1. Flandrian Sedimentation and Palaeoenvironments in Pett Level, the Brede and Lower Rother Valleys and Walland Marsh

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Introduction

Romney Marsh is one of the largest areas of reclaimed marshland in Britain. Despite its size, little is known about the sedimentary sequences of which it is comprised. Early investigations of the marshlands have now largely been superseded, a notable exception being the work on the formation of the shingle barrier at Dungeness (Gulliver 1897; Lewis 1932; Lewis and Balchin 1940). Recent attempts to reconstruct the formation of the marshland (Cunliffe 1980; Brooks 1981; Eddison 1983a, 1983b) have tended to focus on changes occurring during the historic period. Much of the detailed information upon which these discussions are based originates from the work of Green (1968) and his colleagues at the Soil Survey of England and Wales (Green and Askew 1958a, 1958b, 1959, 1960). Green (1968) was responsible for recognising the basic stratigraphic sequence which is thought to characterise the marshland. Examination of the general character of the deeper deposits and a detailed study of the near surface sediments, together with consideration of historical documentation and cartographic evidence, enabled Green to advance a model of the evolution of the marshlands. In spite of these studies there are still many uncertainties. Particularly lacking are data concerning the development of the river valleys during the evolution of the marshland. The lithostratigraphy, depositional environment and chronology of the valley fill deposits and their inter-relationships with the marshland sequences are unknown. The primary aim of this research has been to fill this significant gap in the understanding of the evolution of the Romney Marsh area.

The investigations described in this paper are the result of a series of studies into the deposits of this area (Fig. 1.1). The Flandrian vegetational history of the Brede valley is being investigated by Martyn Waller and a detailed understanding of the lithostratigraphy, pollen assemblages and plant macrofossils is emerging, supported by radiocarbon dating. Initial investigations in the adjacent but smaller Pannel valley were first reported by Woodcock (1984). This work has now been complemented by analyses from a further site. The lithostratigraphy and foraminiferal assemblages of Pett Level have been described by Marlow (1984) and this work has now been extended into the lower Brede. In the Rother valley, subsurface investigations have extended from the fluviatile sequences (see Burrin 1988) to the deposits of the lower Rother, the Rother Levels and out across Walland Marsh to the Rhee Wall. All these investigations have been concerned with the identification and correlation of the sedimentary sequences found, and the reconstruction of depositional environments. Here a preliminary attempt is made to integrate these results in order to produce a clearer understanding of the development of the western tracts of the marshland. However, prior to describing the results of this more recent research, it is useful to outline the ideas of Green (further refined by Cunliffe 1980, Brooks 1981 and Eddison 1983a, 1983b), so that the difficulties and discrepancies encountered in relation to this new material can be more fully appreciated.

The Depositional History of Romney Marsh

The landward boundary of the marshland is marked by a prominent and now abandoned cliff-line, which is best developed on the erosionally resistant sands of the Wealden Series (Fig. 1.2). The age, origin and development of the cliffs remain largely unresolved. Kellaway *et al.* (1975) and Destombes *et al.* (1975) imply that this feature may date from the preceding (Ipswichian) interglacial and that it has been modified, rather than created, by the subsequent Flandrian transgression. A recent investigation of landslides at Lympne (Hutchinson *et al.* 1985) has indicated that the cliff-line here was probably abandoned by *c.* 5000 B.P., with later instability producing the current slope morphology.

Little is also known regarding the characteristics of the deepest deposits of the marsh, for few boreholes have penetrated the alluvium to bedrock. Of the five boreholes quoted in Shephard-Thorn *et al.* (1966) and Smart *et al.* (1966) only two appear to provide reliable information. These record bedrock at *c.* −20m (Langdon) and *c.* −28m (Guldeford Lane Corner) respectively. Two deep boreholes in the valley alluvium of the lower Tillingham and lower Rother also record bedrock at −24.5m O.D. (Tilling Green, Rye) and *c.* −28m O.D. (Wittersham Bridge). The deepest

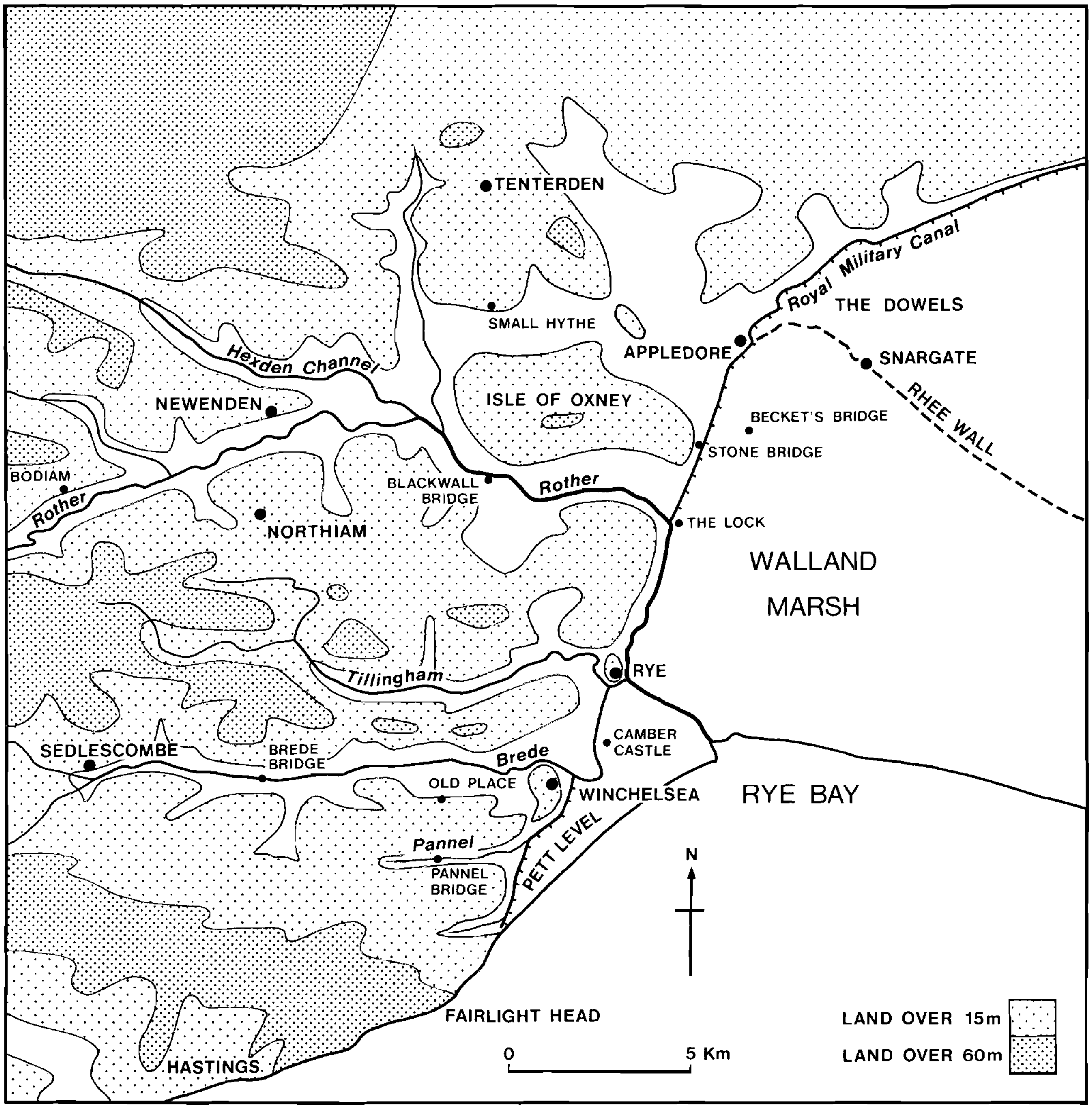


Fig. 1.1 Location of sites

deposits recorded in these boreholes are variable, ranging from peats at Langdon and Tilling Green, of which the latter have been dated to 9565 ± 120 B.P. (Welin *et al.* 1974), to clays and sands with gravel elsewhere. Consequently, comments relating to the general morphology of the bedrock surface, or to the composition and origins of these basal materials, rely on a very restricted database and must be viewed with some caution.

The most reliable information concerning the marshland sediments to-date is that provided by the Soil Survey of England and Wales (Green 1968). The deepest deposit identified is the Midley Sand, so named because it outcrops at the surface in the vicinity of Midley (TR 031232) (Green and Askew 1958b). This sand is relatively coarse when compared with the marshland's younger sandy deposits. Where it occurs close to or at the surface prominent sand ridges are evident trending south-west to north-east. Green (1968) suggests they are part of an extensive feature, such as a sand spit, or a system of sand banks or dunes, which suffered dissection and reworking during subsequent periods.

The Midley Sand is overlain by the Blue Clay, which has a high silt content and contains shells of the estuarine bivalve *Scrobicularia*. Above this deposit is an extensive peat bed, which is thickest in the Dowels east of Appledore but thins to the east and wedges out

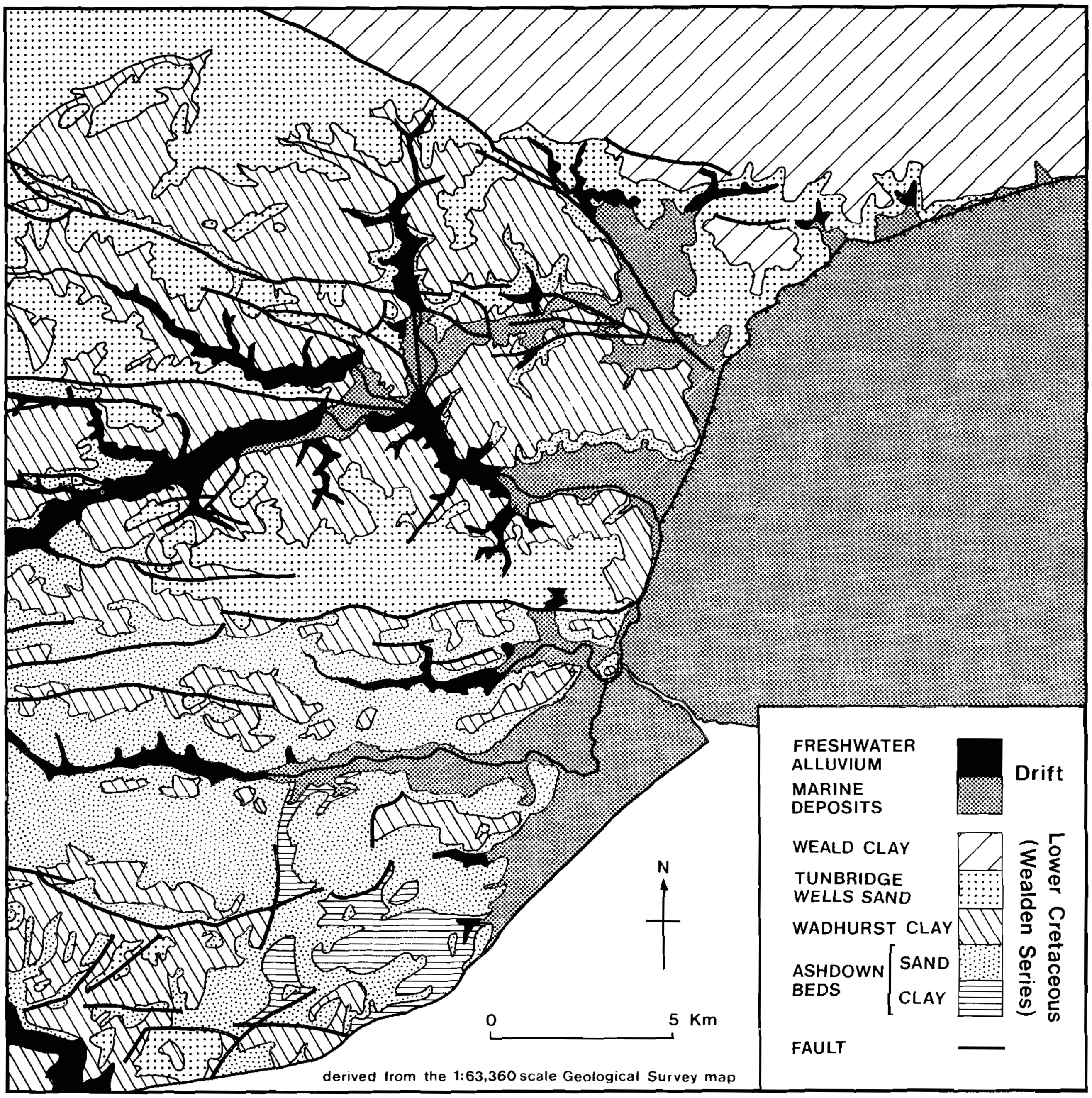


Fig. 1.2 Geology of study area

completely over the Midley Sand deposits near Lydd (Green 1968). The peat is said to contain the trunks of oak and hazel, as well as alder remains (Drew 1864). The original extent and thickness of the peat is likely to have been altered by a number of factors including erosion, compaction and wastage through oxidation. Two radiocarbon dates are available from the main marshland peat bed: 3020±94 B.P. at Appledore Dowels and 3340±92 B.P. from Walland Marsh (Callow *et al.* 1964).

Subsequent deposits, referred to as the 'Young Alluvium' by Green (1968), have been the subject of much attention and speculation in attempts to understand the historic evolution of this area. The marsh was sub-divided by Green into Decalcified (Old) Marshland, where the post-peat deposits are often thin, and Calcareous (New) Marshland, which contain thick post-peat deposits. These more recent events in the marshland's depositionary history are believed to be closely related to the development of barrier beach systems. The earliest date for the origins of such structures is uncertain. An early Flandrian age for barrier beaches further west along the south coast at Langney Point, Eastbourne has been suggested by Jennings and Smyth (1982a). In Romney Marsh, Eddison (1983a, 1983c) has argued that barriers may have provided a sheltered environment behind which peat accumulation could have occurred. As peat was forming by *c.* 5300 B.P. at Pett Level (Welin *et al.* 1972), Eddison suggested that shingle had accumulated significantly by this period. Others however, including Green, have envisaged peat formation occurring during a period of relatively low sea level. The earliest unequivocal evidence for barrier formation (but see Tooley 1988) consists of a series of shingle beaches west of Lydd. These follow the SW–NE alignment of the Midley Sand and are overlain by 'clay with roots' dated to 2740 ± 400 B.P. and a thin peat dated to 2050 ± 90 B.P. (Callow *et al.* 1966), which Green (1968) correlated with the Blue Clay and peat respectively of the marshland. The alignment of the surface outcrops of Midley Sand and early shingle deposits has led to the suggestion that a spit may once have extended from Fairlight to Hythe, forming as a result of the predominantly eastward longshore drift (Lewis 1932; Lewis and Balchin 1940; Cunliffe 1980; Eddison 1983a), this structure being the precursor of the present-day cuspate foreland of Dungeness.

The deposits of the post-peat period (the Young Alluvium) are complex and appear to relate to the episodic breaching of the barrier system. Green (1968) identified three areas of calcareous marshland which have thick post-peat deposits and reveal the location of former estuaries associated with gaps in the shingle barrier. Of particular significance is a large area of calcareous deposits in the north-east of the marsh which represents an estuary with its mouth near Hythe. Cunliffe (1980) correlated this phase of coastal development with archaeological evidence suggesting that a Roman fort near Lympne would have occupied a strategic position controlling access to the eastern Weald if the Rother and its tributaries met the sea near Hythe. However, the arguments for the present-day Sedbrook Sewer representing a northern channel or distributary of the Rother (or *Limen)* as suggested by Green and Askew (1959) remain unsubstantiated. The small scale of this feature makes such a route unlikely and it may only have been a tidal creek feeding into the Hythe estuary (Eddison 1983a). Shells collected from a similar creek, dated to 1550 ± 120 B.P. (Callow *et al.* 1964) are said to indicate that infilling was occurring by late Roman times (Green 1968). Brooks (1981) reviewing the documentary evidence suggests that this north-eastern area of calcareous marshland was available for settlement by the middle Saxon period.

A second area of calcareous marshland and associated relic creek patterns occurs in the vicinity of New Romney and Denge Marsh. Green (1968) detected the course of a natural waterway extending from Appledore to New Romney, where it widens into this area of calcareous marshland. The origin of this channel, usually referred to as the Romney branch of the *Limen,* has not been established. It does not appear to relate to parish boundaries which suggests (Brooks 1981) that it post dates them. Evidence for the existence of this watercourse in the 8th century can be found from land charters (Ward 1940, Brooks 1981). Parallel to this natural course lies the Rhee Wall, the origins and purposes of which have been much debated. It is clearly artificial and is not a depositional boundary (except between Appledore and Snargate) which indicates that the 'wall' did not function as a seabank (Green 1968). All recent authors agree that the Rhee Wall was a canal built prior to 1257, when it was extended seaward to scour the New Romney estuary which was becoming increasingly obstructed by sediment. This problem was exacerbated by the storms of this period which were threatening the existence of New Romney as a port (Green 1968; Cunliffe 1980; Eddison 1983a, 1983b). The Rhee Wall itself appears to have been threatened at Appledore during this period by a marine inundation of Walland Marsh. Brooks (1981) has reopened earlier arguments by challenging Green's (1968) view that the whole of this second area of calcified marshland was reclaimed after the storms of the thirteenth century, as documentary evidence suggests that Denge Marsh formed part of the archepiscopal estate of Lydd as early as the tenth century.

The third tract of calcareous marshland occurs in the vicinity of Rye and Walland Marsh. The boundary with the decalcified marshland in Walland Marsh coincides with an important cordon of old sea walls which zigzag for some 15 miles between Appledore and Broomhill. Green attributed these calcareous deposits to the storms of the thirteenth century which led to the drowning of much of this area and, it was suggested, to the capture of the Rother from New Romney. There is, however, evidence for the existence of an estuary in the Rye area prior to the 13th century. Brooks (1981) notes the absence of Anglo-Saxon place names and Domesday settlements over Walland Marsh, suggesting that this area was not settled during this period, while Eddison (1983a) refers to the Domesday records (Darby and Campbell 1962) concerning the presence of 100 salt pans at Rye. The existence of the port of Old Winchelsea prior to the 13th century storms also suggests the presence of an estuary in this area. The age of this estuary and the associated gap in the shingle barrier therefore remain unknown, although this has important implications for the development of Dungeness, in that the resultant isolation of the shingle to the west was partly responsible for the realignment of the foreland (Lewis 1932). Most of this part of the marsh appears to have been reclaimed by the 17th century as illustrated in Poker's map of 1617.

Lithostratigraphic Investigations

Methods

Information concerning the lithostratigraphy of the lower valleys and western marshland has been obtained from a variety of sources. Much of the data was acquired by hand augering using a gouge sampler at a variety of locations within the specified areas. Penetration of the fine-grained silts, clays and peat was generally effective, although difficulties were encountered with wood remains and compacted sands. The elevation of each borehole relative to Ordnance Datum was surveyed in using a Kern Quickset level, heights being obtained from benchmark lists.

Additional sources of information concerning these deposits include the borehole logs held by East Sussex County Council as part of site investigation reports into plans for a Winchelsea diversion and a by-pass around Rye. These records are sufficiently detailed for them to be included in the database, but the same is unfortunately not true of the county well records collated by Cole *et al.* (1965). The British Geological Survey also provided additional borehole data. The location of the sites described in this paper are shown in Fig. 1.1.

Results

The sedimentary characteristics of Pett Level, the Brede valley, the lower Rother, and the Rother Levels extending out into the marshland, are described in an attempt to identify and define the major stratigraphic units. Description of the organic deposits follows Troels-Smith (1955); the sediment symbols in the accompanying diagrams have, however, been modified from this scheme (Fig. 1.3a).

Pett Level

The augering of fifty-four boreholes on Pett Level revealed a complex sedimentary sequence, full details of which can be found in Marlow (1984). Here a summary of the lithostratigraphy is presented in the form of the long-profile (Fig. 1.3), from TQ 895140 to TQ 903160.

The depth and morphology of the underlying bedrock was not established because of the difficulties in penetrating the lowest deposit identified, a blue grey (5 B 5/1) and grey (5 Y 5/1) compact silty sand, which was found between −5.25m O.D. to −3.28m O.D. Overlying the sand and separated from it by diffuse boundaries is a blue grey (5 B 5/1) silty clay which occurs between −4.40m O.D. to −2.76m O.D. This material is absent in boreholes 2 and 5 where the sand is directly overlain by peat. The peat deposits, found between −4.83m O.D. and −0.80m O.D., are a highly variable element in the lithostratigraphy at Pett Level, often with a widespread, intercalated blue grey (5 B 5/1) clay (between −3.55m O.D. and −2.01m O.D.), with evidence for at least two such layers in some boreholes (Marlow 1984). The peat is largely detrital in character and wood remains occur widely as is apparent in the outcrops which occur along the present-day littoral zone. On the long profile the upper contact of the peat is generally diffuse, although sharp boundaries occur in boreholes 1 and 2. The overlying deposits consist of black (5 Y 2.5/1), dark grey (N4/) and dark bluish grey (5 B 4/1) frequently laminated silty clays with sand, from −4.52m O.D. to 1.13m O.D. This material is in turn buried by a grey (5 YR 5/1) and greyish brown (10 YR 5/2) to brown (10 YR 4/3) mottled with red (2.5 YR 5/8) silty clay found between 0.37m O.D. and 2.35m O.D.

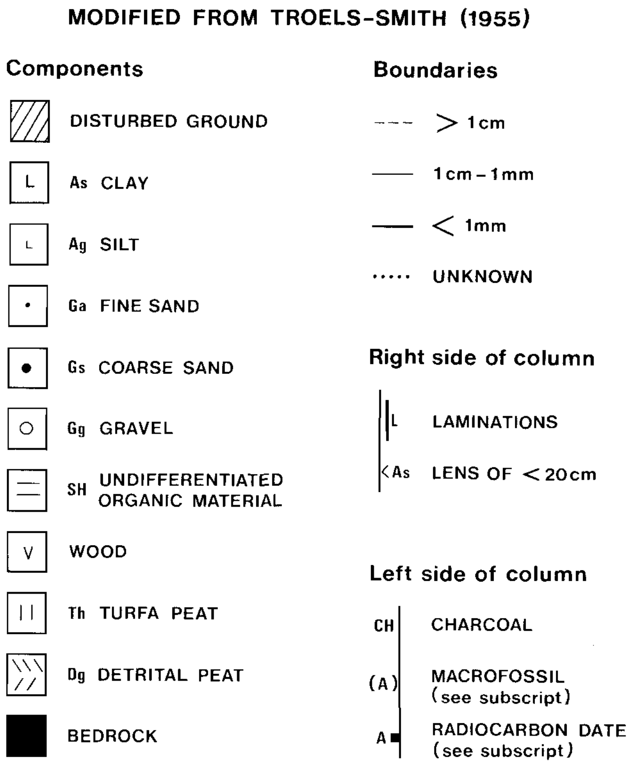


Fig. 1.3a Key to Figures 1.3–1.11

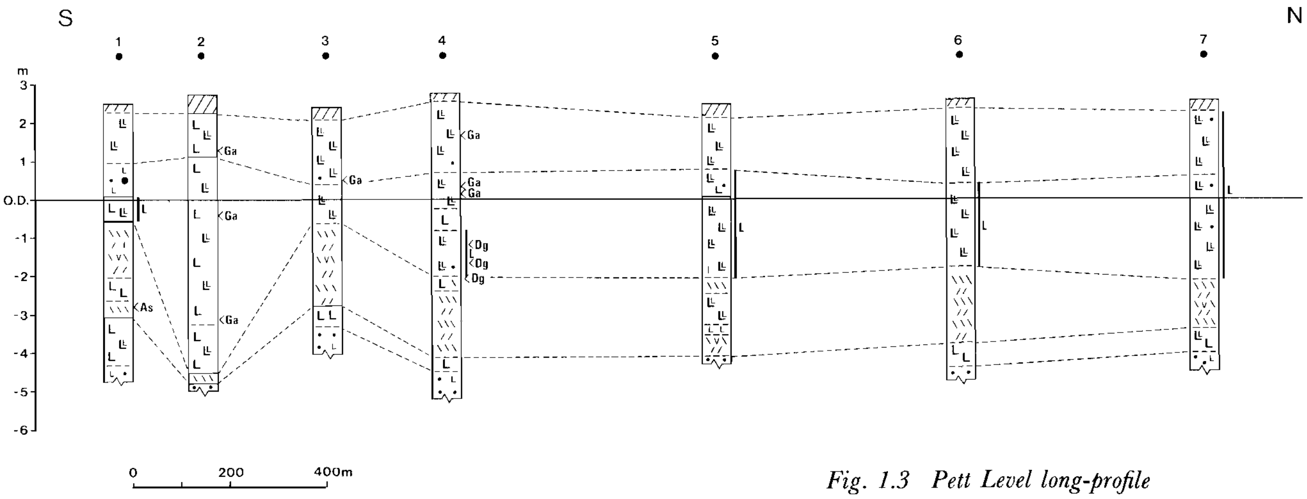


Fig. 1.3 Pett Level long-profile

Brede Bridge

The sixteen boreholes (Fig. 1.4) from TQ 828174 to TQ 827176 at Brede Bridge reveal a polycyclic surface cut into Ashdown Beds with a minimum elevation of − 12.82m O.D. A thin, dissected mantle of yellowish-red (5 YR 5/8) or grey (7.5 YR N5) silty sand with gravel (usually coarse sandstone fragments) overlies part of the rockhead between − 8.16m O.D. and 1.40m O.D. This material is buried by bluish and greenish grey (5 B 6/1, 5 BG 5/1, 5 G 5/2, 5 Y 5/1) clayey silts with fine sand which are generally coarser toward the valley sides and directly overlie bedrock in some boreholes. Such material occurs between − 12.82m O.D. and 2.0m O.D. Over the central part of the floodplain there follows a fining-upward sequence, with the clayey silts being replaced by a blue grey (5 B 7/1) clay, from − 7.40m O.D. to − 4.16m O.D. Except at the floodplain/valley-side margins inorganic sedimentation is followed by detrital peats with abundant wood remains, within which impersistent lenses of greyish brown (10 YR 5/2) clay occur. Although organic material is found at − 7.28m O.D. (borehole 6), widespread peat development occurs upwards from − 5.50m O.D. The transitions from the underlying deposits are gradual with peaty clays and clay with *Phragmites* remains occurring. Organic sedimentation continues until 1.70m O.D. (borehole 10). Beneath the contemporary channel the return to inorganic sedimentation is marked by sharp transitions into black and dark grey (7.5 YR 2/0, 3/0, 4/0) occasionally laminated clayey silts with sand (between − 0.30m O.D. and 0.68m O.D.). The floodplain is underlain by a stiff grey (N6, 5 Y 6/1) mottled with red (2.5 YR 5/8) and strong brown (7.5 YR 5/6) silty clay from 0.32m O.D. to 3.09m O.D.

Old Place

Nineteen boreholes (between TQ 880170 and TQ 881180) were sunk across the floodplain of the lower Brede at Old Place near Icklesham (Fig. 1.5). Bedrock was only proven near the valley sides with the maximum depth of alluvium (12.40m O.D.) recorded in borehole 13. Comparison of the north and south rockhead gradients suggests that the deepest part of the bedrock surface may lie towards the north and that the section is asymmetrical. Overlying the bedrock (boreholes 1–4,6,18,19) is a predominantly grey (5 Y 7/1) or greenish grey (5 GY 6/1), mottled with red (2.5 YR 5/8), clayey silt with fine sand (between − 5.42m O.D. and 1.64m O.D.). In boreholes 5, 7–9, 13, 16–17, the deepest sediment recorded is a blue grey (5 B 7/1) to greenish grey (5 BG 6/1) silty clay which fines upwards into a blue grey clay (between − 12.40m O.D. and − 3.36m O.D.). In borehole 16 this deposit has a high fine sand fraction and between − 10.97m O.D. and − 10.79m O.D. contains a peaty clay lens. Gradual transitions are found between the inorganic silts and clays and the overlying detrital peat, which contains abundant wood remains and occurs between − 4.33m O.D.and 0.61m O.D. Here inorganic material is largely confined to the transitions. Contacts from the peat to the subsequent inorganic deposits are variable, with erosional transitions strongly suggested by the sharp boundaries in boreholes 3, 6 and 8. The immediate post-peat deposits consist of black (7.5 YR N2), dark grey (7.5 YR 3/0, 4/0) and bluish grey (5 B 6/1), frequently laminated clayey silts with fine sand (between − 5.42m O.D. and 1.68m O.D.). *Hydrobia* spp., bivalves and shell fragments are common within this unit. Such deposits directly overlie the blue silty clay in boreholes 12 and 17 with the intervening peat absent. A thin interbedded peat with sand occurs between − 0.37m O.D. and − 0.27m O.D. in borehole 13. Above the frequently laminated deposits is a grey (5 Y 6/1), greyish brown (10 YR 5/2) mottled with red (2.5 YR 5/8) or strong brown (7.5 YR 5/6) silty clay with sand (between 0.64m O.D. and 2.60m O.D.), in which shell fragments are also abundant.

Newenden

Six boreholes have been sunk across the floodplain of the River Rother from TQ 835267 to TQ 834271 (Fig. 1.6). Again, bedrock was only established in two boreholes (1 and 6) close to the valley-sides. In borehole 6 this surface is overlain by a light grey (5 Y 7/2) silty sand found between − 7.77m O.D. and − 6.36m O.D. Elsewhere the deepest deposits identified are bluish grey (5 B 7/1), occasionally with black mottling, silty clays which occur between − 14.15m O.D. and − 4.23m O.D. Gradual transitions predominate between these inorganic sediments and the subsequent greyish brown (10 YR 5/2) detrital peats with wood remains, where the inorganic content of the sediment matrix remains high. This material extends from − 5.63m O.D. to 0.62m O.D. A dark greenish grey (5 GY 4/1) silty sand dominates the sequence, with the peat absent in borehole 5, occurring between − 6.30m O.D. and 0.65m O.D. In the other boreholes, peat gradually gives way to bluish and greenish grey (5 B 6/1, 5 BG 5/1, 5 G 5/2) and dark greenish grey (5 G 4/1) silty clays with occasional fine sand (between − 1.70m O.D. and 1.84m O.D.). This material is followed by a grey (N6, 5 Y 6/1), mottled with red (2.5 YR 5/8) and strong brown (7.5 YR 5/6), clayey silt found between 0.30m O.D. and 2.78m O.D.

Small Hythe

The alluvial deposits of the Rother Levels to the north of the Isle of Oxney were investigated with ten boreholes at Small Hythe (Fig. 1.7), from TQ 895294 to TQ 893299. Although the bedrock surface remains unproven in the central part of the section, it plummets from 1.52m O.D. at borehole 6 to greater than − 9.55m O.D. at borehole 5, over a distance of 16m. A separate shallower (maximum depth − 3.65m O.D.) channel-like depression in the bedrock surface occurs on the northern flank of the valley. Above this surface in borehole 2 is an olive grey (5 Y 4/2) silty sand (between − 6.48m O.D. and − 4.89m O.D.). Beneath the central part of the floodplain the deepest deposits recorded are bluish grey (5 B 7/1) silty clays found between − 19.62m O.D. and − 3.79m O.D., which after gradual transitions are

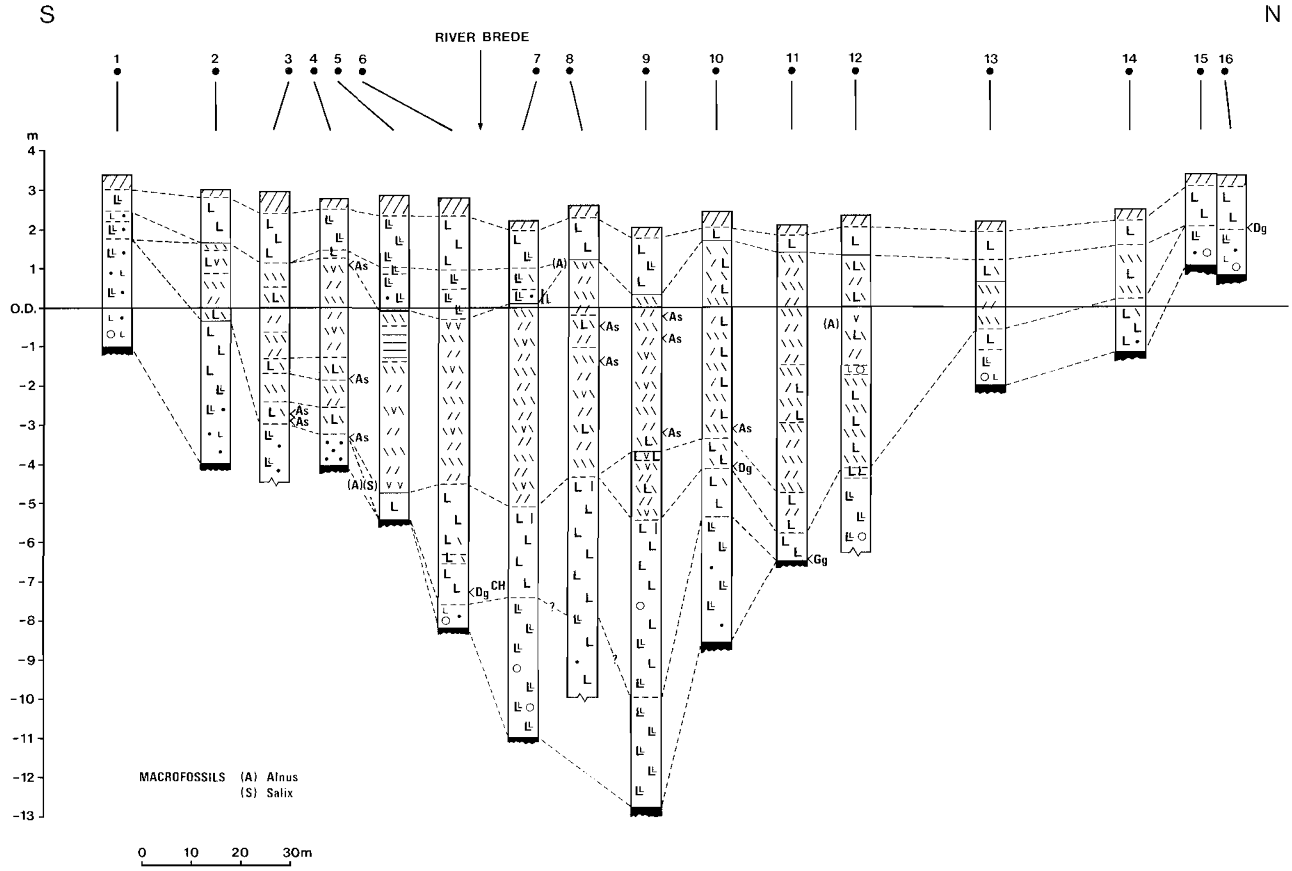


Fig. 1.4 Brede Bridge

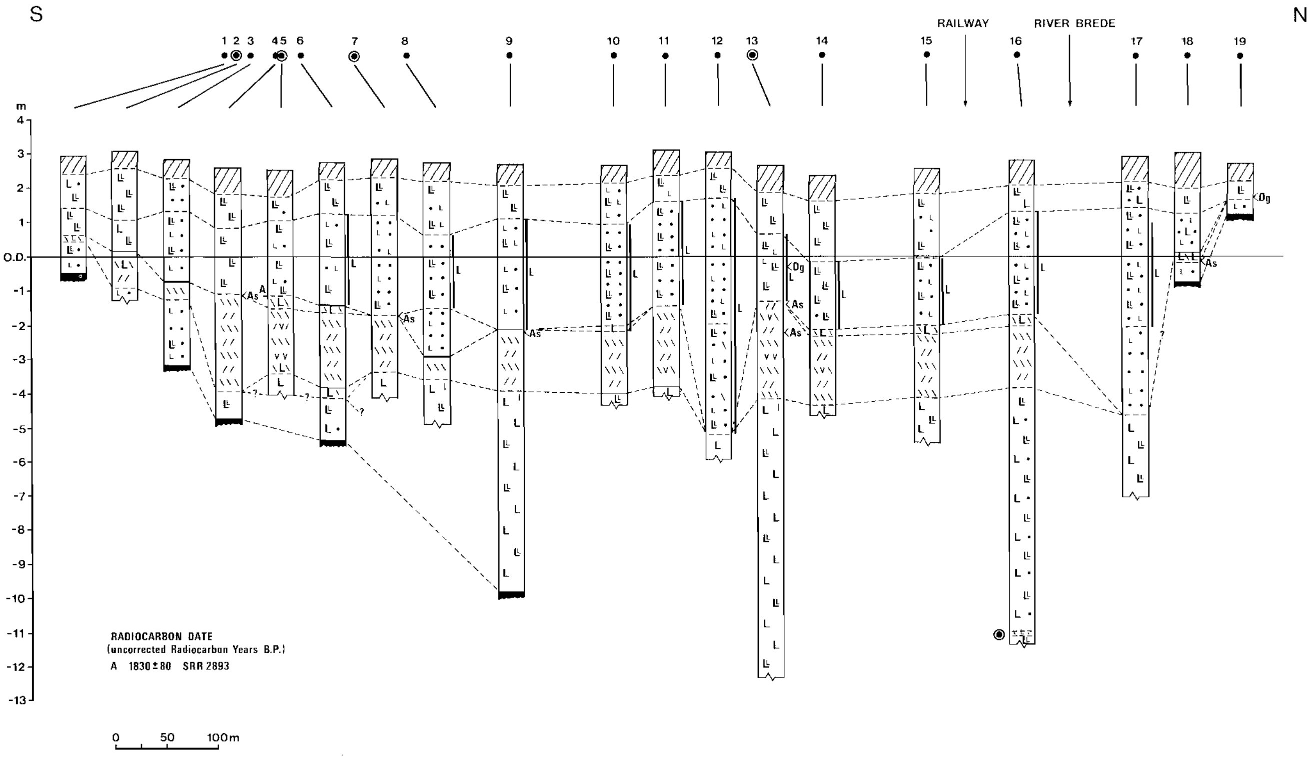


Fig. 1.5 Old Place

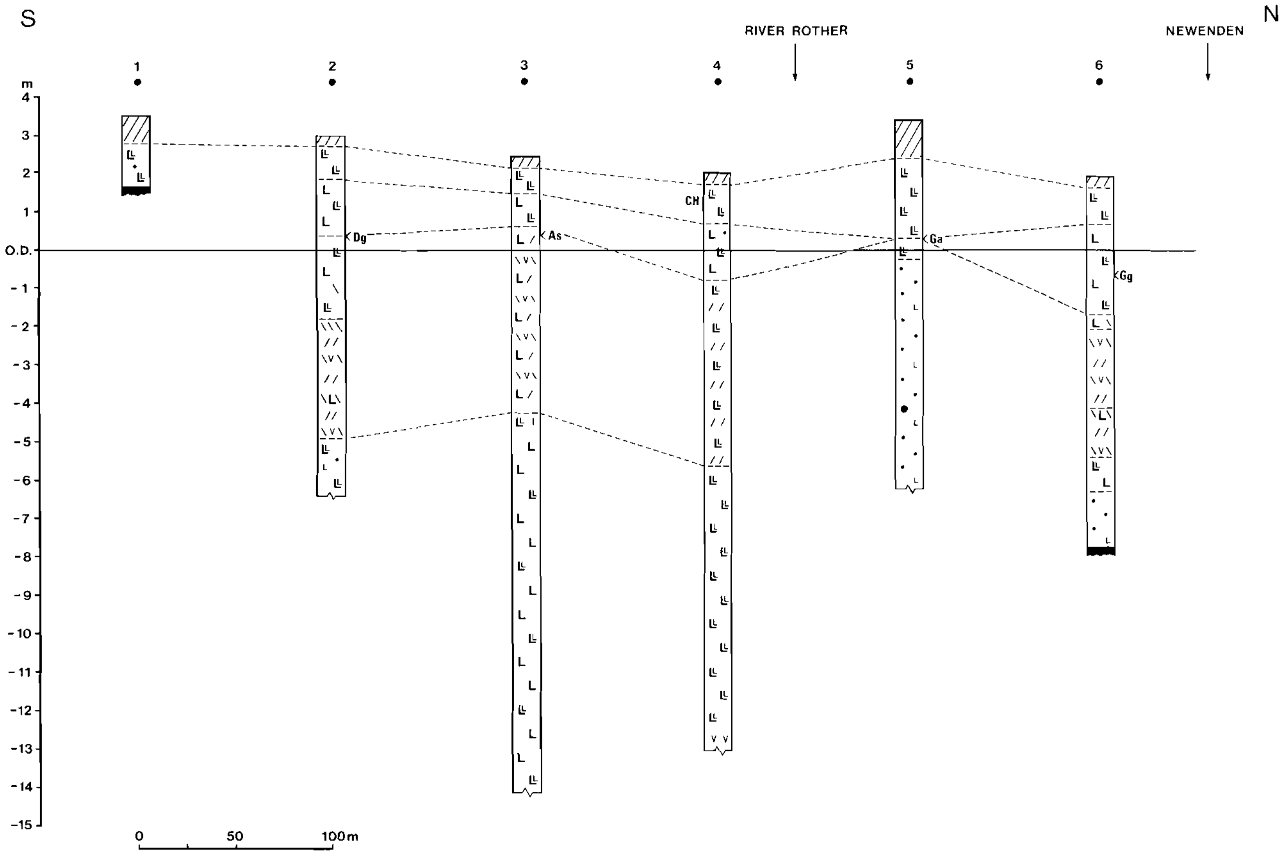


Fig. 1.6 Newenden

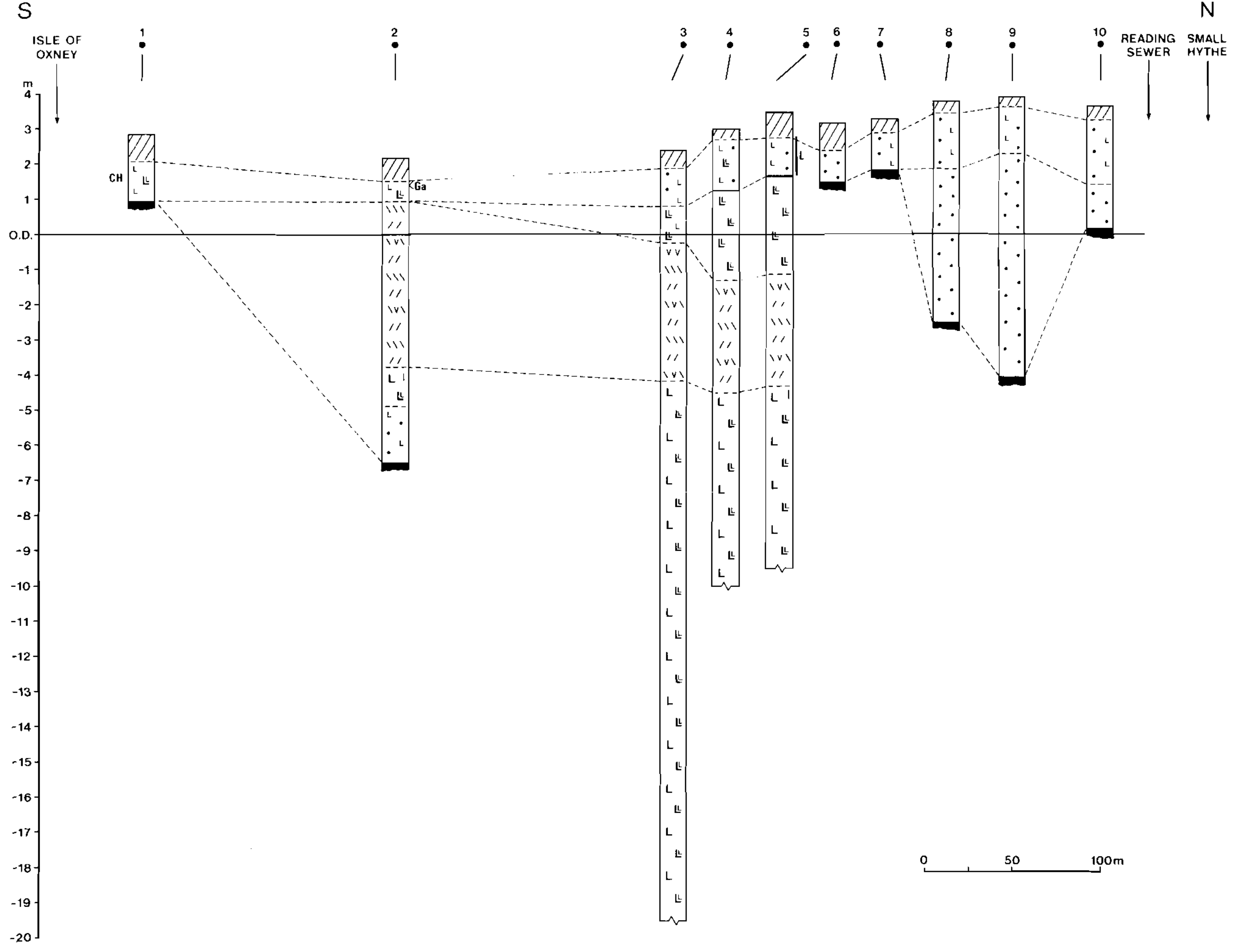


Fig. 1.7 Small Hythe

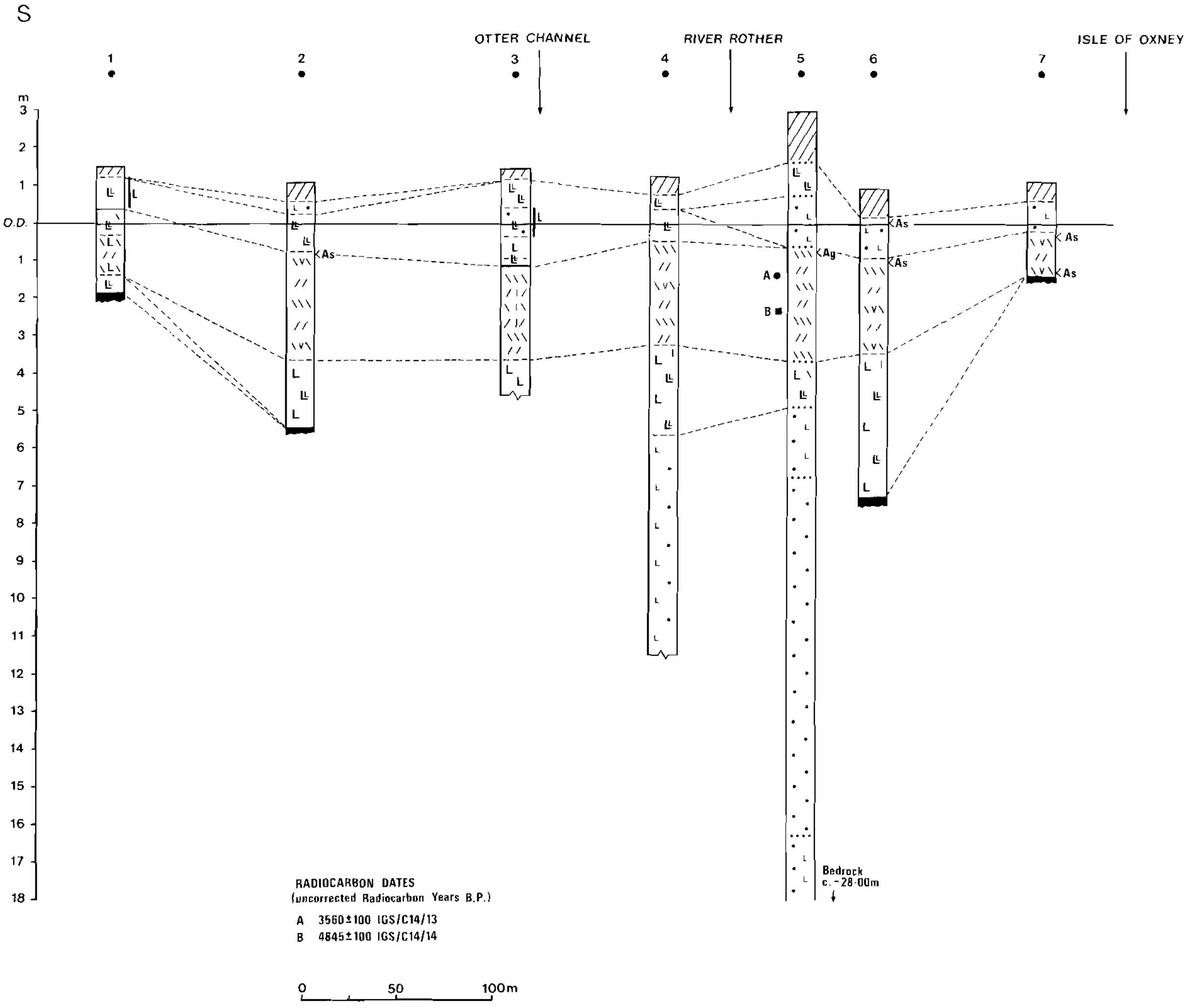


Fig. 1.8 Blackwall Bridge

followed by detrital peats (between −4.49m O.D. and 0.92m O.D.). Inorganic inclusions are almost entirely absent from the peat while wood remains are abundant. In boreholes 3–5, after gradual transitions, black and dark grey (5 GY 4/1) clayey silts occur above the peat (found between −1.29m O.D. and 1.66m O.D.). In boreholes 1 and 2 a grey (5 Y 6/1) and greyish-brown (10 YR 5/2) clay silt occurs above the bedrock and peat respectively (between 0.95m O.D. and 2.05m O.D.). The channel-like feature in the northern part of the profile is filled with predominantly sandy sediments. Between −3.65m O.D. and 2.3m O.D., dark grey (5 GY 4/1) and dark greenish grey (5 Y 4/1) medium sands occur. This material gives way to yellowish brown (10 YR 5/6), mottled with yellow (10 YR 8/6) and very pale brown (10 YR 8/4), fine to medium silty sands (between 0.82m O.D. and 3.04m O.D.), which appear to spread laterally across the valley overlying the dark grey clayey silts in boreholes 3–5.

Blackwall Bridge

Six boreholes, from TQ 882257 to TQ 883261, sunk at Blackwall Bridge south of the Isle of Oxney, complement an existing Kent County Council borehole record of 1968 (shown as borehole 5 in Fig. 1.8). The KCC borehole reached the bedrock surface at *c.* −28.00m O.D. with the deepest deposit recorded as a greenish grey silty sand which is replaced by bluish grey sand. Similar sands were identified in borehole 4 and reach a maximum elevation of −4.9m O.D. These coarser sediments are replaced by a soft bluish grey (5 B 7/1) silty clay (between −7.12m O.D. and −3.23m O.D.). Material similar to this overlies bedrock in boreholes 1 and 7 (though found between −1.86m O.D. and −1.09m O.D.). The transitions to the overlying detrital peats are gradual; here wood remains are common and *Phragmites* is particularly abundant in borehole 3. Organic deposits extend from −3.65m O.D. to 0.39m O.D. Transitions to the overlying inorganic sediments are also generally gradual, although a particularly sharp boundary occurs in borehole 3. The post-peat sediments are variable. South of the Rother, the peat is overlain by dark blue (5 B 4/1), black, olive grey (5 Y 5/2) grey (5 Y 6/1) and greyish brown silty clays which occur between

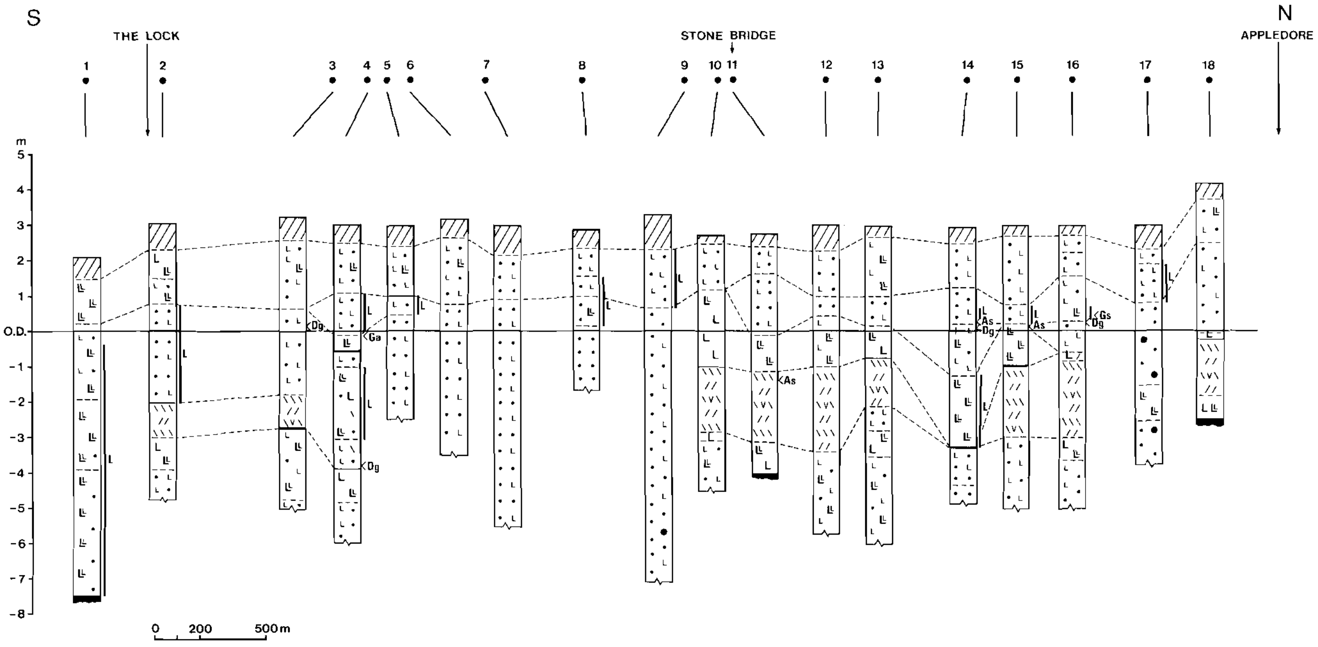


Fig. 1.9 Royal Military Canal

− 1.07m O.D. and 1.10m O.D. and contain *Hydrobia* spp. and shell fragments. To the north such material only occurs as a thin band above the peat, with light grey brown (10 YR 6/2) and light olive brown (2.5 Y 5/6) silty sands occurring between − 0.90m O.D. and 0.61m O.D. A similar yellowish brown silty sand occurs just beneath the floodplain soil (0.62m O.D. to 0.32m O.D.) in borehole 2.

The Royal Military Canal

Eighteen boreholes have been sunk along the edge of the Royal Military Canal (Fig. 1.9), from the old cliff-line near The Lock (TQ 934243) to Appledore (TQ 953287). Bedrock was reached at the ends of the section and in the vicinity of the Isle of Oxney at Stone Bridge (borehole 11). Two boreholes quoted in Shephard-Thorn *et al.* (1966) from near The Lock (TQ 936245) both reached bedrock at *c.* 13m below ground level. In the boreholes described here, a greenish grey (5 G 5/1) silty clay overlies the bedrock in borehole 18 (between − 2.55m O.D. and − 1.87m O.D.). In boreholes 2–4 and 14–16 the deepest deposits consist of dense blue grey (5 B 6/1) to dark grey (N4/) silty sands and sands, which are found between − 6.02m O.D. and − 3.03m O.D., and appear to coarsen with depth (which prevented deeper penetration). Such deposits are usually overlain by a blue grey (5 B 6/1) silty clay (from − 6.00m O.D. to − 2.16m O.D.); the boundary between these sediments is almost imperceptible suggesting a fining upward sequence. There is a variable transition from the blue clay into a detrital peat where wood remains are common and inorganic inclusions rare. Organic material occurs between − 3.42m O.D. and − 0.27m O.D. The upper contact of the peat is also variable though sharp boundaries predominate. To the north of the Isle of Oxney (boreholes 10–13 and 15) a blue grey (5 B 6/1) to grey (5 Y 5/1) silty clay overlies the peat from − 3.34m O.D. to 1.24m O.D.; a similar deposit is found above the lower blue silty sand in borehole 14. South of the Isle of Oxney above the peat a very dark grey (2.5 Y N3/) to dark grey ((N4/) and black, usually laminated silty sand occasionally with clay is found from − 7.49m O.D. to 2.50m O.D. Similar deposits north of the Isle of Oxney overlie the upper blue grey silty clays (except in borehole 10) and directly overlie the peat in boreholes 16 and 18. An additional thin (3–4 cm) peat lens occurs above O.D. in boreholes 3, 14 and 16. In boreholes 5–9 and 17 a dark grey (5 Y 4/1) and dark greenish grey (5 GY 4/1) medium sand with silt dominates the sequence occurring from − 7.18m O.D. and 1.06m O.D. A grey (5 Y 4/1), strong brown (7.5 YR 5/6) and yellowish brown (10 YR 5/6) silty sand and silty clay occurs as the upper unit (between 0.25m O.D. and 3.70m O.D.) across the section.

Stone Bridge to Snargate

Thirteen boreholes (Fig. 1.10) reveal the nature of the alluvial stratigraphy between Stone Bridge (TQ 946265) east of the Isle of Oxney and the Rhee Wall at Snargate (TQ 989290). Bedrock was only recorded in borehole 1 near the Isle of Oxney. Elsewhere along the line of this section penetration below − 5.37m O.D. was prevented by the presence of dense bluish grey (5 B 7/1) silty sands and dark bluish grey (5 B 4/1) sands which occur to a maximum elevation of − 1.90m O.D. These sands are usually superseded, after gradual transitions, by bluish grey (5 B 7/1) silty clays (between − 4.58m O.D. and − 1.17m O.D.). The transitions to peat which follow are variable, with some sharp contacts occurring, notably where the blue sand and peat are adjacent (borehole 10). The peat, largely detrital with wood remains, occurs between − 3.63m O.D. and 0.02m O.D.

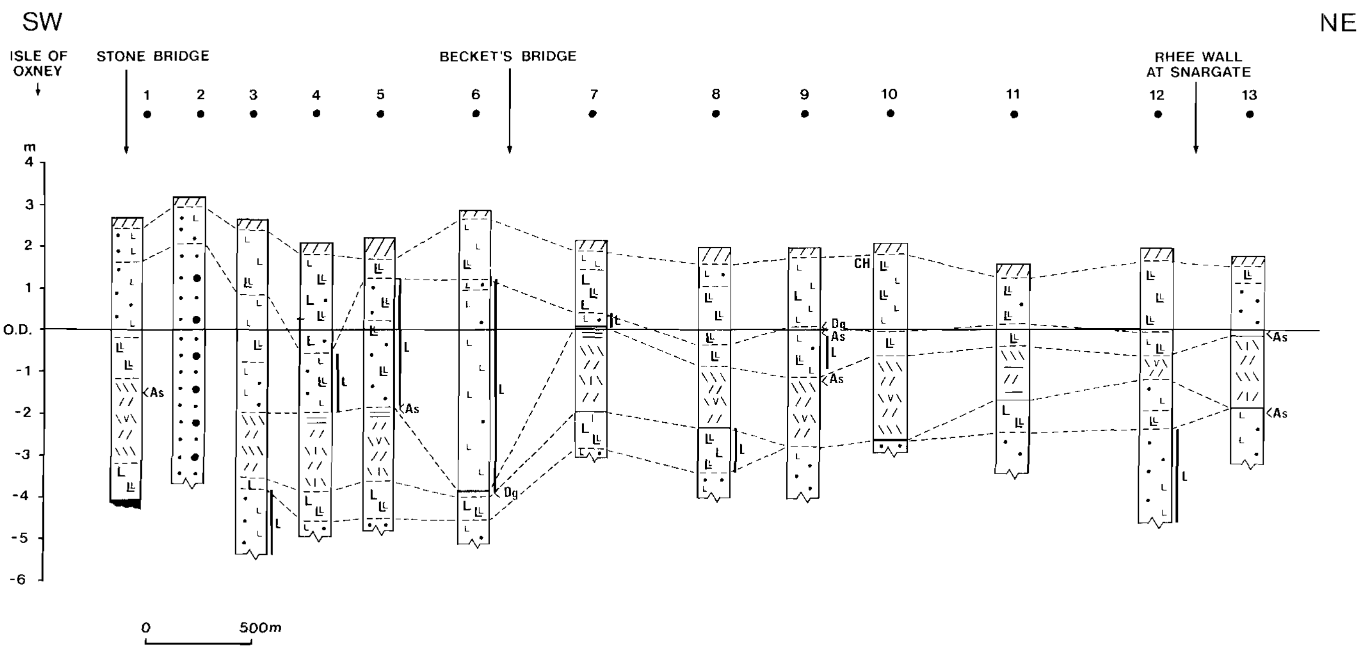


Fig. 1.10 Stone Bridge to Snargate

In three boreholes (4,5,7) the upper part of the peat is highly humified. The upper contacts of the peat are generally gradual, although sharp transitions are evident in boreholes 6 and 7. Black, dark bluish grey (5 B 4/1) and dark grey (7.5 YR N4/,N3/) occasionally laminated, interbedded sands, silts and clays overlie the peat, occurring from −3.87m O.D. to 1.84m O.D. These deposits appear to become finer and thinner in a north-easterly direction (boreholes 8–12), and have not been recognised north-east of the Rhee Wall. In borehole 9 a thin peat lens occurs above O.D. In borehole 2 the sedimentary sequence is dominated by a dark grey (5Y 4/1) sand from the base at −3.69m O.D. to 2.06m O.D. This material is overlain by a yellowish brown silty sand. Similar material also occurs in borehole 1. More usually, the uppermost deposits consist of a grey (5 Y 6/1), greyish brown (10 YR 5/2) and strong brown (7.5 YR 5/6) sandy and clayey silt (between −0.58m O.D. to 3.01m O.D.). The upper sediments which occur north-east of the Rhee Wall are described in the following section.

The Rhee Wall at Snargate

Six boreholes were sunk adjacent to and across the Rhee Wall (Fig. 1.11) in the vicinity of Snargate (from TQ 986287 to TQ 989290). Here, firm sands prevented penetration below a depth of −4.60m O.D. The deepest deposits consist of a bluish grey (5 B 7/1) silty sand and dark bluish grey (5 B 4/1) sand (borehole 2) which have a maximum elevation of −1.70m O.D. A fining upwards sequence into a bluish grey (5 B 7/1) silty clay (from −2.55m O.D. to −1.83m O.D.) then occurs,

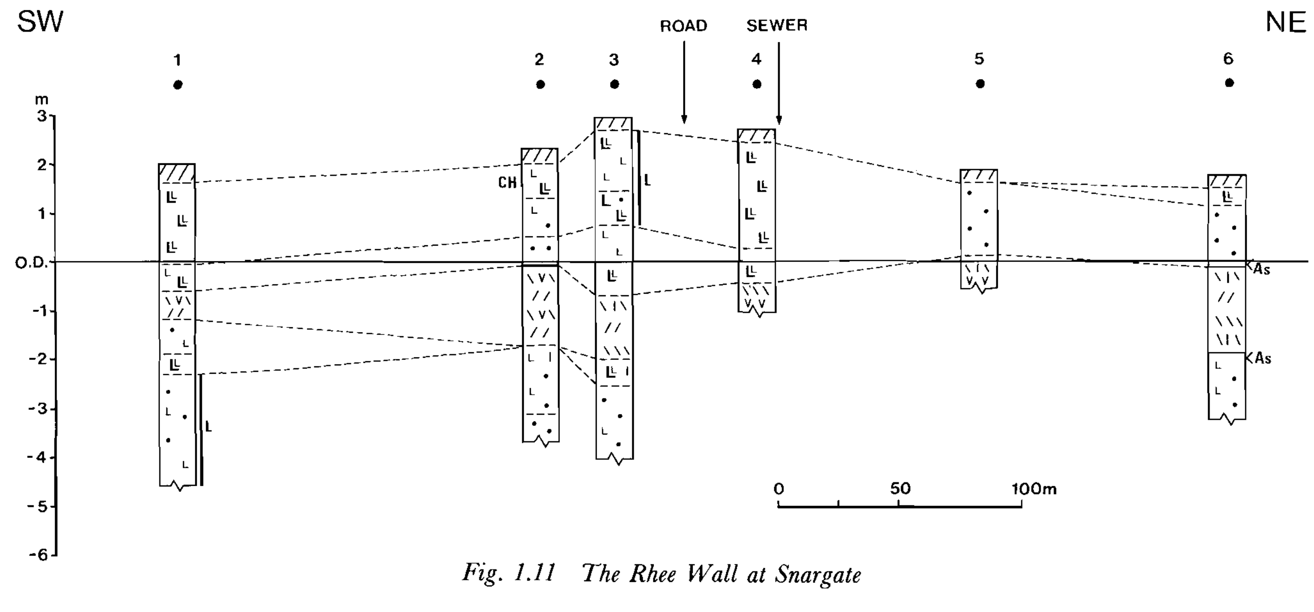


Fig. 1.11 The Rhee Wall at Snargate

though the variation between the individual boreholes is marked. After gradual transitions, where the remains of *Phragmites* are abundant, a predominantly detrital peat with wood is found (between − 1.97m O.D. and 0.10m O.D.). The upper contact of the peat is variable. To the north-east of the Rhee Wall the peat is overlain by light yellowish brown (2.5 Y 6/4) and yellowish brown (10 YR 5/6) medium sands, which occur between −0.13m O.D. and 1.60m O.D. On the Rhee Wall and to the south-west the post-peat deposits are varied, with dark bluish grey (7.5 YR N4/,N3) clayey silts (boreholes 1 and 3) and sands (borehole 2) and a dark grey to black silty clay with abundant shell fragments (borehole 4) occurring above the peat (−0.68m O.D. to 0.75m O.D.). These deposits are in turn overlain by predominantly grey (5 Y 6/1), light grey (5 Y 6/1) and greyish brown (10 YR 5/2) mottled, sometimes laminated, clayey silts with sand found between −0.06m O.D. and 2.75m O.D. No distinctive sediments peculiar to the Rhee Wall were distinguished.

Alluvial lithostratigraphy

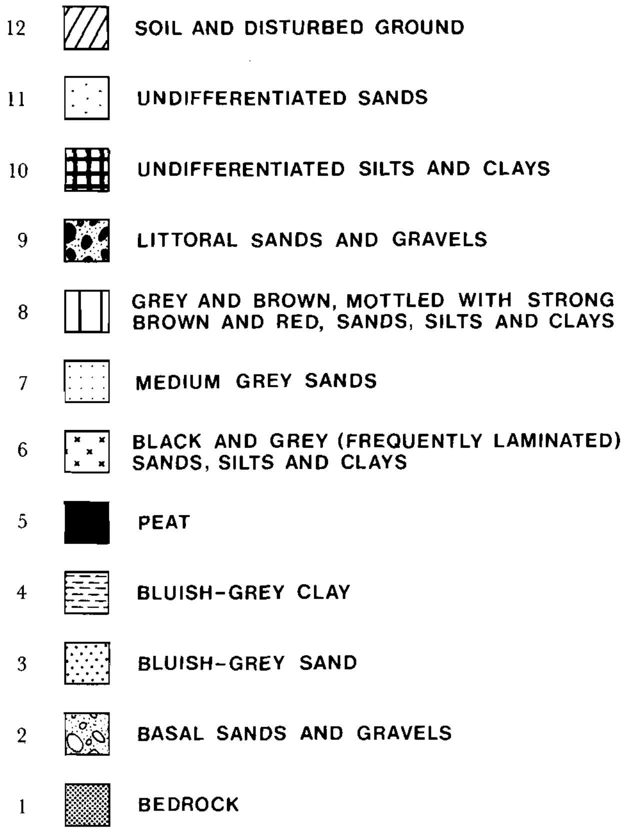
From the descriptions of these sections it has been possible to identify and attempt to correlate a series of lithostratigraphic units which appear to comprise the alluvial stratigraphy of this area. These are outlined in Table 1.1 and form the basis from which the schematic sections presented in Figs. 1.12–1.16 have been constructed.

Table 1.1 Generalised lithostratigraphy of the deposits.

Unit	*Description*
12	Soil and disturbed ground.
11	Undifferentiated sands.
10	Undifferentiated silts and clays.
9	Littoral sands and gravels; found only in contemporary near-shore environments, such as the lower Brede (Fig. 13).
8	Grey and brown, mottled with strong brown and red, sands, silts and clays. These frequently form the uppermost unit and usually extend the full width of the section.
7	Medium grey sands; which are usually dense, structureless and well sorted.
6	Black and grey (frequently laminated) sands, silts and clays. This is a variable deposit which is characterised by its colouration, sedimentary structure and stratigraphic position. While the laminations are an inconsistent feature, both in occurrence and appearance, they usually consist of fine sand lamina of < 1 mm, separated by interstitial clays and silts of variable width. Similar structures composed of laminated peat were also observed.
5	Peat; which usually consists of coarse fragments of plant material (detrital *sensu* Troels-Smith 1955) with wood and *Phragmites* remains. Intercalated inorganic layers also occur.
4	Bluish grey clay; found underlying the peat.
3	Bluish grey sand; which ranges in texture from silty sand to coarse sand and is generally dense. It forms the deepest deposit recognised on the marshland.
2	Basal sands and gravels; which usually consist of weakly cemented fine angular sandstone grits and gravels in a matrix of sands and silts.
1	Bedrock; clays, silts and sandstones of the Lower Cretaceous Hastings Beds Group.

It should be emphasised that the chrono-stratigraphic relationships between these units have not been fully defined. This topic is considered later in some detail.

Fig. 1.12a Key to Schematic Sections, Figs. 1.12–1.16.



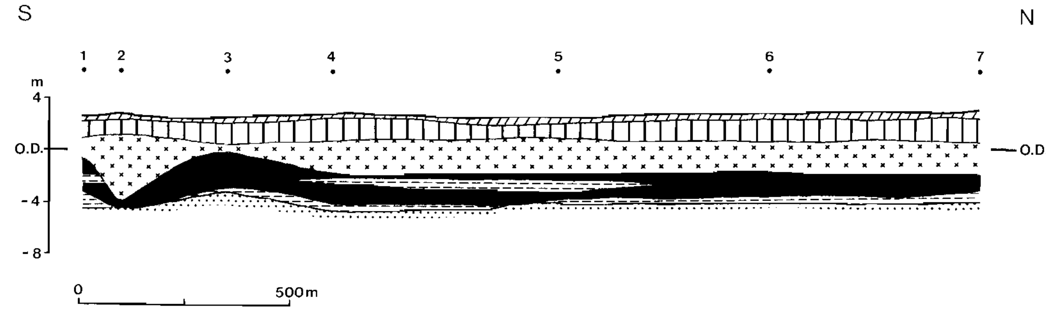


Fig. 1.12 Pett Level long-profile

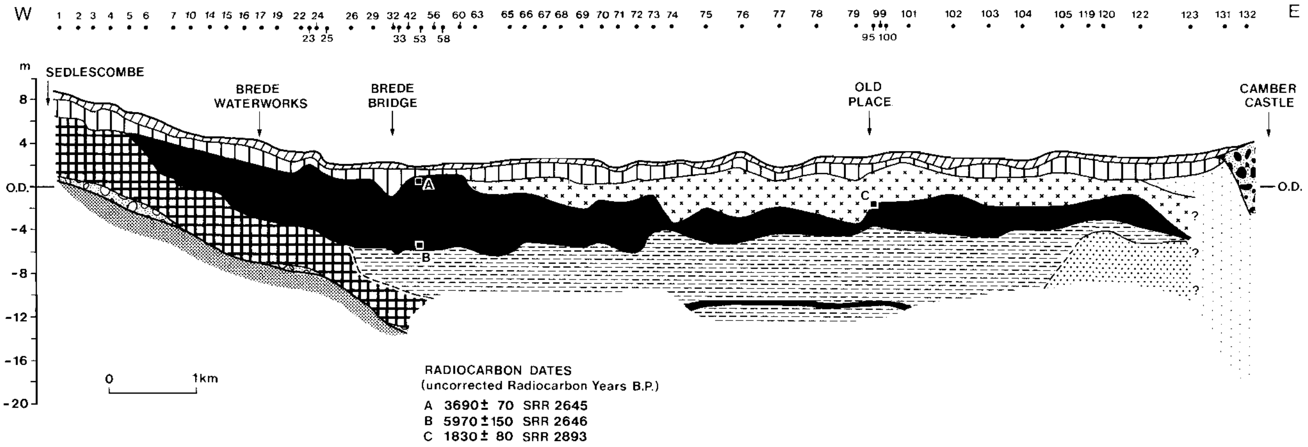


Fig. 1.13 Lower Brede Valley long-profile

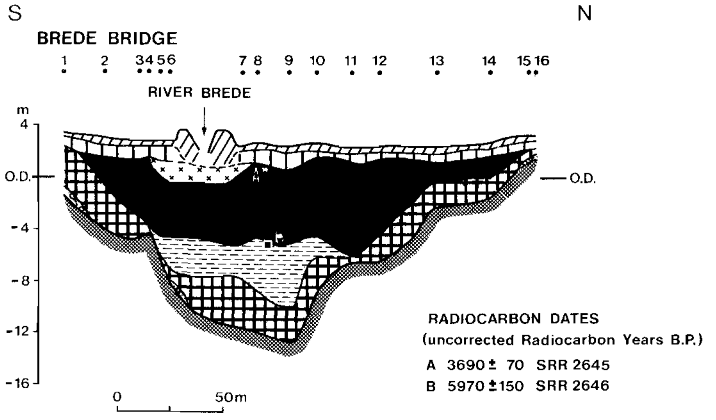
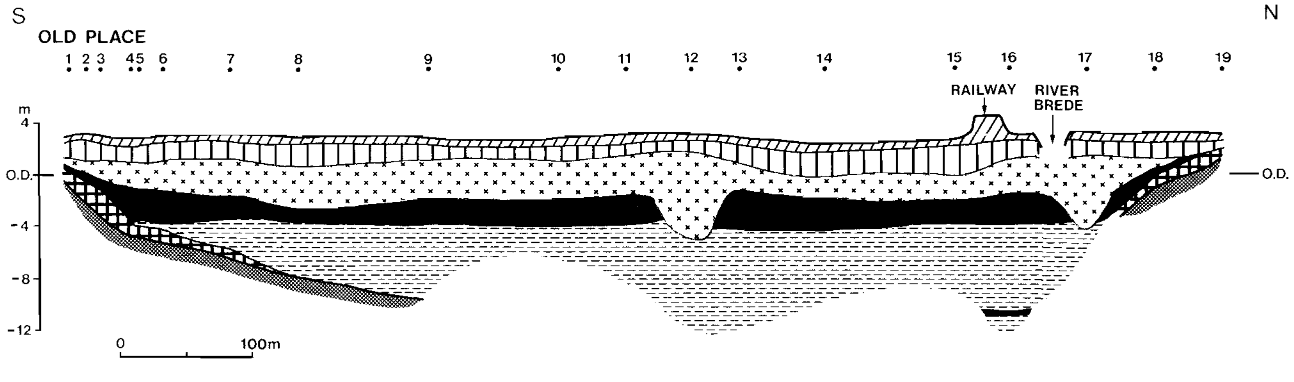


Fig. 1.14 Lower Brede Valley sections



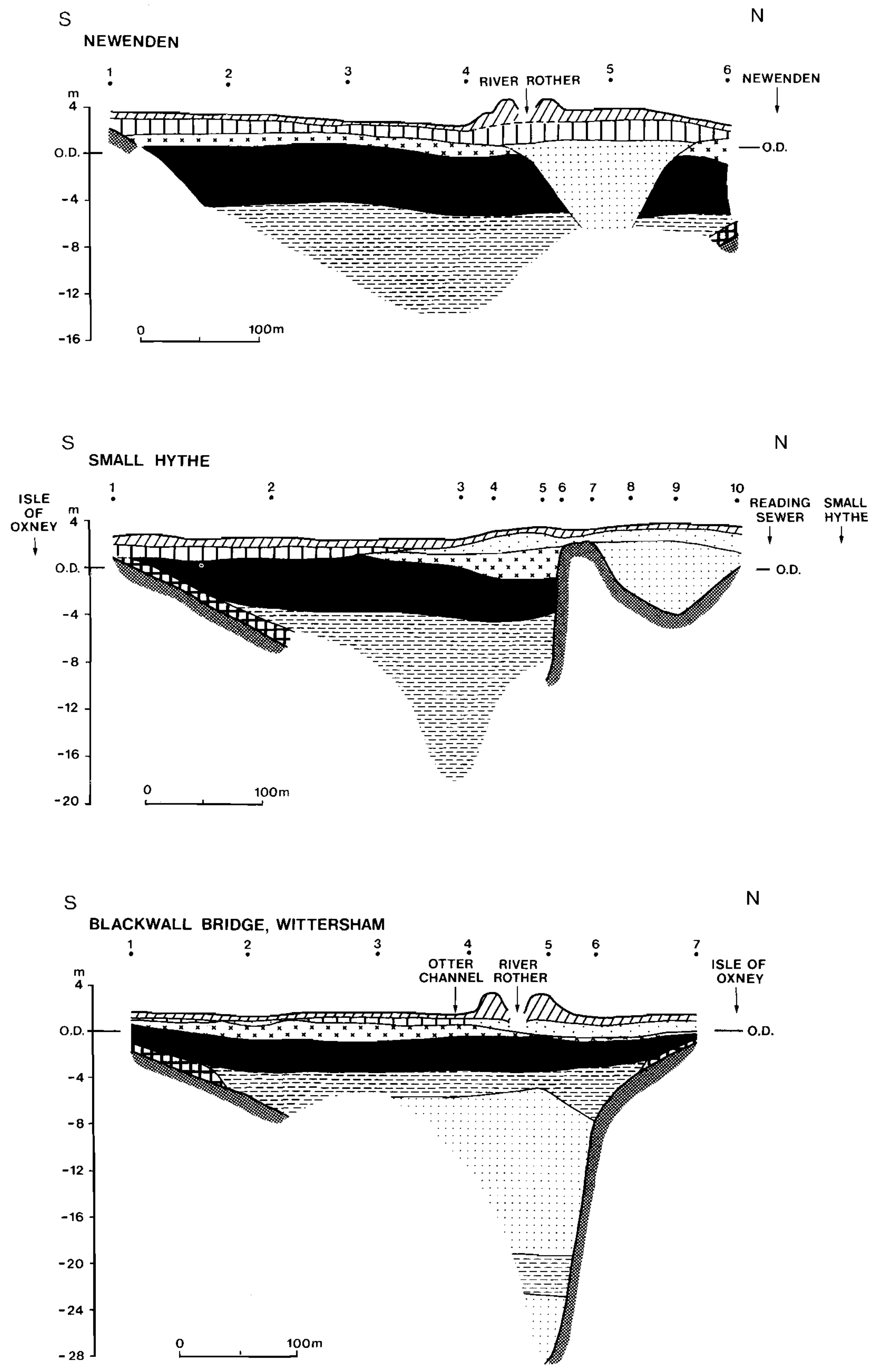


Fig. 1.15 Lower Rother Valley sections

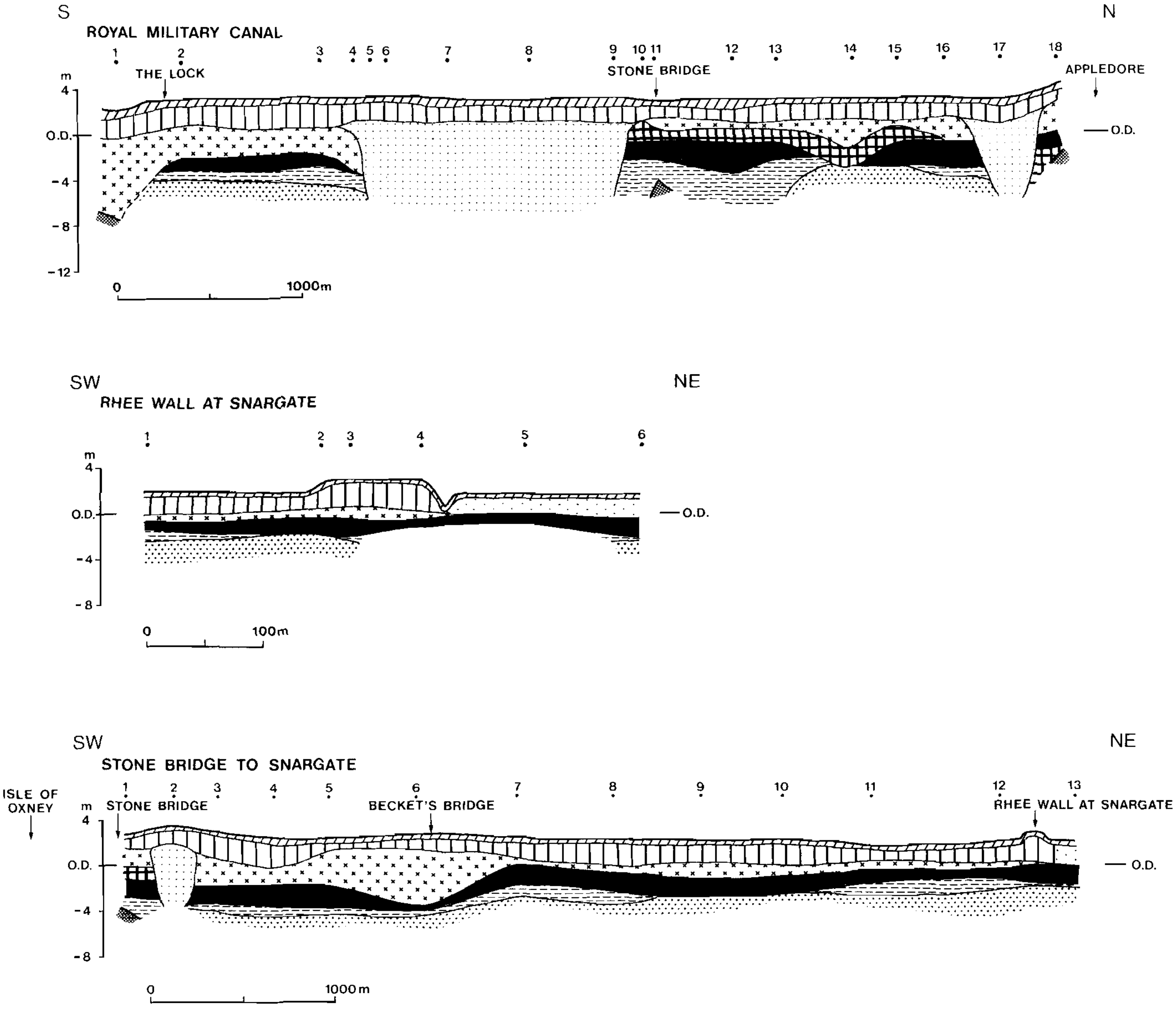


Fig. 1.16 Western Marshland sections

Sedimentology

At the outset of this investigation little was known regarding the more detailed sedimentological characteristics of the deposits of the marshlands and the adjacent valleys. Consequently, a selection of samples was chosen in order to investigate the grain size distributions of some of the units found comprising the lithostratigraphy. This forms but a start to resolving the complex problems concerning the possible sources of the sediments, their spatial variation and likely depositional environments.

Five of the main inorganic units identified in the lithostratigraphy (Table 1.1) were chosen for investigation. These included samples of:

Unit 3: bluish-grey sand (Rhee Wall, borehole 1, −4.00m O.D. to −3.50m O.D.; Royal Military Canal, borehole 2, −5.50m O.D. to −4.50m O.D.)

Unit 4: bluish-grey clay (Snargate, borehole 5, −4.50m to −4.00m O.D.; Small Hythe, borehole 3, −6.00m O.D. to −5.50m O.D.);

Unit 6: black and grey laminated sands, silts and clays (Royal Military Canal, borehole 1, −6.90m O.D. to −5.90m O.D; Rhee Wall, borehole 3, −0.25m O.D. to 0.25m O.D.);

Unit 7: grey sand (Royal Military Canal, borehole 5, −1.95m O.D. to O.D.; borehole 9, −3.0m O.D. to −2.10m O.D.);

Unit 8: grey and brown mottled sands, silts and clays (Royal Military Canal, borehole 1, 0.91m O.D. to 1.31m O.D.; borehole 6, 2.16m O.D. to 2.66m O.D.; Snargate, borehole 3, 1.43m O.D. to 1.83m O.D.).

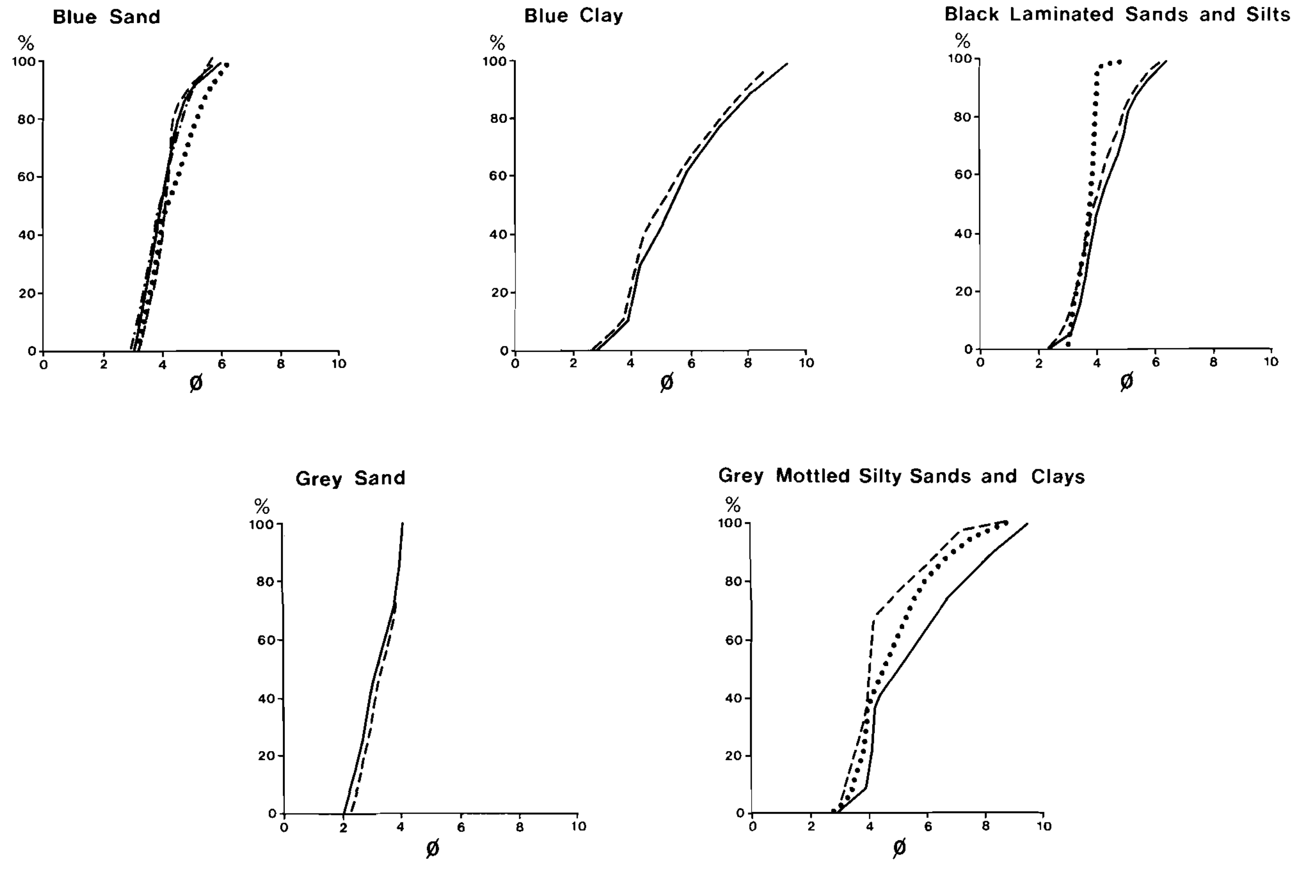


Fig. 1.17 Grain-size distributions

Table 1.2 Moments of the grain size distributions for the deposits.

SAMPLE	LOCATION	M1 *mean*	M2 *sorting*	M3 *skewness*	M4 *kurtosis*
Blue Sand	Rhee Wall	3.99–4.06	0.54–0.59 MS	0.13–0.22 PSk	1.28–1.39 L
	Royal Military Canal	4.10–4.18	0.74–0.77 MS	0.19–0.20 PSk	0.83–0.87 P
Blue Clay	Small Hythe	4.23–4.85	1.20–3.22 PS–VPS	–.04 to .04 NSym	1.50–3.94 L–VL
	Snargate	5.48–5.79	1.64–1.80 PS–VPS	0.21–0.40 P–VPSK	0.85–0.99 P–M
Black & Grey	Royal Military Canal	3.84–3.88	0.28–0.37 WS–VWS	–.51 to –.69 VNSk	1.28–1.38 L
Sands & Silts	Rhee Wall	4.06	0.95 MS	0.09 NSym	1.07 M
Grey Sand	Royal Military Canal	3.26–4.28	0.49–0.89 MS	0.08–0.31 NSym–VPSk	0.85–1.06 P–M
Grey Mottled Sands	Small Hythe	5.97	2.53 VPS	0.59 VPSk	0.88 P
Silts & Clays	Royal Military Canal	4.63–5.59	1.29–1.69 PS	0.44–0.68 VPSk	0.70–1.59 P–VL
	Snargate	4.86	1.36 PS	0.48 VPSk	1.05 M

KEY

M2 *(sorting)*

MS = moderately
PS = poorly
VPS = very poorly
WS = well
VWS = very well

M3 *(skewness)*

PSk = positively
VPSk = very positively
NSym = nearly symmetrical
VNSk = very negatively

M4 *(kurtosis)*

L = leptokurtic
VL = very leptokurtic
M = mesokurtic
P = platykurtic

The samples were all subjected to standard pretreatments and dispersion prior to analysis by the hydrometer method (British Standards Institute, No 1377). The grain size distributions and their moments were then calculated using a micro-computer employing the equations of Folk and Ward (1957). The results are presented as cumulative grain size distributions (Fig. 1.17), with the corresponding moments in Table 1.2. Interpretation of these results has to take into account a number of factors. First, the bedrock sources of sediment are significant in that these determine the initial grain size distributions and moments of the materials available for transportation and subsequent reworking by a range of geomorphic processes. Second, reworking can significantly alter or modify the characteristics of the source materials so that it is possible to suggest the environment of deposition. Finally, reworking of previously deposited sediments can further modify their characteristics. Hence, the sedimentology of a lithostratigraphic unit needs to be considered and interpreted alongside other lines of evidence and enquiry in order to maximise its potential value for palaeoenvironmental reconstruction.

The blue sand has a mean particle size range of 3.99 to 4.18 ϕ (fine sand/coarse silt), is moderately sorted, positively skewed and is platykurtic to leptokurtic. The samples are dominated by very fine sand (*c.* 45% 63μ), the remainder of the distribution consisting of silts with a high coarse silt component (*c.* 45%).

The blue clay samples were found to be comprised largely of silt (the samples analysed here consisted of only 4–8% clay [< 2μ]), with a variable very fine sand content of up to *c.* 15%. The 'clay' has a mean grain size range from 4.23 to 5.79 ϕ, is poorly to very poorly sorted, has a symmetrical to very positively skewed distribution and a variable kurtosis, ranging from platykurtic to extremely leptokurtic. Interestingly, the grey mottled with strong brown sands, silts and clays appear to exhibit similar characteristics to that displayed by the blue clay (Fig. 1.17), having a similar mean grain size range (4.63 to 5.97 ϕ), being poorly or very poorly sorted, very positively skewed and ranging in kurtosis from 0.70 to 1.59 (platykurtic to very leptokurtic). It is also noteworthy that some of the samples have a primary peak in the coarse silt (54μ) fraction. This is a persistent and significant characteristic found in the inland floodplain and valley fill alluvium (see Burrin 1988) and suggests that at least part of these units have been derived from or supplied by fluvial activity.

The grey and black laminated sands, silts and clays have a mean grain size range of 3.84 to 4.06 ϕ, are moderately to very well sorted, very negatively skewed or nearly symmetrical and mesokurtic to leptokurtic in their distribution. These findings are of limited relevance as bulk samples were analysed thereby mixing sand and silt laminae which may have very different distributions if considered separately. Nevertheless, this unit contained high total sand contents of 40–50%, with up to 11% at 125μ and *c.* 35–40% at 63μ, the remainder of the distribution consisting of silts. The grey sand has a mean grain size range of 3.26 to 4.28 ϕ) and is dominated by very fine sand (*c.* 48% at 63μ) and coarse silt (43–49% at 54μ). It is moderately sorted (Table 1.2), ranges from being nearly symmetrical to very positively skewed and has a platykurtic to mesokurtic distribution. There are insufficient differences to allow this unit to be separated sedimentologically from the laminated deposits using these analytical methods.

Pollen and Plant Macrofossil Investigations

Pollen and plant macrofossil investigations have been undertaken as part of a study into the Flandrian vegetational history of the Brede and Pannel valleys. The organic deposits of six sites, one at Brede Bridge (TQ 829174), four from Old Place (boreholes 2 and 5, TQ 880171; borehole 7 TQ 880172; and borehole 13 TQ 881176) and one from Pannel Bridge (TQ 882152) have been intensively studied. Details of the techniques employed and a full discussion of the vegetational history will be published elsewhere. This section will focus on aspects of this work which are relevant to an understanding of the sedimentary development of these valleys.

One of the major problems in reconstructing past vegetation from peats in the coastal zone using pollen assemblages arises from the difficulty of distinguishing provenance for many of the pollen types. In this study plant macrofossils have been used to complement pollen analysis, allowing the past vegetation of the sites studied to be determined and so facilitating the separation of the valley side and local pollen components. The conditions which seem to have prevailed on the Brede floodplain during the major phase of peat accumulation (*c.* 6000 B.P. to *c.* 3700 B.P.) can therefore be outlined.

At four sites (Brede Bridge, and Old Place boreholes 5, 7 and 13) the transition from inorganic to organic sedimentation is marked by a change from salt-marsh to freshwater communities. High frequencies of Chenopodiaceae pollen occur prior to peat formation and *Plantago maritima* and *Armeria* grains are also present. The seeds of *Suaeda maritima* were found at Brede Bridge. The onset of peat accumulation is accompanied by a rapid rise in *Alnus* pollen. The remains of *Alnus glutinos*a (pollen and macrofossils) then dominate throughout most of the period of peat formation. Several fen associated shrubs occur in both the pollen and macrofossil assemblages, including *Rhamnus catharticus*, *Frangula alnus*, and *Viburnum opulus*. The macrofossil record also contains many fen associated herbaceous types. of which *Filipendula ulmaria*, *Lycopus europaeus*, *Rubus* sp., *Rumex* sp., *Oenanthe* sp., Chenopodiaceae, *Ranunculus* sp., and *Carex* sp. are prominent. Other herbs, unambiguously associated with fen conditions, which are well represented in the pollen record during organic accumulation include *Lythrum*, *Lysimachia vulgaris*, *Galium* type, *Valeriana*, *Chrysosplenium* and *Solanum dulcamara*. Several aquatic pollen types are common, particularly *Alisma* and *Typha angustifolia* type. The

Table 1.3 Radiocarbon dates from the Romney Marsh area

NPL.25	Wheelsgate, Old Romney	Shells from creek filling at *c.* +3m O.D.	TR 024237	1550 ± 120 B.P.	Callow et al. 1964
SRR.2893	Old Place, Icklesham	Transition from peat to upper estuarine deposit at –1.16m O.D.	TQ 880171	1830 ± 80 B.P.	Waller 1987
NPL.91	Scotney Court Farm, Lydd	From 2" thick peat layer overlying clay with roots	TR 023202	2050 ± 90 B.P.	Callow et al. 1966
SRR.2885	Pannel Bridge, Pett	Peat at + 1.36m O.D.	TQ 882152	2670 ± 80 B.P.	Waller 1987
NPL.92	Scotney Court Farm, Lydd	Roots in clay *c.* +3.0m O.D.	TR 023202	2740 ± 400 B.P.	Callow et al. 1966
SRR.2886	Pannel Bridge, Pett	Peat at +0.38m O.D.	TQ 882152	2980 ± 80 B.P.	Waller 1987
NPL.23	Higham Farm, Kenardington	Wood in peat at *c.* +3m O.D.	TQ 977308	3020 ± 94 B.P.	Callow et al. 1964
NPL.24	Court Lodge, Old Romney	Wood in peat at *c.* +3m O.D.	TR 032243	3340 ± 92 B.P.	Callow et al. 1964
IGS/C14/13	Blackwall Bridge, Wittersham	Peat at *c.* –1.5m O.D.	TQ 885258	3560 ± 100 B.P.	Welin et al. 1971
SRR.2645	Brede Bridge, Brede	Peat (*Tilia* decline) at +0.4m. O.D.	TQ 829174	3690 ± 70 B.P.	Waller 1987
SRR.2887	Pannel Bridge, Pett	Peat (*Tilia* decline) at –0.76m O.D.	TQ 882152	3700 ± 90 B.P.	Waller 1987
SRR.2301	Roman fort, Lympne	Wood in colluvium at 6.3m O.D.	TR 116342	4400 ± 50 B.P.	Hutchinson et al. 1985
IGS/C14/14	Blackwall Bridge, Wittersham	Peat at *c.* –2.8m O.D.	TQ 885258	4845 ± 100 B.P.	Welin et al. 1971
SRR.2888	Pannel Bridge, Pett	Peat (*Ulmus* decline) at –3.42m O.D.	TQ 882152	5040 ± 80 B.P.	
IGS/C14/55	Pett Level, Pett	Wood from submerged forest at approx. O.D.	TQ 889140	5205 ± 105 B.P.	Welin et al. 1972
IGS/C14/56	Pett Level, Pett	Peat from submerged forest at approx. O.D.	TQ 889140	5300 ± 100 B.P.	Welin et al. 1972
SRR.2889	Pannel Bridge, Pett	Peat at – 4.22m O.D.	TQ 882152	5540 ± 80 B.P.	Waller 1987
SRR.2646	Brede Bridge, Brede	Transition from hyposaline clay to peat at –5.35m O.D.	TQ 829174	5970 ± 150 B.P.	Waller 1987
SRR.2890	Pannel Bridge, Pett	Peat at – 6.14m O.D.	TQ 882152	7000 ± 90 B.P.	Waller 1987
SRR.2891	Pannel Bridge, Pett	Peat at – 7.61m O.D.	TQ 882152	9380 ± 100 B.P.	Waller 1987
IGS/C14/116	Tilling Green, Rye	Peat at – 22.5m O.D.	TQ 915206	9565 ± 120 B.P.	Welin et al. 1974
SRR.2892	Pannel Bridge, Pett	Peat at – 8.42m O.D.	TQ 882152	9960 ± 110 B.P.	Waller 1987

spores of *Osmunda* and *Polypodium* are also abundant in all the Brede valley diagrams.

The pollen and plant macrofossil assemblages suggest the floodplain environment resembled modern alder carr (the *Osmundo-Alnetum* communities of Wheeler 1980) during most of the period of peat accumulation. The peat deposits of the Brede valley are therefore clearly autochthonous, although they have been largely defined as detrital (*sensu* Troels-Smith 1955).

Despite the problems of using pollen zones to provide a relative chronology in the Flandrian, two changes in biostratigraphy, the *Ulmus* (elm) and *Tilia* (lime) declines, may be useful as chronostratigraphic markers with which to compare sequences from the different sites examined. The decline in *Ulmus* over north-west Europe appears to be synchronous at about 5000 B.P. (Smith and Pilcher 1973; Huntley and Birks 1983). At Pannel Bridge this event has been dated to 5040 ± 80 B.P. (SRR. 2888) (Table 1.3). Such a decline in *Ulmus* frequencies occurs at four further sites from this area: at Brede Bridge (at −3.29m O.D.) and Old Place boreholes 5 (−2.34m O.D.), 7 (−2.71m O.D.) and 13 (−3.53m O.D.). In the absence of radiocarbon evidence the initiation of peat growth in the lower Brede valley at Old Place prior to 5000 B.P. can therefore be inferred. In contrast to the *Ulmus* decline, the fall in *Tilia* pollen frequencies which occurs in many Flandrian pollen diagrams has long been recognised to be diachronous (Turner 1962). Despite this, the decline in lime frequencies over such a small area may prove useful as a chronostratigraphic marker. The two dates available for this event, from Brede Bridge (3690 ± 70 B.P. SRR. 2645) and Pannel Bridge (3700 ± 90 B.P. SRR. 2887), are in close agreement, with a rapid and permanent decline in *Tilia* values occurring. Three of the diagrams from Old Place (boreholes 2, 5 and 13) show a distinct fall in *Tilia* percentages prior to the deposition of the upper inorganic sediments. However, in borehole 7 the high *Tilia* frequencies persist until this contact. This provides further evidence for erosion of the upper surface of the peat (see also Fig. 1.5) and illustrates the need for the careful assessment of such transitions if they are to be subject to radiocarbon assay. It is also possible to infer that a thin peat, laminated with inorganic material, which occurs between −0.27m O.D. and −0.37m O.D. in borehole 13 on the Old Place section, was derived from the erosion of material deposited during the main phase of peat accumulation, as high *Tilia* values were recorded.

Although they show the transition from salt-marsh to alder-carr, the heights of the lower contact of the peat at Old Place in boreholes 5 (−3.45m O.D.) and 7

(−3.36m O.D.) are markedly different from borehole 13 (at −4.17m O.D.), matching the variations in elevation at which the *Ulmus* decline was recorded. This can be used to suggest that these differences are the result of post-depositional changes in altitude (rather than, for example, representing diachronous growth over an uneven pre-peat surface), possibly reflecting the quantity of compressible material above the pre-Flandrian surface. The differences in relative elevation between the *Tilia* decline at Brede Bridge (0.40m O.D.) compared with Old Place, near the valley side (0.04m O.D. in borehole 2) and the centre of the valley (−1.67m O.D. in borehole 13), shows the degree of post-depositional change in altitude which can occur below thick post-peat deposits. Comparison of the quantity of sediment found between the chronostratigraphic markers, the elm and lime declines, at Old Place borehole 5 (0.88m) and borehole 13 (1.90m), and Brede Bridge (3.69m), suggests post-depositional compaction relative to Brede Bridge of *c.* 76% has occurred in borehole 5 and *c.* 49% in borehole 13. These may be considered as minimum estimates as some autocompaction could have occurred at Brede Bridge. A comparable correction (50%) to allow for the compaction and consolidation of peat was suggested by Devoy (1982) from a review of the literature, while Smith (1985) applied corrections of 40–50% to the Flandrian sediments of the Nar valley (Norfolk) from the oedometer test.

The radiocarbon dating of the upper contact of the peat at Old Place in borehole 5 (−1.16m O.D.) to 1830 ± 80 B.P. (SRR. 2893) is surprising in that the *Tilia* decline (*c.* 3700 B.P.) was found at −1.46m O.D. If the lime decline can be used as a reliable chronostratigraphic marker in this area, then a considerable hiatus (though possibly exaggerated by compaction) may have occurred towards the end of the organic accumulation. This is supported by the relative lack of post-*Tilia* decline sediments at Brede Bridge (only a further metre was recorded), where the upper inorganic sediments are largely absent. Although the radiocarbon date may be in error, the depth of the sample (3.66m below ground level) suggests contamination from recent material is unlikely. One radiocarbon assessment is clearly an inadequate basis for determining the date of this contact.

A third area where pollen analysis may elucidate the sedimentary development of this area concerns the impact of man's activities on the environment. Both the *Ulmus* and *Tilia* declines have been ascribed to the activities of man. In this area widespread clearance during the elm decline is not apparent from the pollen assemblages, though at both Brede Bridge and Pannel Bridge inorganic lenses in the lithostratigraphy are coincident with this event. Such layers, however, are not confined to this period and tend to be laterally impersistent (see Fig. 1.4). It is not possible, therefore, on the basis of their presence to infer an increase in sediment supply as a result of anthropogenic activity in the area. They may simply be a product of channel migration or avulsion.

However, the dramatic changes in pollen assemblages which occur with the *Tilia* decline suggest widespread forest clearance. Both at Brede Bridge and Pannel Bridge organic accumulation continues beyond these changes, though wetter conditions seem to have prevailed in the local environment. This is consistent with an increase in surface run-off which might be expected after the removal of forest cover (Limbrey 1978, 1983). That widespread forest clearance cannot be shown to have resulted immediately in a direct change in sedimentation may, in addition to lag prior to the onset of any soil erosion, be due to the presence of sediment stores within the fluvial system (Brown and Barber 1985), or reflect complex response mechanisms (Burrin and Scaife 1984, 1986). The sedimentary consequences of such events appear particularly difficult to detect in perimarine and coastal environments, where they may influence, and be masked by, changes in other external environmental factors.

Foraminiferal Investigations

The inorganic sediments of Pett Level and the Brede valley at Old Place and Brede Bridge have been subject to detailed foraminiferal investigations. Subsidiary samples were also taken from the upper Brede valley and from near Stone Bridge. Material was collected using a 10cm diameter gouge auger and sub-samples of approximately 250 grams (dry weight) were taken for analysis. Full details of the techniques employed can be found in Marlow (1984). Each sample was analysed and the taxonomic composition determined. Foraminiferal assemblages were then compared to those recorded from contemporary North West European environments (Feyling-Hanssen *et al.* 1971, Murray 1973, Haynes 1973). Five principal palaeoenvironments were recognised, characterised by foraminiferal assemblages and associated lithological characteristics (Table 1.4). These assemblages have component similarities to those recorded by Haynes and Dobson (1969), Murray and Hawkins (1976), and Culver and Banner (1978).

Pett Level

Four sites have been investigated at Pett Level. Here the results from one borehole (TQ 901152) have been taken as an example of the type of foraminiferal assemblages found. Details of differences within the assemblages recorded from Pett Level and interpretation of such spatial variations can be found in Marlow (1984).

Two samples (−4.40m O.D. and −4.10m O.D.), were taken from the blue sand (unit 3). The foraminiferal assemblage is co-dominated by the euryhaline species *Protelphidium germanicum* (58% and 60%) *Elphidium williamsoni* (7% and 10%). The residue of taxa represent a mixed death assemblage with a small number of stenohaline (open marine) species (*Ammonia batavus, Miliolinella subrotunda* and *Bolivina pseudoplicata*) and hyposaline species (*Trochammina inflata* and *Jadammina macrescens*) present. These species exhibit

Table 1.4 Principal environments as indicated by in situ *foraminiferids*

A. *Supralittoral* (supratidal) No marine foraminifera	
B. *Littoral* (intertidal)	
Marsh	*Trochammina inflata* (Montagu) *Jadammina macrescens* (Brady)
High mud flats	*Ammonia tepida* Cushman *Elphidium williamsoni* Haynes *Protelphidium germanicum* (Ehrenberg)
Low mud flats	*Elphidium williamsoni* Haynes *Protelphidium germanicum* (Ehrenberg)
C. *Littoral/sublittoral*	
Intertidal sandflats	*Ammonia batavus* Hofker *Cibicides lobatulus* (Walker and Jacob) *Elphidium selseyense* (Heron-Allen and Earland) *Elphidium williamsoni* Haynes *Protelphidium germanicum* (Ehrenberg) *Quinqueloculina seminulum* (Linne)
D. *Sublittoral* (marine)	*Ammonia batavus* Hofker *Bolivina pseudoplicata* Heron-Allen and Earland *Brizalina variabilis* (Williamson) *Brizalina pseudopunctata* (Hoglund) *Elphidium clavatum* (Cushman) *Elphidium selseyense* (Heron-Allen and Earland) *Miliolinella subrotunda* (Montagu) *Cibicides lobatulus* (Walker and Jacob) *Spirillina vivipara* Ehrenberg

aberrant size distributions and surface etching of tests which suggests some intra-environmental transportation and local reworking of both littoral and sublittoral sediments. Many of the stenohaline species appear to correspond to the dominant grain-size suggesting selective marine transportation. A slight reduction in the number of stenohaline specimens at −4.10m O.D. was observed. The foraminiferal and lithological evidence, therefore, suggests that deposition probably took place in a transitional area between the low mud flat and sand flat environments. The up-core fining of the sediments and the reduction in stenohaline specimens indicate a decrease in environmental energy and a reduction in access to open marine conditions in the proximity of the blue sand/blue clay contact.

Samples at −3.60m O.D., −3.15m O.D. and −2.5m O.D., from the blue clay (unit 4), are dominated by three main species; the euryhaline *P. germanicum* (40% to 60%) and the hyposaline *Trochammina inflata* (10 to 20%) and *Jadammina macrescens* (10 to 20%). Stenohaline species occur at levels of less than 5% (e.g. *Spirillina vivipara, Brizalina variabilis, Cyclogyra involvens* and *Bolivina pseudoplicata*) adjacent to the blue sand and blue clay interface (−3.60m O.D.). This stenohaline component within the recorded assemblages gradually declines and is vertically replaced by the increasing dominance of the hyposaline species *T. inflata* and *J. macrescens* in the proximity of the blue clay/peat interface. The presence of *P. germanicum* remains significant within all assemblages but gradually declines up-core; from 60% at the blue sand/blue clay contact to 40% at the blue clay/peat interface. The dominance of *P. germanicum* and the presence of *Ammonia tepida*, and *Elphidium williamsoni*, together with several stenohaline species at the base of the blue clay (−3.60m O.D.) suggest deposition within a high mud flat environment open to marine influence. The up-core increase in the dominance of the three main hyposaline species, with a concomitant reduction in marine elements, indicates a gradual transition from a high mud flat to a low energy intertidal marsh environment prior to peat formation.

Nine samples (−0.90m O.D., −0.55m O.D., −0.30m O.D., −0.10m O.D., 0.30m O.D., 0.60m O.D., 1.00m O.D., 1.50m O.D. and 2.30m O.D.) have been examined from the post-peat sediments (units 6 and 8). These assemblages are dominated by the euryhaline species *P. germanicum* (40% to 70%). The hyposaline species *T. inflata* (20% to 25%) and *J. macrescens* (21% to 24%) are well represented close to the upper contact of the peat, but are then replaced by a slight rise in the brackish water species *E. williamsoni, E. articulatum* and *A. tepida* and some stenohaline species (*Brizalina variabilis, Miliolinella subrotunda* and *Cyclogyra involvens*). Hyposaline species continue to be present in small quantities up to 1.00m O.D. Both stenohaline and hyposaline elements exhibit etched and size sorted tests suggesting some local intra-environmental transportation. These assemblages suggest an environmental transition from intertidal marsh (at the peat contact) to deposition within a low energy sand flat/mud flat environment. The low species diversity and specimen density recorded from the post-peat deposits indicates some ecological stress which may be explained by high and variable sedimentation rates and some fluctuation in salinity levels. Such unstable conditions can also be inferred from the presence of laminations, which usually consist of fine sands interbedded with silts and clays. These are indicative of variable flow velocities and their preservation suggests a degree of environmental protection and the suppression of benthic fauna by rapid deposition and/or toxic bottom conditions.

Old Place

The foraminiferal content of two cores (borehole 3 TQ 880171 and borehole 13 TQ 881176) have been examined from the Old Place section in the Brede valley. Foraminifera were absent from the sub-samples taken between −3.25m O.D. and −1.32m O.D., a grey silty sand (unit 10) above bedrock in borehole 3, suggesting that deposition probably did not occur under the influence of marine conditions.

More extensive investigations were carried out in the inorganic deposits of borehole 13. Four samples (−5.57m O.D., −5.27m O.D., −4.87m O.D. and −4.37m O.D.) were taken from the pre-peat deposits, the blue clay (unit 4). The deepest sample (−5.57m O.D.) revealed a superabundance of *P. germanicum* (80%) and a small number of mixed stenohaline (i.e.

Brizalina pseudopunctata, *Gavelinopsis praegeri* and *Lagena clavata*) and hyposaline species (*T. inflata* and *J. macrescens*). A significant up-core reduction in the presence of *P. germanicum* (falling from 80% to 5%) and an increase in the dominance of the hyposaline species in the proximity of the blue clay/peat interface was noted. This evidence suggests an up-core transition from a mud flat environment (at −5.57m O.D.) to an intertidal marsh adjacent to the lower contact of the peat.

Six samples (−1.25m O.D., −1.15m O.D., −0.35m O.D., 0.25m O.D., 1.05m O.D., and 1.85m O.D.) were analysed from the post-peat deposits (units 6 and 8). These assemblages are again dominated by *P. germanicum* (32% to 73%) associated with a small number of brackish water and stenohaline species. The hyposaline species *T. inflata* (29%), *J. macrescens* (16%) and the euryhaline *P. germanicum* (42%) are dominant close to the the upper peat contact. The hyposaline species are replaced up-core by brackish water and stenohaline species and by the increasing dominance of *P. germanicum*. At 0.25m O.D. there is a slight reduction in *P. germanicum* associated with a rise in the stenohaline marine inner shelf species *Quinqueloculina seminulum* (5%), *Massilina secans* (14%), *B. variabilis* (5%), *Gavelinopsis praegeri* (5%), *Spirillina vivipara* (5%), *Elphidium crispum* (6%) and *Ammonia batavus* (8%), together with an increase in particle size. The assemblage recorded at 1.85m O.D. is characterised by the dominance of *P. germanicum* (72%) and *E. williamsoni* (12%) with smaller numbers of *Ammonia tepida* and *Ammonia limnetes*. The foraminiferal record suggests that deposition of these sediments initially occurred within an intertidal marsh environment (at −1.25m O.D.) followed by an up-core increase in marine influence and environmental energy. Deposition of most of this material probably took place within a sand/mud flat environment. Sedimentary and foraminiferal evidence further suggest a slight increase in the marine influence and environmental energy at 0.25m O.D. (suggesting a transition to an intertidal sand flat environment), followed by a slight decrease in marine conditions and environmental energy at 1.05m O.D. and 1.85m O.D., possibly indicating a return to a mud flat environment.

Brede Bridge

Three samples (−6.70m O.D., −6.10m O.D., −5.50m O.D.) have been investigated from the pre-peat sediment, the blue clay (unit 4) at Brede Bridge (borehole 53: see Fig. 1.13, TQ 830175). These assemblages are dominated by the hyposaline species *T. inflata* and *J. macrescens*. A few specimens of the euryhaline *P. germanicum* were also recorded. The low species diversity suggests deposition occurred in a low energy intertidal marsh environment.

An additional sample from the Brede valley was analysed from near Brede Waterworks (borehole 17, TQ 813177). This material, a blue grey silty clay (unit 10) at −4.46m O.D., contained no foraminifera suggesting that deposition probably occurred in a freshwater environment, beyond the limit of marine conditions.

Walland Marsh

A sample from the Stone Bridge to Snargate section (borehole 2, TQ 949264) was taken from the medium grey sands (unit 7) at 0.81m O.D. The mixed death assemblage recorded contains twenty-one different brackish water or stenohaline species including *P. germanicum* (23%), *Ammonia batavus* (16%), *Quinqueloculina seminulum* (6%), *Miliolinella subrotunda* (5%), *Elphidium cuvillieri* (6%), *Massilina secans* (5%) and *Elphidium selseyense* (6%). This suggests that deposition probably took place within a littoral or sub-littoral sand flat environment, with a higher environmental energy than those associated with the other inorganic sediments investigated as part of this study. It is believed that the mobility of sand within this environment may have precluded indigenous habitation; hence, there is no opportunity for faunal domination by species as found in lower energy environments.

Discussion

The Flandrian Deposits

Amongst the deepest deposits recognised within the lower Rother and lower Brede valleys are the undifferentiated silty clays (unit 10) which invariably mantle the valley sides. Their stratigraphic position and lack of fossils (both pollen and foraminifera) suggests a colluvial origin. Similar but coarser deposits have been reported from the lower Ouse valley by Jones (1971, 1981). This colluvium does not appear to interdigitate with the other deposits and therefore pre-dates them.

The overlying valley fills can be subdivided into two major sedimentary facies or associations. The upper valleys are dominated by fluvial deposits which interdigitate with the downstream sequences, occurring prior to, contemporaneously with, and subsequent to, peat accumulation (see also Burrin 1988). However, as is evident from the lithostratigraphy described above, the downstream valley fills are more variable and complex.

The deepest deposit of estuarine origin identified in this study is the bluish grey sand (unit 3). This material is found over a wide area including Pett Level, the lower Brede, the Rother Levels (at Blackwall Bridge), the Royal Military Canal, and on the marshland along the Stone Bridge to Snargate section. Texturally, it ranges in composition from fine sand to coarse silts, and fines upward and laterally into the bluish grey clay deposit (Fig. 1.13) which appears to represent a facies change. The foraminiferal analyses from Pett Level, together with the widespread occurrence of bivalve shells, indicates that this material was deposited under a marine influence. The general composition and stratigraphic position of this unit suggests it can probably be correlated with Green's (1968) Midley Sand. This terminology has not been adopted however, as Green used this name to describe both the near surface sands above O.D. in the vicinity of Midley and the sands underlying the marshland sequence. It has been suggested (Green 1968; Eddison 1983a) that the sands at Midley were deposited within a different depositionary environment, such as a sand spit or dune complex, and they may post-date the bluish grey sand. Until the near surface deposits are more fully investigated the term Midley Sand should therefore be restricted to the near surface sand outcrops in the vicinity of Midley.

Overlying the bluish grey sand is usually the bluish grey clay (unit 4). The facies change from sand to clay suggests a change in the nature of the depositional environment, which is confirmed by the presence in the clay of hyposaline foraminifera. It is not surprising therefore to find that the bluish grey clay is thickest and most widespread in those lower valley sequences where there is a degree of protection. At Blackwall Bridge, to the south of the Isle of Oxney, the blue sand penetrates furthest upstream, for here the lower Rother is particularly exposed. Elsewhere the lower valleys are protected by outliers of the Hastings Beds Group (e.g. Old Place is sheltered by Winchelsea Hill and Small Hythe by Chapel Bank). The bluish grey clay occurs intermittently across the marshland as shown by Green (1968) and by the sections from Pett Level and that between Stone Bridge and Snargate. Its presence above the sand suggests a seaward extension of hyposaline conditions prior to organic accumulation.

One major lithostratigraphically continuous phase of organic accumulation occurs over most of the area considered here, as was suggested by Green (1968) for the marshland. Additionally, an early Flandrian peat occurs at Tilling Green, Rye, a thin intermittent deep peat has been found (*c.* − 10m O.D.) in the lower Brede and isolated peats occur in the perimarine zone of the Brede and Pannel valleys which may have accumulated in response to locally high base levels. These additional accumulations are the subject of further investigations. The deposits of the main peat bed appear to be autochthonous. Caution must, however, be exercised before extrapolating the type of plant communities recognised in the adjacent lower valleys during this phase to Romney Marsh in general. Well defined and laterally consistent clay lenses have only been found during these investigations within the peat on Pett Level, where foraminiferal evidence suggests they were deposited in a hyposaline tidal marsh environment (Marlow 1984). Such intercalations become thinner and wedge out completely to the north, and have not been found in the lower Brede valley.

The collection of material from the organic deposits of the marshland for radiocarbon dating during the 1960's without adequate stratigraphic control is disappointing and seriously limits any attempt to construct a chronology for the area (see Table 1.3). The deep clastic sediments beneath the peat appear to have been deposited prior to *c.* 6000 B.P. in the Brede, *c.* 5300 B.P. on Pett Level (Welin *et al.* 1972) and *c.* 5000 B.P. (Welin *et al.* 1971) at Blackwall Bridge (though only the Brede valley assay is from the lower contact of the peat). No radiometric evidence is yet available for the date of this regressive overlap (terminology follows Tooley 1982) on the marshland and therefore it is unknown whether, or to what extent, peat formation was diachronous. Dates from what is likely to be the main peat bed of the marshland of *c.* 3000 B.P. and *c.* 3340 B.P. (Callow *et al.* 1964) are not incompatible with contemporaneous organic accumulation occurring within both the marshland and the valleys. However, it appears possible that peat formation may have largely ceased in parts of these valleys (e.g. Brede Bridge) while occurring or continuing on the marshland. Green's (1968) correlation of the two inch peat horizon (dated to 2050 ± 90 B.P.) and the underlying 'clay with roots' deposit (2740 ± 400 B.P.) at Scotney Court with the peat and lower blue clay of the marshland must be treated with some scepticism given the differences in elevation (see Green 1968) and the large standard deviation associated with the older date. It should also be noted that the 'clay with roots' deposit cannot be dated by the root remains which presumably penetrated through the deposit. Dating the end of this phase of organic accumulation at different localities on the marshland remains one of the most important outstanding tasks. The problems posed by the only available index point (1830 ± 80 B.P.) have already been stated (see pollen section). However, the difficulties experienced at Old Place (erosion of the peat surface, compression and the possibility of an hiatus at the end of organic accumulation) are worth re-emphasising for they are also likely to affect other sites. Evidence for erosional truncation of the peat surface through sharp contacts and secondary peat deposition is widespread throughout the lower valleys and marshland.

The inorganic sediments (units 6–9) which overlie the peat are the most variable element of the lithostratigraphy. However, the black and grey laminated sands, silts and clays (unit 6) found on Pett Level, the lower Brede and the southern part of the Royal Military Canal contain some readily identifiable features (colour, stratification and shell fragments) through which correlation can be suggested. However, such characteristics were only found infrequently in the other sections. Intensive investigations in the Brede valley have revealed facies changes within this material with the clay content increasing upstream. Similar changes are also apparent in the overlying grey brown mottled sands, silts and clays (unit 8). This unit has therefore only been defined on the basis of colour from the underlying material, which may largely be the result of oxidation above the water table. Foraminiferal analyses shows the uppermost inorganic sediments to have been deposited in low energy, estuarine environments at Pett Level and Old Place, which suggests continuity in the environment of deposition at these sites. Despite the lithostratigraphic correlation of unit 8 along the length of the Brede valley, it is apparent that changes occur in the depositional environment. The grey brown silty clays at Brede Bridge appear to have been deposited in a freshwater environment (the pollen of open fen taxa predominate). Above Brede Bridge, the rise in floodplain altitude indicates these sediments must have been deposited beyond any direct marine influence.

The remaining major unit identified in the lithostratigraphy is the medium grey sand (unit 7) which occurs in the lower Brede, the Royal Military Canal and the western end of the Stone Bridge to Snargate section. It is not found to the south of the Isle of Oxney at Blackwall Bridge, but occurs at Small Hythe where it is most clearly defined, filling a distinct bedrock channel some 125m wide (Fig. 1.15). This deposit can be traced upstream to Newenden but at Bodiam only laminated black, grey and brown sands and silts have been found (see Burrin 1988). This may indicate the inland limit for this unit which fines rapidly beyond Newenden. The broad expanse of this medium sand in the Royal Military Canal section (Fig. 1.16) would appear to be where our boreholes run parallel to the course of these sediments rather than orthogonal to it, as such deposits were not located elsewhere south of the Isle of Oxney (see Fig. 1.15). Stratigraphic correlation with the other deposits is difficult because it was generally found from near the surface to the limit of penetration. Such sediment post-dates the peat and also appears to overlie the black laminated sediments along the Royal Military Canal. Foraminifera from a sample near Stone Bridge suggests deposition occurred at the mouth of an estuary or in a near-shore region with a high environmental energy. The course of this material from Newenden, to the channel at Small Hythe, the vicinity of Appledore, the eastern edge of the Isle of Oxney at Stone Bridge and following the line of the Royal Military Canal south towards The Lock, is in close proximity with the present routes of the Reading Sewer and Highknock Channel, which are believed to correspond to the course of the Rother when it flowed north of the Isle of Oxney between the 14th and 17th centuries (Rendel 1962). Similarly, the grey sand in the lower Brede valley may coincide with the changes documented for this part of the coast since the 13th century (Lovegrove 1953). However, corroborative evidence for the age of this unit is lacking and it should be noted that the grey sand may well be associated and contemporaneous with the black laminated estuarine sands, silts and clays described above. Further research is required to resolve these issues.

The various post-peat deposits described here can be broadly correlated with Green's (1968) 'land-type with common creek relics' which typifies the calcareous marshland over most of Walland Marsh. The conflicting views of previous workers concerning the age of these sediments have already been noted. The new radiocarbon evidence for this phase of sedimentation having been initiated after 1830 ± 80 B.P. (SRR. 2893) at Old Place lends weight to the suggestion (Brooks 1981) of a south-western estuary for the Rother prior to the 13th century. As yet there is no unambiguous evidence for more than one depositional phase within the post-peat sediments which might allow correlation with the documented events of the late 13th century. The silty clays found above the peat on the northern part of the Royal Military Canal section and a thin peat which occurs at *c.* O.D. in three of the boreholes here require further investigation in this respect.

Where this calcareous land-type abuts against a series of old sea-walls between Appledore and Broomhill a sharp contrast in relief is evident (Green 1968), with thick post-peat sediments on the seaward side. While such differences in height may largely have developed because of such sedimentation (so that the sea walls would then provide an indication as to the age of this material) such differences may also have been accentuated by reclamation and drainage of the marshland behind the walls resulting in peat shrinkage or wastage. Whatever the age of these deposits, it is clear that they originated from the south, with the bulk of sedimentation occurring on the western side of Walland Marsh, thinning into the valleys and towards the decalcified marshland to the east. Homan's (1938) suggestion of a breach in the shingle in the Camber-Broomhill area prior to the formation of the present Rye estuary, however, remains unproven.

Finally, it is interesting to compare the medium grey sands (unit 7), which appear to be associated with a palaeochannel, with those described at the Rhee Wall. Here the deposits are essentially fine-grained with the underlying peat intact suggesting a quieter depositional environment. Green's map (1968, 40) shows the course of a natural waterway to be coincident with the artificial channel by Snargate. The lithostratigraphy presented here appears incompatible with the suggestion that a major river such as the Rother followed this route in the post-peat period. No significant channel has been cut into the peat and the sandy sediments to the north-east of the Rhee Wall at Snargate have been shown by Green to be part of a creek-ridge system orientated towards Hythe and to pre-date the Rhee Wall. The natural course as defined by Green (1968) therefore probably only represents a major creek draining into an estuary at New Romney. Such a route for the Rother in the 12th century is also made unlikely by the probable existence of the Walland Marsh (Rye) estuary prior to this date. This is not in conflict with that part of the Patent Roll records of 1257 (Green 1968; Eddison 1983b) that suggests the Rhee Wall was used to connect the two tidal systems, allowing the waters of the estuary at Appledore to be channelled down the 'wall' during ebb flows, thereby helping to scour the New Romney estuary.

Coastal Evolution

Several reviews of the data available for reconstructing Flandrian sea levels on the South Coast have been made in recent years (Ackeroyd 1972; Shephard-Thorn 1975; Devoy 1982), although comparatively few detailed studies have yet been published. The rate of sea level rise during the early Flandrian is considered by Devoy (1982) to have been rapid, rising from *c.* −25m O.D. at 8500 B.P. to *c.* −6m O.D. at 6000 B.P. While the relationship of the Tilling Green peat to sea level is unclear, a rise in relative sea level in the Romney Marsh area of a minimum of 17m can be suggested between *c.* 9500 B.P. (Welin *et al.* 1974) and *c.* 6000 B.P. (Brede Bridge). Not surprisingly, therefore, most of the sediments identified as being deposited during this period in the lower valleys and marshland are minerogenic. Unfortunately, the palaeogeography of the area during the deposition of the lower blue grey sand and clay cannot be constructed until further studies reveal (if preserved) the sedimentary facies seaward of these deposits.

The implications for coastal evolution of the regressive overlap dated at Brede Bridge to *c.* 6000 B.P. are unclear. Several alternative factors can be suggested to account for this. They include: the development of coastal barriers; a fall in relative sea level; the seaward extension of freshwater and brackish facies as a result of a reduction in the rate of sea level recovery which appears to have taken place at about this time (see Devoy 1982), or an increase in sediment supply, so that the upper part of the bluish grey sand on the marsh may form part of a progradational beach system. While the apparent lessening of the marine influence prior to the regressive overlap is inconclusive, an assessment as to whether and to what extent peat development was diachronous may be useful in assessing the significance of these alternatives. It is clear, however, that the apparent arrival of shingle on the coast by *c.* 5300 B.P. and barrier formation (Eddison 1983a, 1983c) cannot be inferred from the accumulation of organic material alone. The earliest reliable evidence for the arrival of these coarse littoral deposits is older than 3500 B.P. as indicated in the Tishy's Sewer Series (Tooley 1988). There is, as yet, no conclusive evidence concerning the early stages in the development of the barrier system. The age, location, composition and processes which led to barrier formation have yet to be clearly defined.

At Brede Bridge a peat accumulation rate of 0.25cm per year can be inferred between *c.* 5970 and *c.* 3690 B.P., assuming a constant growth rate and no subsequent compaction or consolidation. Such a rapid rate in a protected environment, where base levels are likely to be controlled by sea level, suggests that the dominant trend during this period continued to be one of rising relative sea levels. The significance of the intercalated hyposaline clays at Pett Level is unclear. Jennings and Smyth (1982a) have suggested that similar deposits at nearby Combe Haven may be the result of barrier breaching. Such a proposition cannot be assessed here by the investigation of a limited area near the extremity of these sediments, for relative sea-level change could also account for the sedimentary sequences observed.

In contrast, the geographic limits of the transgressive overlap which forms Green's (1968) calcified marshland over Walland Marsh can be adequately defined and appears to correlate with a major gap (*c.* 1800 B.P.?) in the shingle barrier, which was a product of changing coastal dynamics (Lewis 1932; Eddison 1983a). Theories concerning the fashioning of the cuspate foreland and contemporary coastline will require modification as new information on the nature of the associated alluvial sequences becomes available, as our preliminary investigations have demonstrated through the possibility of a western exit for the Rother system existing prior to the 13th century.

The coastal sequences of Sussex

The comparison of the results of this study with other investigations undertaken along the Sussex coast is necessary if the recent debate concerning the relative importance of local processes (e.g. the formation and periodic breaching of barriers, Jennings and Smyth 1982a, 1982b) as opposed to regional factors (such as relative changes in sea level, Burrin 1982) in the development of these sedimentary sequences is to be resolved.

The earliest subsurface information for the lower valleys of Sussex was collated in the geological memoirs (Reid 1898; White 1924, 1926), while the inland limits of late Flandrian estuarine conditions were tentatively identified for the rivers Arun, Adur, Ouse and Cuckmere from their floodplain long-profiles (Kirkaldy and Bull 1940). At Amberley Wild Brooks (Arun valley) Godwin (1943) identified a derelict raised bog overlying a blue clay which was presumed to be of estuarine origin. This contact (at *c.* 1.5m O.D.) was subsequently dated to 2620 ± 110 B.P. (Godwin and Willis 1964) and recent investigations have shown that peat formation continued here beyond 1360 ± 80 B.P. (Waton 1982). However, the first detailed study of the lower valley alluvial deposits was that by Jones (1971, 1981) in the Vale of the Brooks (Ouse valley), south of Lewes. Three major lithostratigraphic units were recognised: fluvial sands and gravels overlying bedrock or soliflucted Chalk (Coombe Rock); bluish or greenish grey silty clays with interbedded peats; and finally, grey to black sands, silts and clays with estuarine shells. Peats near the base of the silty clays have been dated to 6290 ± 180 B.P. and 5677 ± 167 B.P., while the upper limit of this organic material (at −2.3m O.D.) was dated to 3190 ± 125 B.P. Accurate dating of this transgressive overlap may not have been achieved however, as the surface of these fen deposits appears to be truncated and rises to O.D. elsewhere.

More recent studies from the coastal sequences of Sussex have provided additional data. The investigations of Jennings and Smyth (1982a, 1982b, 1985) at Langney Point, Eastbourne have shown that freshwater conditions here were replaced by estuarine deposits at −25.94m O.D., these in turn being overlain by a thin peat (from −24.82m O.D. to −24.70m O.D.). Shephard-Thorn (1975) had earlier reported two dates (9510 ± 75 B.P. from −27.30m O.D. and 8760 ± 50 B.P. from −24.70m O.D.) from peat at Langney Point. Jennings and Smyth (1985) obtained a further date of 8770 ± 50 B.P. from the transgressive overlap between the thin peat and a subsequent bluish-grey estuarine clay. These clays are replaced at −14.20m O.D. by marine sands which coarsen at *c.* −4m O.D. into the shingle forming Crumbles Spit.

The most extensive spread of recent coastal sediments after Romney and Walland Marshes is that of Willingdon and Pevensey levels. At Lottbridge Drove (Willingdon Level) Jennings and Smyth (1982a) describe gravel overlying bedrock which is replaced by a bluish grey estuarine clay (from *c.* −7.5m O.D. to −1.0m O.D.). These sediments are in turn overlain by a thin peat dated between 3750 ± 40 B.P. and 3390 ± 40 B.P. (Jennings and Smyth 1985) and an upper clay in which a change from estuarine to freshwater conditions was recognised. In western Pevensey levels a tripartite sequence consisting of a lower clay overlain by peat and an upper clay was recognised by Barnes (1974). Pottery in the peat was tentatively dated to the medieval period. A similar tripartite sequence was subsequently identified in the eastern levels where the lower (bluish grey) clay/peat contact was dated to 3715 ± 40 B.P., with peat formation continuing beyond 480 ± 50 B.P. at one site (Moffat 1984). Lithostratigraphic investigations (Smyth 1982; Jennings and Smyth 1982a) have also taken place further along the coast at Combe Haven, a small valley between Bexhill and Hastings. Here, gravel is overlain by essentially blue estuarine clays with intercalated peats (below *c.* −6m O.D.). The largely organic unit which follows is in turn superseded by an orange-stained clay which appears to have deposited under estuarine conditions in the lower reaches of the valley.

It is evident from this brief summary that few of these coastal alluvial sequences have yet been studied in detail and the results published. Hence, it is premature to attempt to correlate the sequences from the Romney Marsh area with these other sites. Local processes can only be separated from regional events if comparisons are made from sediments deposited contemporaneously with due regard to variations in physiography and facies changes.

Data concerning the early Flandrian evolution of the Sussex coast is very sparse. Peats of this age occur at Tilling Green, Rye and Langney Point, Eastbourne, though the relationship of these sediments to sea level and coastline configuration remains unclear. The depth of these deposits and the liklihood of the compaction, erosion and reworking of sediments of this age hinder palaeogeographic reconstructions of this period. While the absence of data makes the assessment of the contribution of local and regional processes difficult during this period, the change in sea level from *c.* 10000 B.P. to 6000 B.P. suggested by the data currently available (Devoy 1982) is so great that it must have had a pronounced regional effect.

The influence of a regional process, with a reduction in the rate of sea level rise, or a fall in relative sea level, also appears to be apparent in the mid-Flandrian. The lower Ouse, Brede and Rother valleys, and Combe Haven all contain thick organic deposits of mid-Flandrian age. Although they are located in topographically confined situations, a lessening of the marine influence appears to have occurred prior to the elm decline at these locations. Willingdon Level appears exceptional: the absence of thick peat deposits here was attributed to the relatively limited freshwater input by Jennings and Smyth (1985). Mid-Flandrian peats, dated between *c.* 5400 B.P. and 3850 B.P., also occur in the lower Thames valley (Devoy 1979) and possibly in the Solent (Nicholls and Clark 1986). Further lithostratigraphic studies and dating of the contacts at the East Sussex sites are required in order to determine the degree to which sedimentation here was influenced by local processes during the mid-Flandrian. Of particular significance is the need to resolve the alternative explanations which exist as to the formation of the intercalated clastic sediments which have been identified at several of these sites.

A further regional similarity in the lithostratigraphy of the Sussex coastal deposits is the occurrence of an upper estuarine unit above the main peat deposits in the Ouse (Jones 1971, 1981), Combe Haven (Jennings and Smyth 1982a), the western side of Romney Marsh and associated river valleys, and the thin peat on Willingdon Level (Jennings and Smyth 1985). The available radiocarbon evidence for the initiation of this phase (c. 3400 B.P. at Willingdon Level, *c.* 3200 B.P. in the Ouse and *c.* 1800 B.P. in the Brede) suggests that these deposits may not be contemporaneous. Such incursions might be the result of barrier breaching, as appears likely in the case of the Brede. Barriers have played a significant role in coastal development in the historic period and the existence of shingle deposits at Broomhill on Romney Marsh at *c.* 3500 B.P. (Tooley 1988) suggests the formation of a barrier system by this period. The dating of the transgressive overlaps in these valleys is, however, problematic and the formation of the upper inorganic sediments by such a process does not necessarily imply they were deposited diachronously. Other factors, such as variations in the supply of sediment by longshore drift and storm surges, may also have had an impact which can be detected along the coast. Again, further investigations are required to elucidate fully the processes and reponses involved.

Conclusions

It is evident from these discussions that further investigations are required to resolve a number of significant issues. These include:

1) The establishment of a reliable chronology for the marsh by radiocarbon dating the major peat unit. This should only proceed, however, after extensive lithostratigraphic and biostratigraphic studies have established reliable transitional zones.

2) The delimitation of the sedimentary units identified during the course of these investigations. Only then can the palaeogeography of the area be reliably reconstructed for different periods during the Flandrian. Of importance here is the relationship between the blue sand and the arenaceous deposits in the Midley area.

3) Further investigations are required into the nature and origins of the Rhee Wall and Sedbrook Sewer in order to test the various hypotheses which have been put forward concerning the previous courses of the Rother.

4) Reassessment of the evolution of the shingle barrier. This will require the delimitation of the sedimentary units as suggested above for it is only then that the dynamics of the barrier system can be reconstructed with due regard to the importance of such factors as past sea levels, storm surges and sediment budgets.

5) Further detailed studies of other coastal alluvial sequences in this area are also required in order to understand the regional processes through which these deposits formed during the Flandrian.

This paper is a preliminary attempt to synthesize the results of research in the previously neglected lower valleys of the Romney Marsh area. We are continuing the investigations described here with further emphasis on the sequences of Romney Marsh. It is clear that considerably more data are required before further theories can usefully be constructed concerning the evolution of this area during the Flandrian period. The application of an inter-disciplinary framework as employed here is essential if the problems identified above are to be resolved.

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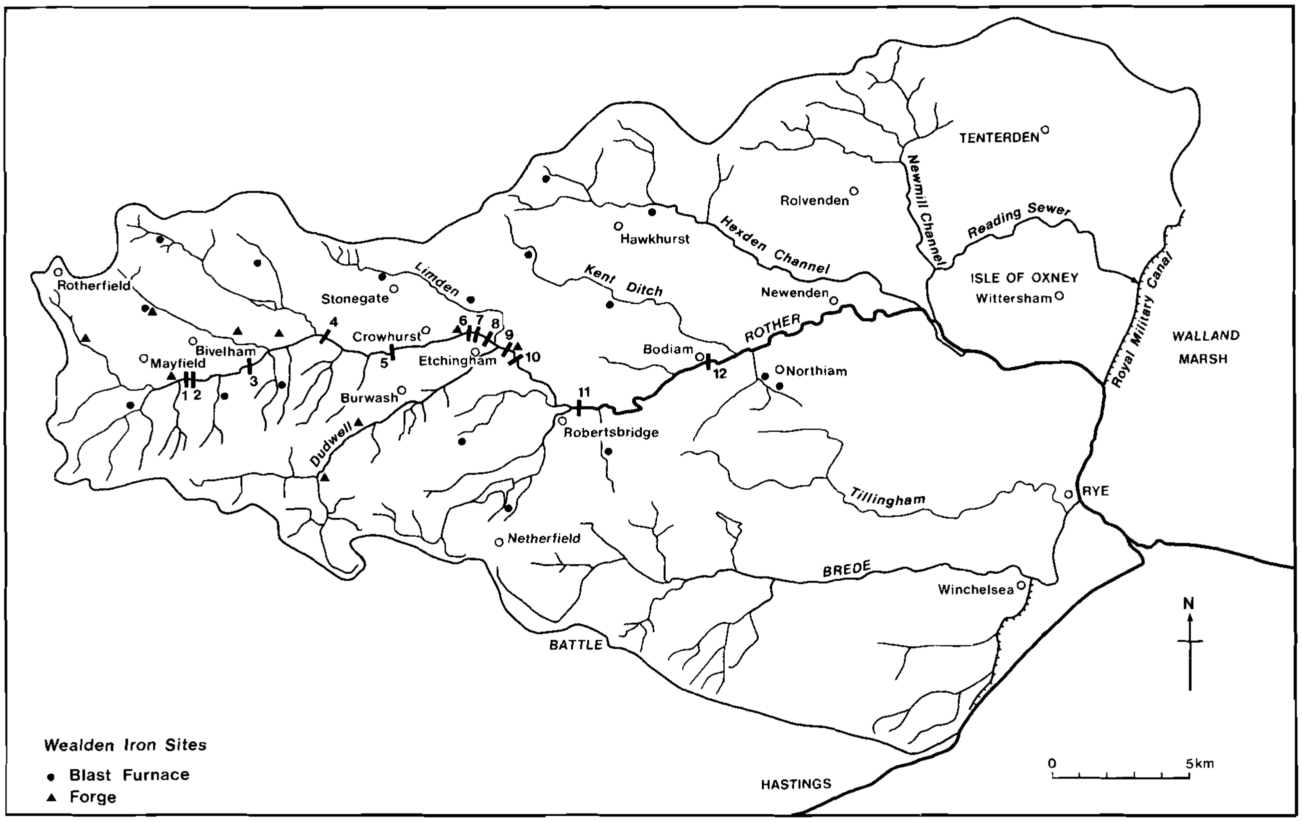

Fig. 2.1 The Rother valley showing location of cross-sections and former Wealden iron-working sites.

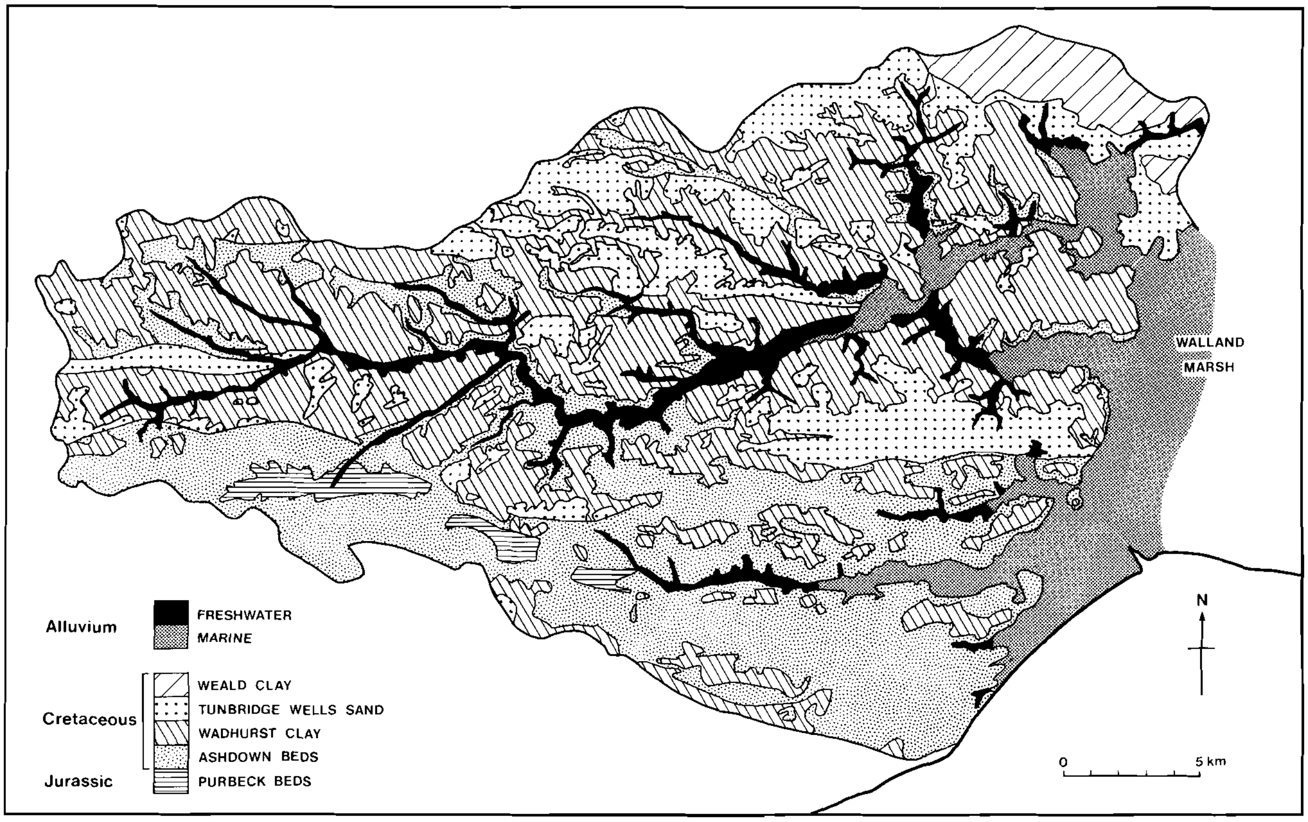

Fig. 2.2 Generalised geology of the Rother valley (modified from the British Geological Survey).