the other hand, showed dark bands which he interpreted as former interglacial land surfaces. The sharp, unrolled, implements found in this bed led Reid Moir to assign the Broom Palaeolithic industry to the 'Third Interglacial', in today's terminology, the Ipswichian.

Also from around this time comes a sketch of the Broom deposits showing an unconformity, representing a subaerial weathering surface, between lower unstratified and overlying stratified gravels (beds 1 and 2) (Paterson *in* Hawkes, 1943; Figure 9.12(b)). Hawkes (1943) commented that the lowest gravels and sands were probably deposited during the 'Third Glacial' (= Riss or Saalian), with the unconformity (land surface) representing the Mousterian (= Ipswichian). The overlying gravels were attributed to the 'Fourth Glacial' (= Devensian). These workers stated explicitly that rolled implements had been recovered from the basal gravels, while sharp, fresh implements had been obtained from the ancient land surface and from the bedded gravels; the different artefacts were therefore considered to represent separate stages of the Acheulian and Clactonian industries (Hawkes, 1943).

J.F.N. Green (1947) undertook reconnaissance mapping of the terrace deposits of the Otter, Dart and Axe valleys, and confirmed that a series of 'flats' could be traced down valley towards the sea; these were classified on the basis of the height of the gravels and correlated with other known terrace remnants in the lower Thames Valley and in the Sleight district of Dorset (J.F.N. Green, 1947; Calkin and Green, 1949).

In referring back to Reid Moir's composite stratigraphy for Broom, Calkin and Green concluded that the Broom section presented a complex sequence with two platforms cut by successive erosional stages of the River Axe (Figure 9.12(c)), together with associated aggradational and reworked ('bluff') gravels. This schematic diagram, which illustrates the disposition of these various erosional and depositional elements, shows how the interpretation of two separate gravel deposits from two different terrace accumulations may have become complicated by the slumping and redistribution of gravels (Figure 9.12(c)). The three terraces illustrated were believed to have been formed by a proto-Axe river flowing at successive heights equivalent to the rivers which deposited the Sleight, Boyn Hill and Iver terraces (respectively descending in height and age). Calkin and Green argued that after the middle terrace (= Boyn Hill Terrace) accumulated at Broom and its river had formed a cliff at the edge of its floodplain, it was likely that gravels and other sediments from an older and higher terrace (= Sleight

Terrace) had slumped or been soliflucted downslope as 'bluff' gravels (Reid Moir's bed 3) to overlie younger, *in situ*, well-stratified gravels (= Reid Moir's bed 2). Subsequently, erosion at a lower level led to cliffing and deposition of the lowest (= Iver) terrace; 'bluff' gravel was later deposited over these sediments in the same manner as described above (Figure 9.12(c)) (J.F.N. Green, 1947; Calkin and Green, 1949). On the basis that the principal source of artefacts had been the stratified gravels (bed 2), Calkin and Green assigned a Boyn Hill age to the industry (= Hoxnian).

Two main recent schools of thought pertain regarding the origin of the Axe Valley gravels. First, Stephens (1970b, 1973, 1974, 1977) speculated that a combination of Irish Sea and Welsh ice had blocked the Bristol Channel and pressed against the north Devon coast (see Brannam's Clay Pit; Chapter 7) in Saalian times, damming natural drainage and forming a large lake – 'Lake Maw' (Maw, 1864; Mitchell, 1960). He argued that such a lake would have overflowed at the lowest point of outlet to the south; the striking dry gap at Chard would have provided an ideal low-level routeway between the Somerset lowland to the north and the Axe Valley to the south (Stephens, 1970b). As this 'outwash' overflowed through the Chard Gap, it picked up Palaeolithic artefacts and incorporated them into a sizeable gravel terrace running all the way from Chard to Seaton. This consisted not only of locally reworked gravels (from plateau and interfluve areas) but, in addition, a variety of non-local rock types. The overspill from the lake was believed to have inundated a number of Palaeolithic working floors as attested by the vast numbers of artefacts found at localities such as Broom.

On the basis of the archaeological evidence for an Early–Middle Acheulian industry in the area, Stephens has argued that the Axe Valley terrace, with its incorporated artefacts, can be no earlier than the Hoxnian and no later than the Saalian (Stephens, 1970b). This fits neatly with the suggestion that proglacial Lake Maw built up during the Saalian Stage (= Wolstonian), approximately at the same time as the Fremington Clay was believed to have been deposited in north Devon (Stephens, 1970a, 1970b). Cryoturbation of the Axe Valley terrace gravels and deposition of brickearth (a silty loessic or colluvial deposit capping many local sequences) were attributed to periglacial conditions during the later part of the Saalian or in the Devensian cold stages (Stephens, 1974).

Second, an alternative explanation for the Axe Valley gravels, including those at Broom, was provided by C.P. Green (1974b) who determined the lithological composition of gravels both within the Axe Valley and in adjacent plateau and interfluve areas. He suggested that the Axe Valley terrace was unrelated to the Chard Gap. The source of erratic pebbles in the terrace gravels was thought to reflect the distribution and composition of adjacent Tertiary plateau gravels. Green has suggested that the incorporation of hand-axes into the terrace gravels at many sites in the Axe Valley was effected by extensive systems of braided streams, choked with chert and flint gravel, which occupied the valley floor where the Palaeolithic working sites had existed. Solifluction on valley sides and small tributary streams probably contributed material from plateau and valley-side sources to the valley floor, where shifting stream channels accomplished only limited sorting of material. All of these processes were believed to have been operative in a periglacial regime (C.P. Green, 1974b).

According to C.P. Green, erratics within the terrace gravels had been derived from Tertiary beds located on adjacent plateau and interfluve areas. A very strong argument in favour of this hypothesis is that deposits of similar composition to the Axe Valley gravels occur in other nearby valleys such as the Yarty and Otter – valleys which could not have been supplied via the Chard Gap. A glacial origin for the far-travelled material was thus rejected (C.P. Green, 1974b).

Campbell (1984) studied microtextural characteristics of sand from the Axe Valley terrace using Scanning Electron Microscopy (SEM). He noted that quartz-grain microtextural assemblages found in samples of the Axe Valley deposits are consistent with a marine origin, indicating reworking of material from Tertiary sources. At the same time, these preliminary SEM data indicated that probably very little reworking or abrasion of quartz grains had occurred since the material was removed from its plateau sources. This is consistent with the view put forward by C.P. Green (1974b) and Shakesby and Stephens (1984).

Shakesby and Stephens (1984) provided a preliminary account of recent excavations in the Ballast Pit, and attached considerable significance to the stained clays, silts and sands which occur within the gravel sequence (Figure 9.12(d)). Analysis of pollen extracted from this bed (Scourse, 1984) shows that the prevailing regional vegetation probably consisted of a boreal forest dominated by pine *Pinus*, spruce *Picea* and birch *Betula*, but also

Figure 9.13 'Cherty' gravels with sand lenses, seen in the south-east faces of the disused Railway Pit at Broom in 1985. (Photo: S. Campbell.)

with silver fir *Abies*. Scourse has argued that these trees were probably restricted to small stands interspersed within large expanses of open country, with ericaceous heath on the higher ground; a depositional environment at the end of a Middle Pleistocene (possibly Hoxnian) interglacial is suggested, although an interstadial origin, perhaps within the Saalian, cannot be ruled out (Scourse, 1984). C.P. Green (1988) has suggested that the apparent diversity of the sediment association reflects generally low energy deposition in a complex of pools and channels on a floodplain surface; in this case, one formed near the confluence of the proto-Axe and tributary Blackwater rivers.

The recent stratigraphic and pollen evidence somewhat complicates the simple depositional model originally put forward by C.P. Green (1974b); an apparently temperate floodplain deposit within a series of cold-climate gravels shows that periglacial braided stream deposition was interrupted by the accumulation of the pollen-bearing clays, silts and sands during a period of more temperate conditions. At present, no firm dating for this sequence is possible; on the basis of the archaeological evidence, however, it is likely that the gravels and associated deposits span the temperate Hoxnian and cold Saalian stages (Shakesby and Stephens, 1984). There is no indication that any part of the terrace sequence accumulated during the Ipswichian; irregular cappings of brickearth, caused by solifluction and rain-wash, and cryoturbation structures in the upper 1–2 m of the terrace gravels, may have formed during the ensuing Devensian (Shakesby and Stephens, 1984).

In conservation terms, Broom Gravel Pits show key exposures in the controversial Axe Valley terrace gravels. In addition to providing representative examples of the gravels themselves, recent site excavations have shown laterally persistent silt and clay bands to be present within the terrace gravels; pollen sampled from these beds (Scourse, 1984) offer, for the first time, the opportunity to begin to reconstruct the palaeoenvironment of the Axe Valley prior to the main formation phase of the large gravel terrace, perhaps at a time when the valley was extensively inhabited by Lower Palaeolithic Man. At present, the only possible clues as to the age of the terrace gravels come from the included Acheulian implements; even then, the age of the deposits is only loosely confined to between approximately the

Figure 9.14 Acheulian hand-axes from Broom, seen during the 1977 INQUA visit to South-West England. (Photo: N. Stephens.)

late Hoxnian and Saalian stages. Broom Gravel Pits have been, without doubt, the most important source of Lower Palaeolithic material from within the Axe Valley. Nonetheless, problems of interpreting the Palaeolithic assemblage from Broom still persist; it is not easily related to Acheulian assemblages found elsewhere in Britain (Rosenfeld, 1969), and it is quite likely that a mixture of industries is represented (Roe, 1968a, 1968b, 1981). Roe has suggested some affinities with the pointed hand-axe industries from Furze-Platt, Cuxton and Stoke Newington, but Broom differs markedly in showing a clear clustering of ovates within a narrow shape range (Rosenfeld, 1969). The unusual profusion of Palaeolithic material, particularly from the Ballast Pit, also presents a problem of interpretation; it may provide unique evidence in the South-West for a working floor. In any case, extremely rapid incorporation and burial of the hand-axes within the gravels is suggested (Shakesby and Stephens, 1984); the generally unrolled condition of the artefacts may suggest that they were originally discarded on the surface of the temperate floodplain deposits, and that they were only displaced over a short distance during low energy reworking on the floodplain (C.P. Green, 1988).

Conclusion

One of the classic geomorphological localities of South-West England, Broom Gravel Pits have long been central to arguments regarding the origin of the controversial Axe Valley terrace gravels. Most workers now hold that the gravels here were derived from Tertiary plateau deposits by Pleistocene solifluction and fluvial activity and then reworked, within the Axe Valley, by periglacial braided streams. Another more ambitious theory has tied the origin of the Axe Valley gravels to the Chard Gap, suggesting that the gravels were deposited (or at least their final terrace form created) as water spilled south from a large proglacial lake – 'Lake Maw' – dammed by Saalian-Stage ice in the Bristol Channel. Recent evidence from Broom shows that gravel accumulation was interrupted by a period of temperate climatic conditions when pollen-bearing clays, silts and sands were deposited. Whether this temperate event was part of a full interglacial within the Pleistocene, or merely a brief interstadial phase within one of the main cold phases, is as yet unresolved.

Broom also provides important evidence, in the form of a profusion of Acheulian implements (over 1800 hand-axes have so far been found at the site), for the activities of Lower Palaeolithic humans in the South-West. The large number of implements found here suggests that the site may have been a 'working floor' used for the manufacture of such tools; it is tempting to speculate that the relatively warm period detected within the sequence was coincident with a major occupation of the immediate area by Palaeolithic hunters who produced hand-axes in the Acheulian tradition. At present, the archaeological evidence is the only means of estimating the age of the sediment sequence here which, on that basis, has been assigned to between the late Hoxnian and Saalian stages.

(B) COLLUVIAL AND FAN-GRAVEL SITES IN MENDIP AND ADJACENT AREAS

This section documents sites which preserve evidence for terrestrial sedimentation patterns, mostly during cold stages, and palaeosol development, during temperate interstadial and interglacial conditions. The sites are chosen as prime examples of a variety of depositional settings and, where possible, because palaeobiological and dating evidence is available. Late Middle Pleistocene slope deposits, palaeosols and terrestrial mollusc faunas are located under the Swallow Cliff raised beach at Middle Hope. The Brean Member, an extensive Late Devensian sequence of rockfall breccias, aeolian sands, silts and palaeosols, spanning Oxygen Isotope Stages 4–2, is preserved at Brean Down. This sequence contains important fossil mammal and mollusc faunas. Alluvial fan gravels containing fossil molluscs and pollen, dating from the coldest part of the Devensian, are represented by the Wookey Station Member at Wookey Station. Older fan gravels, heavily affected by pedogenesis and overlain by aeolian sediments, can be demonstrated at Bourne.

MIDDLE HOPE
C. O. Hunt

Highlights

Middle Hope GCR site is significant because it contains a highly fossiliferous raised beach deposit of interglacial age overlying a complex of cold-stage slope deposits, some of which are affected by pedogenesis and some of which contain terrestrial mollusc fossils. Slope deposits and mollusc faunas of this antiquity are extremely rare in South-West England and provide important evidence for the nature of Pleistocene cold-stage environments in the region. The site is the type-locality for the Middle Hope Formation.

Introduction

Middle Hope is a Carboniferous Limestone horst, bounded by alluvial lowlands to the south and east, and by the Bristol Channel to the north and west. Much of the Middle Hope massif is mantled by Quaternary deposits. These are mostly slope deposits, but at two localities they are interbedded with marine sediments. At Swallow Cliff, Middle Hope, a shore platform is overlain by the Middle Hope Palaeosol (pedogenically altered slope deposits), the Woodspring Member (silty slope deposits with fossil land snails), the Swallow Cliff Member (a raised beach deposit) and then by further slope deposits attributed to the Brean Member (Campbell *et al.*, in prep.).

The raised beach deposits here were first described by Sanders (1841) and Ravis (1869). They were briefly re-described by Woodward (1876) who, with Prestwich (1892), provided faunal lists. These early authors recognized a fossil fauna of *Tellina* (*Macoma*), *Littorina*, *Nassa*, *Cerastoderma*, *Murex* (*?Ocenebra*), *Purpurea* and *Ostrea*. They also recognized the presence of land molluscs.

Palmer (1931) assigned the raised beach to his '10 foot level'. Donovan (1962) recognised a series of erosion features around the Bristol Channel and correlated them with the Main Terrace of the Severn and the Swallow Cliff raised beach. He attributed them to an episode of sea level not far below OD during the Upton Warren Interstadial. Wood (*in* Callow and Hassall, 1969) obtained radiocarbon dates of 33 240 + 760/− 700 BP (NPL-126a) and 38 990 + 1690/− 1390 BP (NPL-126b) which seemed to support this hypothesis, but Kidson (1970, 1977) rejected them as 'almost valueless' since similar dates had been obtained from a number of sites of known interglacial status.

The site was definitively re-studied by Gilbertson (1974), Gilbertson and Hawkins (1977) and Briggs *et al.* (1991). The interglacial nature of the marine fauna was demonstrated, and the raised beach deposits were assigned to the Ipswichian by Gilbertson (1974) and Gilbertson and Hawkins (1977). These authors described in detail the stratigraphy, lithology, palaeontology, micropalaeontology and mineralogy of the sequence of shore platform, cold-climate slope deposits with land molluscs, wind-blown foraminifers and occasional recycled marine shells, raised (storm) beach and upper cold-climate slope deposits.

Andrews *et al.* (1979) provided an amino-acid ratio which was taken to support an Ipswichian (Oxygen Isotope Stage 5e) age for the raised beach deposit (Andrews *et al.*, 1979, 1984). Davies (1983) later provided a higher ratio which she interpreted as indicating a Stage 7 age (*c.* 210 ka BP). More recent reassessment (Campbell *et al.*, in prep.) suggests that attribution of the raised beach deposits to Oxygen Isotope Stage 5e (Ipswichian) is most appropriate.

Description

The deposits at Swallow Cliff, Middle Hope (ST 325661), lie on a shore platform and against a fossil cliff cut in Carboniferous Limestone, ashes and spilites. The shore platform lies between 12.5 and 11 m OD (Gilbertson, 1974; Gilbertson and Hawkins, 1977). It is overlain by *c.* 2.6 m of Quaternary deposits, in the following sequence (Gilbertson and Hawkins, 1977; Briggs *et al.*, 1991; Gilbertson, pers. comm., 1993; Figure 9.15) (maximum bed thicknesses in parentheses):

10. Modern topsoil. (0.25 m)
9. Brown, sandy very stony loam, with angular clasts of Carboniferous Limestone and volcanic rocks. The material has a weak, angular blocky structure and firm consistency, and exhibits abundant fine to medium pores. It has a sharp boundary with bed 8. (0.33 m)
8. Coarse, matrix- and clast-supported cobbly gravel of rounded Carboniferous Limestone clasts in a matrix of fragmented marine shell, porous and cemented at point contact. The fossil assemblage is dominated by *M. balthica*, with some *Littorina littoralis* (Linné) and *Cerastoderma* sp., a few *P. vulgata* and *Littorina littorea* Linné. *Littorina saxatalis* (Olivi), *Buccinum undatum* Linné, *Nucella lapillus* (Linné), *Nassarius reticulatus* Linné, *Lora* sp., *Trophonopsis truncatus* (Ström), *Ocenebra erinacea* (Linné) and *Ostrea* sp. are rare. Aminostratigraphical assays on *Patella* gave a combined D-*alloisoleucine* : L-*isoleucine* ratio of 0.101 ± 0.005 (AAL-771) (Andrews *et al.*, 1979) and a mean ratio of 0.203 ± 0.016 (Group 3 of Davies, 1983). The deposits have a sharp uneven boundary with bed 7. (1.0 m)
7. Dark brown, sandy, slightly stony loam, with rare clasts of weathered subangular ?Triassic sandstone and Carboniferous Limestone and pockets, 3 mm deep, of silty clay loam with platy structure, medium pores and clay skins on ped faces. The bed contains numerous foraminifers, abundant marine shell fragments and some terrestrial molluscs – *Vallonia* cf. *pulchella*, *Trichia hispida* (Linné), *Agrolimax* cf. *agrestis* and Helicids. The material has a moderate, medium, subangular to blocky platy structure, is friable and exhibits abundant fine to medium pores in upper 50 mm; common fine pores are present below this level. Bed 7 has a sharp boundary with bed 6. (0.08 m)
6. Brownish-black silty clay loam with a fine, subangular blocky structure. The deposit is friable and exhibits abundant fine pores. It has a sharp uneven boundary with bed 5. (0.02 m)
5. Brown, extremely stony clay loam, with medium to coarse angular clasts of Carboniferous Limestone and flint, subrounded to subangular clasts of weathered Triassic sandstone and marl. The material has a subangular blocky structure, is friable and exhibits occasional clay skins on ped faces. It shows abundant fine pores and frequent medium to coarse pores and has a clear but uneven boundary with bed 4. (0.15 m)
4. Brown, silty, slightly stony clay loam, with angular to subangular clasts of ?Triassic marl. Abundant foraminifers are present. The deposits demonstrate a moderate, medium, angular, blocky platy structure and exhibit occasional clay skins on peds. They contain abundant fine and medium pores, and have a clear but uneven boundary with bed 3. (0.15 m)
3. Brown, extremely stony silty clay, with coarse subangular clasts of Carboniferous Limestone, weathered ?Triassic marl and sandstone and very infrequent clasts of Carboniferous volcanic rocks. It contains occasional pockets and individual specimens of land snails – *Vallonia* cf. *pulchella*, *T. hispida* and Helicids – and lenses (50–100 mm across) of fragmentary marine molluscs – *N. lapillus* and *L. littoralis*. It is slightly calcareous, cemented at point contact and demonstrates moderate,

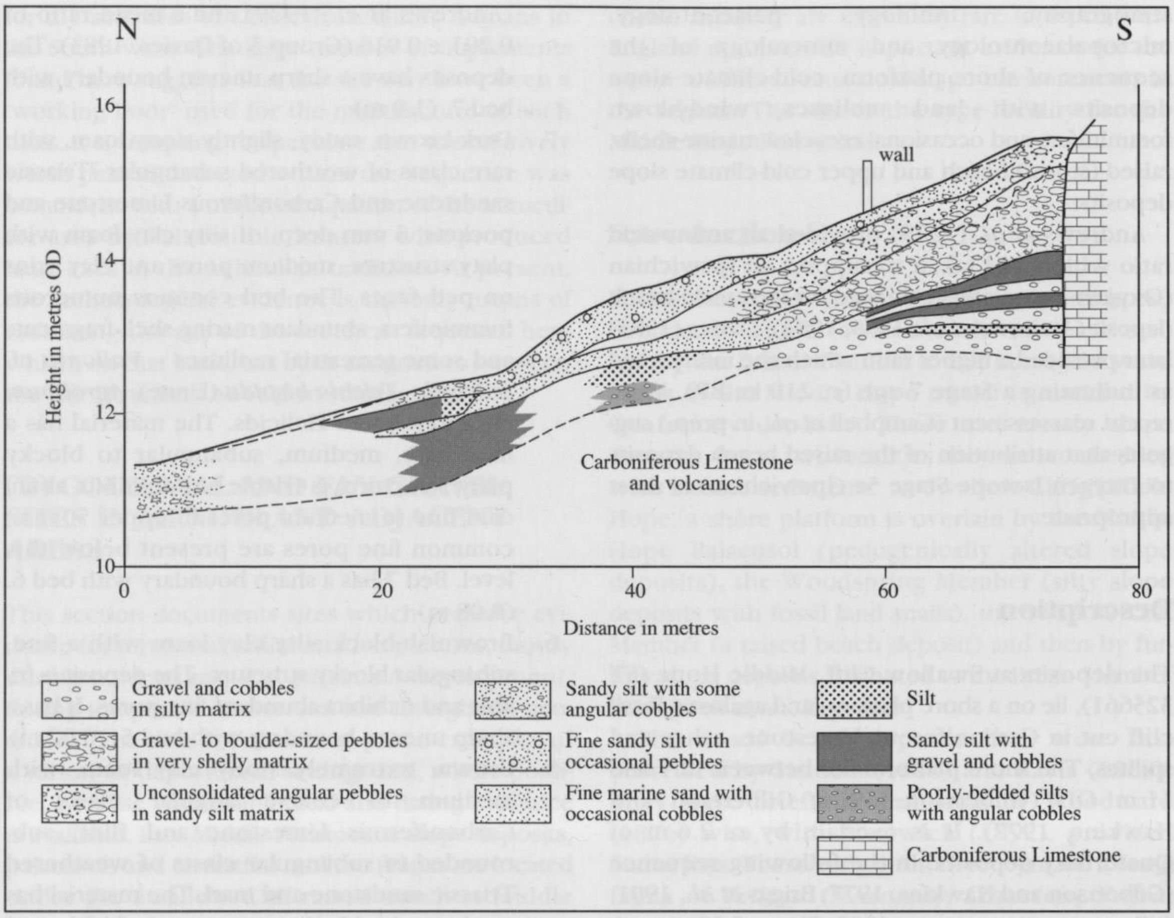

Figure 9.15 Quaternary deposits at Swallow Cliff, Middle Hope, simplified from Gilbertson and Hawkins (1977).

angular blocky structure and firm consistency. The material exhibits abundant fine and common medium pores and has a clear but uneven boundary with bed 2. (0.15 m)

2. Moderately mottled, red-brown, silty, slightly sandy stony clay, with common small to medium subrounded clasts of ?Triassic marl. Some foraminifers are present. The deposit has a moderate, medium, angular structure and firm consistency, and exhibits clay skins on peds. Abundant fine and common medium pores are present and the material merges down into bed 1. (0.10 m)
1. Red, silty, very stony clay, with subangular to subrounded coarse clasts of Carboniferous volcanic rocks and subrounded to rounded clasts of Carboniferous Limestone and ?Triassic sandstone. The bed demonstrates a moderate, medium, angular blocky structure, shows clay skins on peds and has abundant fine to medium pores. It occurs in hollows on the shore platform. (0.35 m)

Interpretation

The basal shore platform and buried cliff most probably reflect one or more episodes of marine erosion of unknown age. The lowest deposits (bed 1) rest on the platform, contain rounded clasts and have a heavy mineral assemblage derived from the platform rocks. They are thus likely to represent a mixture of local weathering products and the remains of a former beach deposit (Briggs *et al.*, 1991; Gilbertson, pers. comm., 1993). The clay coats on peds in beds 1 and 2 are consistent with pedogenic activity (Gilbertson, pers. comm., 1993). Clay content can be used to differentiate the deposits of the Middle Hope Palaeosol (beds 1–3), from the overlying Woodspring Member (beds 4–7): clay enrichment in the former thus reflects a phase of weathering, of at least interstadial status, affecting older slope deposits.

Beds 2–7 contain predominantly angular to subrounded clasts and appear to reflect an alternation of hillwash and aeolian processes (Briggs *et al.*, 1991). The presence of marine molluscs and foraminifera in these deposits is suggestive of the former presence of marine deposits upslope, while the foraminifera could have been emplaced by wind following the deflation of nearby marine deposits (Gilbertson and Hawkins, 1977). The fossil land mollusc assemblages are consistent with open wet grassland.

Bed 8, the Swallow Cliff Member, represents a storm beach probably related to a mean sea level perhaps 5 m higher than that of today. The dominant *Macoma* was derived from sand and mud flats in the Bristol Channel. Many of the other taxa are species typical of rocky shores and are thus consistent with the depositional locality. Gilbertson (1974) and Gilbertson and Hawkins (1977) have demonstrated the interglacial nature of the fauna. The major discrepancy beween the amino-acid ratios given by Andrews *et al.* (1979) and Davies (1983) has not yet been accounted for, and both Ipswichian (Oxygen Isotope Stage 5e) and earlier ages for the beach deposit are possible. If Davies' (1983) interpretation is accepted, a correlation with the marine deposits at Kenn Church (Andrews *et al.*, 1984) becomes probable, although this was rejected by Campbell *et al.* (in prep.). Further work is needed to resolve this problem.

Bed 9 reflects the resumption of cold-climate depositional activity after the interglacial phase. This thin unit can be assigned to the Brean Member.

Conclusion

The deposits at Swallow Cliff, Middle Hope, are important because they provide evidence for depositional and pedogenic environments during two later Middle Pleistocene cold stages and an intervening ?temperate episode. Subsequent temperate-stage beach sedimentation, probably correlated with Oxygen Isotope Stage 5e, is also represented. Further work is necessary to resolve problems with the dating of the sequence.

BREAN DOWN
C. O. Hunt

Highlights

Brean Down provides a spectacular and most unusual example of cold-stage aeolian and slope sedimentation. It has important interstadial fossil mollusc and mammal faunas and preserves a very detailed record of conditions during a considerable part of the Devensian. It is the type-section of the Brean Member.

Introduction

At Brean Down, a thick late Quaternary sequence of sands, silts and breccias rests on a shore platform and against an ancient cliff. The sequence contains abundant mammal bones and fossil molluscs. During Pleistocene cold stages, aeolian and rockfall depositional processes were dominant. Interstadials within the sequence are marked by evidence of pedogenic activity, rich mollusc and mammal faunas, and appear to be characterized by slower rates of deposition.

The Quaternary deposits at Brean Down have been of interest for over a century. Ravis (1869) provided the first short account. Reindeer bones from Brean were described by Knight (1902). Ussher (1914) dealt with the site in a general account of the deposits of the Somerset Levels. Palmer (1930, 1931, 1934) gave brief accounts of a breccia containing reindeer antlers and bones, overlain by a thick sand and an upper breccia. A mineralogical analysis of the sand unit was compared with analyses from Clevedon, Bleadon and the Barnwood terrace of the Severn and from a number of possible sources; an aeolian origin, mostly from the Tertiary deposits of Devon and Cornwall, was suggested. The breccias were ascribed to 'alternations of abnormal cold and excessive moisture' and compared and correlated with the 'combe rock' of the chalklands of southern England. Balch (1937) listed a Pleistocene and Holocene fauna including Neolithic humans, horse, red deer, reindeer and ?northern vole from Brean, but supplied no stratigraphical details. The Pleistocene deposits were then described in passing in a description of archaeological remains from the Holocene sequence (Taylor and Taylor, 1949).

The first detailed account of the site was given by ApSimon *et al.* (1961). They described a

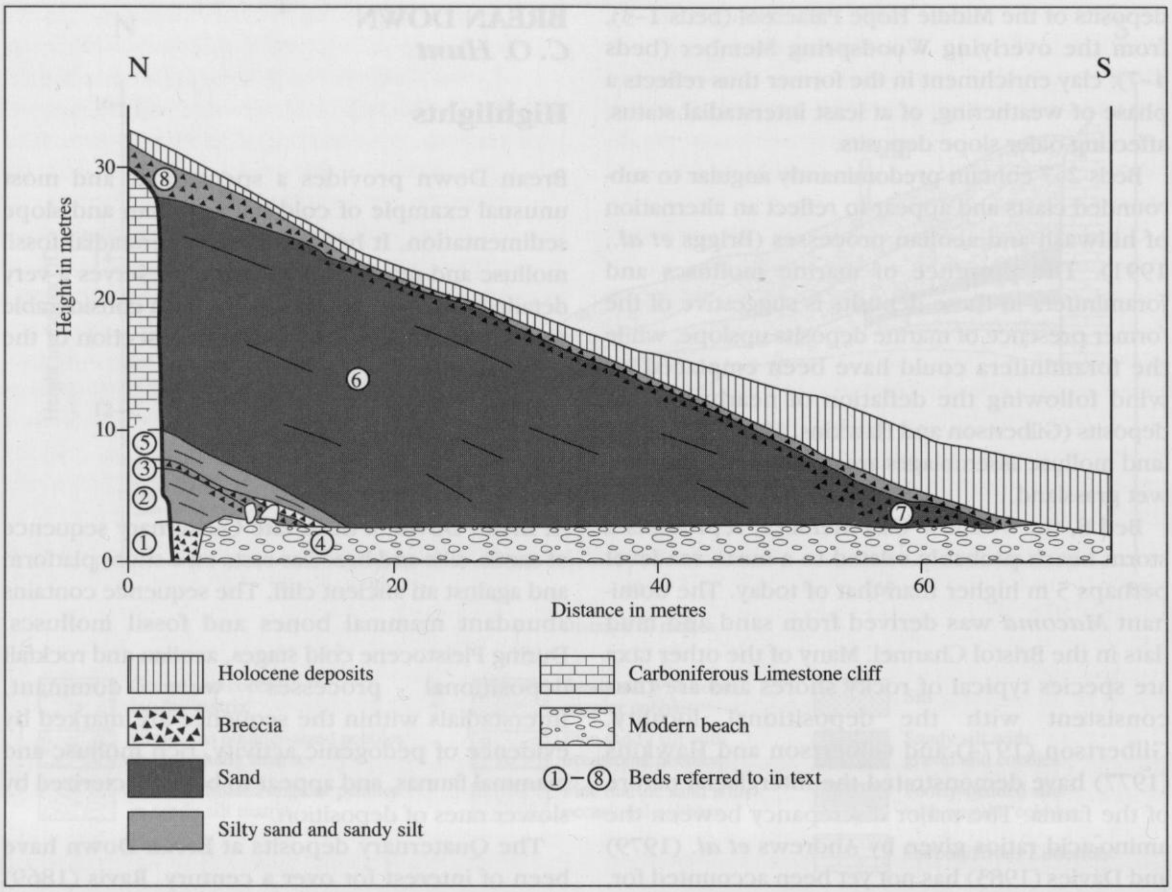

Figure 9.16 The Quaternary sequence at Brean Down, simplified from ApSimon *et al.* (1961).

complex Pleistocene stratigraphy, with a lower breccia, stony silt, middle breccia and bone bed, silty sand, main sand and upper breccia, overlain by an extensive Holocene sequence with Beaker, Bronze Age, Iron Age and post-Mediaeval artefacts. The lower breccia contained bones of vole, arctic fox, reindeer and bison and the stony silt contained reindeer bone and antler, and vole and bison bones. These assemblages were thought to indicate a tundra landscape. The middle breccia showed signs of soil development and contained a mammal fauna with remains of lemming, hare, Arctic fox, elephant, horse and reindeer together with indeterminate bird bones. Some bones showed signs of human workmanship. This horizon also contained both land and marine molluscs. The presence of horse was taken as evidence for a grassland environment but the land mollusc fauna was regarded as indicating a very exposed, poorly vegetated landscape. The marine molluscs were fragmentary and probably blown from nearby marine sediments. The Pleistocene sequence was attributed to the Devensian late-glacial, but ApSimon (1977) later suggested that the lower and middle breccias might be of Early or Middle Devensian age.

The finding of two gold bracelets in 1983 and the necessity for sea defence works (McKirdy, 1990) led to a rescue excavation of the Holocene sequence, which unearthed a Bronze Age village (Bell, 1990, 1992a, 1992b) and a re-study and intensive sampling of the Pleistocene sequence (Hunt, in prep.). The Pleistocene stratigraphy and depositional environments described by ApSimon *et al.* (1961) were substantially confirmed by this recent work, but a more detailed picture of the mollusc fauna of the site has now emerged. The site was proposed as the type-section of the Brean Member by Campbell *et al.* (in prep.).

Description

The Pleistocene deposits of Sand Cliff, Brean Down (ST 295588), lie against the precipitous south face of the Carboniferous Limestone massif of Brean Down and extend *c.* 70 m southwards to where they pass below Holocene deposits and the modern beach. They lie on a platform cut in the Carboniferous Limestone which lies between OD and *c.* − 6 m OD (ApSimon *et al.*, 1961). The deposits dip south at 20–25°. The westerly portion of the deposits has been removed by marine erosion and the remaining deposits are well-exposed in a coastal cliff (Figures 9.16 and 9.17).

The stratigraphical terminology of ApSimon *et al.* (1961) is used in this account, but the bed descriptions, mollusc data and measurements are those from the 1986 re-study (Hunt, in prep.). These differ slightly from the descriptions given by ApSimon *et al.* (1961) because of lateral variability and cliff retreat over the intervening period. The Holocene deposits described by ApSimon *et al.* (1961) are not the central part of the GCR site interest and are not therefore repeated here. The sequence is as follows (maximum bed thicknesses in parentheses):

8. Holocene deposits.

7b. 'Earthy Breccia'. Reddish-brown breccia with gravel- to boulder-sized limestone clasts in a silty sand matrix. This horizon thickens downslope. (6.0 m)

7a. 'Sandy Breccia'. Reddish-brown to strong brown sandy breccias and sands. The layer becomes thicker and sandier downslope. (2.5 m)

6. 'Main Sand'. Orange-brown, fine to medium, sometimes silty sand with large-scale (0.5–1.5 m) cross-bedding. Occasional stone lines and silt lenses are present. *P. muscorum* and fragments of marine molluscs are occasionally present. Sheets and tubular structures of calcite occur in the uppermost 2 m. The horizon from which these structures originated has since been removed by erosion. (27.4 m)

5b. Angular limestone fragments. Clast-supported breccia of gravel-sized, very angular limestone fragments in an orange-brown sandy matrix. (0.2 m)

5a. 'Silty Sand'. Yellow-brown silts and sands becoming redder and sandier upward. The bed comprises centimetre-thick silt/sand couplets, with very occasional stones. Charcoal flecks occur at the base of the unit. *P. muscorum* is locally abundant and *Trichia* cf. *hispida*, *Cepaea* sp. and marine mollusc fragments are present. (2.7 m)

4. Openwork breccia comprising very angular clasts with occasional *Rangifer* bone and antler and rare *Trichia* cf. *hispida*, *Catinella arenaria* (Bouchard-Chantereaux) type and marine mollusc fragments. This bed was not reported by ApSimon *et al.* (1961). (0.8 m)

3b. 'Bone Bed'. Red-brown stony silts in four thin units passing upwards into yellow-brown, stoneless sandy clay loam with occasional *Rangifer tarandus* Linné bone and antler. This is probably the lateral equivalent of the 'bone bed' which was rich in *R. tarandus* bone and antler, some showing signs of possible human working. This layer also yielded *Dicrostonyx* spp., *Lepus timidus*, *Canis lupus*, *Alopex lagopus* (Linné), '*Elephas*' sp., *Megaloceros giganteus* (Blumenbach), *Equus* sp. and indeterminate bird bones (ApSimon *et al.*, 1961; ApSimon, 1977). The mollusc fauna contains abundant *P. muscorum* (up to 92.5%), some *Trichia* cf. *hispida* (up to 22.9%), rare Limacidae, *Cochlicopa* sp., *Cepaea* sp., *D. rotundatus*, *Oxychilus* sp., *Succinea* cf. *oblonga*, *L. truncatula* and marine and freshwater mollusc fragments. (0.7 m)

3a. 'Middle Breccia'. Yellow-brown, passing up into red-brown mottled, yellow-brown, silty sandy breccias and sandy silts with occasional limestone fragments. Bones and antler of *R. tarandus* are fairly common. The terrestrial mollusc assemblage is dominated by *P. muscorum* (85.8%), with some *Trichia* cf. *hispida* (7.5%), Limacidae (3.8%) and rare *Cepaea* sp., *Vallonia costata* (Müller), and *C. arenaria* type. Fragmentary marine and freshwater molluscs are present. (3.35 m)

2c. 'Stony Silt'. Brown to orange-brown sandy clay loam, becoming sandier upwards, and containing occasional angular limestone clasts and thin chocolate-brown silty clay layers. Occasional bones and antler of *R. tarandus*, bird bones, land molluscs, mostly *P. muscorum*, and marine mollusc fragments. (3.1 m)

2b. 'Clay Band' in Stony Silt. 'Gravel' composed of pellets of green-grey and red-brown silty clay. (0.15 m)

2a. 'Stony Silt'. Yellow-brown becoming strong brown sandy loam with angular limestone clasts becoming more frequent upwards. Reindeer antler was found at the base of this unit and occasional bone and antler fragments are distributed throughout, while *Microtus* aff. *nivalis* is present towards the top. *P. muscorum* and marine shell fragments are present. (1.5 m)

Figure 9.17 The Pleistocene sequence at Brean Down. (Photo: S. Campbell.)

1. 'Lower Breccia'. Red-brown breccia of boulder-size limestone clasts, fining upward and becoming clay-rich in the upper 0.3 m where it contains *A. lagopus*, *R. tarandus*, *Microtus* sp. and *Bos* sp. (> 2.2 m)

Interpretation

The platform and cliff on which the Pleistocene deposits rest are most probably of marine origin, though marine deposits have not been found upon them. Such platforms are most probably the result of repeated marine transgressions to approximately the same altitude over long periods (Kidson, 1977). The limestone clasts in the overlying sequence were derived by cliff fall from the limestone cliff to the north, but the overwhelming proportion of the silts and sands in the sequence must have been derived from other sources by the wind, as has been noted at many sites in Avon and Somerset (Gilbertson and Hawkins, 1978a, 1983).

The boulder pile of bed 1 reflects cliff collapse, possibly, but by no means certainly, under frost weathering. The fauna in the top of this bed is certainly characteristic of cold-stage conditions. ApSimon *et al.* (1961) interpreted the transition to bed 2 as a minor climatic amelioration, but the mollusc and mammal faunas of bed 2 reflect cold, exposed landscapes and the sediments probably reflect a considerable period of coversand-style aeolian sedimentation, being derived at least in part from local marine sands, so such an amelioration is by no means certain. The clay-rich layer (bed 2b) was interpreted by ApSimon *et al.* (1961) as derived from local Triassic deposits during a still-stand in aeolian sedimentation. In the 1986 re-study it was interpreted as pellets of an eroded soil (Hunt, in prep.).

Bed 3 was recorded as substantially thicker in the 1986 study than in the work of ApSimon *et al.* (1961), most probably as the result of local facies variation. Bed 3a was interpreted by ApSimon *et al.* (1961) as reflecting colder conditions than bed 2 because of an increase in the number of limestone clasts. The mammal and mollusc faunas of this bed are, however, richer than those of bed 2 and there are signs of soil development which together might indicate a minor climatic amelioration. Bed 3b, with its comparatively diverse faunas including higher incidences of the vegetation-loving *Trichia* and thermophiles such as *D. rotundatus*, *Cepaea* and *Oxychilus*, probably reflects further climatic amelioration and a herbaceous ground cover (Hunt, in prep.). The mammal assemblage may also be taken as compatible with steppe conditions. The breccias of bed 4 and the silts and breccia of bed 5 probably reflect a slow return to cold-stage conditions since there are relatively few mammal remains and mollusc diversity is low.

The aeolian sands of bed 6 are most probably the product of a very exposed and at least episodically arid landscape, and sand sedimentation continued during the deposition of the sandy breccia (bed 7a). A soil profile must then have formed with tree-sized vegetation and considerable carbonate mobilization by soil acids to give rise to the calcite structures. This had been completely eroded away before the deposition of the final Pleistocene unit (bed 7b).

The development of a soil profile and arboreal vegetation before the development of bed 7a most probably reflects a major climatic amelioration, perhaps the Windermere Interstadial. If this is the case, then the original attribution of the 'bone bed' by ApSimon *et al.* (1961) to the Devensian late-glacial cannot be correct and ApSimon's later (1977) suggestion that this reflects an Early or Middle Devensian event is much more convincing. Sea level in Stage 5e and probably Stage 5a would have been high enough to have emplaced raised beach deposits at Brean, rather as happened at Swallow Cliff, Middle Hope (this chapter). The absence of raised beach deposits might therefore be used as evidence that the whole Brean Down sequence post-dates Stage 5. It is perhaps reasonable to suggest, therefore, that the interstadial reflected by bed 3 is equivalent to Oxygen Isotope Stage 3. Broadly comparable mollusc faunas of Stage 3 age are known from Pin Hole Cave, Creswell Crags (Hunt, 1989). On this basis, beds 4–7a at Brean Down may have formed during Oxygen Isotope Stage 2, and bed 7b during the Younger Dryas (= Loch Lomond Stadial).

Conclusion

The Brean Down sequence is nationally important because it provides a very detailed, though inevitably incomplete, history of changing terrestrial depositional environments, and especially aeolian sedimentation, through much of the last cold stage. It has important mammal and mollusc faunas. A dating programme is urgently needed to place the environmental history of the site in context and enable its full potential to be realized.

BOURNE
C. O. Hunt

Highlights

Bourne shows an excellent example of ancient interglacial soil formation, periglacial aeolian deposition and mass movement on the older alluvial fan deposits of Mendip. Well-developed palaeosols have been reported extremely rarely in South-West England. The site is the type-section for the Burrington Member and the Burrington Palaeosol.

Introduction

At Bourne, deposits of the alluvial fan at the mouth of Burrington Coombe were exposed in temporary sections. A basal gravel unit, the Havyat unit, contains in its upper part a 'weathered horizon' – a soil profile with characteristics indicating pedogenesis in interglacial conditions. This is overlain by a second gravel body, the Ashey unit, which probably dates from the Devensian.

Gravel deposits along the foot of the Mendips have been known since the work of Woodward (1876) and Morgan (1888). Modern work started with the work of Clayden and Findlay (1960), Green and Welch (1965) and Findlay (1965) and has recently included the morphological work of Pounder and Macklin (1985). Gravels were first described from Bourne by Woodward (1876), who described 5 feet of sandy angular to subangular gravel in a roadside exposure. Findlay (1977) described the section at Bourne in detail, and suggested it showed evidence for a major episode of fluvial deposition and two phases of aeolian sedimentation separated by a phase of pedogenesis of interglacial status. Pounder and Macklin (1985) described the morphology of the fan deposits. They recognized four phases of aggradation, the Langford (oldest), Havyat, Ashey, and Link Lane units (Figure 9.18). Campbell *et al.* (in prep.) proposed the site as the type-section of the Burrington Member (Oxygen Isotope Stage 6) and the Burrington Palaeosol (Stage 5).

Description

Bourne GCR site lies at the eastern end of the Churchill–Burrington–Rickford alluvial fan complex, the morphology of which was described by Pounder and Macklin (1985). In temporary sections

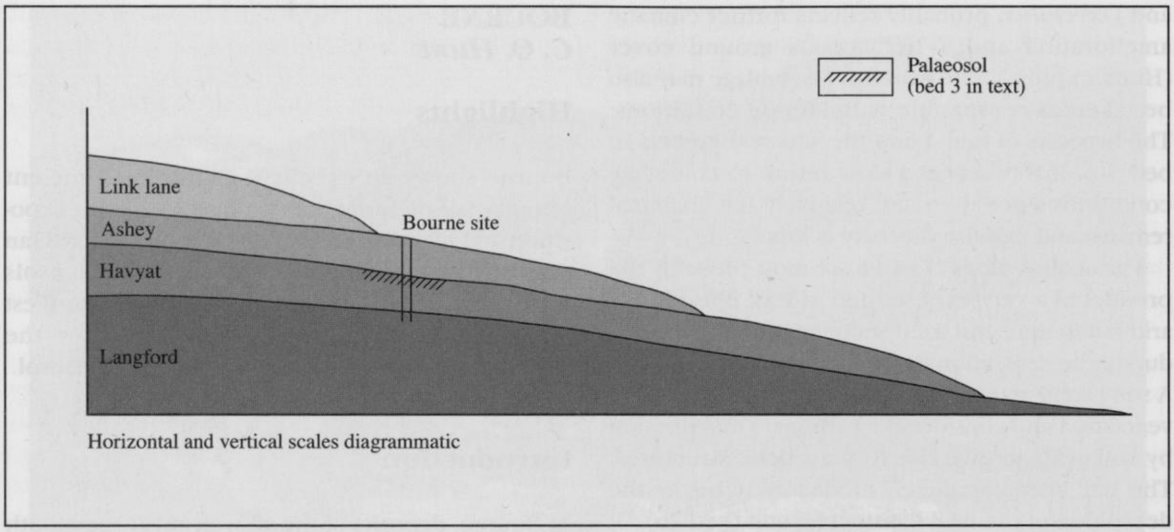

Figure 9.18 Schematic cross-section of the Burrington fan at Bourne, showing the aggradational components of the fan and their relationship to the Bourne section. (Adapted from Pounder and Macklin, 1985.)

at ST 483598, over 3 m of Quaternary deposits were exposed in the Ashey and Havyat units defined by Pounder and Macklin (1985). The following description is modified from that given by Findlay (1977) (maximum bed thicknesses in parentheses):

9. Dark brown, sandy silt loam topsoil. (0.15 m)
8. Brown and reddish-brown, slightly stony sandy silt. The clasts in this bed are mostly of sandstone with some of chert. Tongues or wedges containing material similar to the deposits in this bed extend from its base downwards into the underlying beds. (0.20 m)
7. Reddish-brown, slightly stony clayey silt passing down into a sandy clayey silt. The clasts are mostly sandstone with some chert. (0.30 m)
6b. Reddish-brown and red clay, with 20% black manganiferous mottle. The bed occurs as discontinuous lenses and merges with bed 5 when bed 6a is absent. (0.15 m)
6a. Yellowish-red to reddish-brown sandy silt. The bed occurs as discontinuous lenses. (0.20 m)
5. Reddish-brown and red very stony clay, with 20% manganiferous mottle on ped faces and stones. The clasts are mostly sandstone with some chert. When bed 5 is absent, this bed merges with bed 6 with decreasing black staining. (0.20 m)
4. Yellowish-red to reddish-brown sandy silt with layers of reddish-yellow silty sand, with occasional sandstone and chert cobbles and small boulders. The bed has sharp upper and lower boundaries and occurs as discontinuous lenses which attenuate downslope. (0.50 m)
3. Reddish-brown very stony clay. The clasts are predominantly sandstone with some chert and quartz. A wide range of clast sizes up to 250 mm is present and the clasts vary from round to subangular. In thin-section, the matrix of the bed can be seen to comprise almost entirely illuvial clay. There is a clear but highly undulating lower boundary to the bed. (0.75 m)
2. Reddish-brown to dark reddish-brown, very stony, sandy clayey silt. The clasts are predominantly of Carboniferous Limestone, with some sandstone and a little chert. In the top 0.3 m of this horizon, Carboniferous Limestone clasts are largely decalcified and surrounded by black clay. This bed passes gradually into bed 1. (0.55 m)
1. Loose, clast-supported cobbly gravel with gritty matrix. Base unseen. (> 0.20 m)

Interpretation

Beds 1 and 2 contain lithotypes derived from the Mendip Hills, including Carboniferous Limestone, Old Red Sandstone and Carboniferous chert, but contain no far-travelled material. The 'gravels' lie at the margins of the Churchill–Burrington–Rickford alluvial fan, which is well known from the work of Woodward (1876), Findlay (1965) and Pounder and Macklin (1985). There is no reason to interpret them as other than gravels of an alluvial fan. Clayden and Findlay (1960) and Macklin and Hunt (1988) have linked deposition of similar alluvial fan gravels around Mendip to short-lived fluvial flood events during stadial episodes in the Pleistocene.

Findlay (1977) suggested that bed 3 was a palaeosol which formed shortly after the deposition of the alluvial fan gravels of beds 1 and 2. The evidence for this includes the high incidence of illuvial clay in the bed, the 'clear but highly undulating' boundary between beds 2 and 3 '… so typical of weathering limestone materials' (Findlay, 1977; p. 24), and the decalcified higher part of bed 2. A weathering episode of considerable intensity, probably of interglacial status, would be needed to form a palaeosol of this type.

Silty sand and sandy silt deposits very similar to bed 4 have been widely reported around the Avon lowland as 'coversands' of relatively local aeolian origin laid down during periglacial phases (Gilbertson and Hawkins, 1978a). A similar origin can be suggested for this bed. Findlay's (1977) section appears to show that bed 4 had become disrupted by loading, with the underlying bed 3 being partially displaced. The most likely explanation is that these beds were deformed by mass-movement processes during a periglacial phase. Beds 5, 6a and 6b may represent material partially reworked from beds 3 and 4 at this time. They may, alternatively, reflect further phases of soil formation (bed 5), aeolian coversand deposition (bed 6a) and soil formation (bed 6b). Further research is needed to clarify this interpretation.

Findlay (1977) suggested that beds 7 and 8 were laid down during a final episode of aeolian silt sedimentation, and later altered by Holocene pedogenesis.

An important though enigmatic sequence can thus be seen at Bourne. The episode of alluvial fan sedimentation can be linked with flash-flood events originating from Mendip during a stadial phase. It was followed by a period of temperate weathering and soil development. This in turn was followed by aeolian coversand sedimentation during a stadial phase and a phase of periglacial mass movement. Other temperate soil-forming intervals and a further coversand depositional event may be represented, but this is by no means certain. Finally, a further episode of aeolian silt sedimentation occurred, again most probably during a stadial episode.

Conclusion

The temporary section at Bourne showed a well-developed palaeosol formed on alluvial fan gravels. Aeolian 'coversand' was then laid down and was subsequently deformed by mass-movement processes before a final phase of aeolian silt sedimentation. The aeolian silt was affected by Holocene pedogenesis. Well-developed palaeosols have been reported extremely rarely in South-West England. Bourne is unusual in providing clear evidence of two phases of aeolian sedimentation.

WOOKEY STATION

C. O. Hunt

Highlights

Wookey Station provides an excellent example of alluvial fan sedimentation on the Mendip margin, dating from a stadial in the Devensian. It is of special importance because uniquely it contains fossil molluscs and pollen, critical to an understanding of the depositional environment of the Mendip alluvial fans. It is the type-section of the Wookey Formation and of the Wookey Station Member.

Introduction

Deposits of the Wookey alluvial fan are exposed in old railway cuttings at Wookey Station. Coarse, sometimes cryoturbated, gravels with occasional small palaeochannel features containing fossil molluscs, pollen and recycled palynomorphs are overlain by a broad silty palaeochannel-fill (Figure 9.17).

The deposits at Wookey Station were first mentioned by Woodward (1876), who noted that up to 10 feet of gravel was visible and that the long-axes of many stones were vertical. Green and Welch (1965) noted additionally that the gravels vary from round to angular and include clasts of Carboniferous Limestone and Old Red Sandstone. The site was described in detail by Macklin (1985, 1986) and Macklin and Hunt (1988), from whose work the following description is largely taken. Campbell *et al.* (in prep.) proposed the site as the type-section of the Wookey Formation and of the Wookey Station Member.

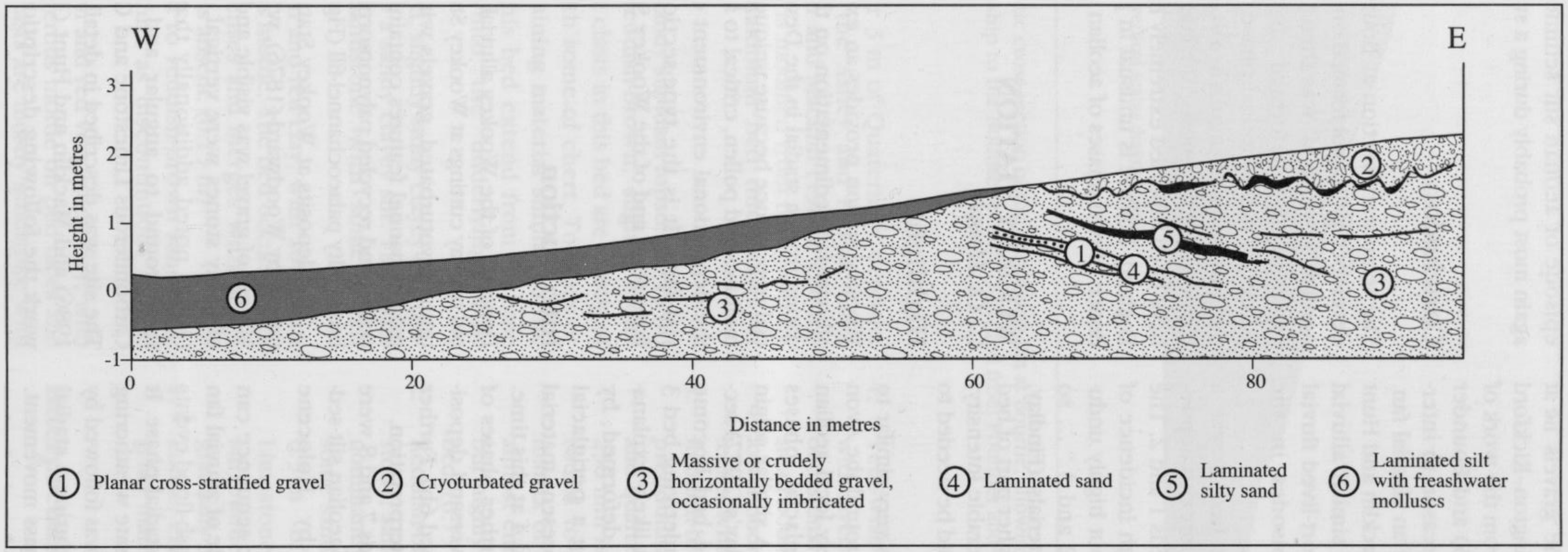

Figure 9.19 The Quaternary sequence exposed in the old railway cutting at Wookey Station. (Adapted from Macklin and Hunt, 1988.)

Description

At Wookey, two gravel aggradations have been distinguished. The younger is a valley-fill of early Holocene age (Macklin and Hunt, 1988). This lies in a trench incised through the earlier aggradation, which has the morphological and sedimentological characteristics of an alluvial fan, with a convex upper surface and containing radiating palaeochannels (Macklin and Hunt, 1988). Cuttings at the old Wookey Station (ST 53154630; Figure 9.19), expose the following sequence (maximum bed thicknesses in parentheses):

3. Strong brown to dark red-brown slightly clayey silt with occasional stones, thickening towards the line of the modern River Axe and apparently filling a palaeochannel. (> 1.0 m)
2. Red-brown, massive- or crudely bedded, sandy cobbly gravel, involuted, with numerous vertical pebbles and cobbles and many split clasts. Disturbed gravel of this sort is present only in those parts of the section not overlain by bed 3. (1.0 m)
1. Red-brown, massive- or crudely bedded, clast-supported sandy cobbly gravel. Two graded units, separated by silty sand partings are present. In some places, the massive sandy gravel passes down-valley into planar cross-stratified openwork and clast-supported sandy gravel with occasional sand and silty sand beds. The gravels contain occasional scour channel-fills of normally graded plane-bedded sand or coarse silt. Some of these channel-fills contained shells of *P. muscorum* and *C. arenaria*, pollen of *Callitriche* and recycled palynomorphs derived from rocks of Carboniferous, Triassic, Jurassic and Pleistocene age. (> 2.0 m)

Interpretation

Beds 1 and 2 were interpreted by Macklin and Hunt (1988) as gravels of an alluvial fan laid down by a low-sinuosity single-channel stream. The fossil molluscs are taxa typical of British cold-stage deposits: *P. muscorum* is a xerophile tolerant of open exposed ground and *C. arenaria* today lives among sand dunes. Together, they indicate an exposed arid environment. The absence of pollen of terrestrial plants may also be taken as evidence for a largely unvegetated landscape or may be due to taphonomic problems. The *Callitriche* pollen probably reflects the vegetation of shallow, sun-warmed, relatively ephemeral pools. The recycled palynomorphs include taxa derived from rocks not present upstream from Wookey Station: the most probable explanation for their presence is that they were recycled by aeolian processes. The involutions of bed 2 post-date deposition of gravels in beds 1 and 2 and the colluvial deposits of bed 3. The latter is probably best interpreted as the colluvial-fill of a large channel, composed of sediments comparable with the aeolian coversands (Vink, 1949; Gilbertson and Hawkins, 1978a, 1983) of Avon and north Somerset. These sediments are thus probably at least partly of aeolian origin.

Conclusion

Wookey Station railway cutting exposes an excellent example of Devensian alluvial fan sedimentation on the margins of the Mendip Hills. The site is important because it contains fossil molluscs, pollen and recycled palynomorphs critical to an understanding of the depositional environment of the Mendip alluvial fans. The palaeobiological evidence suggests very open exposed landscapes. The recycled palynomorphs and sedimentary evidence points to considerable quantities of aeolian sediment being recycled by colluvial processes and to gravel deposition by streams on the alluvial fan.