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DEDICATION

This thesis is dedicated to my  
mother and father with love,  
and to 'P.T. 7'.

'FLANDRIAN SEA-LEVEL CHANGES  
ON THE SOUTH COAST OF ENGLAND'

by

FIONA MARGARET JEAN SUTHERLAND

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Submitted for the degree of Master of  
Science, University of Durham.

Department of Geography, September 1984.



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A B S T R A C T

The South Coast of England is one of the few remaining areas in the British Isles where there is a relatively limited knowledge of past sea levels.

Five sites were investigated in the present study for evidence of past sea-level movements. These were at The Moors in Dorset, Studland Heath in Dorset, Browdown in Hampshire, Yarmouth on the Isle of Wight and Pett Level in East Sussex. Indications of sea-level movement were gained from the stratigraphic, pollen and diatom analyses at the sites.

A series of phases of positive and negative sea-level tendencies, over the last 10,000 years, are presented at each site. These are correlated, within a regional setting, with other sites from the South Coast of England.

DECLARATION

This thesis is the result of all my own work. No part of this thesis has been taken for publication prior to submission. Where data have been taken from other authors it has been acknowledged in the customary manner.

C O P Y R I G H T

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F.M.J. SUTHERLAND  
September, 1984.

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C H A P T E R 1

INTRODUCTION

1:1 OBJECTIVES OF THESIS

To date the South Coast of England lacks a detailed, comprehensive study of sea-level fluctuations during the Flandrian Age. Minor studies, at an undergraduate level, have been performed but no information has been compiled for the whole of the South Coast area. Radiocarbon dated samples of Flandrian material are available for a number of sites and there are also a number of pollen diagrams which have been drawn up for sites on the South Coast, but these data are not directly linked with sea-level studies.

The objectives of this thesis are to attempt to draw together the information derived from the specifically researched sites of this study with the information already available from other authors in order to produce a relative chronology of sea-level events along the South Coast during the Flandrian Age.

1:2 A SHORT HISTORY OF SEA-LEVEL STUDIES

The study of oscillating sea levels can be traced for many decades. This type of study involves many disciplines including; astronomy, archaeology, biology, climatology, geology, geomorphology, geophysics, hydrology and oceanography (Everard 1980). The oscillation of sea level results in two major processes; a marine transgression causes the submergence and retreat of coastlines, except in the case where cliffs flank the coast or where submergence is offset by deposition, and marine regression leads to the emergence and



advance of coastlines, except again where the shore is bounded by cliffs or where the emergence is counteracted by erosion (Bird & Paskoff 1979).

There are many features which indicate former sea levels including high-level denudation surfaces, raised shore-platforms, raised beaches and cliffs, submerged channels and terraces and also submerged sediments and organic deposits. Unfortunately, the methodology by which these features are investigated is not consistent between all workers and thus correlations between different sites which have been studied is difficult. Godwin & Godwin (1933) were one of the first to use stratigraphic, pollen and formaniferal analyses while Iversen (1937) used stratigraphic, pollen and diatom analyses for the same purposes. In 1974 an UNESCO - IGCP project was set up in order to alleviate this problem of differing methodologies in sea-level studies. The aim of this project was to standardize the sea-level data and to establish a trend of sea level over the last 15,000 years and to predict future trends along the densely populated sea-boards of the world.

A great many difficulties arise when one comes to analyse the data available on sea levels. These include the following:-

- 1) Assessing the relationship of the deposit to the sea level at the time of deposition.
- 2) The time-lag variations within the depositional environment.
- 3) Variations in tidal range.
- 4) Assessing the fluctuations of eustatic sea level.
- 5) Assessing the fluctuations of isostatic sea level.
- 6) Dating the deposit.

1) Assessing the relationship of the deposit to the sea level at the time of deposition.

This involves the nature of the deposit and its relationship to sea level, problems of consolidation and compaction of sediments and the effects of rare events such as storm surges.

The nature of the deposit which is to be used as an indicator of past sea levels is all important. The commencement of peat accumulation over a marine sediment is often used to indicate a regression of sea level, but this layer can be formed anywhere between mid-tide and high-tide levels. Some workers (Gilbertson 1967 and Devoy 1972) have used the peat-clay boundary in order to date sea-level positions, but these boundaries are determined by competing rates of sediment accumulation and vegetation growth (Kidson & Heyworth 1979). Van de Plassche (1982) notes that fen-wood peat and Phragmites-Carex peat are formed at about groundwater level but that Phragmites peat can be formed in water depths of up to a few decimetres. Peat may accumulate behind a physical barrier such as a spit or sea-wall and if this barrier is overcome by an especially high tide or by erosion, marine deposition will occur over the organic material. Thus a transgressive episode may be simulated where no such event has occurred. Generally one can tell when this type of deposition has happened as there will be a sharp break in the lithological succession with no gradual change from the terrestrial to marine facies. Heyworth (1978) believes that Oak remains in coastal submerged forests are good indicators of past sea levels because he believes that they were once part of the natural coastal vegetation. The trees died not by permanent inundation of sea-water but by rising freshwater tables and the slow ingress of saline water. The best indications of past sea

levels can be gained by pollen and diatom analyses of inorganic and organic beds, where evidence from these analyses points to the lowest completely freshwater facies. It must be remembered when using diatoms as indicators of water conditions that the diatom flora can be sorted by wind and water, especially if the assemblage lives as a film on the surface of mud which can easily be dried out.

Consolidation and compaction of sediments can alter the stratigraphic altitude of a stratum. Consolidation in a deposit with a high sand fraction is low, but in a deposit with a high fraction of organic material, compaction can be as great as 90% of the volume (Jelgersma 1961). The deposits most likely to be affected are those in contact with an overlying mineral horizon, as well as those over deeper peats. If the organic stratum is in contact with a mineral substratum, no change in stratigraphic position is likely to occur. A peat deposit will decay naturally resulting in the loss of volume. The rate of this decay is a function of the water content of the deposit together with the oxygen content and the temperature and rate of peat growth. MacFarlane (1965) says that peat consolidation takes place in two stages; the primary stage occurs very rapidly and can account for up to 50% of the total consolidation. The secondary stage is much slower and has a viscous movement, but allows for rebound if the overburden, causing the compaction, is lessened or removed. Over-consolidation of a peat deposit occurs when a large overburden has been present at the site resulting in great compaction, but this overburden has since been removed leaving the deposit highly consolidated but with no evidence of the agent of consolidation.

The effects of rare events, such as storm surges or exceptionally high tides have been considered by Kidson & Heyworth (op.cit.).

Events such as these can be useful indicators of sea levels and will effect the stratigraphic sequence at a site. Smith et al. (1983) working in the River Ythan Valley in north-east Scotland record a grey, micaceous, silty fine sand truncating a peat deposit, which is thought to have been deposited as the result of a sudden marine event, such as a storm surge. This deposit is similar to other finds of grey, micaceous, silty fine sand layers in eastern Scotland and all are thought to belong to a North Sea storm surge early in the Flandrian Stage. Tooley (1979) however argues that after the storm flooding of 1953 no evidence of this event was found, except at Scott Head Island where a thin veneer of clay and sand was deposited. This deposit was considered to be associated with a breach in the sand dunes (Steers 1976; in Tooley op. cit.).

2) Time-lag variations within the depositional environment.

The time-lag variations within a depositional environment are sometimes experienced between the cessation of mineral sedimentation and organic sedimentation or vice versa. Depending on the sedimentary environment, a period may elapse between the two deposits thus giving a false indication of past specific sea levels when the boundary zone is dated.

3) Variations in tidal range.

The tidal range at a site plays an important part in the determination of past sea levels. Variations in tidal range makes the identification of sea level most difficult between sites and within a site over time (Kidson & Heyworth op. cit.). A number of factors go to make up the tidal range at a site; exposure to storm and swell waves, wave refraction at the site, the distribution of wave energy along a crenulated coastline and the fetch of the wave.

Differences in wave energy alone can produce differences in altitude of greater than six metres within a storm-beach deposit (Kidson & Heyworth op. cit.). At Chesil Beach the north-west section is less than + 7 m.O.D. but at the south-west end of the beach it is + 15 m.O.D. This leads to a difference in altitude of features of the same age. Also it must be remembered that waves can move sediments higher up the coast than the height of the highest waves. Biological communities are thought to be precise indicators of the nature and duration of tidal cover (Kidson & Heyworth op. cit.) although Jelgersma (1961) found that fen-wood peat will accumulate up to fifty centimetres above or below the high-tide level. Jardine (1975) says that where the tidal range at a site is great, one should use the mean tide-level to equate the mean sea level.

#### 4) Assessing the fluctuations of sea level due to eustatic effects.

Fluctuations of sea level due to eustatic effects are world wide phenomena partly resulting from the amount of water stored in ice-caps during glaciations. If the Greenland and Antarctica ice-caps were to melt the world wide sea level would be raised by sixty-six metres. Donn et al. (1962; in Goudie 1977) estimate that sea level was lowered by one hundred and five metres to - 123 m.O.D. in the last glaciation. Mörner (1969) attempted to develop an eustatic curve of sea level for southern Scandinavia, showing sea level to be - 42 m ca. 10,950 to 10,000 years before present (yBP) and rising to ca. + 0.4 m between 3350 yBP and 3600 yBP. Mörner (1976) viewed the surface of the ocean in a geoidal configuration. He followed this idea up by stating that sea-level curves from data from different regions of the world could not be compared if the changing geoidal shape of the earth and ocean were not considered. Sea levels can intersect the

coasts of different continents at different altitudes with a range in altitude of up to one hundred and eighty metres.

5) Assessing the fluctuations of sea level due to isostatic effects.

Isostasy is a local component of sea-level fluctuations whereby ice masses and sea water are applied and removed causing deformation of the earth's crust. When an area is glaciated, depression of the land occurs under the weight of the ice-load, but after deglaciation the area will begin to undergo rebound back to the position before glaciation. In areas peripheral to the glaciated regions Newman et al. (1971; in Goudie 1977) have suggested there was a bulging up of the land surface but these areas have since collapsed during the deglacials resulting in the submergence of the land to a greater degree than would normally have occurred. In view of this fact one must remember that the South Coast of England did not undergo glaciation during the last cold phase. In Britain, the north of the country is being elevated while the south is sinking due to isostatic rebound. Valentin (1953) has said that the strongest uplift in the British Isles is happening in the Scottish Highlands, which was the last area to be deglaciated. He considered that the present movements can be correlated with older events in the Tertiary such as rifting and volcanic activity. Subsidence along the South Coast is given as greater than 2 cm/100 years but no definite figure is stated. Churchill (1965) takes mean sea level ca.6500 yBP to be 3.05 m below present sea level, this figure being based on data from South Africa. Using a number of data he calculated that the Bristol Channel is still at the same level as ca.6500 yBP. This idea conflicts with Valentin's zero datum which runs through Dunbar and Holyhead. Churchill goes on to say that to the north of the Bristol Channel uplift occurred at a rate of  $14 \pm 4.7$  cm per 100 years, while to the east the land is

subsiding at a rate of  $9.4 \pm 4.7$  cm per 100 years. West (1972) disagrees with the sea level given by Churchill and says that the sea level ca.6500 yBP was - 9 m.O.D. Neither author states how the sea-level figure was computed. Various rates of subsidence for the South Coast have been given by different authors and are shown in Table 1.

Table 1 Subsidence Rates for the South Coast During the Flandrian.

Rate (cm/100 yrs.)	Area	Author
11.54	S.England	Churchill (1965)
13 - 16	SE. England	Akeroyd (1972)
12.5	Isle of Wight	Devoy (1972)
12.7	Thames Estuary	D'Olier (1972)
10.99	Fawley	Hodson & West (1972)
20	S. England	king (1972)

In North-West Europe glacio-eustasy and glacio-isostasy act together to produce fluctuations of sea level and it is difficult to isolate the two factors.

5) Dating the deposit.

Dating deposits causes great problems. The most widespread method of dating is by radiocarbon assay. Shotton (1967) points out a number of limitations of this method: Errors can be incurred by a number of different ways. It is thought that warmer climatic periods result in higher concentrations of  $^{14}\text{C}$  in the atmosphere. This factor can cause problems in dating but variations in the  $^{14}\text{C}$  concentration can be allowed for over the past 6000 years and before that time the error is proportionally small and may not even be present. If a plant can photo-synthesise under water it will have a lower  $^{14}\text{C}$  content than would be normal and thus if an

organic mud is dated it will give an age that is too large. Such errors are unlikely to exceed 3000 years but of course this is very important if Flandrian deposits are to be dated. Overestimation of age can occur when mollusc shells are dated due to isotope replacement which takes place within the material of the shell. Finally, contamination can occur when the deposit to be dated is in contact with old or modern carboniferous material such as root penetration.

It is generally accepted that sea levels have fluctuated over long time spans such as glacial and interglacials but controversy has arisen over whether or not such fluctuations are marked over shorter time spans. At present there are three schools of thought over sea-level movements during the Flandrian Stage; the first school believes that there has been a continuous rise of sea level to the present day, although the rate of this rise has lessened with time (Shepard 1963). The second school thinks that sea level rose to c.3600 yBP and then remained constant (Godwin et al. 1958) and the third school believes that there was an oscillating rise of sea level to present which has been fluctuating above or below present sea level (Fairbridge 1958 and Morner 1971).

Thus one can see that a great many problems are involved in the study of past sea levels. All the factors mentioned above must be considered when interpreting material for sea-level studies although it is very difficult to isolate each component in order to construct reliable sea-level curves for different areas during the Flandrian Age.

### 1:3 THE GEOLOGICAL BACKGROUND OF SOUTHERN BRITAIN

The rock platform under southern Britain consists of rocks of Carboniferous through Devonian to Lower Palaeozoic age. During the Hercynian earth movements, about 280 million years ago, these older rocks underwent upheaval to create an upland area. This upland was subsequently planed down to form the London Platform, upon which Mesozoic sediments were deposited. During the Jurassic subsidence occurred in the Weald area at a rate of 5.8 mm/ 100 years, with the deposition of 1.5 Km of shallow water sediments. In Early Cretaceous times deposits of a freshwater nature were laid down in an area that was subsiding at a rate of 1.4 mm/ 100 years. The Cenomanian Transgression occurred in Late Cretaceous times covering great areas of Europe with shallow water seas and the deposition of the chalk strata. Since the Late Cretaceous there was rifting to the west of Britain and the drifting apart of the American and Eurasian continental masses began (Blackett, Billard & Runcorn 1965; in Dunham 1972). This was followed by a period of subsidence at a rate of 1.8 mm/ 100 years during the Early Tertiary (Palaeogene) when the Reading and Woolwich Beds and London Clays were deposited. Subsidence was renewed in the Late Tertiary and Early Pleistocene (Neogene) when the deposition of the Crag deposits were laid down. The ice-sheets of the Pleistocene created a relative fall of sea level which exposed the continental shelf to subaerial erosion and marine planation.

### 1:4 PRE-FLANDRIAN SEA-LEVEL MOVEMENTS

A number of sites in Southern Britain and The Netherlands record pre-Flandrian sea levels. These two areas have been

investigated by West (1972) and Zagwijn (1979) and are correlated below in chronological order.

1) Ludhamian

This interglacial period correlates with the Middle Tiglian of Europe and is dated to 2 million years ago (mya) by van Montfrans (1971; in Zagwijn 1979). In East Anglia the deepest deposits of the Crag Basin are of a Ludhamian to Thurnian age (West 1968, 1972) and can be correlated with beds of a Middle and Upper Tiglian age in The Netherlands.

2) Antian

During the Antian interglacial the sea was still covering East Anglia with the deposition of the Coralline Crag beds which outcrop at Orford in Suffolk at O.D. In The Netherlands however the sea had retreated.

3) Barentian

This glacial period is thought to have started ca. 1.6 mya (van Montfrans op. cit.). During this time the Red Crag deposits were laid down in a shallow sea covering East Anglia. These deposits are found below O.D. in east Suffolk and up to 183 m.O.D. at Netley Heath in Surrey (Chatwin 1927; in West 1972). The eustatic change of sea level resulted in a fall of 50 m during this time.

4) Pastonian

The sea level rose to 8 m above present (ap) during this interglacial (West op. cit.). The deposits of this age are centred at O.D. in the Happisburgh area and a few metres above O.D.

at Sheringham.

5) Beestonian

The Beestonian glacial shows a regressive phase of sea-level movement with fluviatile sediments being laid down.

6) Cromerian

The Cromer Forest Beds of freshwater and marine sediments were deposited during the Cromerian interglacial period. These beds are found in east Norfolk and north Suffolk outcropping at O.D. on the coast (West & Wilson 1966; in West op. cit.). In the northern Netherlands marine beds are found at 50 to 60 m below present sea level and can be correlated with the deposits of East Anglia. At this time there was no connection between the North Sea and the sea to the south of the Strait of Dover (Zagwijn op. cit.). The rise of eustatic sea level was to 3 or 4 m ap (West op. cit.)

7) Anglian

This glacial period reveals a regressive phase of sea level with the advance of ice into East Anglia and The Netherlands.

8) Hoxnian

The eustatic rise of sea level during this phase was to more than 23 m ap. Estuarine and marine clays have been found at Clacton from 3 to 9 m.O.D. (Pike & Godwin 1953; in West op. cit.) and in the Nar Valley from 5 to 20 m.O.D. (Stevens 1960; in West op. cit.). The transgressive phase of sea level occurred at Clacton during the pollen zone Ho III and in the Nar Valley during Zone Ho II with a maximum sea level of 23 m.O.D. During this interglacial the sea

penetrated the Strait of Dover and invaded parts of the northern German lowlands. No deposits of this age are found in the western Netherlands.

9) Wolstonian

Sea-levels were low during the Wolstonian glaciation. Donn et al (op. cit.) suggest a sea level of - 159 m below present.

10) Ipswichian

This last interglacial sees a rise of eustatic sea level to 7.5 m.ap (West op. cit.). At Selsey in Sussex estuarine deposits show that a marine transgression attained levels of - 1.8 m.O.D. in Zone Ip IIb (West & Sparks 1960). These deposits are overlain by raised beach deposits up to an altitude of 7 m.O.D. At Brighton and Littlehampton raised beach deposits are also found which indicate a mean sea level of 7.5 m.ap in Zones Ip IIb and Ip III. In the Fenlands Baden-Powell (1934; in West op. cit.) has identified the March Gravel deposit up to an altitude of 10 to 12 m.O.D. which are related to this sea-level movement.

11) Devensian

The last glaciation sees a regression of sea level to - 123 m below present before the Flandrian Transgression took place ca.14000 yBP as the great ice-sheets melted.

Thus we see some correlation between the glacial and interglacial periods of the Pleistocene and the regressive and transgressive phases of sea level in Southern Britain and The Netherlands.

## 1:5 STUDY AREAS AND GEOLOGICAL BACKGROUNDS

In this work five sites, bordering the South Coast of England are investigated and can be seen in Figure 1. These sites are The Moors in Dorset, Studland Heath in Dorset, Browdown in Hampshire, Yarmouth on the Isle of Wight and Pett Level in East Sussex.

### 1) The Moors (SY 94 86)

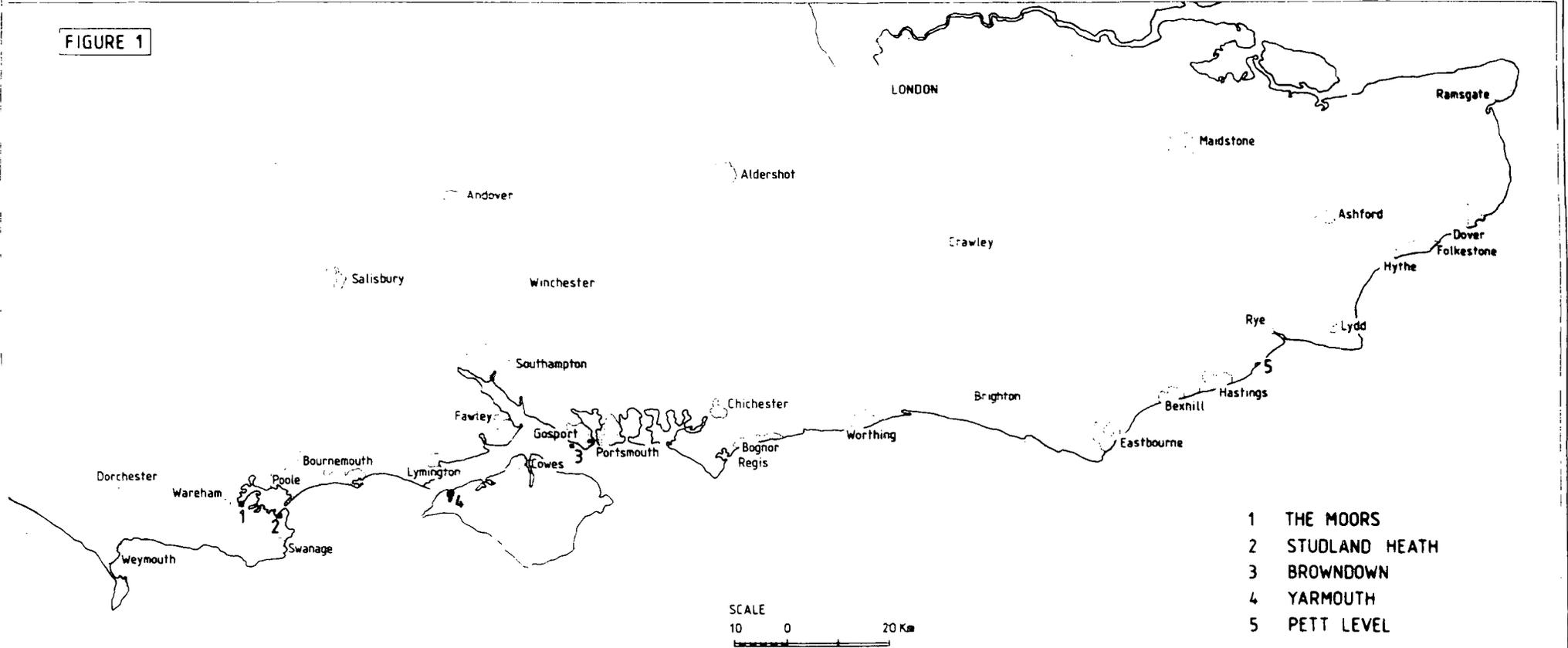
The location of The Moors site is shown in Figures 1 and 6. The site is found to the east of the mouth of the River Frome on the southern shore of Poole Harbour. The site was discovered by Byrne (1975) and proved to be suitable for detailed work to be carried out which was initiated in the summer of 1980.

At Wareham the range of Spring Tides varies from 0.8 m.O.D. at MHWS to - 0.7 m.O.D. at MLWS, giving a tidal range of 1.5 m.

The solid rock geology of the region around the site according to Strahan (1898) can be seen in Figure 3. The Moors site has a bedrock of Bagshot Beds, which are clays and sands from the Eocene epoch. The site lies on the northern limb of the Isle of Purbeck, the general structure of which is similar to that of the Isle of Wight. A series of folds and faults of post-Cretaceous age traverse the Isle of Purbeck but only one of these affects the study area. This is the main Isle of Purbeck fault and anticline which stretches from West Lulworth in the west to Ballard Point in the east. The fault was formed mostly after the Mid-Oligocene, after the deposition of the Hamstead Beds and is the same as the Brighstone anticline of the Isle of Wight. This hogs-back of incised chalk crosses the centre of the Isle of Purbeck in an east-west direction,

# SOUTH COAST FIELDWORK SITES

FIGURE 1



# SITES MENTIONED IN TEXT

FIGURE 2

LEGEND

- 1 RIMSMOOR
- 2 EAST STOKE
- 3 COLDHARBOUR
- 4 WAREHAM
- 5 MORDEN A
- 6 MORDEN B
- 7 KEYSWORTH FARM
- 8 THE MOORS
- 9 SLEPE HEATH
- 10 REMPSTONE
- 11 LUSCOMBE
- 12 GODLINGSTONE
- 13 LOWER HAMWORTHY

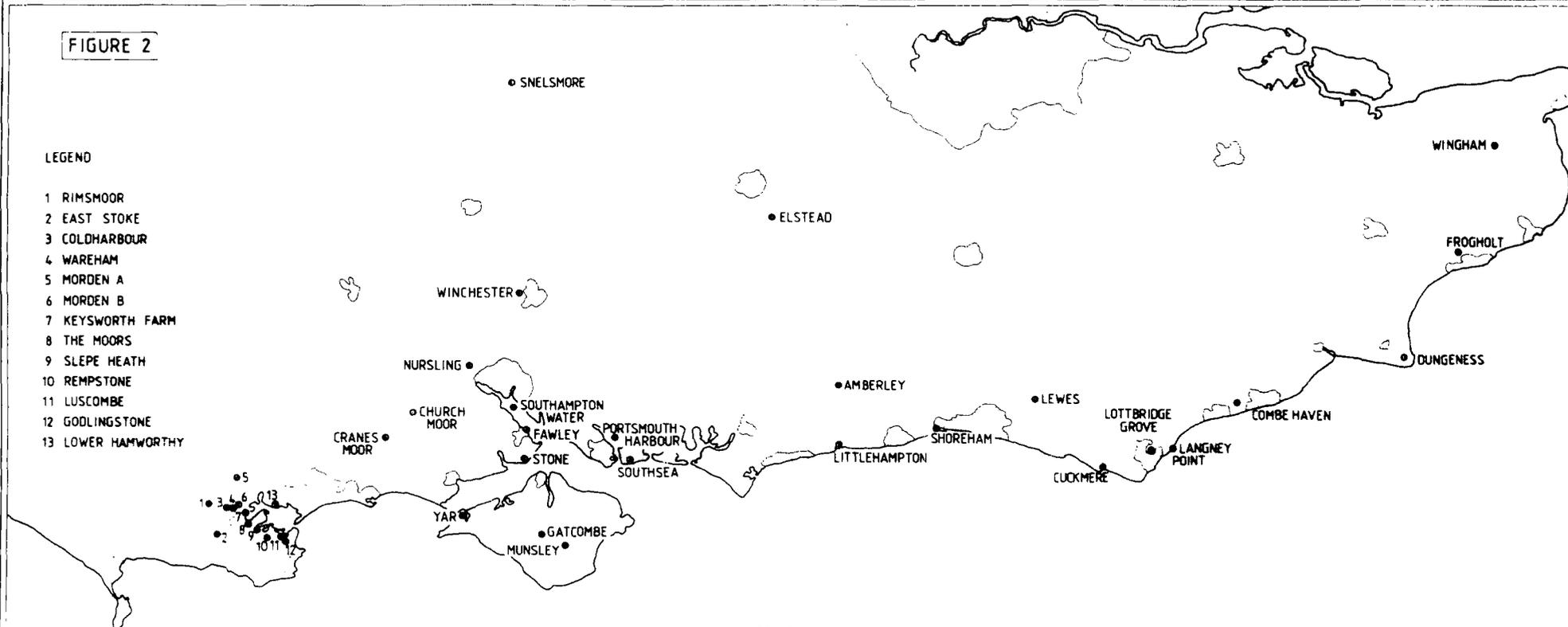
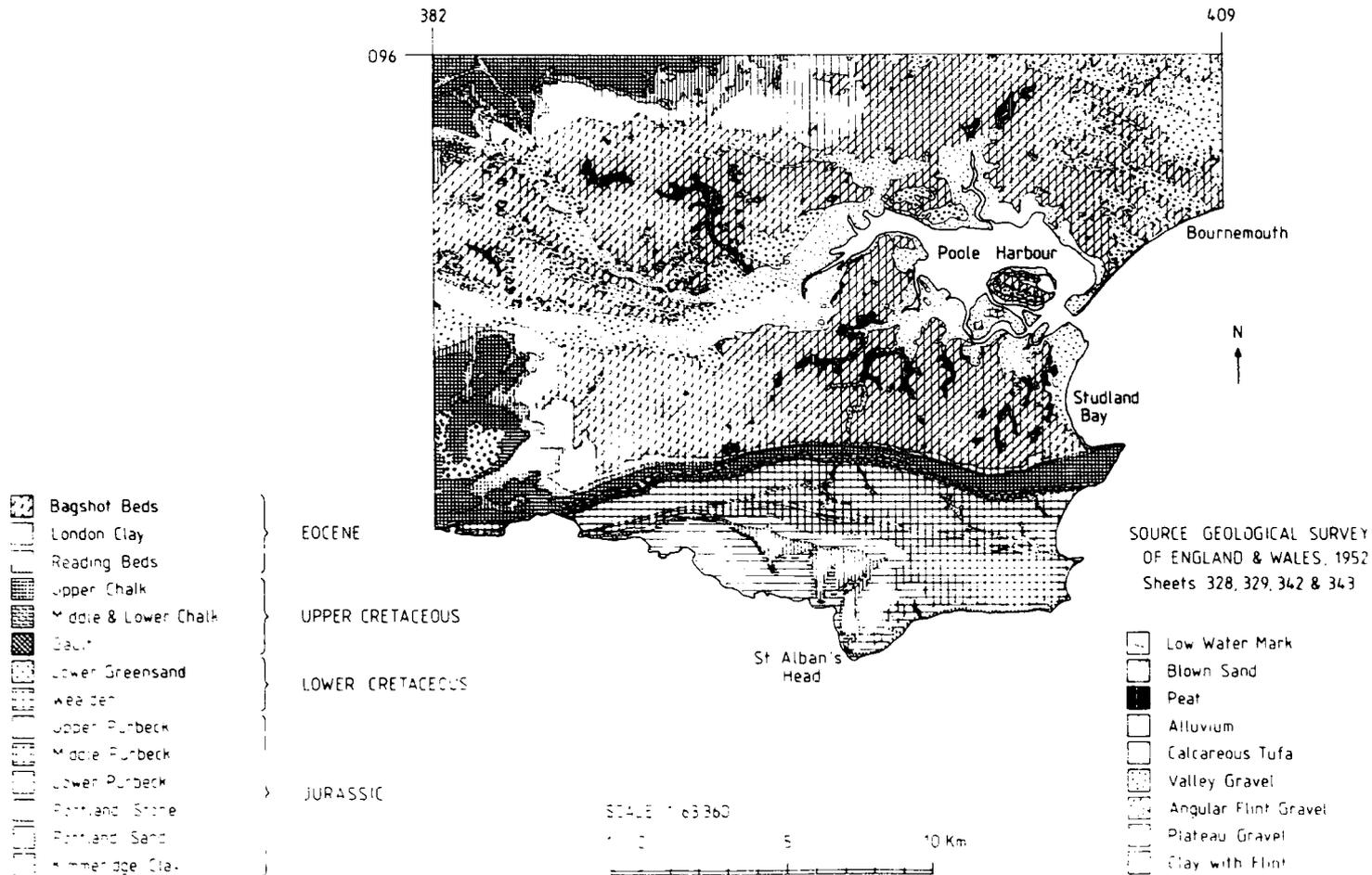


FIGURE 3

# THE GEOLOGY AROUND POOLE HARBOUR



with the strata on the northern limb plunging more steeply than those on the southern limb. The rocks of the Isle of Purbeck were faulted as well as folded in this upheaval whereas the rocks of the Isle of Wight were only folded. The features of the Dorset coast are due to subaerial denudation of the anticlinal region, similar to the processes of the Wealden district, together with the destruction of the surrounding synclinal region by sea invasions.

## 2) Studland Heath (SZ 02 84)

The location of the Studland Heath site is shown in Figures 1 and 18. This site is found on the southern shore of Poole Harbour and is sheltered from the open sea by the South Haven Peninsula to the east. This site had not previously been worked on and was chosen due to its extensive stretches of tidal salt marshes. Fieldwork at the site began in the summer of 1982.

At the entrance to Poole Harbour the range of Spring Tides varies from 0.6 m.O.D. at MHWS to - 1.1 m.C.D. at MLWS, giving a tidal range of 1.7 m.

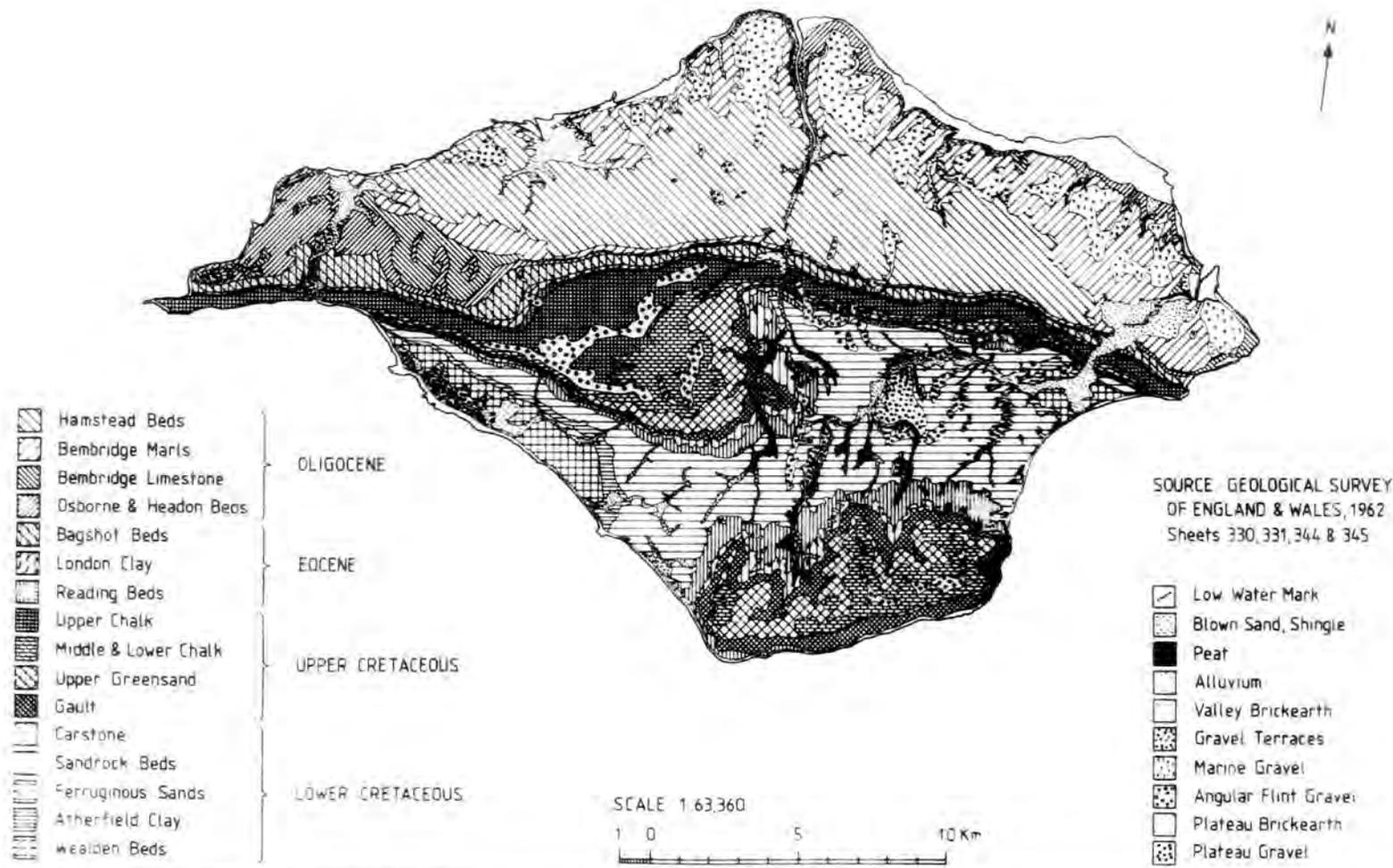
The bedrock at Studland Heath is Bagshot Beds as at The Moors and the solid rock geology of the area can be seen in Figure 3. The geological structure of the site is the same as at The Moors, and has already been discussed above.

## 3) Yarmouth (SZ 35 89)

The location of the Yarmouth site can be seen in Figures 1 and 23. The site borders the Western River Yar on the Isle of Wight near the town of Yarmouth. Although the site is known as Yarmouth it really comprises two areas; to the west of the river is the location of the Yarmouth Boatyard site (SZ 352 892) while to the east of the river

FIGURE 4

# THE GEOLOGY OF THE ISLE OF WIGHT



SOURCE: GEOLOGICAL SURVEY OF ENGLAND & WALES, 1962  
Sheets 330, 331, 344 & 345

SCALE 1:63,360  
1 0 5 10 Km

FMJS

is Yarmouth Carpark site (SZ 354 894). These two sites are both tidal salt marshes. The area around the River Yar was worked on by Devoy (1972) and as the site proved potentially valuable for sea-level studies this work was initiated in late 1980.

The range of Spring Tides at Yarmouth varies from 1.12 m.O.D. at MHWS to - 1.38 m.O.D. at MLWS, giving a tidal range of 2.5 m.

The solid rock geology of the Isle of Wight according to Bristow (1889) is shown in Figure 4. At the Yarmouth site the bedrock is of Headon Beds which are clays of freshwater, estuarine and marine origins. A series of folds traverse the Isle of Wight, the main one resulting in the anticlinal chalk ridge stretching from The Needles in the west to Culver Cliff in the east. This is a continuation of the Isle of Purbeck fault. The ridge produced by this divides the island into two; to the north the rocks are of a Tertiary age and lie in a broad syncline of heavy clays while to the south the rocks are Cretaceous in age resulting in light and loamy soils. As in the Isle of Purbeck the northern limb of the anticline is steeper than the southern limb. The date of the disturbance which produced this feature is probably after the deposition of the Hampstead Beds in the Mid-Oligocene. There are a few faults on the Isle of Wight due to the folding but the ones present do not alter the physical features of the island.

#### 4) Pett Level (TQ 89 13)

The Pett Level site is shown in Figures 1 and 42. It is found to the east of Hastings on the foreshore south of Cliff End. The existence of a submerged forest deposit on the foreshore has been known for a long time but at the time of this study no work had been

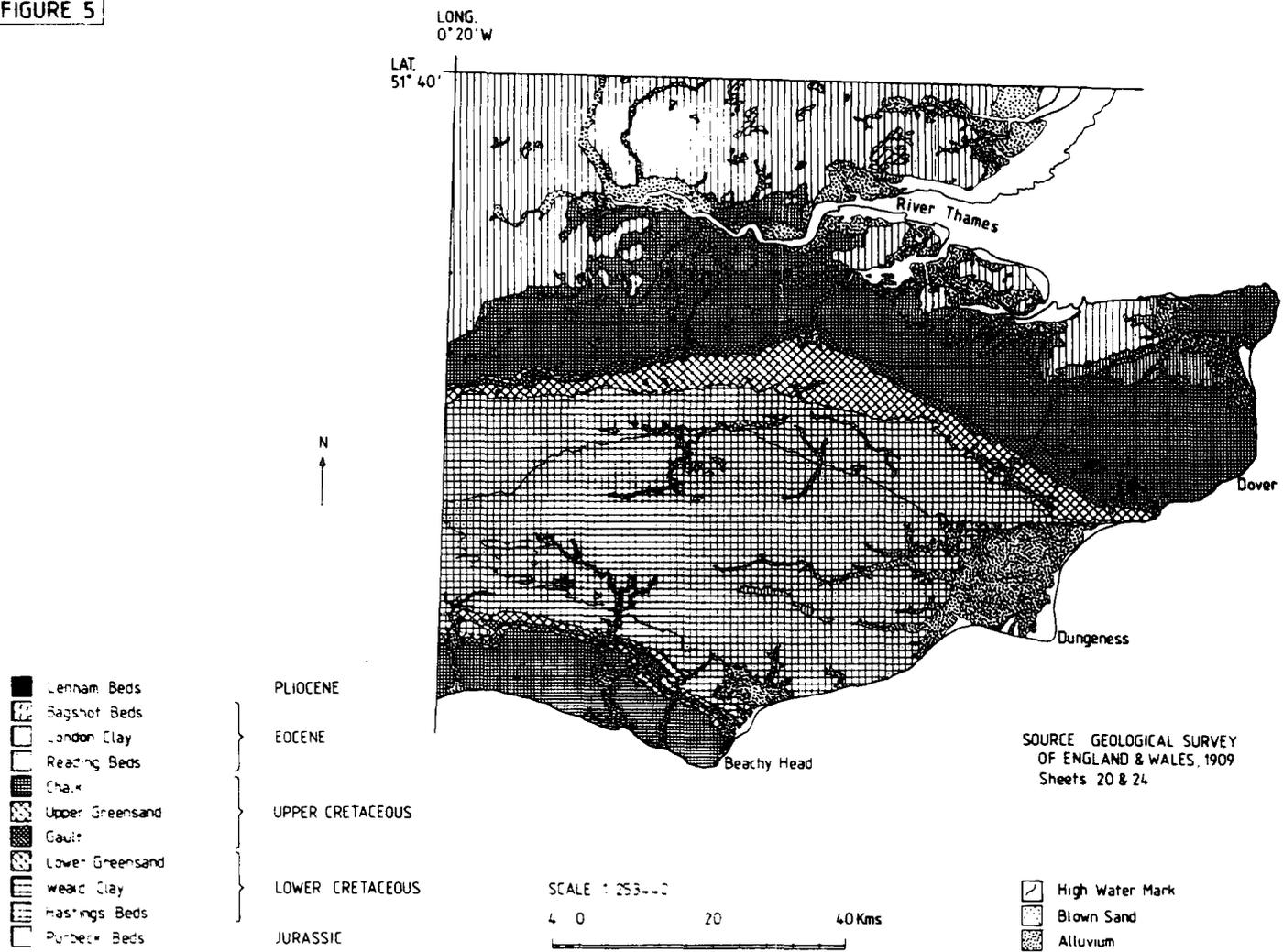
carried out at the site and so the present investigation was initiated in September 1982.

At Hastings the range of Spring Tides varies from 3.7 m.O.D. at MHWS to - 3.1 m.O.D. at MLWS, giving a tidal range of 6.8 m.

The solid rock geology of Pett Level is shown in Figure 5 according to Edmunds (1935). The bedrock at the site is of Fairlight Clays and Ashdown Sands of a Cretaceous age. These are lacustrine and deltaic deposits of clays and sands. The site lies at the edge of the Wealden area and thus the geological structure is bound by the movements of the Weald. The general structure of the Wealden area is a broad anticline, running east-south-east to west-north-west, superimposed upon a synclinal area of deposition. The inception of the movement resulting in this structure was in pre-Eocene times reaching a maximum intensity in the Miocene Epoch. The topography of the area can be described as deeply dissected high ground of Hastings Beds which are surrounded by a broad low-lying zone of Weald Clay, which in turn is surrounded by hills of Lower Greensand encircled by Chalk downs. The study area is in a region which has been effected by many folds and faults. The folds of the Upper Jurassic and Lower Cretaceous rocks can be divided into three anticlines along the coast; The Haddock's Anticline crosses the coast close to Haddock's Cottages (TQ 844 124). The Fairlight Anticline crosses south-east of Fairlight Church (TQ 860 119) and Page's Anticline is found between Bexhill and Cooden Coastguard station. These are all gentle features and cannot be traced far inland. The Haddock's Anticline and Fairlight Anticline lie 'en echelon' and expose Fairlight Clays at Pett (TQ 87 14), Ore (TQ 83 11) and Guestling (TQ 85 13). An overthrust fault can be

# THE GEOLOGY OF SOUTH-EAST ENGLAND

FIGURE 5



seen in section at the coast by the steps at Haddock's Rough (TQ 884 124), to the south-west of Cliff End while at Cliff End Point (TQ 888 132) a normal fault is exposed in the cliff of Ashdown Sands (Edmunds 1935).

5) Browndown (SZ 585 985)

The Browndown site is shown in Figures 1 and 48. The site of the boring by the Civil Engineering Department of Portsmouth Polytechnic is south of Gosport in Stokes Bay. The core was taken from the sea bed as part of an investigation by the department of the structure of the sea bed in the Solent. Laboratory analyses were carried out, at Durham, during 1980.

The range of Spring Tides at Lee-on-the-Solent varies from 1.56 m.O.D. at MHWS to - 2.04 m.O.D. at MLWS, giving a tidal range of 3.6 m.

The geological background of the core at Browndown is not discussed as it is the only underwater core in this study and the precise details of the boring is not known.

C H A P T E R 2

TECHNIQUES EMPLOYED

2:1 INTRODUCTION

The sea-level studies in this work are carried out using six traditional techniques; levelling, sampling, stratigraphic analysis, pollen analysis, diatom analysis and particle-size analysis. These methods are outlined below together with a summary of their advantages and disadvantages in order to assess the reliability of results obtained and therefore, the conclusions based upon the data.

2:2 LEVELLING

The boreholes used in this study were levelled to Ordnance Datum (Newlyn), using a Kern Automatic Level, GK1-AC. The sites were levelled to local benchmarks with altitudes obtained from the Survey Services Department of the Ordnance Survey. In some instances, temporary benchmarks were set up where the distance to existing benchmarks was too great. These temporary benchmarks were later levelled to Ordnance Survey benchmarks.

The method of levelling employed in this study is prone to errors. The readings are subjective and different readings can be obtained from different operators. Only one person took the readings during this work and therefore this problem was overcome. It is often difficult to see, and therefore to take accurate readings from, the staff in windy and rainy weather. In most

cases these were the weather conditions prevalent during levelling. Every site in this study had a very wet ground surface which was not stable and therefore the accuracy of readings was also impaired by the staff and level sinking into the ground. In order to try and reduce this problem the driest ground was chosen on which to rest the staff and level.

Closing errors were found at The Moors and Studland Heath sites. These errors were equally redistributed over the change-points. At The Moors, a closing error of 22 cm was found over 44 change-points which covered a distance of 5.5 km and an altitude range of 0.7 m. The closing error at Studland Heath was calculated as 36 cm from 90 change-points, with an altitude range of 10.9 m over 3.4 km. At Yarmouth and Pett Level no closing errors were calculated as open levelled transects were used. The borehole at Browdown was levelled by the Civil Engineering Department of Portsmouth Polytechnic.

### 2:3 SAMPLING METHODS

The sediments investigated in this study are found in chronologically, stratified sequences, and so it is important to preserve the sequence in situ when sampling the material. To achieve this, one of four methods of sampling can be used; The Gouge sampler, the Russian-type sampler, the Percussion corer and the Monolith tin, each of which is outlined below.

#### 2:3:1 The Gouge Sampler

The Gouge sampler has the simplest design of all devices used in this study. It is an open-chambered sampler, with a

diameter of 2 cm and a length of 1 m. Connecting rods of 1 m length can be attached for deep samples.

The Gouge sampler is pushed into the ground manually. When the required depth is reached, the sampler is rotated through  $360^{\circ}$  and lifted out vertically. The face of the material, contained within the chamber is cleaned and the stratigraphy can be recorded. This type of sampler is usually used for preliminary investigations of the stratigraphy of sites, as the material retained is too little for taking sub-samples for microfossil analyses.

There are a few disadvantages to using a Gouge sampler. Contamination, from upper strata, can occur as the sampling chamber is not enclosed. This can result in misleading positions of strata in the stratigraphy. This is demonstrated at YBS 3, YBS 9 and Studland Heath 4 (Figures 25, 26 and 20), where adjacent boreholes were taken using the Gouge sampler and the Percussion corer.

The Gouge sampler was used at Yarmouth, Studland Heath and Pett Level. At Studland Heath sub-samples were taken from the Gouge sampler for microfossil analyses as no other sampling devices were available.

#### 2:3:2 The Russian-Type Sampler

The Russian-type sampler, first described by Jowsey (1966), can be used either for stratigraphic investigations or for obtaining material for laboratory analyses. The sampler is composed of a movable sampling chamber, 50 cm by 5 cm, which can be rotated through  $180^{\circ}$  against an anchored fin. Thus the Russian-type

sampler can only retrieve a semi-cylindrical core of sediment.

The sampler is pushed into the ground by hand. As soon as the required depth is reached, the chamber is rotated against the fin, thus enclosing the sediment. The sediment recovered can be transferred to 50 cm half-diameter plastic piping, which is then sealed in polythene and stored in a cold-room until later analyses.

Contamination of the samples is not so great a problem with this device as the sampling chamber is closed until the right depth is reached and the sample is enclosed during retrieval. There is also less disturbance of the sediment in sampling. The Russian-type sampler is best used for stratigraphy in the field, or in the laboratory, as a large surface of material is exposed on the fin. The one serious disadvantage of using this type of sampler is that it is very difficult to use in stiff sediments or when wood is encountered in the borehole.

This Russian-type sampler was used at The Moors and at Yarmouth.

### 2:3:3 The Percussion Corer

The Percussion corer used in this work is a modified Livingstone piston corer and percussion drill, as described by Merkt & Streif (1970). The corer is used to recover large samples for laboratory analyses, after a preliminary site investigation has been carried out, either by the Gouge sampler or the Russian-type sampler. The Percussion corer consists of a movable piston in an open-ended sampling tube, 1 m by 4.8 cm diameter. The sampling tube is pushed into the ground by the

vibrator. When the required depth for sampling is reached, the piston is held in place by a wire while the sampling tube is pushed on down until the piston reaches the top of the tube. The sample is held in place by suction. The whole sample tube is removed from the ground by a jack. The ends of the tube are sealed with polythene for transportation back to the laboratory. The sample is removed from the sampling tube using an extractor, which pushes the sediment out into a plastic tubing, which is then sealed and later stored in a cold-room.

Sampling with a Percussion corer ensures that no contamination can take place as the sample is enclosed completely. The vibrating action, as the tube is pushed into the ground, also ensures that the material is not disturbed as it is sampled. The material at the sides of the tube do suffer distortion, but the material in the centre remains intact. It is difficult to use this sampler in stiff sediments and it can not be used in sandy sediments. The piston can easily open too early and so sample unwanted material and it can also open too late and so miss the required material. The major disadvantage is that compaction of the sediments can occur, either during sampling or extraction.

The Percussion corer was used at The Moors, Yarmouth Studland Heath and Browndown.

#### 2:3:4 Monolith Tins

The Monolith tin is composed of an aluminium alloy with dimensions of 50 cm by 10 cm by 10 cm. Monolith sampling can be carried out either on a cleaned natural free-face or in a prepared

pit. In either case, the face has to be cleaned using a spatula or trowel, before the sample can be taken. The Monolith tin can either be pushed in by hand or hammered into the sediment. The tin, once in place, can be dug out containing the sampled material and sealed in polythene. When consecutive samples are required, the tins are placed with an overlap of at least 5 cm, to ensure a true sequence of stratigraphy.

A large amount of material can be retained in a Monolith tin, which can be useful for stratigraphic analyses and for radio-carbon dating. It is very important to keep the Monolith tin vertical when sampling.

Monolith tins were taken at Pett Level from pits dug in the foreshore.

All the methods of sampling sediments described here have their own advantages and disadvantages and it is good practice to use at least two methods together at one site to ensure that a true stratigraphic record is obtained.

#### 2:4 STRATIGRAPHIC ANALYSES

A Percussion corer, a Russian-type sampler, a Gouge sampler and Monolith tins were used in this study, as already described. In most instances the stratigraphy was recorded in the field, in order to determine the two-dimensional pattern of strata, using the notation proposed by Troels-Smith (1955). The borehole with the deepest organic strata were then re-sampled for laboratory analyses, using either the Russian-type sampler or the Percussion corer. At most sites a grid pattern of boreholes was employed

although this was not always possible.

Each stratum of the core is labelled with depth, in centimetres, from the top of the core and assigned a number from the base upwards. The strata are dealt with separately and are described using the three-part scheme of Troels-Smith (1955).

The first part of the description deals with the component parts of the stratum; the nature of the material and the proportions. Seventeen component parts are described within the scheme, which are divided into five main classes. Table 2 shows these divisions. Not all of the seventeen parts were employed in this work. The Limus detrituosus (Ld) terminology was dispensed with as it was found to be too difficult to distinguish from the Substantia humosa (Sh) component, as a result the latter was used throughout. The proportions of these component parts are defined on a five-class scale; 0 denoting an absence of and 4 denoting a maximum presence of each component part.

For example, at The Moors site stratum 6 of Moors 1 is described as:-

Ag 1, As 3, Ga +, Lf +, Dh +.

This indicates that approximately 25% of the stratum is composed of silt particles 0.06 - 0.002 mm (Ag) and approximately 75% are clay particles <0.002 mm (As). Also present are traces of mineral particles 0.6 - 0.2 mm (Ga), particles of non-hardened rust <0.1 mm (Lf) together with fragments of herbaceous plants <2 mm (Dh).

The second part of the description deals with the physical properties of the stratum; the tone density, structure, elasticity, and degree of dryness, together with an indication of the

Table 2 Component Parts of Troels-Smith Stratigraphic Classification

<p>I <u>Turfa</u></p> <p>Sh <u>Substantia humosa</u></p> <p>Tb<sup>0-4</sup> <u>T.bryophytica</u></p> <p>Tl<sup>0-4</sup> <u>T.lignosa</u></p> <p>Th<sup>0-4</sup> <u>T.herbacea</u></p>	<p>Humous substance, homogeneous microscopic structure.</p> <p>Mosses +/- humous substance.</p> <p>Stumps, roots, intertwined rootlets of ligneous plants +/- trunks, stems, branches.</p> <p>Roots, intertwined rootlets, rhizomes of herbaceous plants +/- stems, leaves etc.</p>
<p>II <u>Detritus</u></p> <p>Dl <u>D.lignosus</u></p> <p>Dh <u>D.herbosus</u></p> <p>Dg <u>D.granosus</u></p>	<p>Fragments of ligneous plants &gt;2mm.</p> <p>Fragments of herbaceous plants &gt;2mm.</p> <p>Fragments of ligneous &amp; herbaceous plants &lt;2mm &gt;0.1mm.</p>
<p>III <u>Limus</u></p> <p>Ld<sup>0-4</sup> <u>L.detrituosus</u></p> <p>Lso <u>L.siliceous organogenes</u></p> <p>Lc <u>L.calcareus</u></p> <p>Lf <u>L.ferrugineus</u></p>	<p>Plants &amp; animals(except diatoms, sponge needles, siliceous skeletons of organic origin). Particles &lt;0.1mm +/- humous substance.</p> <p>Diatoms, sponge needles, siliceous skeletons of organic origin. Particles &lt;0.1mm.</p> <p>Marl, not hardened like calcareous tufa, lime etc. Particles &lt;0.1mm.</p> <p>Rust, not hardened. Particles &lt;0.1mm.</p>
<p>IV <u>Argilla</u></p> <p>As <u>A.steatodes</u></p> <p>Ag <u>A.granosa</u></p>	<p>Particles of clay &lt;0.002mm.</p> <p>Particles of silt 0.06 - 0.002mm.</p>
<p>V <u>Grana</u></p> <p>Ga <u>G.arenosa</u></p> <p>Gs <u>G.saburralia</u></p> <p>Gg(min) <u>G.glareosa minora</u></p> <p>Gg(maj) <u>G.glareosa majora</u></p>	<p>Mineral particles 0.6 - 0.2mm.</p> <p>Mineral particles 2.0 - 0.6mm.</p> <p>Mineral particles 6.0 - 2.0mm.</p> <p>Mineral particles 20.0 - 6.0mm.</p>

Source: Troels-Smith 1955.

sharpness of the boundary between the stratum in question and the one immediately above. These properties are again defined on the five-class scale (0 - 4) and are outlined in Table 3.

Table 3 Physical Properties of Troels-Smith Stratigraphic Classification

I	<u>Nigror</u>	(Nig)	degree of darkness
II	<u>Stratificatio</u>	(Strf)	degree of stratification
III	<u>Elasticitas</u>	(Elas)	degree of elasticity
IV	<u>Siccitas</u>	(Sicc)	degree of dryness
V	<u>Lines superior</u>	(Lim(sup))	sharpness of upper boundary
		Lim 0	boundary area >1 cm.
		Lim 1	boundary area <1 cm and > 2 mm.
		Lim 2	boundary area <2 mm and >1 mm.
		Lim 3	boundary area <1 mm and >0.5 mm.
		Lim 4	boundary area <0.5 mm.

Source: Troels-Smith 1955.

For example, at The Moors site stratum 6 of Moors 1 is described as:- Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0.

This indicates that it is a medium-toned stratum with no structure or elasticity, which is found below the water-table, with no definite upper boundary.

The third part of the description is a verbal account of the stratum. Thus the complete description of stratum 6 of Moors 1 can be shown as:-

6) 26 - 65 cm.

Ag 1, As 3, Ga +, Lf +, Dh +.

Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0.

Grey silty-clay with iron-staining, traces of sand and herbaceous plant remains.

Once the strata of the core have been described, the stratigraphy can be recorded graphically. In the present study,

the method of graphic representation proposed by Troels-Smith is not employed as it was found too difficult to stencil the symbols clearly in a small area without them becoming confused. The original symbols of Troels-Smith are used but in a simpler scheme with four symbols to a line, representing the five-class scale.

The advantages of this system of classification of borehole strata are numerous. A standardized system of description is possible which will distinguish each stratum from another simply, where-in the elements of the stratum are described separately and also in combination. This system can be used either as a rough guideline or as a more precise classification.

The main drawback to using the Troels-Smith classification is the possibility of a lack of consistency. As all descriptions are subjective and non-quantitative, variations can occur between cores and operators. It is however, consistent within each core for one operator. In general, the advantages of this classification outweigh the disadvantages. All the stratigraphic analyses of this study are compiled according to the system described here.

## 2:5 POLLEN ANALYSES

### 2:5:1 Introduction

Palynology is the study of the structure and formation of pollen grains and spores, together with an investigation of their dispersion and preservation under different environmental conditions. Fossil pollen was first described by Goppert (1836; in Faegri & Iversen, 1964) in Pre-Quaternary deposits, and by Geinitz (1887; in Faegri & Iversen, 1964) in Post-Glacial

deposits. The first pollen percentage calculations were done by Lagerheim (1905; in Faegri & Iversen, 1964), although these calculations cannot be regarded as accurate indicators of past environmental conditions. The first modern pollen percentage analyses were carried out by Von Post (1916; in Erdtman, 1943). The science of pollen analysis has dominated investigations of Late-Quaternary development of vegetation and climate since the Mid-Twenties.

The pollen grains are formed in the anther of the flowering plants, and are released in great numbers, by some anemophilous taxa, during the flowering season. The pollen grain is made up of three concentric layers; the inner cytoplasmic material, the middle intine and the outer exine. If the pollen grain fails to reach the stigma of another plant, both the cytoplasmic interior and the intine will perish, leaving the durable exine to survive. The exine is also made up of layers; the inner endexine and the outer ektexine. Both these layers are composed of sporopollenin, which is a very durable and slow to decompose material. The endexine is an homogeneous, continuous membrane with few morphological developments, except those which are connected with apertures. The ektexine however, is composed of small radial rod-like elements, which give the exine its morphological variability; the structure of the exine. The sculpturing of the exine consists of the external features, which are sometimes independent of the structure. It is the combined structure and sculpturing of pollen exines, together with their shape and the type, and arrangement, of the germinal apertures that gives each pollen grain distinct diagnostic features. Most pollen grains possess germinal apertures in the exine, through one of which,

the pollen tube will eventually grow. These apertures consist of furrows (colpi) and pores (pori). The colpi are the primitive stage before the pori developed. These apertures can occur as colpi, pori or a combination of both.

#### 2:5:2 Extraction of Pollen

Before the pollen in a deposit can be identified and counted, it must first be concentrated and isolated. This is done by a series of physical stages and chemical digestions, including deflocculation, removal of extraneous material and finally, embedding the prepared sample in a suitable medium to facilitate counting. The chemical and physical stages are outlined in Appendix I. It was thought best to embed the samples in silicone fluid, as this has a low refractive index and does not change the size of the pollen grains. It is also useful in that the grains can be rotated under the coverslip, which aids identification. There are problems encountered during pollen preparation. Pollen can be lost by decanting supernatants too soon or by insufficient centrifuging. Pollen can also be lost during the sieving stage of preparation. One must always make sure that all the equipment used is thoroughly cleaned or contamination, either by fossil or modern pollen, can occur.

#### 2:5:3 Pollen Counts

The pollen is counted using a microscope with a mechanical stage, which enables traverses of the slide to be made at regular intervals; in this case intervals of 1.5 fields of view were used throughout the work. Identification and counting was carried out at x400 on a Zeiss binocular microscope, but where grains needed

closer attention, an oil immersion lens was used at x1000. The pollen was identified with the aid of pollen keys of Fægri & Iversen (1964) and Moore & Webb (1978) and also a comprehensive reference collection. Once identified, species were recorded on a count sheet until the required pollen sum was achieved.

#### 2:5:4 Pollen Sums

Before choosing a pollen sum, the objectives of the study must be defined; in this case to elucidate the local and regional changes in vegetation associated with a rising, or falling, sea-level, and also to assess the relative chronology of the deposits. The usual method of expressing pollen data is the frequency of each taxon, expressed as a proportion of a fixed sum. Von Post (1916) initiated counting to a pollen sum of 150 trees. In most cases this is thought sufficient, but it must be remembered that changes in the frequency of one taxon causes changes in another. Thus if a taxon is found to be local to the site, changes recorded in it may result in changes in the pollen frequency from the non-local pollen. It is best, in such cases, to separate and eliminate the local pollen taxa from the pollen sum, especially in studies of regional vegetation change. Two basic methods of representing the pollen data were employed during this study. Taxa were either expressed as a percentage of the total arboreal pollen ( $\Sigma$ AP) plus life form or taxonomic group ie.  $\Sigma$ AP + Shrubs,  $\Sigma$ AP + Herbs,  $\Sigma$ AP + Aquatics and  $\Sigma$ AP + Spores or expressed as a percentage of the total land pollen (TLP) plus group ie. TLP + Aquatics or TLP + Spores. Confidence limits of 95% were imposed upon the data using a program written by Dr. I. Shennan (Department of Geography, University of Durham); NEWPLOT. The confidence limits enable

one to see real changes in percentage fluctuations, which would otherwise be unnoticed. Pollen sums for each site will be dealt with in the relevant sections.

#### 2:5:5 Pollen Diagrams

It is normal to represent the data of pollen counts in diagrammatic form. Pollen frequencies are indicated on the ordinates and the sampling level and depth below the surface on the abscissi, together with an indication of the stratigraphic column of the sampled core.

Pollen diagrams are usually divided into pollen zones, each of which should be independent and have uniform characteristics. The zone boundaries are subjective and are placed where there are sudden changes in pollen frequencies. Godwin (1940) constructed a system of zones which was considered representative of the whole of Southern Britain. This system was based on fluctuations of tree pollen, but became associated with climatic periods, eg. Zone VIIa was associated with the Atlantic Period, which was warm and wet. The idea of synchronicity of pollen zone boundaries was criticised by Smith & Pilcher (1973) and Moore & Webb (1978). E.J.Cushing (1967) applied the term assemblage zone, a term used in solid rock geology. These assemblage zones are delimited entirely on the basis of internal characteristics of the site where the study was first made. Local assemblage zones may be tentatively correlated with the pollen zones of Godwin (1940), subsequently dated at Scaleby Moss (Godwin, Walker & Willis, 1957), in order to assess a relative chronology of the site.

## 2:5:6 Interpretation of Pollen Diagrams

Before interpreting a pollen diagram, with regard to local and regional vegetational changes, we must first consider a number of factors.

- viz. 1) Origins of fossil pollen  
2) Dispersal of pollen  
3) Productivity of pollen  
4) How representative of environmental change is the pollen?

### 1) Origins of fossil pollen

This concerns the initial origin of the pollen. Rempe (1937; in Fægri & Iversen, 1964) showed that pollen is carried upward in thermal winds during the day, but falls rapidly during calm nights. Some of the lighter grains may remain in the lower air currents to be carried upward again the next day. Fægri & Iversen (1964) state "Enormous quantities of pollen are liberated, float in the air for shorter or longer periods, and are eventually sifted out over the surroundings as the dense and even pollen rain". This is a simplistic view and does not take into account meteorological controls on pollen dispersal. Tauber (1965) set about constructing a model to include such factors as wind velocity and turbulence. He showed that pollen deposition at sites is of a composite nature, In forested areas, at least three components must be considered; pollen transport in the trunk space, above the canopy and pollen brought down by the rain. Pollen grains carried through the trunk space originates within hundreds of metres, pollen above the canopy reflects a distance of several kilometres, while rain components reflect

more regional origins. This model has since been revised by Tauber (1977) to show that the trunk space component originates within 200 m, the canopy component within 1000 m and rainout 2-400 m. Pollen is also susceptible to water transport either via rivers or the sea (Pennington 1970). It is best to carry out a study of the contemporary pollen rain of a site, in order to understand all the factors involved in the origins of pollen rain.

## 2) Dispersal of pollen

The way in which pollen is transferred from the anther to the stigma of plants is of great importance in the interpretation of pollen data. There are basically four types of pollination: The hyp-hydrogamous species of plants are pollinated underwater eg. Zostera, but as the pollen grains have no exines, no remains may be found in deposits. The obligate-autogamous plants flower after fertilization has taken place within the flower and so, no pollen is liberated. Entomophilous plants have their pollen transferred from anther to stigma by carriers such as animals, birds or insects. Some of these species only release their pollen for specific carriers and therefore are under-represented in the pollen rain. These pollen grains usually have a heavily sculptured exine. Some of the entomophilous plants can produce large quantities of pollen eg. Tilia and Calluna. Thus the pollen of entomophilous plants is likely to be more of a local type in origin as the grains are not designed for long-distance transport. The most important type of pollen grain in fossil pollen studies is that of the anemophilous plants. These grains are dispersed by wind action and can be carried for long distances. Erdtman

(1921) considered that pollen which has been carried long distances could have originated 200 to 1500 km away from the site of deposition, whereas Rudolph & Firbas (1927; in Faegri & Iversen, 1964) considered the distance to be nearer to 20 km. It follows that pollen from these types of plants will be carried long distances and so will make up the regional component of the pollen rain.

It must be remembered that pollen can also be of a secondary nature, either reworked from erosion contacts or washed into the site by rivers.

### 3) Productivity of pollen

Hyde (1950) did a study of pollen rain in Great Britain including day to day variation and place to place variation. The productivity of pollen from different species of plants varies enormously, as does the flowering time of the plant. Entomophilous species usually produce less pollen eg. Acer produces ca.1000 grains in an anther. Anemophilous species produce great numbers of pollen grains as many are 'lost' eg. Betula produces ca.10,000 grains per anther. Hesselman (1919; in Faegri & Iversen, 1964) found that the Spruce forests of Southern and Middle Sweden produced ca.75,000 tons of pollen per year. Hedera and Corylus are found to produce pollen early in the year whereas Lonicera produces late, this can also affect pollen deposition. Table 4 shows pollen productivity of different species according to three authors.

Differences of pollen productivity can lead to over-representation of species in the pollen rain. Davis & Deevey (1963)

Table 4 Pollen Productivity of Main Tree Species ( in decreasing order of importance).

Fægri & Iversen (1950)	
<u>Pinus</u> , <u>Betula</u> , <u>Alnus</u>	
<u>Picea</u> , <u>Quercus</u> , <u>Fraxinus</u> , <u>Fagus</u>	
<u>Tilia</u>	
Jonassen (1950)	
<u>Pinus</u> , <u>Betula</u> , <u>Alnus</u> , <u>Quercus</u>	
<u>Fagus</u>	
<u>Picea</u>	
Andersen (1976)	
<u>Pinus</u> , <u>Betula</u> , <u>Quercus</u> , <u>Alnus</u>	
<u>Carpinus</u>	
<u>Ulmus</u> , <u>Picea</u>	
<u>Fagus</u> , <u>Abies</u>	
<u>Tilia</u> , <u>Fraxinus</u>	

Table 5 R-Ratio Values for Main Tree Species.

Iversen (1947)	
<u>Pinus</u> , <u>Betula</u> , <u>Alnus</u>	1 ÷ 4
<u>Picea</u> , <u>Quercus</u> , <u>Fraxinus</u> , <u>Fagus</u>	1 x 1
<u>Tilia</u>	1 x 2
Jonassen (1950)	
<u>Quercus</u>	1 ÷ 5
<u>Betula</u> , <u>Alnus</u>	1 ÷ 4
<u>Fagus</u>	1 x 1
Andersen (1976)	
<u>Pinus</u> , <u>Betula</u> , <u>Quercus</u> , <u>Alnus</u>	1 ÷ 4
<u>Carpinus</u>	1 ÷ 3
<u>Ulmus</u> , <u>Picea</u>	1 ÷ 2
<u>Fagus</u> , <u>Abies</u>	1 x 1
<u>Tilia</u> , <u>Fraxinus</u>	1 x 2

proposed a method to allow for the differences between species, with respect to their dispersal efficiency and productivity. Her idea was to calculate a correction value, called the R-ratio where:-

$$R(a) = \frac{\% \text{ pollen of species (a)}}{\% \text{ representation of species (a) in vegn.}}$$

Using R-ratio values, species can be represented realistically by correcting the pollen percentage by the relevant R-ratio value. A number of authors have calculated tables of R-ratio values and some of these can be seen in Table 5 . Variations are seen between these sets of calculations. It must be stressed that these are calculated for specific sites and therefore must only be used for these areas. If correction factors are to be employed, they must be calculated with regard to the site under investigation.

Another factor which might influence the representation of the pollen in a deposit is the differential destruction of some pollen grains. Corrosion can occur in aerated peats at, or above, the water-table. Obviously corrosion and destruction of grains will alter the composition of the pollen spectrum. An additional cause of misrepresentation of true pollen in a deposit is the tendency for pollen grains to be moved around within soil profiles. This especially happens in podsoles where grains may be leached downwards through the horizons.

#### 4) How representative is pollen of environmental change?

In the interpretation of pollen diagrams, it is assumed that the vegetation reflects the environmental conditions at the time of deposition. It is known that each plant has optimum needs for many different ecological variables. Therefore, the factor that is in the shortest supply will affect the distribution of the plant.

This is Liebig's Law of Limiting Factors. In the cool and moist climate of North-West Europe, the moisture content of the atmosphere is sufficient to allow free plant growth, but the temperature is too low for optimum development of some species of plants, and so vegetation will reflect temperature changes in this environment. It must be remembered that plants respond very slowly to temperature change. Iversen (1944) regarded Viscum, Hedera and Ilex as climatic indicators as they were particularly susceptible to frost, but Troels-Smith (1960) has shown that Viscum and Hedera were important fodder crops in Prehistoric cultures and therefore, decreases in these taxa do not necessarily mean that there was a decrease in temperature.

When interpreting pollen diagrams all these factors must be considered. Overall, one must be wary when drawing conclusions from pollen diagrams. The information gathered must be combined with other investigations, such as diatom analyses and microfossil studies.

## 2:6 DIATOM ANALYSES

### 2:6:1 Introduction

The term 'Diatomaceen' was first used in 1786 by O.F.Müller. Studies of diatoms were more common in Scandinavia in the Early Nineteenth Century than in Britain. Diatoms were first mentioned, in Sweden, by C.A.Agardh (1824), and the first major work there was by P.T.Cleve (1868), in which 189 species were described. The subject was first noticed in Britain when W.M.Smith published his 'Synopsis of British Diatomaceae' in 1853-1856. These two volumes described 466 species. A major contribution to

the study of diatoms was made by A.Cleve-Euler who compiled 'Diatomeen von Schweden und Finnland', (1951-1955). This work comprised five volumes of data on taxonomy, ecology and geographical distribution, with 1600 figures. Van der Werff & Huls (1958-1974), in Holland, and Hustedt (1927-1962), in Germany, also produced works of great importance to the study of diatoms.

Diatoms are unicellular plants which can photosynthesize. A rigid skeleton of hydrated silica, the frustule, surrounds the cell. This frustule is made up of two halves, or valves. The classification of diatoms is based on the shape and differences in the structure of the frustule, which can be highly variable. Apart from the taxonomic classification, diatoms can be classified according to their biological distribution and salinity requirements. Three main biological groupings are found; benthonic forms (b) live in the bottom muds of the oceans, rivers and lakes, epiphytic forms (e) live attached to a substrate such as other algae, plants or mineral particles and planktonic forms (p) live in the photic zones of water masses, where they move with streams and currents, usually in colonies. There are other sub-divisions of the biological distribution of diatoms. Forms that can live on the bottom and in the plankton (bp) which are counted as planktonic forms, diatoms which live as epiphytes and are in the plankton (e(p)) and forms which can live as epiphytes or on the bottom ((b)e). The latter two are counted as epiphytes and are more common than the (bp) forms. The salinity classification of seven groups, by Van der Werff & Huls (1958-1974), was used in this work and is outlined in Table 6 .

Table 6 Salinity Classification of Diatoms  
(after Van der Werff & Huls, 1958-1974)

Grouping		Chloride ion concentration	
M	Marine	>17,000	mg Cl <sup>-</sup> / l
MB	Marine/Brackish	10,000 - 17,000	"
BM	Brackish/Marine	5,000 - 10,000	"
B	Brackish	1,000 - 5,000	"
BF	Brackish/Fresh	500 - 1,000	"
FB	Fresh/Brackish	100 - 500	"
F	Fresh	<100	"

#### 2:6:2 Extraction of Diatoms

The samples for diatom analyses were treated with 30% hydrogen-peroxide, to remove any organic material (see Appendix II). Two drops of sample were placed on a coverslip (22 by 40 mm) and left to evaporate on a warm plate. A small amount of Microps 163 mountant was placed on a slide and heated until most of the solvent, xylene, had evaporated. The coverslip was then mounted on the slide, any excess mountant being removed.

#### 2:6:3 Diatom Counts

The diatom slide was counted using a Zeiss binocular microscope at x400 for routine counting and at x1000, using an oil immersion lens, where identification was difficult. The slide was traversed using a mechanical micrometer stage, with traverses 1.5 fields of view apart, at x400. A count of 200 diatom valves was thought to be sufficient, but this was not always possible where levels were poor in diatom remains. As frustules are rarely found complete, each single valve was counted as one unit and therefore only represents half the number of

frustules present. Only relative counts were made as absolute counts were deemed unnecessary in this work, because only an indication of the water-type prevalent during deposition at the site was needed. Identification of the species was aided by the use of Cleve-Euler (1951-1955), Hendey (1964), Miller (1964) and Van der Werff & Huls (1958-1974). The nomenclature follows that of Cleve-Euler (1951-1955).

#### 2:6:4 Diatom Sums

There are a number of ways of expressing diatom data. The frequency of species was expressed as a percentage of the total valves counted for the main diatom diagram. The summary diagrams were constructed using ratio calculations. The ratio of Marine: Brackish : Fresh types were calculated for valves, benthonic valves, species and benthonic species. More detailed calculations were carried out for the valves and species using the seven salinity groups M, MB, BM, B, BF, FB and F. Two further calculations were performed to express the valves and species as ratios of b : e : p forms. The diagrams were zoned with reference to floristic changes in diatom assemblages.

#### 2:6:5 Interpretation of Diatom Diagrams

When interpreting diatom diagrams it must be remembered that the changes in the composition of the diatom flora are more important than the changes in individual species. The changes of diatom flora are closely connected with changes in the sedimentation of the deposit and thus, indirectly reflect changes in water and climatic conditions at the time of deposition. Each habitat type will reflect a different diatom assemblage, but because of the

environment ie. water, the diatoms recovered from sampled levels may be confused by inwash of other assemblages from different environments. The diatoms of estuaries may well fluctuate in composition, due to the influence of tides and weather conditions together with changes in river discharge. one must also remember that like pollen, diatom valves can be reworked from older sediments. Thus great care must be taken when interpreting diatom diagrams.

## 2:7 PARTICLE-SIZE ANALYSES

The particle-size analyses were carried out using the dry-sieving and sedimentation processes of the British Standards Institute Handbook, BS 1377:1967. Samples of approximately 30 g were taken from the inorganic strata of the cores and were first air-dried and then weighed. Analysis, using the test described in Appendix III was then performed. The results of the test expressed the original samples in proportions of gravel, coarse sand, medium sand, fine sand, coarse silt, medium silt, fine silt and clay. The gravel and sands were determined by the dry-sieving, the medium and fine silt together with the clay were determined by the sedimentation and the coarse silt fraction by calculation. In this way, the coarse silt can easily be over-represented as any loss of material, during testing, will be incorporated into the coarse silt fraction by calculation. Particle-size analyses were done at Browdown, Yarmouth and The Moors.

C H A P T E R 3

BIOSTRATIGRAPHIC AND LITHOSTRATIGRAPHIC ANALYSES OF SITES

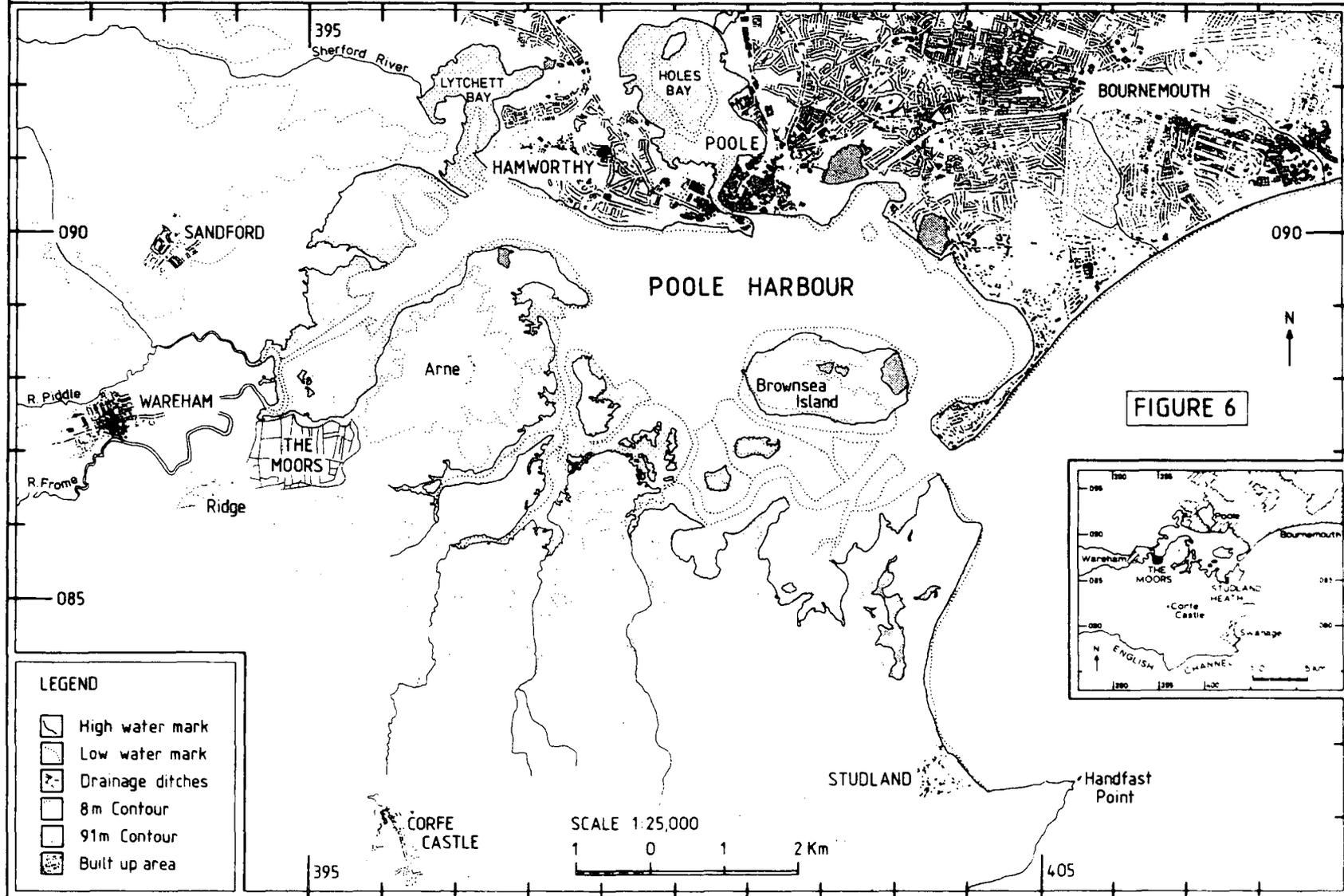
3:1 THE MOORS

3:1:1 Stratigraphy

The Moors is situated on the Arne Peninsula, to the east of Wareham, in Dorset (Figure 6). It is bounded to the north by a two metre high sea-wall, which protects the site from flooding at the mouth of the River Frome. To the east the land rises to + 25 m.O.D. at Arne Village. The site is drained by an extensive system of dykes and ditches which probably date from Roman times. A large east-west dyke traverses the site. To the south of this dyke, the land is wet and marshy but to the north it is well drained and grazed by cattle.

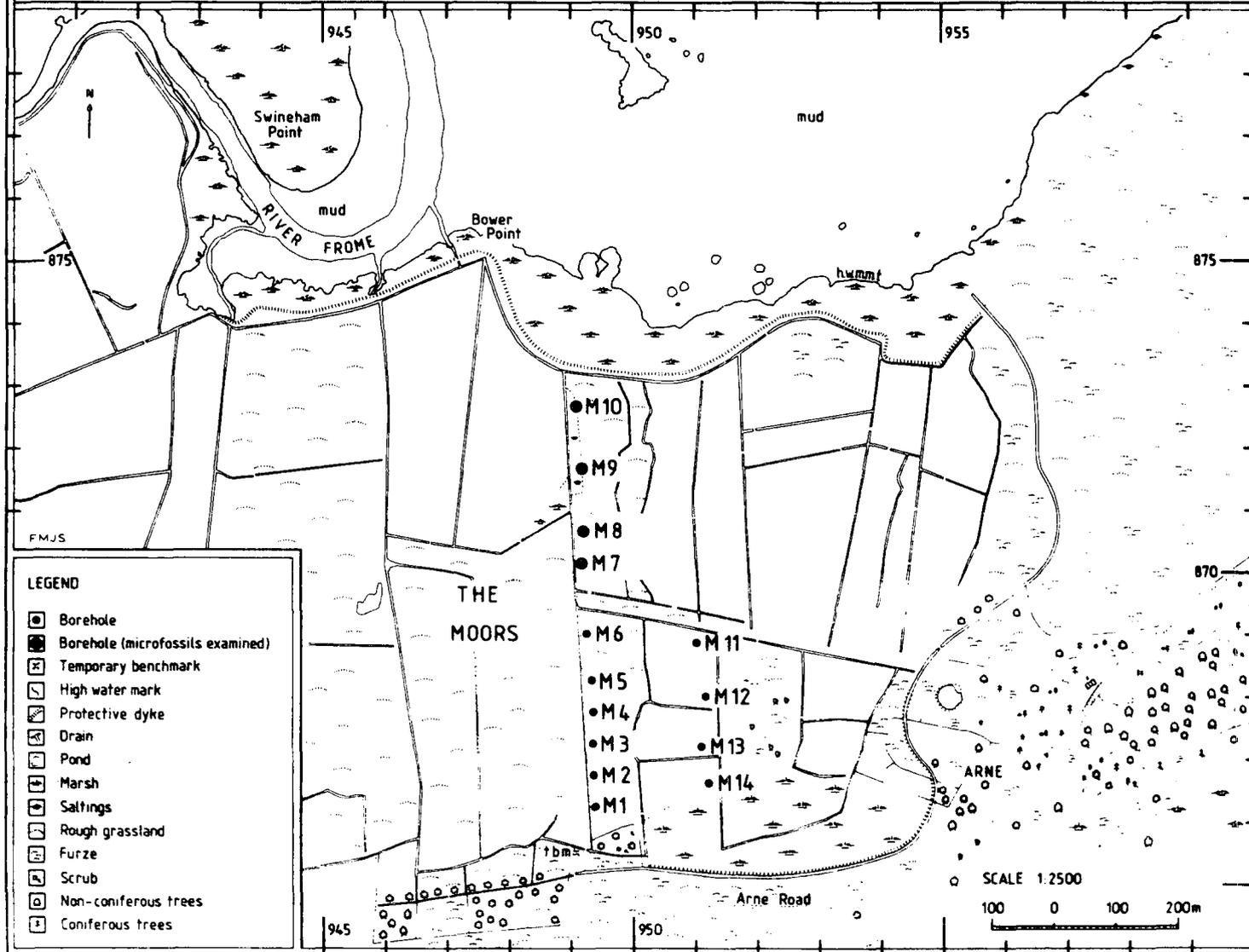
Fourteen boreholes were investigated at The Moors (Figure 7) in two transects. The first transect comprises of M 1 (SY 9493 8663) to M 10 (SY 9491 8727). These boreholes were taken at 50 m intervals up to M 6. M 7 to M 10 were taken at 100 m intervals. The second transect was taken parallel to the first and consists of four boreholes M 11 (SY 9510 8689) to M 14 (SY 9512 8666). These last four boreholes could not be taken at regular intervals due to the intervening ditches. The ground level at these fourteen boreholes was calculated after redistributing the levelling closing error of 22 cm. It varies from + 0.37 m.O.D. to + 0.11 m.O.D. All boreholes except M 7 to M 10, were taken using the Russian-type sampler as described in Section 2:3:2 and the stratigraphy was recorded in the field. The remaining boreholes were sampled with the Percussion corer

# SITE LOCATION OF THE MOORS



# THE MOORS SITE (BOREHOLES)

FIGURE 7



(Section 2:3:3) and the samples obtained were taken back to Durham for analyses.

In general, the stratigraphy of The Moors can be divided into three predominant strata (Figure 8). A lower inorganic stratum, present in nearly all boreholes, underlies an organic stratum which in turn underlies an upper inorganic stratum. This pattern can be seen in all boreholes.

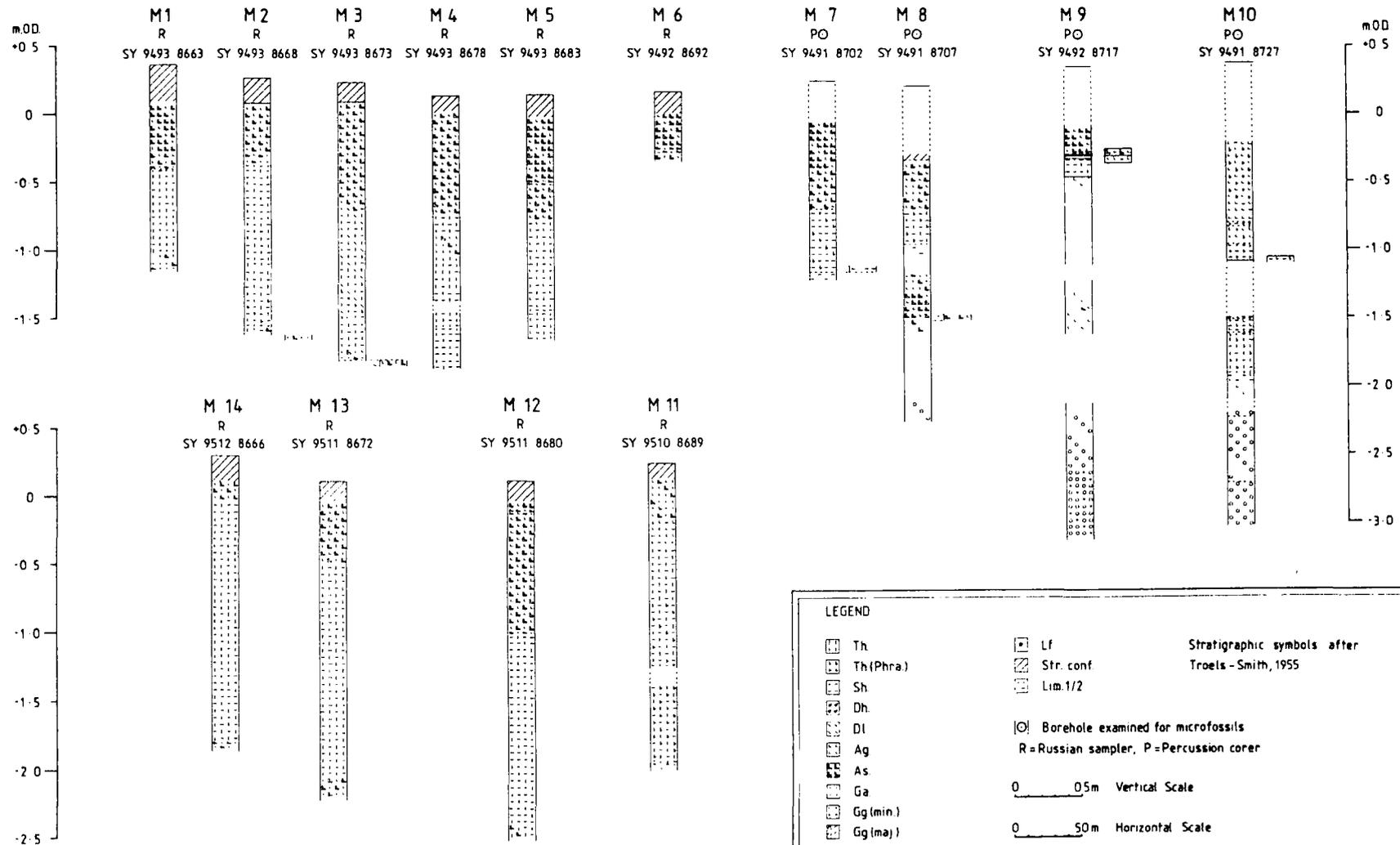
The lower inorganic, or clastic, stratum reflects the presence of the local bedrock, Bagshot Beds. It ranges in composition from coarse gravels and sands at M 10, through sands at M 9 and M 8, to finer sediments of clays and silts towards the landward side of the site. It is difficult to assess the depth of these deposits as it is not sampled completely in all boreholes, but at M 9, 2.67 m was recovered. It does not appear in the stratigraphy of M 4 and M 5 as it was reached but not sampled.

The organic stratum which overlies the basal inorganics was found in all boreholes. The composition of these beds does vary but in general can be said to be an herbaceous peat changing to Phragmites peat towards the sea. The altitude of the peat deposit varies enormously from - 2.29 m.O.D. at M 12 to - 0.46 m. O.D. at M 9. The depth of this ranges from 13 cm at M 9 to 176 cm at M 14. This depth increases eastwards and southwards.

The upper inorganic deposits appear in all boreholes except M 10. The altitude varies from - 1.02 m.O.D. at M 12 to - 0.04 m.O.D. at M 14. These deposits consist, in the main, of two grain-size fractions; a lower silt and clay underlies an upper silty-clay. The lower coarser stratum extends from M 1 to M 9 and from M 11

# THE MOORS - STRATIGRAPHY

FIGURE 8



F.M.J.S.

to M 14, attaining a maximum depth of 73 cm in M 3 and 98 cm in M 12, it thins to 1 cm in M 9. The finer silty-clay does not appear in all boreholes. It can be seen in M 1 and M 4 to M 9 and M 12. Its maximum depth is 48 cm in M 5. Again this thins out towards the sea.

Although the general three-layered stratigraphy of lower and upper inorganics with an intercalated peat holds true for the two transects, there are exceptions at M 4 and M 10, where two peat bands are found. At M 4 a lower organic stratum of 77 cm passes upward, through a transitional layer, to a clayey-silt, which is 17 cm deep. An upper organic stratum of 13 cm is found above this clayey-silt. The altitude of the lower and upper peats is - 1.88 m.O.D. and - 0.88 m.O.D. These strata are thought to be true lithological strata and not the result of contamination, as depths found suggest true strata and contamination was kept to a minimum by use of the Russian-type sampler. Although no adjacent boreholes show any indications of a second organic stratum, it is interesting to note that the organic band in M 5 is mainly a transitional silty-peat, with only 14 cm of true herbaceous peat found at the base. The stratigraphic configuration of M 10 will be described in the next section.

Boreholes M 7, M 8, M 9 and M 10 were sampled with the Percussion corer and taken back to Durham for analyses. These were chosen as the organic strata were above sands and so the risk of compaction of sediments was minimum, also the ground surface was less wet and so sampling was easier. The stratigraphic succession of these boreholes is given below.

The Stratigraphy of Moors 7.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
7)	+0.24 to -0.05	0 to 29	Not sampled
6)	-0.05 to -0.40	29 to 64	Ag 1, As 3, Dh +, Lf +. Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0. Light-grey silty-clay.
5)	-0.40 to -0.54	64 to 78	Ag 2-, As 2+, Dh +, Lf +. Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0. Grey silty-clay with iron staining.
4)	-0.54 to -0.69	78 to 93	Ag 1, As 2, Sh 1, Dh +, Gg(min) +. Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 0. Dark-grey silty-clay with herbaceous remains.
3)	-0.69 to -1.15	93 to 139	Th <sup>3</sup> (Phrag) 1, Sh 3, Dh +. Nig 3, Strf 0, Elas 1, Sicc 3, L(s) 1+. Dark-brown peat.
2)	-1.15 to -1.16	139 to 140	Sh 3, Ga 1, Ag +, Dh +, Th <sup>3</sup> (Phrag) +. Nig 3+, Strf 0, Elas +, Sicc 3, L(s) 0. Dark peat with sand.
1)	-1.16 to -1.22	140 to 146	Sh 2, Ga 2, Dh +, Ag +. Nig 3, Strf 0, Elas +, Sicc 3, L(s) 1-. Dark sandy-peat.

Strata 1, 2 and 3 were sampled for pollen and strata 1, 2, 4, 5 and 6 for diatoms. Particle-size analysis samples were taken from strata 4, 5 and 6.

The Stratigraphy of Moors 8.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
16)	+0.20 to -0.30	0 to 50	Not sampled
15)	-0.30 to -0.34	50 to 54	Topsoil/Ditchfill
14)	-0.34 to -0.49	54 to 69	Ag 2, As 2, Th +, Lf +. Nig 2, Strf 2, Elas 0, Sicc 3, L(s) 1. Grey(mottled red) silty-clay with roots.
13)	-0.49 to -0.61	69 to 81	Ag 3, As 1, Th +. Nig 2+, Strf 2, Elas 0, Sicc 3, L(s) +. Grey clayey-silt with root remains.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
12)	-0.61 to -0.71	81 to 91	Ag 2, Sh 2, Th +. Nig 3-, Strf 1, Elas 1, Sicc 2+, L(s) 0. Transitional silty-peat.
11)	-0.71 to -0.96	91 to 116	Th <sup>2</sup> (Phrag) 1, Th 1, Sh 2, Ag +. Nig 3, Strf 0, Elas 1, Sicc 2, L(s) 0. Black herbaceous peat.
10)	-0.96 to -1.04	116 to 124	Ga 3, Sh 1, As +, Th <sup>2</sup> (Phrag) +. Nig 3-, Strf 0, Elas 0, Sicc 3-, L(s) 1+. Dark-grey transitional layer with sand.
9)	-1.04 to -1.18	124 to 138	Ga 4, Th <sup>2</sup> (Phrag) +, As +, Gg(min) +. Nig 2+, Strf 0, Elas 0, Sicc 3-, L(s) 0. Grey-brown sand with <u>Phragmites</u> .
8)	-1.18 to -1.31	138 to 151	Ag 3-, As 1, Ga +, Th <sup>2</sup> (Phrag) +. Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 0. Clayey-silt with <u>Phragmites</u> .
7)	-1.31 to -1.35	151 to 155	As 3, Ag 1, Ga +, Dh +. Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 0. Transitional layer.
6)	-1.35 to -1.51	155 to 171	As 3-, Ag 1+, Ga +, Th <sup>2</sup> (Phrag) +, Sh +. Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0. Grey silty-clay with organic remains.
5)	-1.51 to -1.52	171 to 172	Ga 1, As 2, Ag 1. Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 1. Transitional layer.
4)	-1.52 to -1.60	172 to 180	Ga 3+, As 1-, Th <sup>2</sup> (Phrag) +. Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0. Sandy layer with <u>Phragmites</u> .
3)	-1.60 to -1.90	180 to 210	Ga 4. Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0. Light grey sand.
2)	-1.90 to -2.10	210 to 230	Ga 4, Gg(maj) +. Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0. Sand with pebbles.
1)	-2.10 to -2.26	230 to 246	Ga 3, Gg(maj) 1. Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0. Sand with pebbles.

Strata 1, 3, 6, 8, 9, 10, 12, 13 and 14 were sampled for diatoms  
and strata 7, 8, 9, 13 and 14 for particle-size analysis.

The Stratigraphy of Moors 9.

<u>Stratum</u>	<u>Height</u>	<u>Depth</u>	<u>Description</u>
	m.O.D.	cm	
21)	+0.34	0	Not sampled
	to	to	
	-0.08	42	
20)	-0.08	42	As 3, Ag 1, Dh +, Lf +.
	to	to	Nig 2, Strf 0, Elas 0, Sicc 3, L(s) ?.
	-0.30	64	Grey clay with iron stains & organic parts.
19)	-0.30	64	Ag 2, As 2, Dh +.
	to	to	Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 2.
	-0.31	65	Grey silty-clay with some organic parts.
18)	-0.31	65	Ag 3+, Sh 1, Dh +.
	to	to	Nig 3-, Strf 0, Elas 0, Sicc 3-, L(s) 2.
	-0.33	67	Dark brown-grey transitional layer.
17)	-0.33	67	Sh 3, Th <sup>1</sup> 1, Ga +, Ag +.
	to	to	Nig 3+, Strf +, Elas 1, Sicc 2, L(s) 2.
	-0.46	80	Dark brown-black peat with sand.
16)	-0.46	80	Ga 3, Ag 1-, Dh +.
	to	to	Nig 3-, Strf 0, Elas 0, Sicc 3, L(s) 2.
	-0.55	89	Transitional layer.
15)	-0.55	89	Ga 4, Th <sup>2</sup> (Phrag) +.
	to	to	Nig 1, Strf 0, Elas 0, Sicc 3, L(s) 0.
	-0.66	100	Light-grey sand with organic remains.
14)	-0.66	100	Not sampled.
	to	to	
	-0.71	105	
13)	-0.71	105	Ga 4, Th <sup>2</sup> (Phrag) +, Gg(min) +.
	to	to	Nig 1, Strf 0, Elas 0, Sicc 3, L(s) 0.
	-0.91	125	Light-grey sandy layer.
12)	-0.91	125	Ga 4, Th <sup>2</sup> (Phrag) +, Gg(min) +.
	to	to	Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0.
	-1.12	146	Darker sandy layer with <u>Phragmites</u> .
11)	-1.12	146	Not sampled.
	to	to	
	-1.22	156	
10)	-1.22	156	Ga 4, Th <sup>2</sup> (Phrag) +, Gg(min) +.
	to	to	Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0.
	-1.32	166	Darker sandy layer.
9)	-1.32	166	Ga 3, Ag 1, Gg(min) +, Lf +.
	to	to	Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0.
	-1.50	184	Dark silty-sand with black stains.
8)	-1.50	184	Ga 2+, Ag 2-, Th <sup>2</sup> (Phrag) +, Lf +, Gg(min) +.
	to	to	Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0.
	-1.62	196	Light silty-sand with <u>Phragmites</u> .

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
7)	-1.62 to -2.12	196 to 246	Not sampled.
6)	-2.12 to -2.15	246 to 249	Ga 4, Lf +, Th <sup>2</sup> (Phrag) +. Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 0. Light-brown sand.
5)	-2.15 to -2.22	249 to 256	Ga 4, Ag +, Gg(maj) +. Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 0. Grey sand.
4)	-2.22 to -2.39	256 to 273	Ga 3, Gg(maj) 1, Gg(min) +, Ag +. Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 0. Grey sand.
3)	-2.39 to -2.47	273 to 281	Ga 3, Gg(maj) 1, Gg(min) +, Ag +. Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0. Dark sand.
2)	-2.47 to -2.62	281 to 296	Gg(maj) 2, Ga 2, Ag +. Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0. Orange-yellow sand.
1)	-2.62 to -3.12	296 to 346	Gg(maj) 3, Gg(min) 1, Ga +. Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0. Large-pebbled sand.

Strata 4, 8, 9, 10, 13, 15, 16, 17 and 20 were sampled for diatoms and strata 13, 15, 19 and 20 were sampled for particle-size analysis.

#### The Stratigraphy of Moors 10.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
20)	+0.37 to -0.19	0 to 56	Not sampled.
19)	-0.19 to -0.24	56 to 61	Ag 3, Sh 1, Th <sup>2</sup> (Phrag) +, As +. Nig 2+, Strf 1, Elas +, Sicc 2, L(s) 0. Dark-grey silty layer with organic remains.
18)	-0.24 to -0.62	61 to 99	Ag 2, Th <sup>2</sup> (Phrag) 2, As +, Sh +. Nig 3-, Strf 3-, Elas 1, Sicc 2, L(s) 0. Dark-grey silty-peat with <u>Phragmites</u> .
17)	-0.62 to -0.74	99 to 111	Ag 3, Sh 1, Th <sup>2</sup> (Phrag) +, Lf +, As +. Nig 2+, Strf 0, Elas 0, Sicc 2, L(s) 0. Dark-grey silty layer with organic remains.
16)	-0.74 to -0.80	111 to 117	Ag 4, Sh +, Th <sup>2</sup> (Phrag) +. Nig 2+, Strf 0, Elas 0, Sicc 2, L(s) 0. Dark-grey silt with organic remains.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
15)	-0.80 to -0.82	117 to 119	Th <sup>2</sup> ( <u>Phrag</u> ) 3, Sh 1, Ag +. Nig 3, Strf 1, Elas 1+, Sicc 2, L(s) 1. <u>Phragmites</u> peat ball.
14)	-0.82 to -0.95	119 to 132	Ag 3, Th <sup>2</sup> ( <u>Phrag</u> ) 1, Sh +. Nig 2+, Strf 2, Elas +, Sicc 2, L(s) 1. Grey silt with <u>Phragmites</u> .
13)	-0.95 to -1.07	132 to 144	Th <sup>2</sup> ( <u>Phrag</u> ) 2, Sh 2. Nig 3+, Strf 1, Elas 2, Sicc 2-, L(s) 1+. Dark grey-black peat with silt ball.
12)	-1.07 to -1.09	144 to 146	Th <sup>2</sup> ( <u>Phrag</u> ) 2, Sh 2, Ag +. Nig 2, Strf 1, Elas 1, Sicc 2-, L(s) 2-. Dark-grey <u>Phragmites</u> peat with silt.
11)	-1.09 to -1.48	146 to 185	Not sampled.
10)	-1.48 to -1.50	185 to 187	Sh 3, Ag 1, Th <sup>2</sup> ( <u>Phrag</u> ) +. Nig 3-, Strf 1. Elas 1, Sicc 2, L(s) ?. Dark-grey silty-monocot. peat.
9)	-1.50 to -1.60	187 to 197	Sh 2, Th <sup>2</sup> ( <u>Phrag</u> ) 1, Ag 1. Nig 3-, Strf 1+, Elas 1, Sicc 2, L(s) 1. Dark-grey monocot. peat with <u>Phragmites</u> .
8)	-1.60 to -1.91	197 to 228	Th <sup>2</sup> ( <u>Phrag</u> ) 1, Sh 1, Th <sup>2</sup> 2, Dl +. Nig 3, Strf 0, Elas 3, Sicc 2-, L(s) 1. Dark-brown-black herbaceous peat with wood.
7)	-1.91 to -1.99	228 to 236	Sh 2, Ag 1, Ga 1. Nig 3-, Strf +, Elas +, Sicc 2, L(s) 0. Transitional brown sandy-peat.
6)	-1.99 to -2.09	236 to 246	Ga 3, Ag 1, Th <sup>2</sup> ( <u>Phrag</u> ) +, Gg(min) +. Nig 2-, Strf 0, Elas 0, Sicc 2+, L(s) 0. Light sandy layer with <u>Phragmites</u> .
5)	-2.09 to -2.27	246 to 254	Not sampled.
4)	-2.27 to -2.31	254 to 258	Ga 2, Gg(maj) 2, Th <sup>2</sup> ( <u>Phrag</u> ) +, Ag +. Nig 2, Strf 0, Elas 0, Sicc 2+, L(s) ?. Light sandy layer with large pebbles.
3)	-2.31 to -2.59	258 to 286	Ga 2, Gg(maj) 2, Th <sup>2</sup> ( <u>Phrag</u> ) +. Nig 2, Strf 0, Elas 0, Sicc 2, L(s) 1-. Light sandy layer with large flints & quartz.
2)	-2.59 to -2.79	286 to 306	Ga 3, Gg(maj) 1. Nig 2, Strf 0, Elas 0, Sicc 2, L(s) 0. Light sand with large pebbles.
1)	-2.79 to -3.11	306 to 338	Ga 2, Gg(maj) 2, Th <sup>2</sup> ( <u>Phrag</u> ) +. Nig 2, Strf 0, Elas 0, Sicc 2, L(s) 1-. Light sand with flint and quartz.

Strata 7, 8, 9, 13, 14, 17, 18 and 19 were sampled for pollen and strata 14, 17, 18 and 19 for diatoms.

### 3:1:2 Particle-size Analyses

Particle-size analyses were carried out on Moors 7, Moors 8 and Moors 9, using the procedure outlined in Section 2:7. The samples tested were chosen in order to try and show real differences in the strata that had been identified using the Troels-Smith notation.

#### 1) Moors 7

At Moors 7, three strata were chosen from the upper inorganic deposit for testing. The results of the analysis, together with a summary of the Troels-Smith classification (shown in brackets), can be seen in Table 7

Table 7 Particle-size Analysis of Moors 7.

Sample N <sup>o</sup>	Altitude (m.O.D.)	% Clay	% Silt	% Sand
6	-0.11 to -0.16	55.3 (75)	43.6 (25)	1.1 (-)
5	-0.21 to -0.26	48.5 (75)	50.9 (25)	0.6 (-)
4	-0.36 to -0.41	46.9 (75)	52.8 (25)	0.3 (-)
3	-0.41 to -0.46	44.3 (50)	54.5 (50)	1.3 (-)
2	-0.46 to -0.51	45.5 (50)	53.2 (50)	1.3 (-)
1	-0.56 to -0.61	35.7 (50)	62.8 (25)	1.6 (-)

In general, the analysis shows that the strata become finer towards the top of the core, away from the underlying organic stratum. Samples 2 and 3 were taken from the same stratum, as were samples 4, 5 and 6. There is a very close correlation between the results of the particle-size analysis of samples 2 and 3, as would be expected. The resemblance between samples 4, 5 and 6 is not so strong. Samples 4 and 5 closely correlate but 6 is different, having a much finer and coarser character with more

FIGURE 9



Coord. 50° 40' 58" N  
 7° 05' 41" W  
 Grid ref. SY 9491 8702  
 Fieldwork 800622

sand and clay present. This could be due to the proximity of the top-soil to the sampled level. The results of the stratigraphic analysis, according to Troels-Smith's methodology, also shows an increase in finer sediments towards the top of the core. No other resemblance between the two sets of data can be discerned.

2) Moors 8

At Moors 8, five strata were tested for their particle-size components. The results of this analysis, together with the summarised version of the Troels-Smith description (shown in brackets) are to be found in Table 8

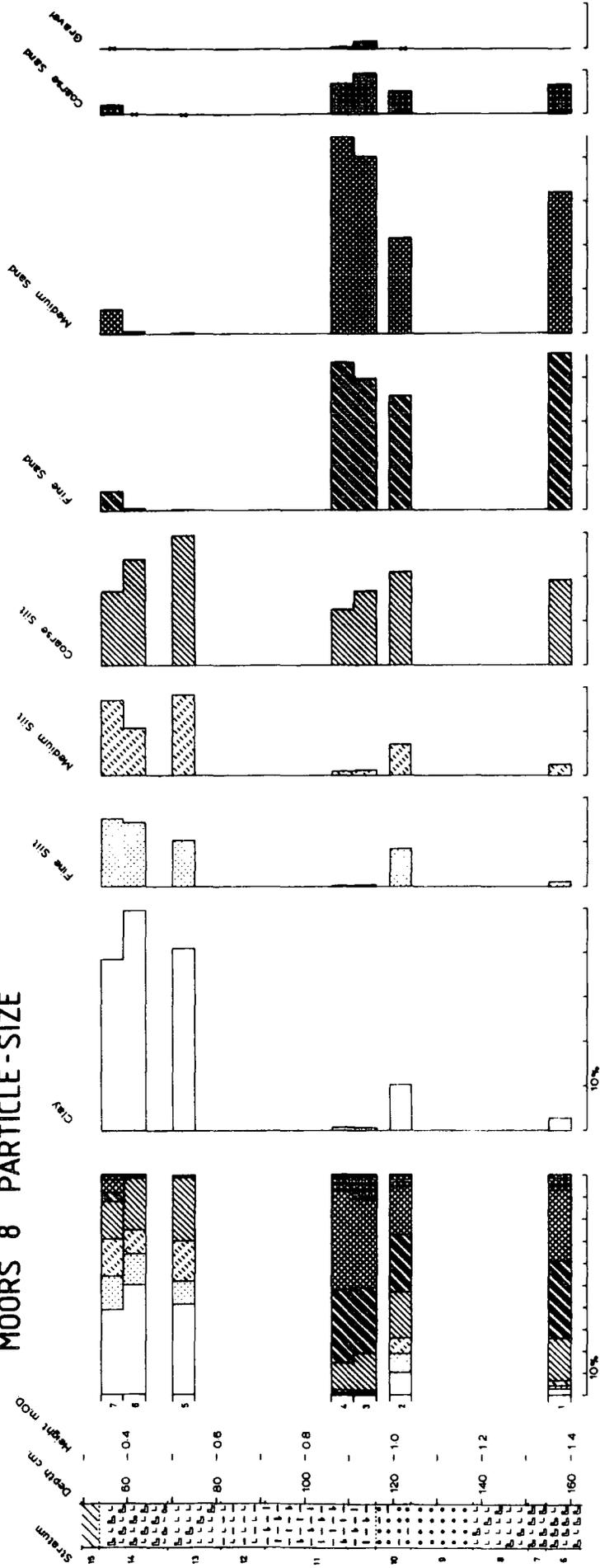
Table 8 Particle-size Analysis of Moors 8

Sample	Altitude(m.O.D.)	% Clay	% Silt	% Sand	% Gravel
7	-0.36 to -0.41	38.6(50)	49.5(50)	11.9(-)	0.1(-)
6	-0.41 to -0.46	49.7(50)	49.2(50)	1.1(-)	-
5	-0.51 to -0.56	41.2(25)	58.1(75)	0.7(-)	-
4	-1.06 to -1.11	0.6(+)	13.9(-)	85.2(100)	0.3(+)
3	-1.11 to -1.16	0.6(+)	18.4(-)	79.4(100)	1.5(+)
2	-1.21 to -1.26	10.3(25)	36.8(75)	52.8(+)	0.1(-)
1	-1.36 to -1.41	2.8(75)	22.9(25)	74.3(+)	-

Samples 1, 2, 3 and 4 are from the lower inorganic deposit which lies below the peat. The results clearly show that this inorganic deposit is predominantly sandy, becoming more so towards the transition with the peat above. Samples 5, 6 and 7 are from the upper inorganic deposit. Of these, samples 3 and 4 are from the same stratum as are samples 6 and 7. Again it can be inferred, from the results, that samples 3 and 4 are from the same stratum, but the resemblance between 6 and 7 is not so apparent, sample 7

FIGURE 10

MOORS 8 PARTICLE-SIZE



Coord 50° 40' 53" N  
P 05° 41' W  
Grid ref 51 3481 8701  
Fieldwork 800622

being much coarser than sample 6. This again could be due to the proximity of the top-soil to the sampled level. The correlation between the two sets of data is very poor. The greatest discrepancy seems to be in sample 1, where the particle-size analysis reveals a very high percentage of sand but the Troels-Smith description shows a stratum with a high proportion of clay and just a trace of sand.

3) Moors 9

At Moors 9, three strata were tested for their particle-sizes. The results are shown below with a short summary of the Troels-Smith description.

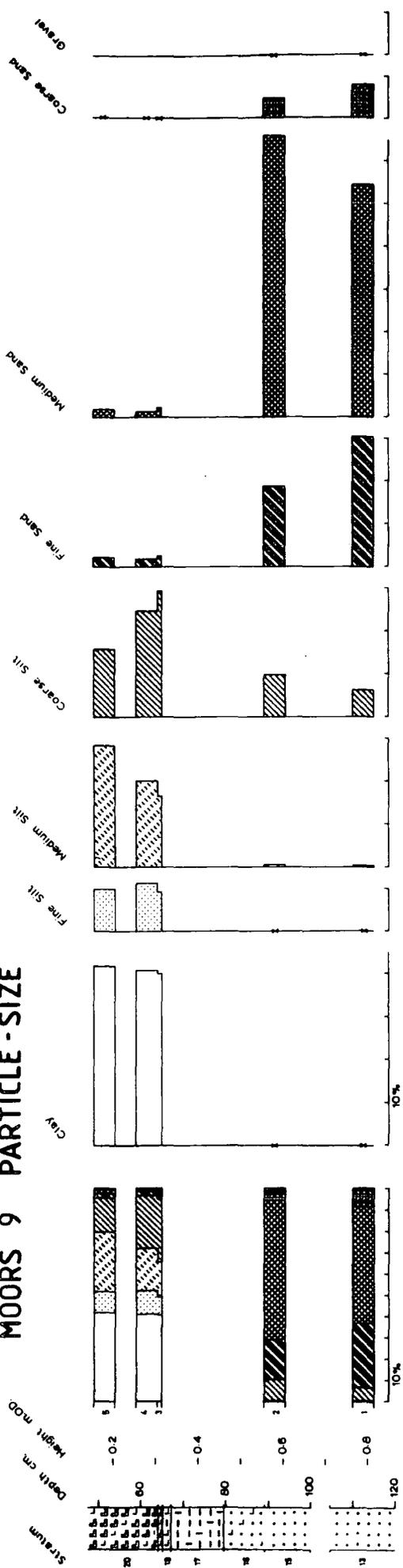
Table 9 Particle-size Analysis of Moors 9.

Sample	Altitude(m.O.D.)	% Clay	% Silt	% Sand	% Gravel
5	-0.15 to -0.20	41.7(75)	53.9(25)	4.4(-)	-
4	-0.25 to -0.30	40.9(75)	55.9(25)	3.2(-)	-
3	-0.30 to -0.31	40.2(50)	54.9(50)	4.9(-)	-
2	-0.55 to -0.60	0.1(-)	10.3(-)	89.4(100)	0.1(-)
1	-0.75 to -0.80	0.1(-)	6.7(-)	92.9(100)	0.2(+)

Samples 1 and 2 were taken from the same stratum, below the organic deposit and clearly shows a very coarse sandy deposit. Samples 4 and 5 were also taken from the same stratum and show a close correlation. No true separation can be seen between samples 4 and 5, and 3 but it must be noted that sample 3 was a very small band of 1 cm and thus accurate sampling was difficult. When one compares the two sets of data one can see that samples 1 and 2 are the only ones to show any correlation, and these are virually total sand. The apparent differences between samples 4 and 5, and 3 , which is picked out in the Troels-Smith description, is not seen

FIGURE 11

# MOORS 9 PARTICLE-SIZE



Coord 50° 41' 01" N  
 2° 05' 41" W  
 Quad ref. 21 81 8717  
 File ref. 800822

in the results of the particle-size analysis.

4) Discussion of the results of particle-size analyses of The Moors site.

With regard to Moors 7, the upper inorganic deposit was divided into two separate strata, using the Troels-Smith methodology; an upper fine stratum of silty-clay and a lower coarser stratum of silt-clay. When one looks at the results of the particle-size investigation, this division can be tentatively confirmed if one ignores the upper sample 6 as being contaminated by its proximity to the top-soil. The main evidence for this division of strata is the sand fraction, which is more in evidence in the lower stratum, and the increase in the clay fraction of the upper stratum. In Moors 9 however, this division between lower coarser and upper finer sediment is not in evidence, although one must remember that the sample from the lower 'coarser' deposit was poor in quality.

The particle-size analyses confirm a correlation between the lower inorganic samples 3 and 4 in Moors 8 and 1 and 2 in Moors 9. The correlations between samples 4, 5 and 6 in Moors 7 and samples 4 and 5 in Moors 9 and between samples 2 and 3 in Moors 7, 6 and 7 in Moors 8 and sample 3 in Moors 9 that were found in the Troels-Smith analyses are not obvious in the results of the particle-size tests. The particle-size analyses are more reliable than the field analyses and thus it must be assumed that these latter correlations are not necessarily true.

This investigation of particle-size by dry-sieving and sedimentation is very useful as it has shown the major discrepancies that can arise using the Troels-Smith description alone. It is

important to realise that stratigraphic analysis in the field or laboratory will only give a subjective view of the sediment and that a quantitative assessment of the sediment is also needed in order to assess real changes in the lithology of deposits. However, it must be remembered that no indication of organic proportions are given in particle-size analyses, as all organic material is destroyed during preparation of the samples.

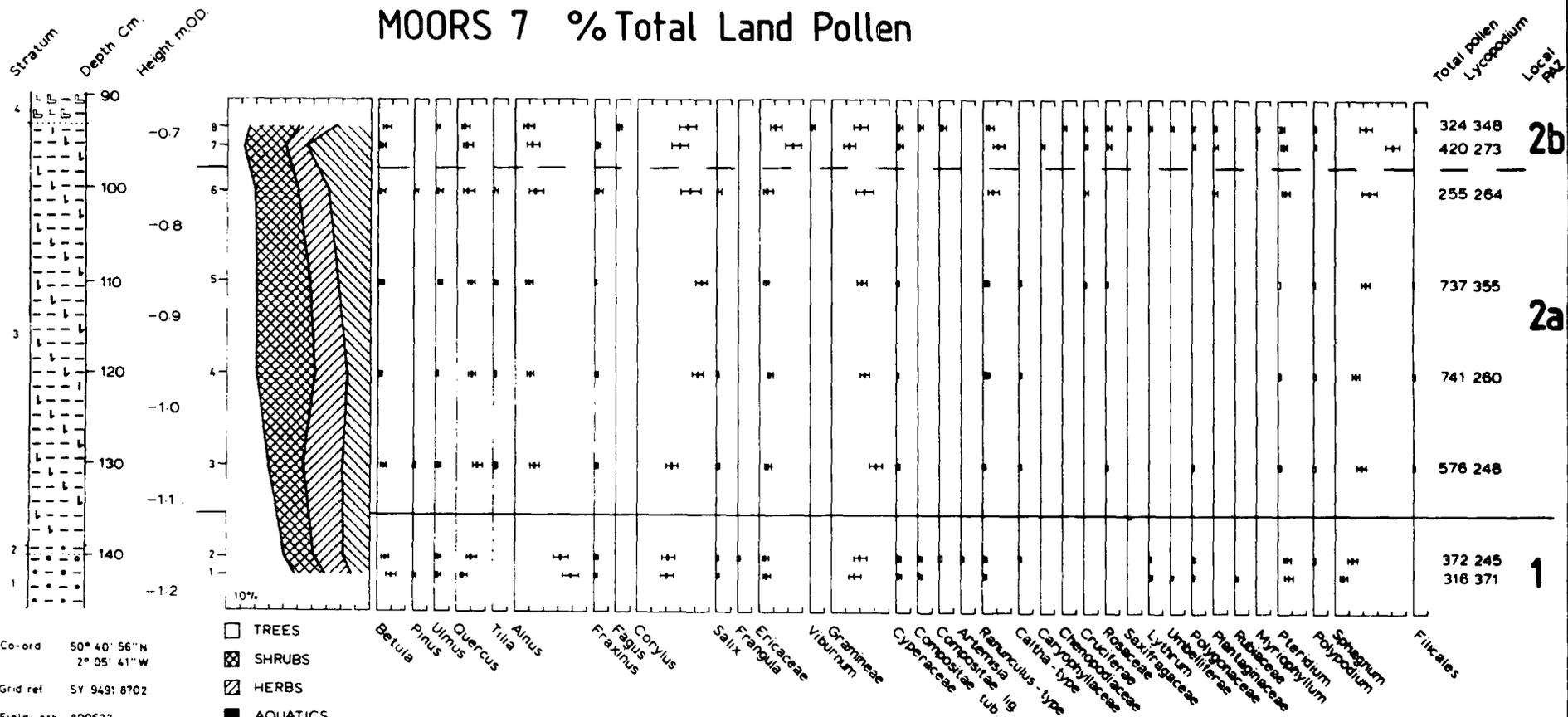
### 3:1:3 Pollen Analyses

Samples for pollen analyses were taken from cores Moors 7 and Moors 10. Samples from the peat strata were taken, including samples from the transitional strata bordering the organic deposits. The pollen was prepared and counted as described in Section 2:5 and all the results are tabulated in Appendix IV.

#### 1) Moors 7

At Moors 7, strata 1, 2 and 3 were sampled for pollen. Samples from the dark Phragmites peat were taken at 10 cm intervals, while the transitional zone from the lower sandy-peat to the peat of stratum 3, and also the top levels of the peat, were sampled at 2 cm intervals. In all, eight levels were taken; 1) -142, 2) -140, 3) -130, 4) -120, 5) -110, 6) -100, 7) -95 and 8) -93 cm. A pollen sum of 150 tree pollen was counted in levels 1 to 5, but in levels 6 to 8 a sum of 50 tree pollen was counted as the tree pollen became too scarce for a fuller count. For example in level 8 a total of 348 Lycopodium spores were counted to reach a sum of 50 tree pollen. The data from the pollen analyses has been displayed as a percentage of the total land pollen (TLP)

# MOORS 7 % Total Land Pollen



Co-ord 50° 40' 56" N  
 2° 05' 41" W  
 Grid ref SY 9491 8702  
 Field-work 800622

- TREES
- ▣ SHRUBS
- ▨ HERBS
- AQUATICS
- ◻ SPORES

Betula  
 Pinus  
 Ulmus  
 Quercus  
 Tilia  
 Alnus  
 Fraxinus  
 Corylus  
 Fagus  
 Salix  
 Ericaceae  
 Frangula  
 Viburnum  
 Gramineae  
 Cyperaceae  
 Compositae tub  
 Compositae lig  
 Ranuncul - type  
 Artemisia  
 Caltha type  
 Caryophyllaceae  
 Chenopodiaceae  
 Cruciferae  
 Rosaceae  
 Saxifragaceae  
 Lythrum  
 Umbelliferae  
 Polygonaceae  
 Plantaginaceae  
 Rubiaceae  
 Myricaceae  
 Pteridium  
 Myrica  
 Sphagnum  
 Polytrichum  
 Filicales

FIGURE 12

as a result of the paucity of tree pollen and can be seen in Figure 12. Data on dry-land pollen is based on calculations of  $\Sigma$ AP plus group and has been included for relative dating purposes. A record of the pollen counts, expressed as a percentage of TLP, are to be found in Appendix IV. Two local pollen assemblage zones (LPAZ) have been recognised in this core and are outlined below.

LPAZ M7:1 -142 cm to ca.-135 cm

The characteristics of this zone are a dominance of tree pollen with static frequencies of shrub and herb pollen. The dominant tree pollen in this zone is Alnus which reaches a maximum of 38.6% TLP at -142 cm. Other important taxa are Corylus with 27.6% TLP at -140 cm and Gramineae, which reach 19.5% TLP at the same level. The major dry-land tree pollen comes from Betula with 16.7% of trees at -142 cm and Quercus with 20.0% of trees at -140 cm. Frangula, Artemisia and Rubiaceae pollen are only found in this first LPAZ. Overall the concentration of pollen rises to the top of this zone in most taxa, but it is interesting to note that although Alnus concentrations rise, the percentage of Alnus pollen falls. The upper boundary of this zone has been placed where there is a marked fall in Alnus from 31.8% TLP to 13.3% TLP and where Gramineae increase from 19.5% TLP to 30.7% TLP.

LPAZ M7:2

This second LPAZ has been divided into two sub-zones, a) and b) on the basis of changes in the NAP (Non-Arboreal Pollen).

LPAZ M7:2a ca.-135 cm to ca.-97.5 cm

The sub-zone is characterised by decreasing tree pollen upwards through the levels and increasing shrubs and spores. The most important tree pollen comes from Quercus with 14% TLP at -130 cm and Alnus with 13.8% TLP at -100 cm. Other prominent taxa are Corylus with 44.2% TLP at -110 cm and Gramineae with 30.7% TLP at -130 cm. Sphagnum frequencies are consistently high reaching 23.9% TLP + Spores at -100 cm. The major dry-land taxa are Quercus with 40.7% of trees at -120 cm, Ulmus with 11.3% AP at -110 cm and Betula with 10.7% AP at -130 cm. Tilia and Plantaginaceae first appear here at -130 cm and -100 cm. The concentration of Corylus pollen reaches a marked peak at -120 cm with  $54 \times 10^2$  grains/cc., although the percentage curve shows no indication of a marked rise at this level. Gramineae also show a peak of  $29.8 \times 10^2$  grains/cc. at the same level. The upper boundary of this sub-zone is marked by Pinus and Tilia dying out and a sharp increase in Ericaceae and Sphagnum frequencies together with a decrease in Gramineae pollen.

LPAZ M7:2b ca.-97.5 cm to ca.-93 cm.

This sub-zone is characterised by a renewed increase in AP accompanied by a sharp increase in shrub and herb pollen and a decrease of spores. The most numerous tree taxa here are Alnus with 11.6% TLP at -95 cm and Quercus with 6.5% TLP at -95 cm. Corylus totals are high with an increase to 34.4% TLP at -93 cm. Ericaceae drop to 10.7% TLP at -93 cm from 22.8% TLP at -95 cm, and Gramineae increase to 19.7% TLP at -93 cm. There is also a marked decrease in Sphagnum to 21.4% TLP + Spores at -93 cm. The major dry-land tree pollen come from Quercus with 30.0% AP at -95 cm

and Betula with 26% AP at -93 cm. Fraxinus has 6% AP at -95 cm while Fagus has 6% AP at -93 cm. Fagus first appears in this sub-zone as does Viburnum, Caryophyllaceae, Chenopodiaceae, Saxifragiaceae and Myriophyllum. Tree pollen concentrations are relatively low throughout this sub-zone.

These zones can tentatively be correlated with the lithological sequence described for the core. LPAZ M7:1 represents the lower sandy-peat transitional strata 1 and 2, together with the lower levels of the true peat. Tree pollen is shown to be most numerous in the lower sandy-peat. LPAZ M7:2a represents the bulk of the Phragmites peat of stratum 3. Here we see that tree pollen declines upwards and shrub pollen becomes predominant. Spores also increase in the upper levels of this sub-zone. LPAZ M7:2b can be said to represent the upper peat levels before the stratigraphy changes to a clastic deposit. Here shrub pollen are most numerous but spores are dominant in the last level of -95 cm.

Moors 7 was chosen to represent this site due to the depth of peat, which was over 45 cm. Moors 10 had the greatest depth of peat but this borehole was not chosen due to its proximity to the large sea-wall and the danger of disturbed samples. As a result the LPAZ of Moors 7 have been tentatively dated using pollen evidence.

#### Dating of the LPAZ of Moors 7.

The peat at Moors 7 ranges in altitude from -0.69 m.O.D. (93 cm) to -1.15 m.O.D. (139 cm). Two LPAZ were recognised, which are summarised below with dominant AP and NAP.

Table 10 Dating of LPAZ at Moors 7.

Flandrian Chronozone	LPAZ	Altitude (m.O.D.)	Depth (cm)	Dominant Lifegroup	Dominant AP	Dominant NAP
III	M7:2b	-0.70 to -0.75	-93 to -97.5	Spores & Shrubs	Q-A-B-Fr-Fg	Sph-Co-Gr-Er
	M7:2a	-0.75 to -1.12	-97.5 to -135	Herbs & Shrubs	Q-A-U-B-Fr	Co-Sph-Gr
II	M7:1	-1.12 to -1.19	-135 to -142	Trees/ Shrubs	A-B-Q-U	Co-Gr-Sph-Pt

Q = Quercus, A = Alnus, B = Betula, Fr = Fraxinus, Fg = Fagus,  
 U = Ulmus, Sph = Sphagnum, Co = Corylus, Gr = Gramineae,  
 Er = Ericaceae and Pt = Pteridium.

These two LPAZ at Moors 7, have been divided into two chronozones on the basis of the dominant AP. LPAZ M7:1 is thought to belong to an age of Flandrian Chronozone II (Godwin's Zone VIIa) where Alnus is the dominant tree pollen producer. LPAZ M7:2a and LPAZ M7:2b are thought to belong to the early part of Flandrian Chronozone III (Godwin's Zone VIIb) where Quercus becomes the dominant tree pollen producer with an increase in Sphagnum, Ericaceae, Fraxinus and Fagus.

2) Moors 10

At Moors 10, strata 7, 8, 9, 13, 14, 17, 18 and 19 were sampled for pollen. A sampling interval of 10 cm was used throughout, except in stratum 13, the Phragmites peat where the sampling interval was much closer in order to incorporate the whole peat stratum. In all, fifteen levels were taken; 1) -230, 2) -220, 3) -210, 4) -200, 5) -190, 6) -143, 7) -135, 8) -130, 9) -120, 10) -110, 11) -100, 12) -90, 13) -80, 14) -70 and 15) -60 cm.



At least 200 Lycopodium spores were counted at each level and the record of these counts can be found in Appendix IV. The data have been displayed graphically in Figure 13. Again due to variable tree pollen counts, the data have been expressed as percentages of TLP. Five LPAZ have been recognised and are outlined below.

LPAZ M10:1 -230 cm to ca.-215 cm

This zone is characterised by a large peak of AP, 58% of total pollen, at -220 cm. Shrub and herb pollen decreases to -220 cm and then begins to increase above this level while spores increase to -220 cm and then decrease. The predominant AP comes from Alnus and Betula. Alnus increases to 34.9% TLP at -220 cm and Betula also increases to this level with 22.7% TLP. Quercus pollen does not contribute a high percentage in this zone and is decreasing. Other dominant taxa are Gramineae with 38.2% TLP at -230 cm and Corylus with 24.5% TLP at the same level. Ericaceae have relatively high counts with 7.8% TLP at -230 cm. Hedera is only found in this zone. The concentrations show very large increases in the AP to the top of this zone. Alnus pollen reaches a concentration of  $109 \times 10^2$  grains/cc at -220 cm and Betula reaches  $70.8 \times 10^2$  grains/cc. This is in part due to the large AP sum of 710 AP counted at this level. The upper boundary of this first zone was placed where large decreases in percentages of Betula and Alnus pollen are found together with an increase in Tilia pollen. Also at this boundary a large increase in Ericaceae pollen is noted.

LPAZ M10:2 ca.-215 cm to ca.-195 cm

This zone is distinguished by an evening out of AP percentages to roughly 13% of total pollen counted. Shrub pollen constitutes

the dominant taxonomic group at -210 cm but lose their dominance to herb pollen at -200 cm. Spores increase sharply to 31% of the total count at -200 cm. The dominant AP comes from Alnus with 8.2% TLP at -200 cm. The most important NAP is from Gramineae with 44.8% TLP at -200 cm. Corylus rises to 18.5% TLP at the same level and Ericaceae pollen, although decreasing, have 48.2% TLP at -210 cm. Sphagnum spores reach 29.6% TLP + Spores at -200 cm. Pinus and Fagus disappear from this zone as do Ilex and Hedera. Rhamnus pollen is first recorded here. In this zone the concentrations of pollen are very high at -210 cm, as shown by Ericaceae with  $265 \times 10^2$  grains/cc. Again we find that although Alnus and Corylus percentages show increases in this zone, their concentrations show decreases. The Tilia concentration decreases very strongly here. The upper boundary of the zone was placed where Pinus first appears and Tilia dies out, also a marked change occurs in Corylus and Gramineae pollen curves.

LPAZ M10:3 ca.-195 cm to ca.-190 cm

This zone includes only one level as the material above was not recovered from the borehole. In this zone AP shows a decline while shrub pollen increases greatly and spores decline. Alnus is the most important AP producer with 7.1% TLP. Corylus is the most important NAP taxum with 45.4% TLP and Gramineae pollen have 20.7% TLP. Pinus and Fagus return to the diagram as does Ilex while Rumex and Typha latifolia are first found. The upper boundary of this zone is an artificial one due to the lack of sampled material

LPAZ M10:4 ca.-143 cm to ca.-132.5 cm

The beginning of this zone is taken to be where the first level was sampled after the break in stratigraphy. AP was very scarce in this zone and shrub pollen dominates with over 50% of the total pollen. Herbs, aquatics and spores all begin to increase to the top of the zone. The most numerous tree pollen comes from Quercus with 5.6% TLP at -143 cm. Corylus pollen is dominant with 58.9% TLP at -143 cm. Gramineae are also high with 24.6% TLP at the same level. Ulex pollen is only found in this zone. AP concentrations are uniformly low. Corylus shows the highest concentrations with  $56 \times 10^2$  grains/cc at -143 cm. The upper boundary is marked by large changes in Corylus and Chenopodiaceae, and where Compositae pollen curves reappear with relatively high percentages.

LPAZ M10:5 ca.-132.5 cm to -60 cm.

This last zone shows a slight increase in AP with a marked decrease in shrub pollen and an increase in herb pollen. Overall, herb pollen dominates this zone. The predominant AP is from Alnus which rises, through the zone, to 7.9% TLP at -70 cm. Betula and Quercus pollen show small peaks at -110 cm with 8.5% TLP and 6.8% TLP. The most important NAP taxa are Gramineae with 47.9% TLP at -70 cm, Corylus with 30.2% TLP at -120 cm and Ericaceae with 15.4% TLP at the same level. The Compositae pollen reappears in this zone as does Tilia, Artemisia, Caltha and Polygonum. Galium and Nymphaea are only found in this last zone. Concentrations of pollen are generally low throughout this zone.

These five LPAZ can be correlated with the stratigraphic

column. LPAZ M10:1 can be considered representative of the lower transitional stratum 7 and the lower levels of the Phragmites peat of stratum 8. This zone shows a dominance of herb and shrub pollen in the transitional stratum, which changes to a dominance of tree pollen in the lower peat. LPAZ M10:2 represents the upper levels of this peat, showing a decline in the AP and increasing herb and shrub pollen, together with a sharp increase in spores just at the top of the zone. LPAZ M10:3 can be said to correlate with the silty-peat of stratum 9, where AP continues to decline and shrub and herb pollen is dominant. LPAZ M10:4 correlates with the Phragmites peat of strata 12 and 13, where shrub pollen are dominant and aquatic pollen begins to increase. The last zone LPAZ M10:5 covers the whole of the upper mixed silty-peat where herb pollen is dominant and aquatic pollen is present throughout.

#### Conclusions Based on the Pollen Analyses at The Moors Site.

The results of the pollen analyses at The Moors site show that the three strata found at the site; stratum 3 of Moors 7, stratum 8 of Moors 10 and strata 12 and 13 of Moors 10, are three separate peat units which suggests that there could of been three terrestrial periods, at The Moors, when peat growth took place. These results will be discussed in full in Chapter 4.

#### 3:1:4 Diatom Analyses

Diatom samples were taken from Moors 7, Moors 8, Moors 9 and Moors 10, in the upper and lower clastic deposits. The results of these analyses are outlined below and can be seen in tabulated form in Appendix V.

1) Moors 7

At Moors 7 the upper and lower clastic deposits were sampled for their diatom content. These deposits consisted of five strata; 1, 2, 4, 5 and 6 as previously described in Section 3:1:1. Eight levels were taken and of these, only the upper six, in strata 4, 5 and 6 yielded diatoms. These levels are 1) -93, 2) -90, 3) -83, 4) -65, 5) -50 and 6) -38 cm. A count of 200 diatom valves per level was made wherever possible. A full record of the results is given in Appendix V. The data are expressed as percentages of the total valves (TV) counted per level, or of the total number of species (TS) per level. Eight summary diagrams are given, as described in Section 2:6:4, together with a composite diagram of the frequency of each species identified, showing 95% confidence limits. These diagrams are shown in Figures 14a and 14b. In the following descriptions 'Freshwater' types of diatoms will be taken to include both Fresh and Fresh-Brackish types, 'Brackish' types will indicate Brackish-Fresh, Brackish and Brackish-Marine diatoms and 'Marine' types will include Marine-Brackish and Marine unless otherwise stated.

At Moors 7, 44 species of diatoms were identified, the ratio of F : B : M being 5 : 12 : 27. In total, 1194 valves were counted throughout the six levels and the ratio of F : B : M was 16 : 640 : 538.

Overall there are two dominant species of diatoms at this borehole; Nitzschia navicularis (B b) with 406 valves and Melosira sulcata (M p) with 277 valves counted. When one looks at the summary diagrams for valves and species (Figure 14a) it is obvious that few significant changes in diatom flora occur in this

# MOORS 7 DIATOMS

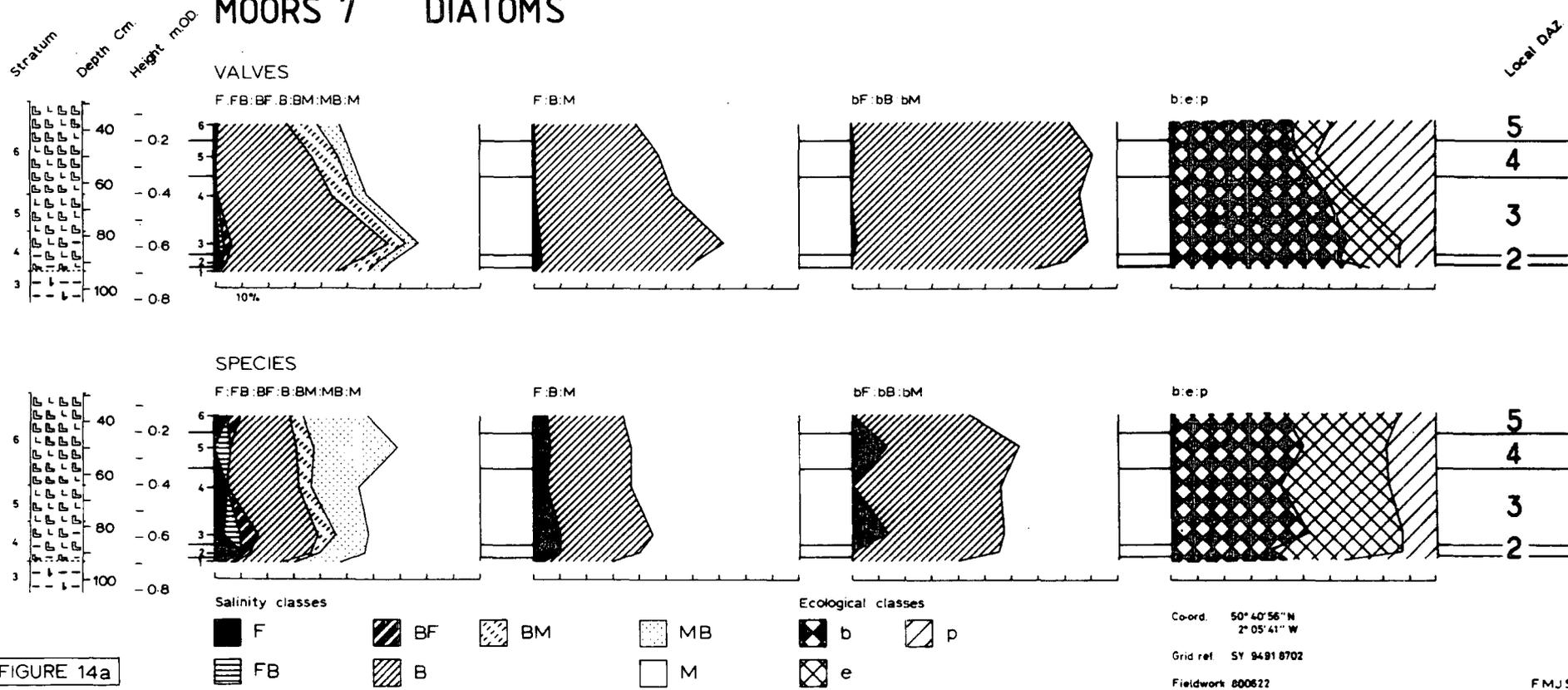


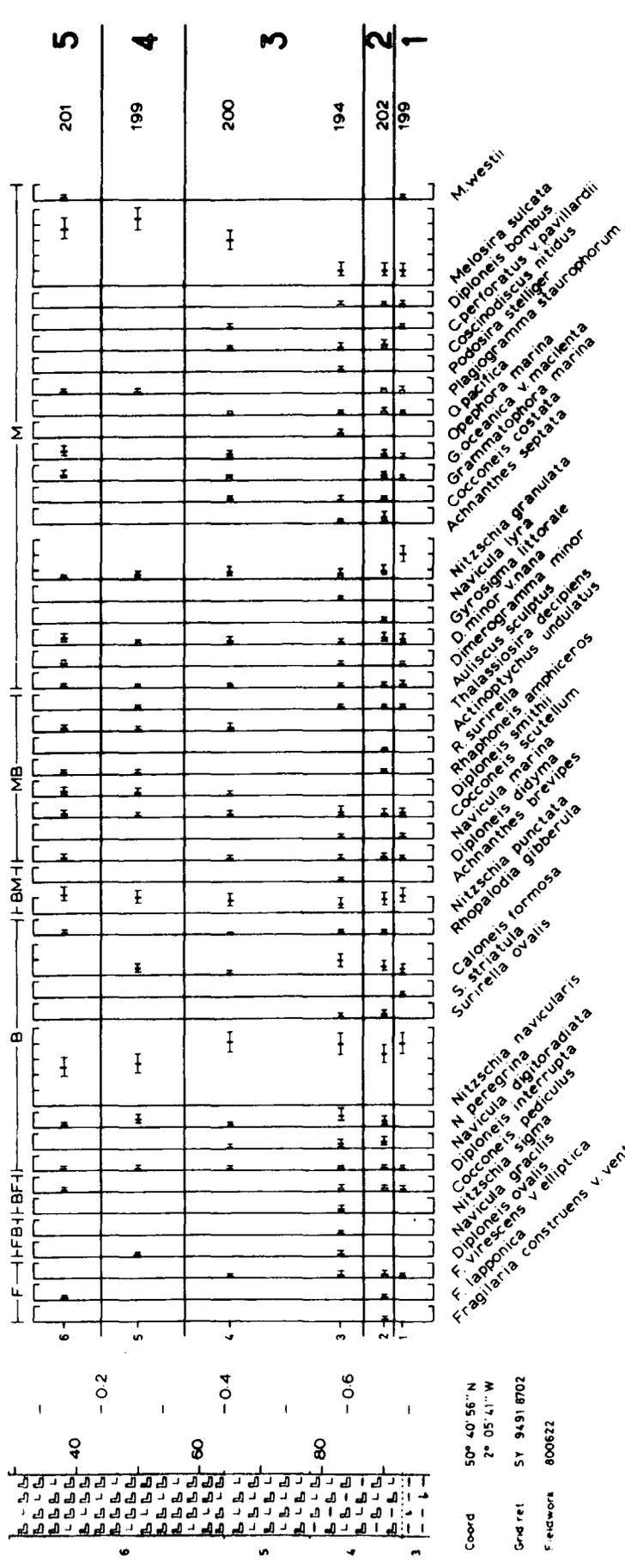
FIGURE 14a

FMJS

# MOORS 7 DIATOMS

Local DAZ  
Total Values

Depth cm  
Stratum



Coord: 50° 40' 56" N  
2° 05' 41" W  
Grid ref: SY 9491 8702  
Fieldwork: 800622

FIGURE 14b

borehole. More Fresh valves are found in the lower levels, together with more Brackish valves. Marine diatoms become more important in the upper levels of the core. The Fresh species also decrease upwards, but Marine species have taken over in dominance from Brackish species. It may be of interest to note differences recorded in the summary diagrams between valves and species. One might assume that an increase in a species of a specific salinity grouping would register in the valve diagram of that same salinity grouping, but this is not always the case. As previously stated, the same fluctuations are seen in Fresh valves and species, but there is a major difference in the Brackish and Marine valves and species. Far less Brackish species are recorded than Marine species but the number of valves of Brackish types is higher than those of the Marine diatoms and this indicates a Brackish dominance of the levels. It is the number of N.navicularis valves counted that gives this impression. The summary diagrams of lifestyle are also shown in Figure 14a. Again there is great variation between the diagrams for valves and species. In general there is a decrease in the number of benthonic valves found upwards through the core. As the benthonic valves decrease, the planktonic valves increase. This rise in planktonic valves is due to the marked increase of M.sulcata valves at -50 cm. The epiphytic valves show constant presence throughout the levels. When one looks at the species summary diagram again disparities are found. Benthonic species stay fairly constant, as do the epiphytic and planktonic species, but there are more benthonic species than epiphytic and planktonic species.

Five tentative local diatom assemblage zones (LDAZ) have been identified at Moors 7, where major changes in the diatom flora occur.

It must be added that although Fresh diatoms yielded a small proportion of the total counts, they are considered significant in this work.

LDAZ M7:1 -93 cm to ca.-91.5 cm

The dominant species of this zone are N.navicularis with 39.7% TV, Nitzschia granulata (M b) with 16.1% TV, Nitzschia punctata (BM b) with 11.1% TV and M.sulcata with 9.5% TV. The upper boundary is placed where N.granulata fall to 5% TV at -90 cm. This zone is distinguished by increasing Fresh diatoms, constant Brackish types and decreasing Marine diatoms. No Fresh-Brackish diatoms are found in this zone. In general, Brackish diatoms dominate this first zone. Benthonic valves and species decrease sharply with a corresponding rise in epiphytic diatoms. Planktonic valves remain constant, while there is a sharp decrease in planktonic species. It is interesting to note that none of the Fresh valves or species are benthonic in this zone.

LDAZ M7:2 ca.-91.5 cm to ca.-86.5 cm

The dominant species here are N.navicularis with 32.7% TV, M.sulcata with 9.4% TV and N.punctata with 8.4% TV. The upper boundary is marked by a sharp increase in Brackish diatoms together with a corresponding decrease in Marine diatoms. Fresh-Brackish diatoms first appear in this zone, although there is an overall decrease in Fresh diatoms. Benthonic diatoms begin to increase in these levels and epiphytic types also increase. Planktonic diatoms remain constant. Again this zone shows no Fresh diatoms to be benthonic.

LDAZ M7:3 ca.-86.5 cm to ca.-57.5 cm

The dominant species in this third zone are N.navicularis with 41% TV at -65 cm, M.sulcata with 29.5% TV at the same level and Caloneis formosa (B e) with 8.8% TV at -83 cm. N.punctata has 8% TV at -65 cm. The upper boundary is shown by a decrease in the number of N.navicularis and the dominance of Brackish diatoms being over-ridden by Marine diatoms. The increase in Marine diatoms is due to the rise of M.sulcata, which increase from a count of 19 valves at -83 cm to 59 valves at -65 cm. The Fresh diatoms remain constant and low. Benthonic diatoms begin to decline while planktonic diatoms increase. The first benthonic-Fresh diatoms appear here.

LDAZ M7:4 ca.-57.5 cm to ca.-44 cm

The dominant species here are M.sulcata with 43.7% TV, N.navicularis with 27.1% TV and N.punctata with 10.1% TV. The upper boundary is placed where the Brackish diatoms begin to decrease rapidly and Marine types increase. True Fresh (F) diatoms disappear altogether from this zone. The increase in Marine types is again due to the rise of M.sulcata valves, together with an increase of the number of Marine species present. The decrease in Brackish diatoms is largely due to the decrease of N.navicularis. Benthonic valves continue to decrease but the species increase. Planktonic valves reach a peak at -50 cm. Epiphytic diatoms begin to increase at the top of this zone.

LDAZ M7:5 ca.-44 cm to -38 cm

The dominant species in this last zone are M.sulcata with 36.8% TV, N.navicularis with 24.4% TV and N.punctata with 11.9% TV. This zone has increased Marine diatoms, mostly indicated by an

increase in Marine species present. The decrease in Brackish diatoms continues and Fresh valves decrease markedly, although the number of species is constant. Benthonic valves remain constant here but the species decline in numbers. Epiphytic valves and species continue to increase and planktonic diatoms begin to fall.

These five LDAZ correlate closely with the lithological divisions found in this core. LDAZ M7:1 and LDAZ M7:2 correspond to the transition between the underlying biogenic deposit and the upper clastic deposit. As would be expected, the Fresh diatoms are most abundant here. LDAZ M7:3 can be regarded as representative of the clay-silt deposit, stratum 5. The Fresh influence is removed in this zone and it is replaced by Brackish dominance. LDAZ M7:4 and LDAZ M7:5 represent the upper silty-clay stratum, which shows an increase in Marine influence with a decrease of Brackish diatoms. Thus the Fresh influence decreases away from the peat deposit and is gradually replaced by a strong Brackish and then Marine influence, upwards through the levels. It is interesting to note that the results of the diatom analysis confirm the division of the upper clastic deposit into a silt-clay and an upper silty-clay; the silt-clay is dominated by Brackish diatoms whereas the silty-clay is dominated by Marine types.

## 2) Moors 8

At Moors 8, the upper and lower clastic strata were sampled for their diatom content. These deposits consisted of seven strata; 1, 3, 8, 9, 12, 13 and 14. Twelve levels were taken but only the top five, in strata 12, 13 and 14 yielded frustules. These levels are 1) -90, 2) -80, 3) -70, 4) -60 and 5) -50 cm.

FIGURE 15a

# MOORS 8 DIATOMS

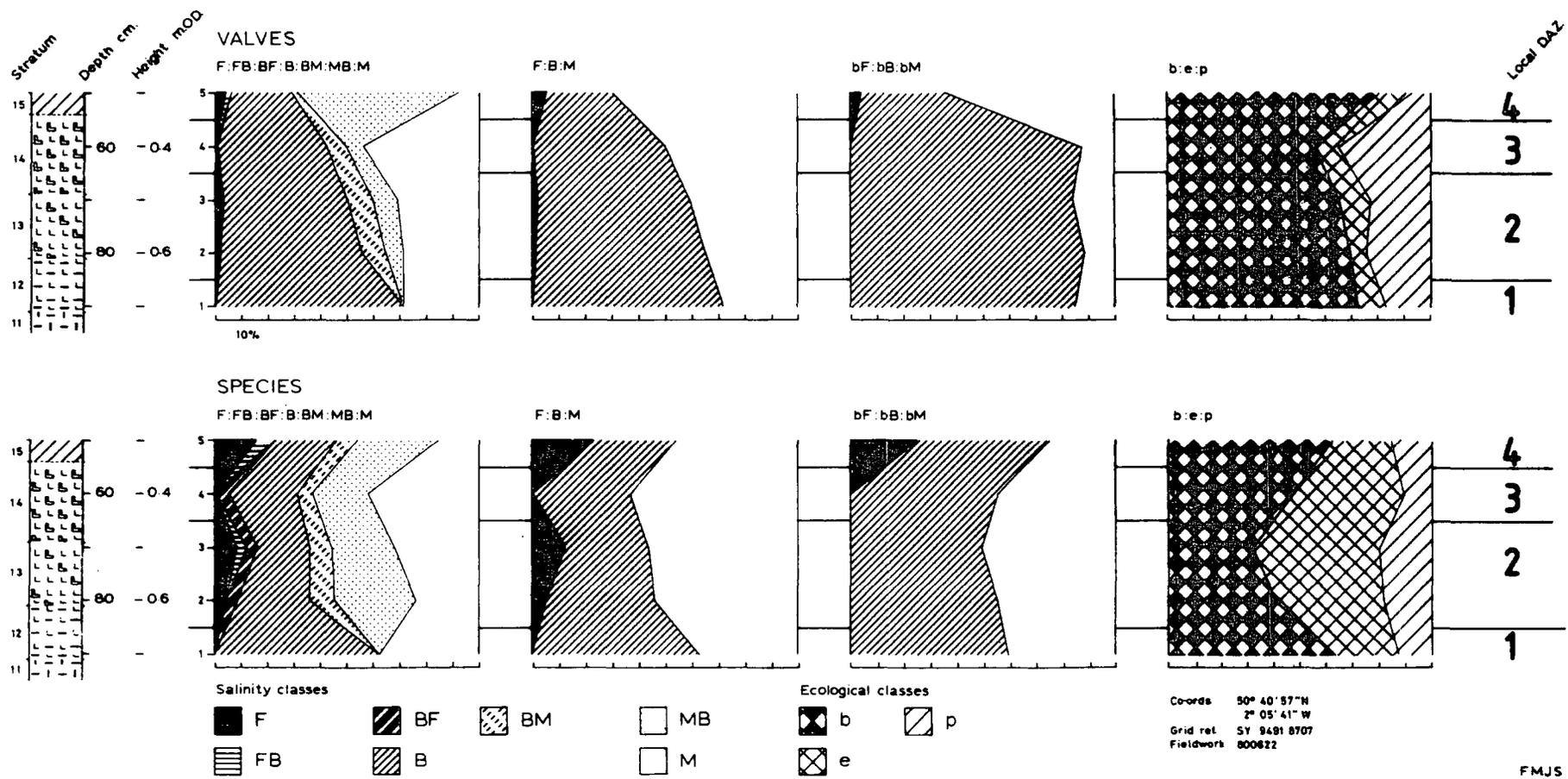
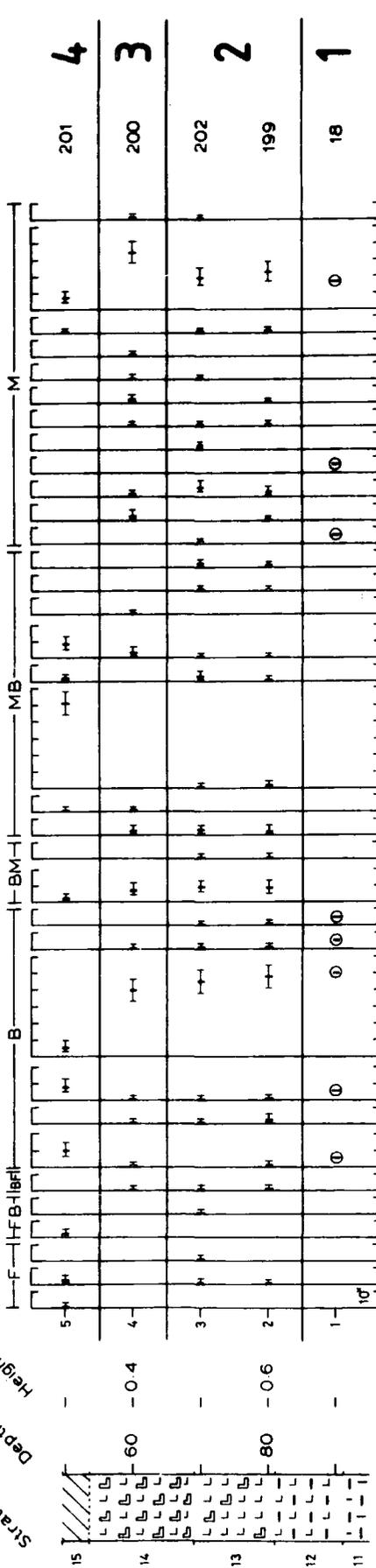


FIGURE 15b

# MOORS 8 DIATOMS

Total valves  
Local DAZ

Stratum  
Depth cm.  
Height m. OD.



- M. westii
- Melosira sulcata
- Coscinodiscus nitidus
- Plagiogramma staurorophorum
- Opephora marina
- G. oceanica v. macilenta
- Grammatophora marina
- Cocconeis discoides
- N. panduriformis
- Dimerogramma granulata
- Auliscus sculptus
- Thalassiosira decipiens
- Actinoplychus undulatus
- Raphoneis amphiceros
- Diploneis smithi
- Cocconeis scutellum
- N. marina
- Navicula abrupta
- Diploneis didyma
- Achnanthes brevipes
- Nitzschia punctata
- Rhopalodia gibberula
- Caloneis formosa
- Nitzschia navicularis
- N. peregrina
- Navicula digitoradiata
- Diploneis interrupta
- Cocconeis pediculus
- Gomphonema constrictum
- F. virescens v. elliptica
- Fragilaria lapponica
- Pinnularia microstauron

Coord. 50° 40' 57" N  
2° 05' 41" W  
Grid ref. SY 9491 8707  
Fieldwork 800622

Only 18 valves were found at level 1, but a count of 200 diatom valves was made at each of the other four levels. A full record of these counts is given in Appendix IV. The data are presented graphically in Figures 15a and 15b.

At Moors 8, 34 species of diatoms were identified; the ratio of F : B : M being 5 : 9 : 20. In the five levels 820 valves were counted and the ratio of F : B : M was 16 : 407 : 397. Again we see that although more Marine species were identified, more Brackish valves were counted overall.

The two dominant species are Nitzschia navicularis (B b) with 284 valves and Melosira sulcata (M p) with 170 valves. A total of 107 valves of Navicula marina (MB b) were counted but 103 of these occurred at -50 cm. The summary diagrams (Figure 15a) show that Fresh valves do not vary greatly throughout the core but the Brackish and Marine valves do vary considerably. Brackish valves decrease upwards, away from the peat, whereas the Marine valves increase upwards. This increase is not of a simple nature. There is a sharp decrease in true Marine (M) valves at the top of the core but this is accompanied by a very large increase in Marine-Brackish (MB) valves. The combination of these two curves gives the overall increase in Marine types. The summary diagrams for species reflect changes in the diatom flora, similar to those changes in diatom valves. The Brackish species decline upwards while the Marine species increase in the same direction, to a peak just below the top-soil.

The summary diagrams for habitat, for both valves and species show that benthonic diatoms dominate throughout the levels. The species diagram is not so simple. In the bottom levels the

benthonic species dominate but decrease upwards to -70 cm and then begin to increase. Epiphytic species increase to -70 cm and then decrease, but the number of epiphytic valves remains constant throughout. Planktonic species remain constant but the number of valves increases to -60 cm and then decrease to the top of the core. Four LDAZ have been identified at Moors 8 and are outlined below.

LDAZ M8:1 -90 cm to ca.-85 cm

The dominant species of the first zone are N.navicularis with 50% TV and M.sulcata with 16.7% TV. The upper boundary has been put where the rise of Fresh diatoms begins and a sharp decrease in Brackish species is accompanied by a sharp increase in Marine species. The Brackish diatoms dominate this zone. The lifestyle diagram shows that benthonic diatoms dominate, but are decreasing with increasing planktonic diatoms.

LDAZ M8:2 ca.-85 cm to ca.-65 cm

The dominant species of this zone are N.navicularis with 47.7% TV at -80 cm, M.sulcata with 22.5% TV at the same level and Nitzschia punctata (BM b) with 8.9% TV at -70 cm. The upper boundary is marked by the increase of M.sulcata. The zone is characterised by stable, but low, numbers of Fresh valves, although Fresh species increase. Brackish diatoms decrease and Marine ones increase. Brackish types are dominant in this zone. The benthonic species reach a minimum here although the valves show a steady decrease. Epiphytic and planktonic species reach a maximum. It is of interest to note that no Fresh valves or species are benthonic here.

LDAZ M8:3 ca.-65 cm to ca.-55 cm

The dominant species in this third zone are N.navicularis with 39.5% TV, M.sulcata with 34.5% TV and N.punctata with 7.5% TV. The upper boundary is placed where M.sulcata and N.navicularis begin to decrease sharply, while Diploneis interrupta (B b(e)) and Diploneis smithi (MB e) begin to increase. Fresh diatoms disappear from this zone. Brackish valves decrease rapidly to be replaced by rising numbers of Marine valves. The Marine species (M) reach a peak at -60 cm with 42% of the total species identified. Benthonic species and valves begin to increase sharply in this zone while epiphytic species decline. A peak of planktonic valves is seen at -60 cm but this level also records a minimum of planktonic species, this being due to the large count of M.sulcata.

LDAZ M8:4 ca.-55 cm to ca.-50 cm

This zone is dominated by the species N.marina with 51.2% TV, D.interrupta with 10% TV, D.smithi with 8.5% TV, Navicula peregrina (B b) with 8% TV and M.sulcata with 7% TV. There is a re-appearance of Fresh diatoms, a sharp decrease in Brackish valves and an increase in Marine valves, although Marine species decrease in numbers. The sharp increase in Marine valves is caused by the rise of MB valves from 6.5% at -60 cm to 62% at -50 cm. This is in part due to a count of 103 N.marina valves at -50 cm. This rise in Marine valves also can be attributed to the decrease in N.navicularis. Benthonic valves and species increase greatly in this zone, while epiphytic species decrease but the number of valves slightly increase. The opposite is true for planktonic diatoms where species increase but the number of valves decreases to a minimum.

Once again these four LDAZ correlate reasonably well with the lithological strata. LDAZ M8:1 represents the transitional organic-silt between the peat below and the clayey-silt above, being dominated by Brackish diatoms. LDAZ M8:2 correlates with the clayey-silt deposit where Fresh diatoms increase and Marine ones begin to increase as the Brackish diatoms, although dominant, decrease in numbers. LDAZ M8:3 represents the upper silt-clay with Marine diatoms taking over in dominance and the disappearance of Fresh diatoms. LDAZ M8:4 can be said to represent the top-soil of the borehole where Fresh diatoms reappear and Marine ones are dominant. To conclude, Brackish diatoms dominate the bottom levels of this core but gradually decline in importance upwards where Marine types take over in dominance. This change-over of dominance of valves takes place in LDAZ M8:3. Again the distinction between the upper two clastic deposits is brought out in the results of the diatom analyses. The lower clayey-silt is dominated by Brackish diatoms whereas the upper silt-clay is dominated by Marine types.

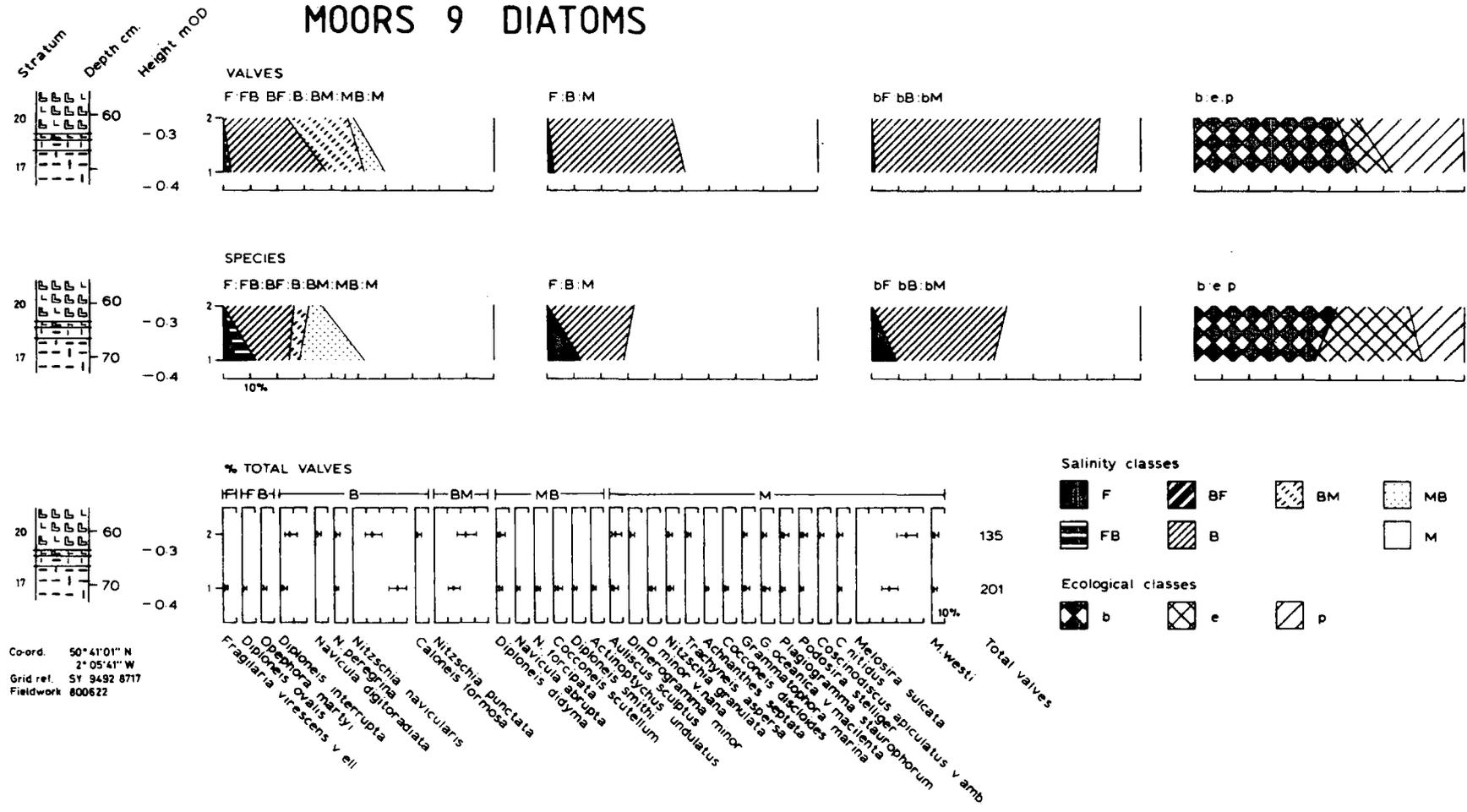
### 3) Moors 9

At Moors 9 the upper and lower clastic deposits were sampled for their diatom content. These deposits consist of eight strata; 1, 2, 4, 13, 15, 16, 17 and 20. Twelve levels were taken but of these only the upper two levels contained diatom frustules. These two levels are 1) -70.5 and 2) -60.5 cm. A full record of the results are found in Appendix V and are displayed in Figure 16.

A total of 30 species of diatoms were identified at this borehole and the ratio of F : B : M species was 3 : 6 : 21. 336 valves were counted and the ratio of F : B : M was 5 : 161 : 170.

FIGURE 16

# MOORS 9 DIATOMS



Overall three dominant species were encountered at this borehole; Melosira sulcata (M p) with 99 valves, Nitzschia navicularis (B b) with 84 valves and Nitzschia punctata (BM b) with 60 valves.

In the summary diagrams (Figure 16) Fresh valves and species are seen to decrease upwards from the peat. Brackish valves remain fairly constant although a great decrease in species is found upwards. The opposite is true of the Marine diatoms; the valves increase upwards but the species are found to decrease in the same direction. No Fresh valves are found in the upper silty-clay. The change-over in dominance of Brackish valves, at the base, to Marine valves, at the top, is due to the decrease of N.navicularis and the rise in M.sulcata. The lifestyle diagram shows approximately the same pattern for both valves and species. Benthonic types dominate the two levels, although valves decrease as species increase. The epiphytic diatoms decrease upwards as the planktonic diatoms increase. No zones have been applied to these data. One can say however that the Marine influence is strong in the upper silty-clay with 37% TV being M.sulcata.

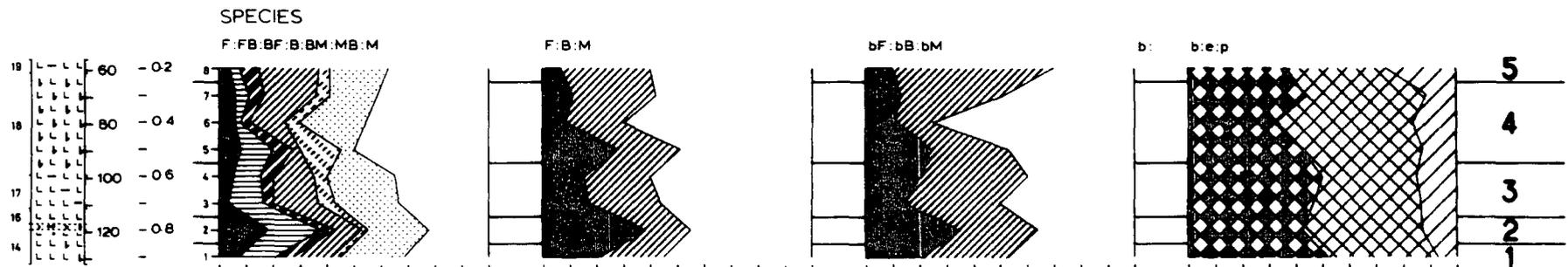
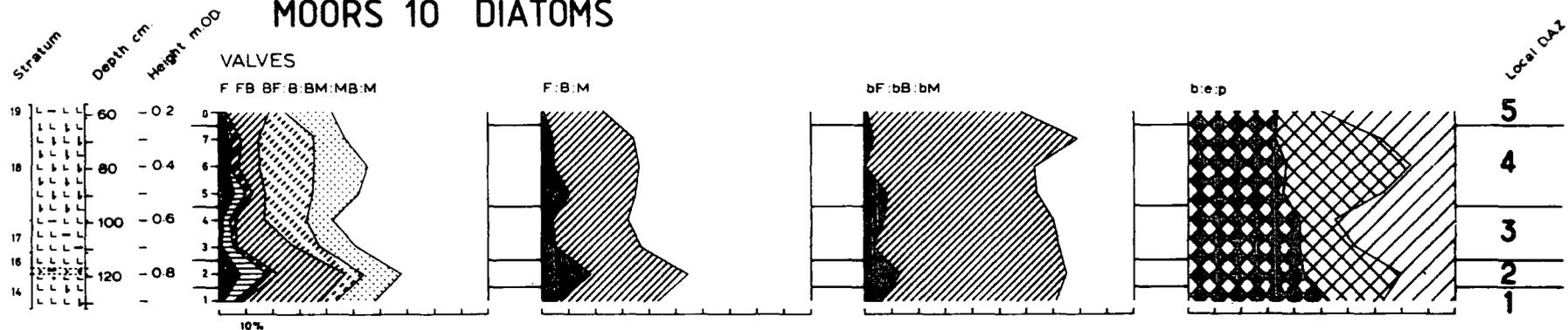
#### 4) Moors 10

At Moors 10 eight strata were sampled for diatoms; 1, 2, 3, 14, 16, 17, 18 and 19. Fourteen levels were examined but of these only the upper eight levels contained diatom frustules. These were 1) -130, 2) -120, 3) -110, 4) -100, 5) -90, 6) -80, 7) -70 and 8) -60 cm. A full record of these results is found in Appendix V and can be seen in Figures 17a and 17b.

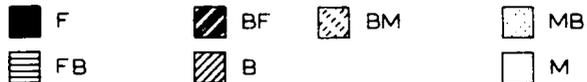
In total 72 species of diatoms were identified, the ratio

FIGURE 17a

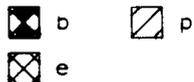
# MOORS 10 DIATOMS



Salinity classes



Ecological classes



Co-ords. 50° 41' 04" N  
2° 05' 41" W

Grid ref. SY 9491 8727

Fieldwork 800622

FMJS



of these, according to salinity classes F : B : M was 21 : 14 : 37. The eight levels yielded 1407 diatom valves and the F : B : M ratio of these was 95 : 426 : 886. These data are presented in Figures 17a and 17b, and in Appendix V.

Overall there are six dominant species present throughout these levels; Melosira sulcata (M p) with 370 valves, Nitzschia punctata (BM b) with 171 valves, Nitzschia navicularis (B b) with 129 valves, Cocconeis scutellum (MB e) with 87 valves, Grammatophora oceanica v. macilenta (M e) with 82 valves and Dimerogramma minor v. nana (M b(e)) with 68 valves.

The summary diagrams (Figure 17a) show that Fresh, Brackish and Marine diatoms fluctuate throughout the levels and no general trend is apparent in the curves. Five zones are proposed for this borehole and are outlined below.

LDAZ M10:1 -130 cm to ca.-125 cm

The dominant species in this first zone are M. sulcata with 26.5% TV and N. navicularis with 25.2% TV. The upper boundary to this zone is placed where M. sulcata decline. The zone is characterised by increasing Fresh valves and species and decreasing Marine and Brackish diatoms. The Marine influence is strong here. Benthonic valves and species are declining. Epiphytic valves increase, although the species remain constant. Planktonic species increase while the valves decrease.

LDAZ M10:2 ca.-125 cm to ca.-115 cm

The dominant species in this zone are N. navicularis with 16.6% TV and M. sulcata with 16.1% TV. The upper boundary was

placed where M.sulcata begins to increase sharply and Diploneis interrupta (B ble') begin to increase. Fresh diatoms reach a peak in this zone at -120 cm before they begin to decline. Brackish species reach a minimum at the same level although the valves are constant. Marine valves and species also reach a minimum in this zone before increasing. Benthonic diatoms become constant while epiphytic diatoms increase. Planktonic valves decrease but species increase.

LDZ M10:3 ca.-115 cm to ca.-95 cm

The dominant species in this zone are M.sulcata with 42.2% TV at -100 cm, N.punctata with 15.7% TV at the same level, N.navicularis with 11.3% TV at -110 cm and D.interrupta with 7% TV at the same level. The upper boundary is marked by a decline in M.sulcata, an increase in C.scutellum and where N.navicularis decreases to a minimum. Fresh diatoms remain constant and low here. Brackish species remain stable but the valve numbers drop. Marine diatoms increase in this zone. Benthonic valves reach a maximum while epiphytic diatoms are at a minimum. Planktonic species remain constant, although the number of valves reaches a peak at -100 cm.

LDZ M10:4 ca.-95 cm to ca.-65 cm

The dominant species in this zone are M.sulcata with 26% TV at -70 cm, N.punctata with 19.2% TV at -80 cm, G.oceanica v. macilenta with 12.1% TV at the same level, C.scutellum with 10.6% TV at -90 cm and D.minor v. nana with 6.5% TV at -70 cm. The upper boundary was placed where N.punctata begins to decrease rapidly as does G.oceanica v. macilenta and N.navicularis increases again.

Decreasing Fresh diatoms are found in this zone together with increasing Brackish and Marine diatoms. Marine diatoms dominate this zone. The benthonic valves remain constant here although the species reach a minimum at -80 cm. Epiphytic diatoms reach a peak at this same level. Planktonic valves also reach a minimum at -80 cm.

LDAZ M10:5 ca.-65 cm to -60 cm

The dominant species in this last zone are M.sulcata with 46% TV, N.navicularis with 10.5% TV and Diploneis didyma (MB b) with 8.5% TV. Fresh diatoms continue to decrease in this zone as do Brackish valves, although Brackish species increase. There is also an increase in Marine diatoms. Benthonic diatoms reach a constant state overall, but epiphytic types decrease. There is a sharp rise in planktonic diatoms caused by M.sulcata.

Again a close correlation exists between the lithological strata of the core and these LDAZ. LDAZ M10:1 represents the peaty-silt at the base of the sampled layers. Here the main water type appears to have been Marine although a relatively large amount of Fresh water must have been close to the site at the time of deposition. LDAZ M10:2 can be said to represent the organic stratum 15, with the large contribution of Fresh diatoms. Here a decrease of Marine diatoms is found but they are still dominant in numbers. LDAZ M10:3 correlates with strata 16 and 17, the silt which is overlain by a peaty-silt. This zone is once again Marine in nature but with an increase of Brackish diatoms. LDAZ M10:4 represents the peat-silt of stratum 18. The Fresh diatoms show a rise at the base of this zone but steadily decrease throughout. The Marine influence is again strong with a peak at

-80 cm, in the middle of the stratum. Epiphytic diatoms begin to increase to the top of this zone. LDAZ M10:5 correlates with the transitional stratum 19. Fresh diatoms decrease and Marine ones increase in numbers.

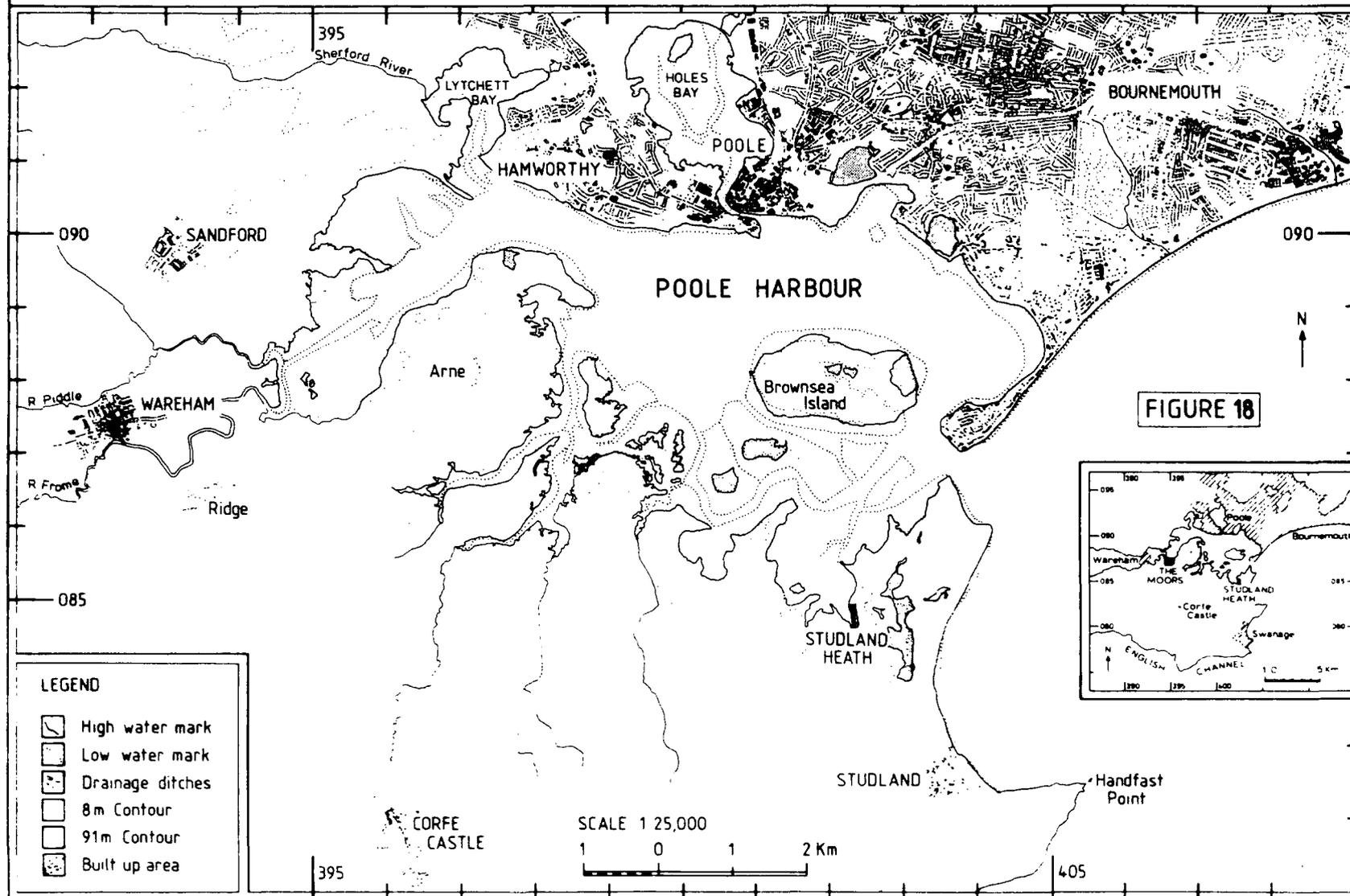
### 3:2 STUDLAND HEATH

#### 3:2:1 Stratigraphy

The site known as Studland Heath is located on the peninsula to the north of Studland Heath (Figure 18). It is found to the west of the main road from Studland to the ferry terminus on the east of Brand's Bay. The site is a saltmarsh adjacent to the tidal flats of Brand's Bay. It is a wetland but does not get totally inundated in the tidal regime of the bay.

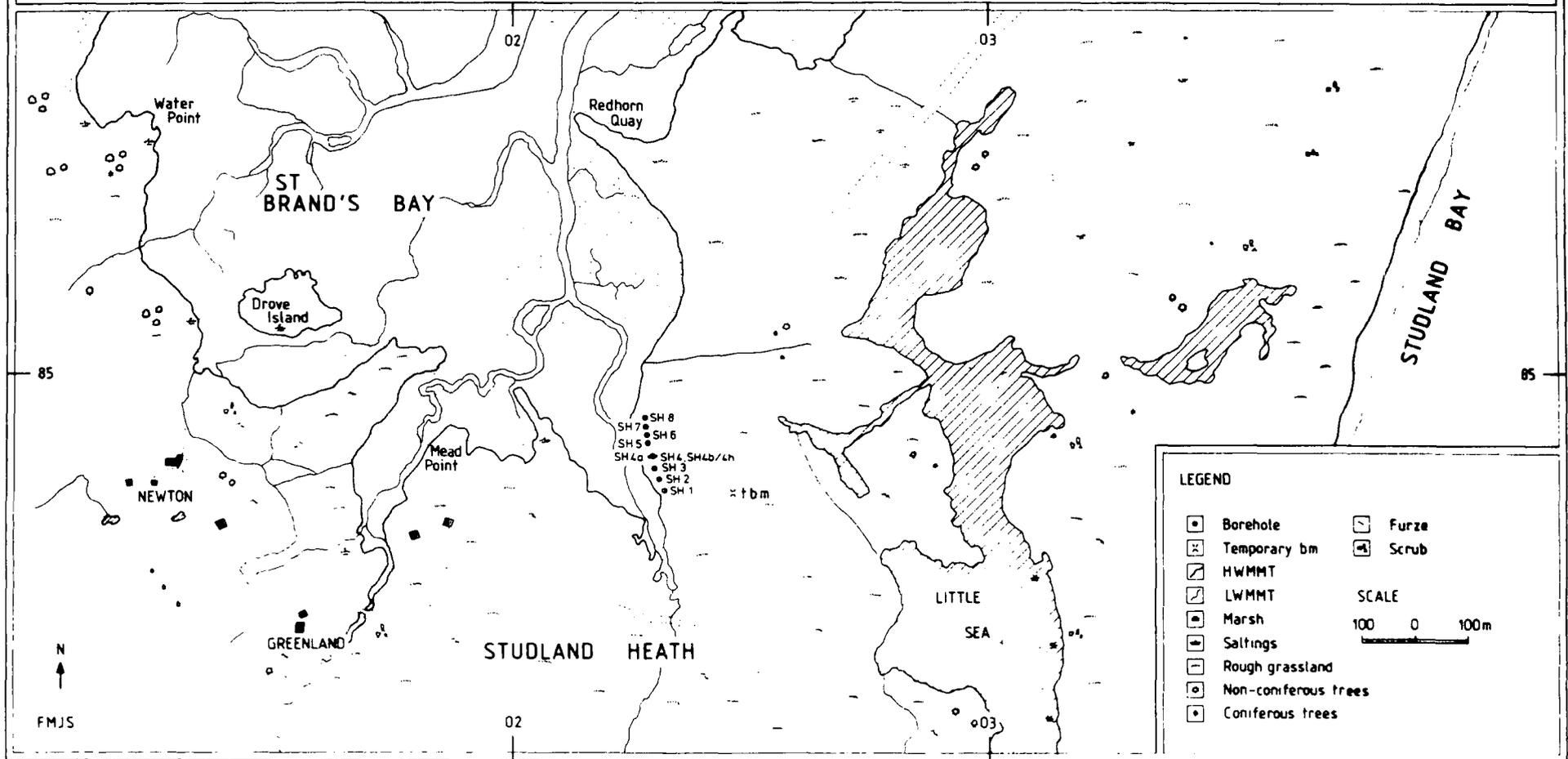
A total of eleven boreholes were taken at this site, in two perpendicular gridlines, intersecting at SH 4 (Figure 19). SH 1 to SH 8 (SZ 0231 8473 to SZ 0228 8490) were taken at intervals of 25 m, while SH 4a to SH 4h (SZ 0228 8480 to SZ 0230 8480) were taken at intervals of 5 m. This second transect, SH 4a to SH 4h, was taken in order to ascertain the extent of the organic deposit found in SH 4, which was the only borehole in the original transect to produce a peat deposit. The ground level of these boreholes varies from + 1.81 m.O.D. at SH 1 to + 1.53 m.O.D. at SH 5. All boreholes were taken using a Russian-type sampler, with the exception of SH 4h which was sampled with a Percussion corer. The stratigraphy of the boreholes was taken in the field and samples for pollen and diatom analyses were taken from SH 4b at the site. The core SH 4h was taken back to Durham for further analyses.

# STUDLAND HEATH SITE



# STUDLAND HEATH BOREHOLES

FIGURE 19



## LEGEND

- ◻• Borehole
- ◻⊗ Temporary bm
- ◻/ HWMMT
- ◻| LWMMT
- ◻| Marsh
- ◻| Saltings
- ◻| Rough grassland
- ◉ Non-coniferous trees
- ◉ Coniferous trees
- ◻/ Furze
- ◻⊗ Scrub

SCALE  
100 0 100m

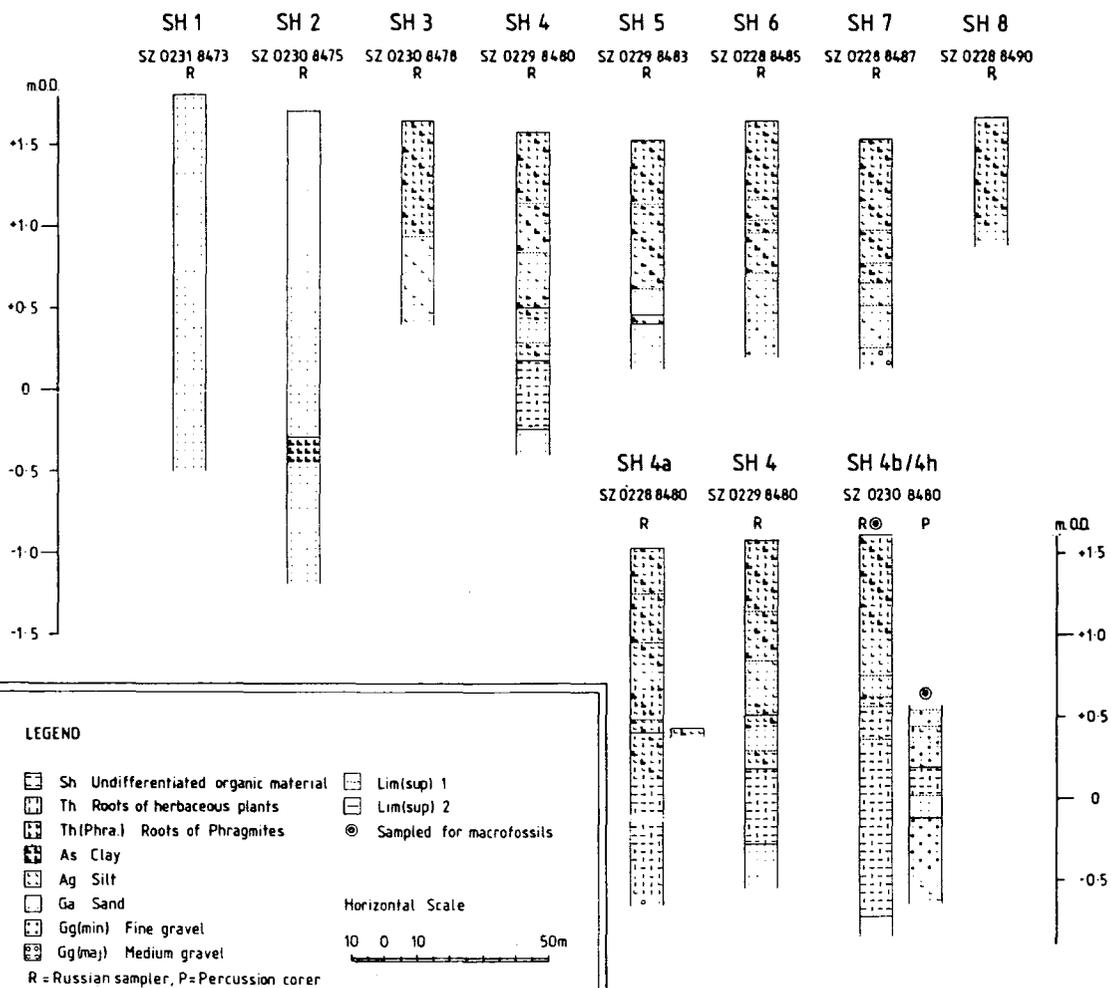
FMJS

The stratigraphy of this site is very complex and can be seen in Figure 20. As mentioned previously organic material was only found at SH 4, in the original transect while it was found in all boreholes of the second east-west transect. It may be more simple to describe the stratigraphy of these two transects separately with altitudes quoted indicating the upper contact of the deposit.

The main transect, SH 1 to SH 8, is found to be predominantly clastic with one organic band in SH 4. These boreholes reveal a four-part stratigraphy, a basal sand overlain by a silty-clayey sand which is topped by a sandy-silt and above all is a mixed band of top-soil material. The basal sand increases in depth from 11 cm in SH 8 to 54 cm in SH 3. This sand deposit is composed of a lower pure sand or gravelly-sand, as found in SH 7, 6, 5 and 4, and an upper silty-sand which is found in all boreholes except SH 5. The altitude of this deposit ranges from + 0.99 m.O.D. in SH 8 to + 0.62 m.O.D. in SH 5 and back to + 0.94 m.O.D. in SH 3, thus it forms a 'basin-shaped' formation. In SH 4 and SH 5 this basal sand deposit has been interrupted by a thin band of sandy-clayey-silt (Ga 1, As 1, Ag 2) which is only 7 cm deep at its thickest in SH 4. This ranges in altitude from + 0.58 m.O.D. in SH 4 to + 0.46 m.O.D. in SH 5. The second stratigraphical unit is a silty-clayey-sand (Ag 1, As 1, Ga 2) which is found in SH 4 to SH 6. This deposit varies in thickness from 16 cm in SH 5 to 25 cm in SH 6 and ranges in altitude from + 1.06 m.O.D. in SH 4 to + 0.78 m.O.D. in SH 5. Above this is found a band of clayey-sandy-silt (As 1, Ga 1, Ag 2) which is found in all boreholes except SH 3. This upper clastic deposit ranges in altitude from + 1.17 m.O.D. in SH 6 to + 1.08 m.O.D. in SH 8 and varies in thickness from 8 cm in SH 4 to 46 cm in SH 7. This deposit is

# STUDLAND STRATIGRAPHY

FIGURE 20



capped by a finer clayey-silt of 8 cm in SH 5. This clayey-silt also appears in SH 6, but in a basal position to the clayey-sandy-silt. The upper deposit found in all boreholes is a mixed peaty-silt, which is probably associated with the top-soil. This deposit ranges in thickness from 39 cm in SH 5 to 71 cm in SH 3.

The exceptions to this general stratigraphic description are SH 1, SH 2 and SH 4. SH 1 was found to be composed only of sand while SH 2 had 2 m of sand above a blue clay. SH 4 will be dealt with in the next section on the stratigraphy of the second transect.

The east-west transect includes boreholes SH 4a, SH 4, SH 4b and SH 4h. Again a generalised stratigraphic scheme of four deposits can be recognised; a lower sand, an organic deposit, an upper clastic deposit and the top-soil. The lower deposit is again a sand which ranges in altitude from + 0.02 m.O.D. in SH 4h to - 0.72 m.O.D. in SH 4b and varies in thickness from 66 cm in SH 4h to 5 cm in SH 4a. This deposit, in SH 4h, includes 32 cm of gravelly-sand. Above this sand deposit is the organic material which is present in all boreholes. This is a mixed herbaceous peat which ranges in altitude from + 0.31 m.O.D. in SH 4b to + 0.11 m.O.D. in SH 4a and varies in thickness from 17 cm in SH 4h to 103 cm in SH 4b. At SH 4a the peat is overlain by 58 cm of transitional material with 2 cm of intercalated clayey-silt at + 0.40 m.O.D. This transitional material is also found in SH 4b where 31 cm of material is present. The upper clastic deposit found in all boreholes above the peat is not of a uniform nature. A silty-sand is found immediately above the

peat in SH 4h. In SH 4a, 3 cm of this silty-sand is found at + 0.75 m.O.D. At SH 4 the peat is overlain by 26 cm of clayey-silt with 14 cm of sand intercalated at + 0.43 m.O.D. before reaching the silty-sand found in SH 4h and SH 4b. The silt-sand deposit, found in the first transect, is also found here ranging in altitude from + 1.06 m.O.D. in SH 4 to + 0.80 m.O.D. in SH 4a and varying in thickness from 9 cm in SH 4a to 23 cm in SH 4b. Again a band of clayey-silt is found, as in the first transect, at the top of the clastic material in SH 4a and SH 4. This ranges in altitude from + 1.14 m.O.D. in SH 4 to + 0.96 m.O.D. in SH 4a and varies in thickness from 16 cm in SH 4a to 8 cm in SH 4. These deposits are not found in SH 4h but are replaced by 27 cm of gravelly-sand with 5 cm of transitional peaty-silt at + 0.44 m.O.D. Again all three boreholes SH 4a, SH 4 and SH 4b are topped by a transitional deposit which is probably associated with a top-soil.

Thus in the first transect we find a wedge-shaped deposit of sand which increases in thickness southwards to SH 1. This is capped with a silty-clayey-sand of uniform thickness extending to SH 4. Above this is another wedge-shaped deposit of clayey-sandy-silt which decreases in thickness southwards. The sequence of strata is not so clear in the second transect. The sand deposit, at the base of the cores, increases in thickness inland, away from the river, and is capped by a peat which attains its maximum thickness and altitude in SH 4b. Above this peat the strata can not be described in any clear pattern.

As mentioned earlier cores SH 4h and SH 4b were sampled for microfossil analyses. The detailed stratigraphy of these cores is given below.

The stratigraphy of SH 4b.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm.	<u>Description</u>
9)	+1.61 to +1.16	0 to 45	Ag 2, As 1, Th 1. Nig 2, Strf 0, Elas 0, Sicc 3. Light organic silt.
8)	+1.16 to +0.98	45 to 63	Ag 2, As 1, Th 1, Ga +. Nig 2+, Strf 0, Elas 0, Sicc 3-, L(s) +. Light organic silt with sand.
7)	+0.98 to +0.75	63 to 86	Ga 2, Ag 2, As +, Th +. Nig 3-, Strf 0, Elas 0, Sicc 2, L(s) +. Darker silt-sand with organic remains.
6)	+0.75 to +0.62	86 to 99	Ga 3, Ag 1, Th +. Nig 2+, Strf 0, Elas 0, Sicc 2, L(s) 1. Silty-sand with organic remains.
5)	+0.62 to +0.56	99 to 105	Sh 2, Ga 1, Ag 1. Nig 3-, Strf 0, Elas +, Sicc 2, L(s) 1. Dark peat with sand and silt partings.
4)	+0.56 to +0.36	105 to 125	Sh 2, Th( <u>Phrag</u> ) 1, Ag 1. Nig 2, Strf 0, Elas 0, Sicc 2, L(s) 1. Lighter silty-peat with <u>Phragmites</u> .
3)	+0.36 to +0.31	125 to 130	Sh 1, Th ( <u>Phrag</u> ) 1, Ga 1, Ag 1. Nig 2+, Strf 0, Elas 0, Sicc 2, L(s) 1. Mixed transitional deposit.
2)	+0.31 to -0.72	130 to 233	Sh 3, Th 1, Th( <u>Phrag</u> ) +. Nig 2+, Strf 0, <u>Elas</u> 1, Sicc 2, L(s) 1. Light peat with <u>Phragmites</u> .
1)	-0.72 to -0.84	233 to 245	Ga 4, Sh +. Nig 2+, Strf 0, Elas 0, Sicc 2, L(s) 2. Sand with some organic remains.

At this borehole only stratum 2 was sampled for pollen.

The stratigraphy of SH 4h.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm.	<u>Description</u>
12)	+0.57 to +0.54	96 to 99	not sampled.
11)	+0.54 to +0.49	99 to 104	Ga 3, Gg(min) 1, Ag +. Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 1. Grey gravelly-sand.
10)	+0.49 to +0.44	104 to 109	Ga 3, Gg(min) 1, Th +. Nig 3, Strf 0, Elas 0, Sicc 3, L(s) +. Darker gravelly-sand with organic remains.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm.	<u>Description</u>
9)	+0.44 to +0.39	109 to 114	Ag 2, Ga 1, Th 1. Nig 3+, Strf 0, Elas 0, Sicc 3, L(s) 1. Dark sandy-silt with organic remains.
8)	+0.39 to +0.33	114 to 120	Ga 3, Gg(min) 1, Ag +. Nig 3, Strf 0, Elas 0, Sicc 3, L(s) +. Dark gravelly-sand.
7)	+0.33 to +0.22	120 to 131	Ga 2, Gg(min) 2, Ag +. Nig 3m Strf 0, Elas 0, Sicc 3, L(s) +. Dark Gravel-sand.
6)	+0.22 to +0.19	131 to 134	Ga 3, Ag 1, Gg(min) +. Nig 3, Strf 0, Elas 0, Sicc 3, L(s) +. Dark silty-sand.
5)	+0.19 to +0.02	134 to 151	Sh 3, Th 1, Ag +. Nig 4, Strf 0, Elas 1, Sicc 3, L(s) 2. Very dark peat.
4)	+0.02 to -0.12	151 to 165	Ga 4, Gg(min) +, Sh +. Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 1. Light sand with organic remains.
3)	-0.12 to -0.44	165 to 197	Ga 2, Gg(min) 2. Nig 2m Strf 0, Elas 0, Sicc 3, L(s) 2. Light sand-gravel.
2)	-0.44 to -0.52	197 to 205	Ga 4, Ag +, Gg(maj) +. Nig 2, Strf 0, Elas 0, Sicc 2, L(s) +. Light sand with large pebbles.
1)	-0.52 to -0.64	205 to 217	Ga 3, Ag 1, Gg(maj) +. Nig 2, Strf 0, Elas 0, Sicc 3, L(s) +. Light silty-sand with pebbles.

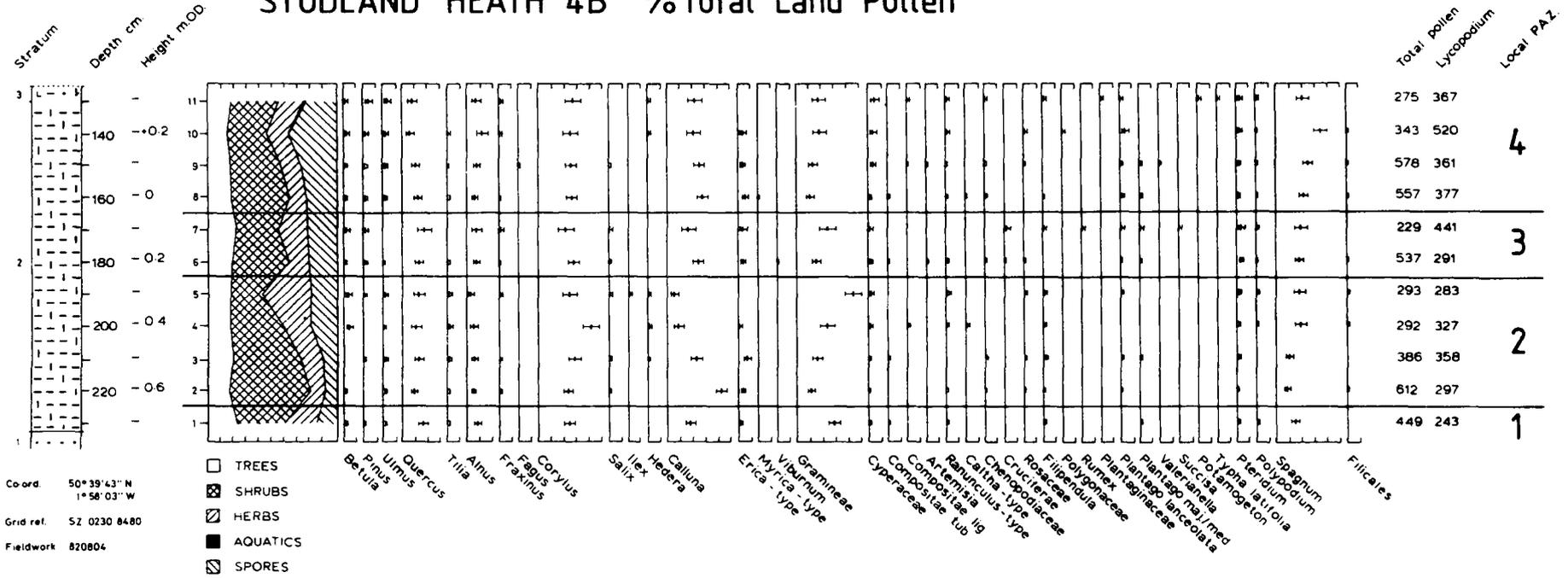
Strata 4, 5 and 6 were sampled for their pollen content.

### 3:2:2 Pollen Analyses

Two boreholes at the Studland Heath site were sampled for their pollen content; these were SH 4b and SH 4h. These two boreholes were taken adjacent to each other but SH 4b was sampled with a Russian-type sampler, samples for pollen analyses being taken in the field. This core provided the greatest depth of organic material, with over 100 cm being recovered. Borehole SH 4h was taken with a Percussion corer. It was hoped that a similar amount of organic material would be recovered but only 17 cm was found due to compaction of the sediments during sampling and extraction of the core. The detailed analyses

FIGURE 21

## STUDLAND HEATH 4B %Total Land Pollen



Coord. 50° 39' 43" N  
 1° 58' 03" W  
 Grid ref. S2 0230 8480  
 Fieldwork 820804

of the pollen from these two cores will be described in the following section.

1) Studland Heath 4b

At this borehole only one stratum was sampled for pollen; stratum 2, the mixed herbaceous peat. Eleven samples were taken in the field at 10 cm intervals through the organic material. These samples were 1) -230, 2) -220, 3) -210, 4) -200, 5) -190, 6) -180, 7) -170, 8) -160, 9) -150, 10) -140 and 11) -130 cm. A pollen sum of at least 50 tree pollen was counted. In some levels (3, 4, 6, 10 and 11) a count of 100 tree pollen was possible. In all cases a minimum of 200 Lycopodium spores were counted. The data are displayed as percentages of the total land pollen (TLP) for comparison with other sites. The results of this analysis can be found in Appendix IV and seen in Figure 21. Four LPAZ have been identified at this borehole and are described below.

LPAZ SH 4b:1 -230 cm to ca.-225 cm

This first zone is dominated by shrub pollen. The most important tree pollen comes from Quercus with 15.7% TLP and Alnus with 8% TLP. Gramineae are the most important NAP with 28.5% TLP. Corylus pollen reaches 24% TLP, Calluna has 17.6% TLP and Sphagnum reaches 14.7% TLP + Spores. The major dry-land tree pollen comes from Quercus with 59% of trees. As to be expected Gramineae pollen are found in the greatest concentrations with  $49.8 \times 10^2$  grains/cc. Corylus pollen records a concentration of  $41.9 \times 10^2$  grains/cc. The concentration of Calluna and Sphagnum are both  $30.7 \times 10^2$  grains/cc while Quercus pollen drops to a concentration of  $27.4 \times 10^2$  grains/cc. The upper boundary of this first zone was placed where Quercus pollen drops from 15.7% TLP to 9% TLP, Calluna

increases from 17.6% TLP to 42% TLP, Gramineae fall from 28.5% TLP to 11% TLP and Sphagnum spores decrease from 14.7% TLP plus Spores to 8.7% TLP + Spores.

LPAZ SH 4b:2 ca.-225 cm to ca.-185 cm

This zone is characterised by a dominance of shrub pollen through the lower three levels but a dominance of herb pollen at the top of the zone. The most important tree pollen arises from Quercus with 12.6% TLP at -210 cm while Alnus has 5.6% TLP at the same level. Gramineae are again the dominant NAP with 43.3% TLP at -190 cm, which accounts for the dominance of herb pollen at this level. Calluna pollen has increased to 42% TLP at -220 cm while Corylus is represented by 41% TLP at -200 cm. Sphagnum once again is high with 19.2% TLP + Spores at -200 cm. Fraxinus pollen is first found in this zone while Ilex pollen is only found here. The major dry-land tree pollen comes from Quercus with 58% of trees at -190 cm, Betula with 18% of trees at -200 cm and from Tilia with 8% of trees at the same level. It is interesting to note that although Gramineae are seen to have the highest representation of the TLP, Calluna pollen records the highest concentration with  $88.3 \times 10^2$  grains/cc at -220 cm. Corylus pollen also has a high concentration with  $49.1 \times 10^2$  grains/cc at -220 cm, although the highest percentage of TLP was recorded at -200 cm. Gramineae records a concentration of  $40.3 \times 10^2$  grains/cc at -190 cm. Sphagnum spores have a concentration of  $21.2 \times 10^2$  grains/cc at -190 cm, again not at the level that records the highest percentage count. The upper boundary of this zone was placed where Alnus pollen increases from 2.6% TLP to 7.4% TLP, Calluna pollen increases from 5.2% TLP to 24.2% TLP and Gramineae fall from

43.3% TLP to 15.1% TLP.

LPAZ SH 4b:3 ca.-185 to ca.-165 cm

This zone is again characterised by a dominance of shrub pollen. Once again Quercus pollen is the most important representative of the tree pollen with 17% TLP at -170 cm. Corylus pollen is the dominant NAP with 27.8% TLP at -180 cm. Calluna pollen has a record of 24.2% TLP at -180 cm, Gramineae have 23.9% TLP at -170 cm and at the same level Sphagnum spores record 19.2% TLP + Spores. The major dry-land trees are identified as Quercus with 60% of trees at -170 cm and Pinus with 7% of tree pollen at -180 cm. Four species of pollen are only found in this zone, these are Viburnum, Rumex, Succisa and Cruciferae. Corylus pollen records the greatest concentration with  $45 \times 10^2$  grains/cc at -180 cm, Calluna pollen has a concentration of  $39.2 \times 10^2$  grains/cc at -180 cm while at the same level Sphagnum spores show a concentration of  $37.7 \times 10^2$  grains/cc and Gramineae have  $24.5 \times 10^2$  grains/cc. These last two taxa both record their highest percentages of TLP at -170 cm. The upper boundary is marked by a fall in Quercus pollen from 17% TLP to 12.1% TLP, an increase in Calluna pollen from 16.5% TLP to 27.4% TLP and a fall in Gramineae from 23.9% TLP to 10.4% TLP.

LPAZ SH 4b:4 ca.-165 cm to -130 cm

This last zone is characterised by a dominance of shrub pollen at all levels except -140 cm, where spores are dominant. Aquatic pollen first appears at the top of this zone. The most important tree pollen comes from Quercus with 12.1% TLP at -160 cm and Alnus with 11.8% TLP at -140 cm. Calluna is the most important shrub

with 27.4% TLP at -160 cm, while Corylus pollen has 27.3% TLP at -130 cm. Gramineae record 17.5% TLP at -140 cm. The dominance of spores at -140 cm is due to the high percentage of Sphagnum with 35% TLP + Spores. The major dry-land tree pollen comes from Quercus with 51% of trees at -160 cm, Pinus with 16% of trees at -130 cm and Ulmus with 14% of trees at -130 cm. Five species are only found in this last zone. These are Fagus, Polygonaceae, Potamogeton and Typha latifolia. Sphagnum records the highest concentrations with  $46 \times 10^2$  grains/cc at -150 cm. Calluna pollen has a concentration of  $34.8 \times 10^2$  grains/cc at -160 cm, Corylus pollen records  $33.3 \times 10^2$  grains/cc at the same level and Gramineae have a concentration of  $16.3 \times 10^2$  grains/cc at -150 cm.

Thus we have a stratum of peat which does not have a uniform nature, as might be expected from the stratigraphic description. Shrub pollen dominates throughout the levels, except at -190 cm where herb pollen is dominant, as shown by the high Gramineae presence, and at -140 cm where spores dominate. Corylus and Calluna pollen makes up the dominant shrubs throughout the levels with Gramineae being the dominant herb pollen. Quercus remains the most important tree pollen throughout but is present in relatively low frequencies. The bottom two zones are dominated by Gramineae pollen while LPAZ SH 4b:3 is dominated by Corylus pollen and LPAZ SH 4b:4 is dominated by Calluna pollen. Aquatic pollen is only found in the top level where the boundary with stratum 3, the transitional deposit, is present.

Studland Heath 4b was chosen to represent this site due to the depth of organic material in the borehole.

Dating of the LPAZ of Studland Heath 4b.

One organic stratum was found at SH 4b from + 0.31 m.O.D. (-130 cm) to - 0.72 m.O.D. (-233 cm). This stratum was overlain by a sandy deposit with a transitional silty-peat intercalated. Four LPAZ were recognised at this borehole, which are summarised below with their dominant AP and NAP.

Table 11 Dating of LPAZ at Studland Heath 4b.

Flandrian Chronozone	LPAZ	Altitude (m.O.D.)	Depth (cm.)	Dominant Lifegroup	Dominant AP	Dominant NAP
III	SH 4b:4	+0.31 to -0.04	-130 to -165	Shrubs & Spores	Q-A-P-U	Sph-Gr-Er-Co.
	SH 4b:3	-0.04 to -0.24	-165 to -185	Shrubs	Q-A	Sph-Gr-Co+Er.
	SH 4b:2	-0.24 to -0.64	-185 to -225	Shrubs & Herbs	Q-A-B-T	Gr-Co-Sph-Er.
	SH 4b:1	-0.64 to -0.69	-225 to -230	Shrubs	Q-A	Gr-Sph-Co-Er.

These four LPAZ are all thought to belong to the early part of Flandrian Chronozone III (Godwin's Zone VIIb). Quercus values are all greater than 69% of the tree pollen throughout the LPAZ.

2) Studland Heath 4h.

At SH 4h three strata were sampled for their pollen content; these were stratum 4, the lower sand below the mixed herbaceous peat of stratum 5 and stratum 6, the silty-sand above the peat. 15 samples were taken in total at 1 cm intervals over the upper and lower transitional levels of the peat and at 2 cm intervals through the main body of peat. These levels are 1) -153, 2) -151, 3) -150, 4) -149, 5) -148, 6) -147, 7) -145, 8) -143, 9) -141, 10) -139,



11) -137, 12) -136, 13) -135, 14) -134 and 15) -133 cm. A pollen sum of 150 tree pollen was counted through the main body of peat but levels 1 to 4 were counted to 75 tree pollen while the upper two levels, 14 and 15, were counted to 100 and 50 tree pollen. Due to an error in the preparation the number of Lycopodium marker spore tablets added to the samples was not uniform; levels 1 to 5 received 5 tablets, levels 6 to 9 received none and levels 10 to 15 received 1 tablet. As a result the concentration figures were corrected to indicate the concentration of pollen in levels 1 to 5 if one tablet had been added instead of five. The results of this analysis can be seen in Figure 22 and a full table of counts is given in Appendix IV.

Four LPAZ were identified at this borehole. LPAZ SH 4h:3 has been divided into two sub-zones 3a and 3b, on the basis of changes in the NAP curves, namely Corylus, Gramineae and Sphagnum, although no changes are seen in the AP curves. These four LPAZ are described in detail below.

LPAZ SH 4h:1 -153 cm to ca.-152 cm

This first zone is characterised by a dominance of shrub pollen. Tree pollen are at their greatest percentages in this zone but are decreasing rapidly. The most important tree pollen comes from Pinus with 28.9% TLP. Ericaceae pollen is represented in the greatest numbers with 34% TLP while Corylus pollen accounts for 32.8% TLP. The concentration figures are low in this zone with Ericaceae only having  $5.3 \times 10^2$  grains/cc. The upper boundary is placed where Pinus pollen falls from 28.9% TLP to 10.7% TLP, Corylus pollen increases from 32.8% TLP to 52.5% TLP and Sphagnum first appears.

LPAZ SH 4h:2 ca.-152 cm to ca.-146 cm

This zone is still dominated by shrub pollen but this is decreasing while herb pollen and spores increase. Pinus pollen still represents the most important tree with 10.7% TLP at -151 cm, Quercus pollen records 10% TLP at -147 cm and Ulmus pollen has 7.2% TLP at -149 cm. Corylus is the dominant NAP with 60.5% TLP at -149 cm, Ericaceae pollen is represented by 32% TLP at -151 cm while Sphagnum has 26.7% TLP + Spores at -147 cm and at the same level Gramineae pollen records 13.8% TLP. Tilia and Fraxinus pollen is first recorded in this zone while Hedera and Leguminosae pollen is only found here. Pollen concentrations of Corylus are very high with  $205.2 \times 10^2$  grains/cc at -149 cm while at the same level the concentration of Sphagnum is  $57.5 \times 10^2$  grains/cc and Calluna has  $50.6 \times 10^2$  grains/cc. Pinus and Ulmus also have high concentrations. The upper boundary to this zone is drawn where Pinus decreases from 7.6% TLP to 1.9% TLP and Ulmus increases from 3.4% TLP to 8.5% TLP. At this boundary Corylus pollen drops from 49.6% TLP to 41.6% TLP.

LPAZ SH 4h:3a ca.-146 cm to ca.-135.5 cm

The dominant life group in this sub-zone is once again shrub pollen. Quercus constitutes the most important tree pollen with 13% TLP at -141 cm. Corylus is still the dominant NAP with 41.6% TLP at -145 cm, Gramineae pollen has 28.7% TLP at -136 cm and Sphagnum makes up 29.5% TLP + Spores at -145 cm. Frangula and Mercurialis pollen is only found in this sub-zone. Concentration figures are only available for the upper levels of this sub-zone and these show that Sphagnum has a concentration of  $175.4 \times 10^2$  grains/cc at -139 cm, while Corylus pollen is concentrated with

148.3 x 10<sup>2</sup> grains/cc at the same level. Concentrations of Gramineae pollen are 91.3 x 10<sup>2</sup> grains/cc at -139 cm and of Quercus are 50.7 x 10<sup>2</sup> grains/cc at -137 cm. The upper boundary of this sub-zone is marked by a rise in Corylus pollen from 28.7% TLP to 38.6% TLP, a fall in Gramineae pollen from 28.7% TLP to 18.5% TLP and a rise in Sphagnum from 24.1% TLP + Spores to 30.9% TLP + Spores.

LPAZ SH 4h:3b ca.-135.5 cm to ca.-134.5 cm

Shrub pollen dominates this sub-zone and Quercus pollen still comprises the most important tree pollen with 10.1% TLP. The NAP is dominated by Corylus with 38.6% TLP, Sphagnum spores record 30.9% TLP + Spores, Gramineae have 18.5% TLP and Calluna pollen is recorded as having 10.9% TLP. Concentrations of pollen are very high in this sub-zone with Sphagnum recording 242.7 x 10<sup>2</sup> grains/cc. The concentration of Corylus pollen is 205.4 x 10<sup>2</sup> grains/cc and that of Gramineae is 98.3 x 10<sup>2</sup> grains/cc. The upper boundary of this sub-zone was placed where Fagus pollen first appears and Corylus pollen drops from 38.6% TLP to 25.6% TLP, Gramineae pollen rises from 18.5% TLP to 29.6% TLP and Sphagnum spores fall from 30.9% TLP + Spores to 20.5% TLP + Spores.

LPAZ SH 4h:4 ca.-134.5 cm to -133 cm

This last zone is dominated by herb pollen at the base but by shrub pollen at the top. Alnus pollen is now the most important representative of the tree pollen with 11.8% TLP at -133 cm while Quercus pollen has dropped to 11.3% TLP at -134 cm. Gramineae are the most important NAP with 29.6% TLP at -134 cm, Corylus pollen records 28.9% TLP at -133 cm, Sphagnum spores comprise 20.5% TLP +

Spores at -134 cm and Calluna pollen has 11.8% TLP at -133 cm. In this zone five species are first recorded; these being Fagus, Compositae liguliflora, Chrysosplenium, Umbelliferae and Plantago major/media. Concentrations of pollen are once again low with Gramineae having the highest with  $15.7 \times 10^2$  grains/cc, Sphagnum spores being concentrated with  $13.9 \times 10^2$  grains/cc and Corylus pollen having a concentration of  $13.6 \times 10^2$  grains/cc.

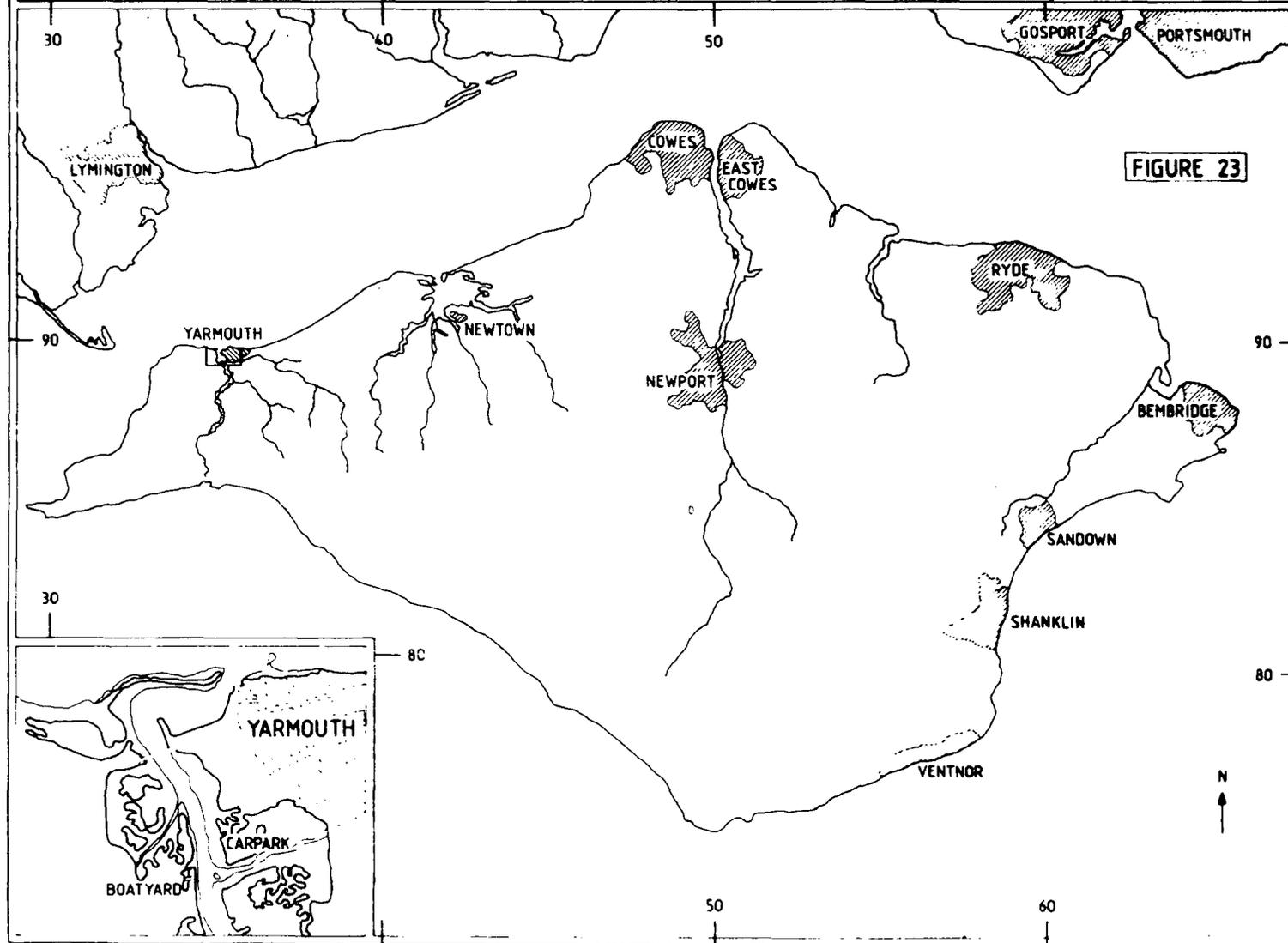
These LPAZ can tentatively be correlated with the stratigraphic column. LPAZ SH 4h:1 corresponds with the basal sand of stratum 4. Here Pinus pollen is the most important representative of the tree pollen with Ericaceae and Corylus being the dominant NAP. LPAZ SH 4h:2 can be said to represent the lower levels of the peat where Pinus pollen is still the most important tree pollen although Quercus pollen is increasing. Corylus becomes the dominant form of NAP with Ericaceae pollen. The upper levels of the peat correspond with LPAZ SH 4h:3a and LPAZ SH 4h:3b, where Quercus becomes the dominant tree pollen together with Alnus. Corylus pollen still comprises the dominant shrub pollen but Gramineae pollen have become the most important herb pollen. LPAZ SH 4h:4 correlates with stratum 6, the silty-sand where Alnus is the most important tree pollen and Gramineae the most important NAP with Corylus.

### 3:3 YARMOUTH

#### 3:3:1 Stratigraphy

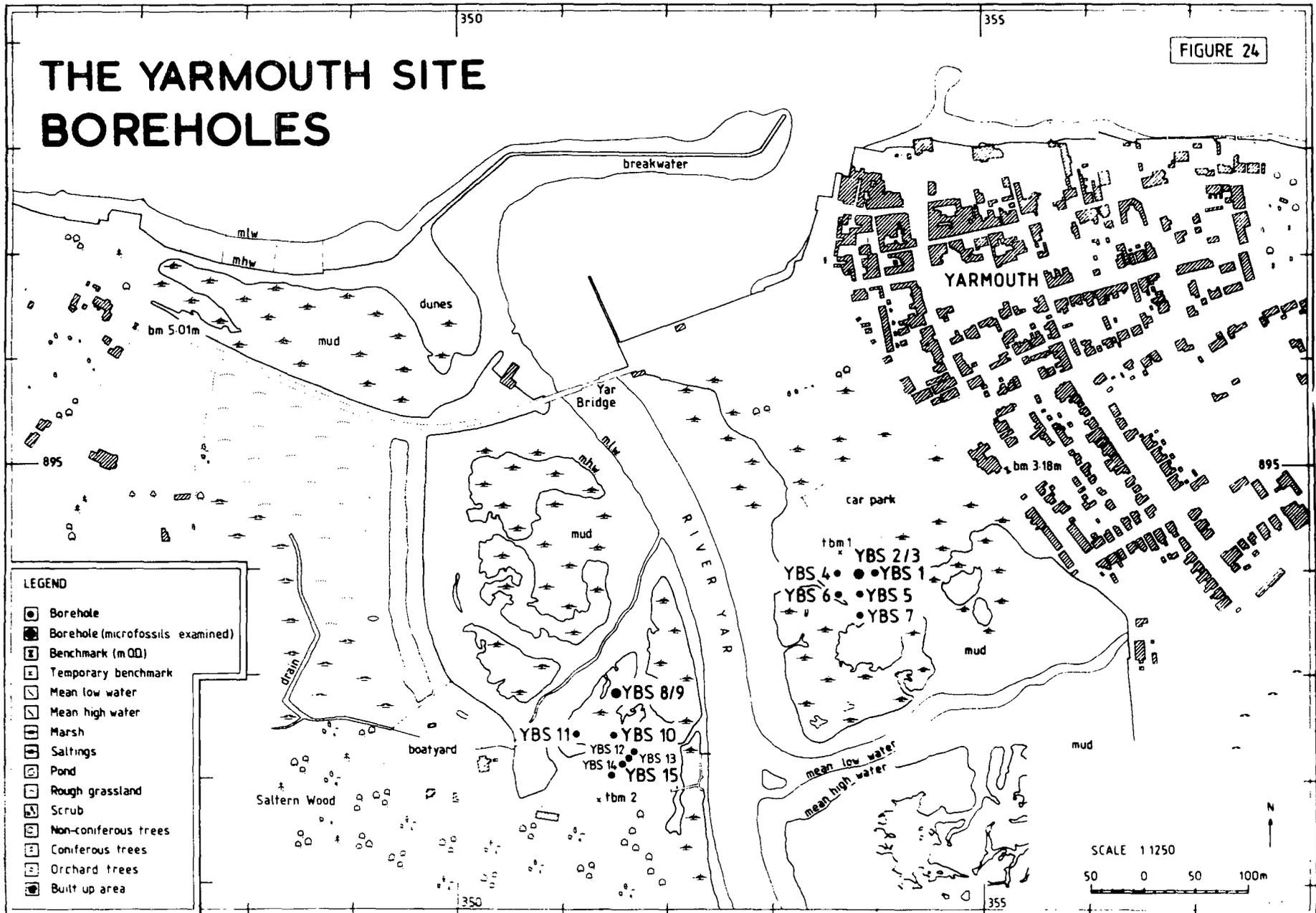
The Yarmouth site is found to the south-west of the town of Yarmouth on the Isle of Wight. The site spans the River Yar and is divided into two sections; to the east of the river is Yarmouth Carpark site and to the west is Yarmouth Boatyard site. Both sites

# YARMOUTH SITE



# THE YARMOUTH SITE BOREHOLES

FIGURE 24



## LEGEND

- Borehole
- ◼ Borehole (microfossils examined)
- ⊠ Benchmark (m OD)
- ⊞ Temporary benchmark
- ▭ Mean low water
- ▭ Mean high water
- ▭ Marsh
- ▭ Saltings
- Pond
- ▭ Rough grassland
- ▭ Scrub
- ▭ Non-coniferous trees
- ▭ Coniferous trees
- ▭ Orchard trees
- ▭ Built up area

SCALE 1:1250  
50 0 50 100m

are on the saltmarshes adjacent to the river intertidal flats. The location of these sites can be seen in Figure 23.

At Yarmouth Carpark seven boreholes were taken in a grid-like pattern (Figure 24), with a maximum of 20 m between boreholes. A regular grid pattern was impossible due to the intervening creeks. YBS 1, YBS 4, YBS 5, YBS 6, and YBS 7 were taken using the Russian-type sampler, YBS 2 was sampled with a Gouge sampler and YBS 3 was taken adjacent to YBS 2 with a Piston corer. The ground surface at Yarmouth Carpark varies in altitude from + 0.72 m.O.D. at YBS 7 to + 0.78 m.O.D. at YBS 6.

At Yarmouth Boatyard eight boreholes were taken (Figure 24). Again these were in the form of a grid. The sampling interval between the cores was under 30 m. A series of four boreholes, YBS 12 to YBS 15, were taken at 7 m intervals towards the river. YBS 10, YBS 12, YBS 13 and YBS 14 were taken with the Russian-type sampler, YBS 8, YBS 11 and YBS 15 were taken with the Gouge sampler and YBS 9 was sampled with the Piston corer, adjacent to YBS 8. The ground surface at Yarmouth Boatyard varies in altitude from + 0.74 m.O.D. at YBS 8 to + 0.91 m.O.D. at YBS 14.

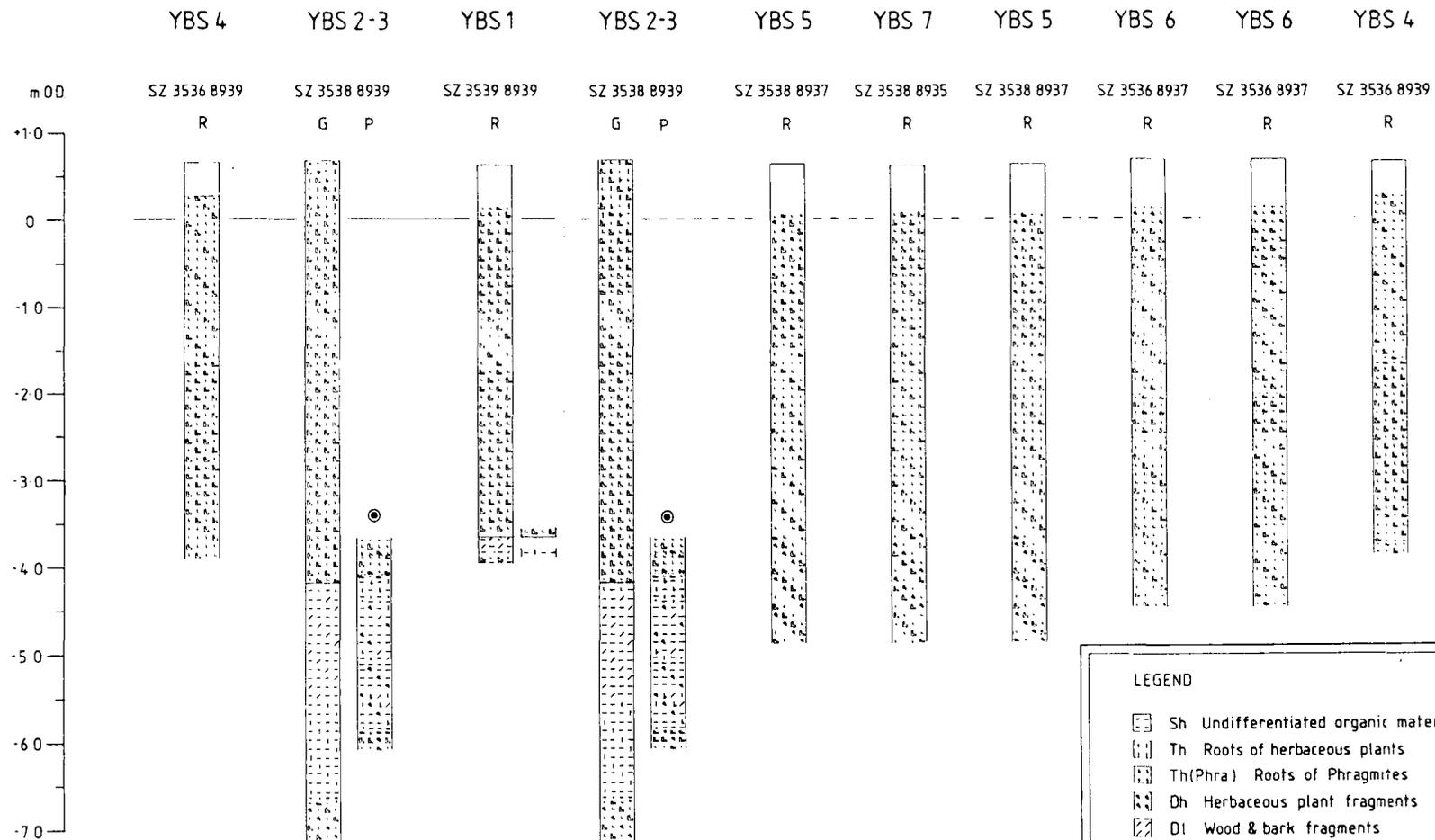
The boreholes at Yarmouth Carpark and Yarmouth Boatyard will be discussed separately in the following sections.

#### 1) Yarmouth Carpark

The stratigraphy of the seven boreholes at Yarmouth Carpark is shown in Figure 25. These boreholes have been drawn up in four ways

# YARMOUTH CARPARK STRATIGRAPHY

FIGURE 25



**LEGEND**

- Sh Undifferentiated organic material
- Th Roots of herbaceous plants
- Th(Phra) Roots of Phragmites
- Dh Herbaceous plant fragments
- Di Wood & bark fragments
- As Clay
- Ag Silt
- Ga Sand
- ⊙ Sampled for macrofossils
- G = Gouge sampler, R=Russian sampler, P=Percussion corer

Transects  
4 2/3 1  
6 5  
7

along the following gridlines.

SZ 3539 8939 to SZ 3536 8939

SZ 3538 8937 to SZ 3536 8937

SZ 3538 8939 to SZ 3538 8935

SZ 3536 8939 to SZ 3536 8937

In general, the stratigraphy of these boreholes is predominantly clastic in composition. True organic deposits are only found in YBS 1, 2 and 3 although transitional deposits are found in YBS 5, 6 and 7. The organic deposits are all found at the bottom of the boreholes and range in altitude from - 3.55 m.O.D. in YBS 1 to - 4.22 m.O.D. in YBS 2. The depth of this deposit in YBS 1 is 28 cm with a 5 cm transitional band of clayey-peat. YBS 2 displays 233 cm of this organic material. In general this organic material can be described as a mixed woody peat. The bottom transitional deposit found in YBS 2, 3, 5, 6 and 7 ranges in altitude from - 3.50 m.O.D. in YBS 7 to - 4.28 m.O.D. in YBS 6. The depth of this varies from 9 cm in YBS 6 to 123 cm in YBS 5. The transitional deposit is of a woody nature in all boreholes although it becomes more sandy in boreholes YBS 5 and 7.

The upper clastic deposit is found in all boreholes. The altitude of this varies from + 0.37 m.O.D. in YBS 4 to - 0.78 m.O.D. in YBS 5 and the depth ranges from 276 cm in YBS 5 to 429 cm in YBS 6. In general this can be described as a silt-clay with a lower sandy band in YBS 5, 6 and 7. A second sandy band is found higher up in all cores except YBS 7. YBS 1, 2, 5 and 6 all display an upper transitional deposit which can be allied with a top-soil.

The borehole YBS 3 was sampled with the Percussion corer and the material was used for further analyses. The detailed stratigraphy is

given below:

The Stratigraphy of YBS 3

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
17)	-3.55 to -3.59	433 to 437	Ag 4, As +. Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey silt.
16)	-3.59 to -3.75	437 to 453	Ag 3+, As 1-, Ga +, Lf +. Nig 2, Strf 0, Elas 0, Sicc 3, L(s) + Grey silt with dark staining.
15)	-3.75 to -3.93	453 to 471	Ag 3, As 1, Ga +, Dh +, Lf + Nig 2, Strf 1, Elas 0, Sicc 3, L(s) 1 Darker grey silt with more staining.
14)	-3.93 to -3.97	471 to 475	Ag 2, As 2, Dh +, Part.test.(moll.) + Nig 2+, Strf 2, Elas +, Sicc 3, L(s) 0 Darker grey clayey-silt.
13)	-3.97 to -4.02	475 to 480	As 2, Ag 1, Dh 1, Ga +, Dl + Nig 3, Strf 2, Elas 1, Sicc 3-, L(s) 1 Dark grey transitional layer.
12)	-4.02 to -4.26	480 to 504	Th( <u>Phrag</u> )1, Th 1, Sh 2, Dl + Nig 3+, Strf 2, Elas 2, Sicc 2, L(s) 0 Dark brown monocot. peat.
11)	-4.26 to -4.41	504 to 519	Sh 2, Dh 1, Th 1, Th( <u>Phrag</u> ) + Nig 3-, Strf 1+, Elas 1+, Sicc 2, L(s) 0 Lighter brown peat.
10)	-4.41 to -4.50	519 to 528	Sh 3, Dl 1, Dh + Nig 3, Strf 1, Elas 1+, Sicc 2, L(s) 0 Dark brown peat.
9)	-4.50 to -4.78	528 to 556	Sh 3, Dh 1, Th( <u>Phrag</u> ) + Nig 3, Strf 1, Elas 1+, Sicc 2, L(s) 0 Dark brown peat.
8)	-4.78 to -4.94	556 to 572	Dl 1, Th( <u>Phrag</u> ) 1, Sh 2, Dh + Nig 3+, Strf 2, Elas 2, Sicc 3, L(s) 0 Dark brown peat.
7)	-4.94 to -5.03	572 to 581	Sh 4, Dh +, Dl + Nig 3, Strf 1, Elas 1, Sicc 3, L(s) 0 Dark brown peat

- |    |                      |                  |  |
|----|----------------------|------------------|--|
| 6) | -5.03<br>to<br>-5.27 | 581<br>to<br>605 | Sh 3, Dh 1, Dl +<br>Nig 3, Strf 1, Elas 1, Sicc 3, L(s) 0<br>Dark brown peat.                  |
| 5) | -5.27<br>to<br>-5.52 | 605<br>to<br>630 | Dl 1, Dh 1, Th( <u>Phrag</u> ) 1, Th 1<br>Nig 3, Strf 1, Elas 1, Sicc 3, L(s) 0<br>Mixed peat. |
| 4) | -5.52<br>to<br>-5.61 | 630<br>to<br>639 | Sh 3, Dh 1, Dl +<br>Nig 3, Strf 1, Elas 1, Sicc 3, L(s) 0<br>Dark brown peat                   |
| 3) | -5.61<br>to<br>-5.74 | 639<br>to<br>652 | Sh 3, Th( <u>Phrag</u> ) 1, Dh +<br>Nig 3, Strf 1, Elas +, Sicc 3, L(s) 0<br>Dark brown peat.  |
| 2) | -5.74<br>to<br>-5.90 | 652<br>to<br>668 | As 3, Dh 1, Ag +, Dl +<br>Nig 2+, Strf 1, Elas 0, Sicc 3, L(s) 0<br>Transitional clay.         |
| 1) | -5.90<br>to<br>-5.96 | 668<br>to<br>674 | Ag 3, As 1, Lf +<br>Nig 2, Strf 0, Elas 0, Sicc 2, L(s) 0<br>Clayey-silt.                      |

Strata 3, 4, 5, 6, 7, 8, 9, 11 and 12 were sampled for pollen content. Strata 1, 2, 12, 13 and 14 were sampled for diatoms and strata 1, 2, 3, 13, 14, 15, 16 and 17 were examined for particle-size.

## 2) Yarmouth Boatyard

At Yarmouth Boatyard eight boreholes were taken. The stratigraphy of these boreholes is shown in Figure 26. These boreholes are displayed in four ways following grid-lines.

SZ 3515 8928 to SZ 3514 8920

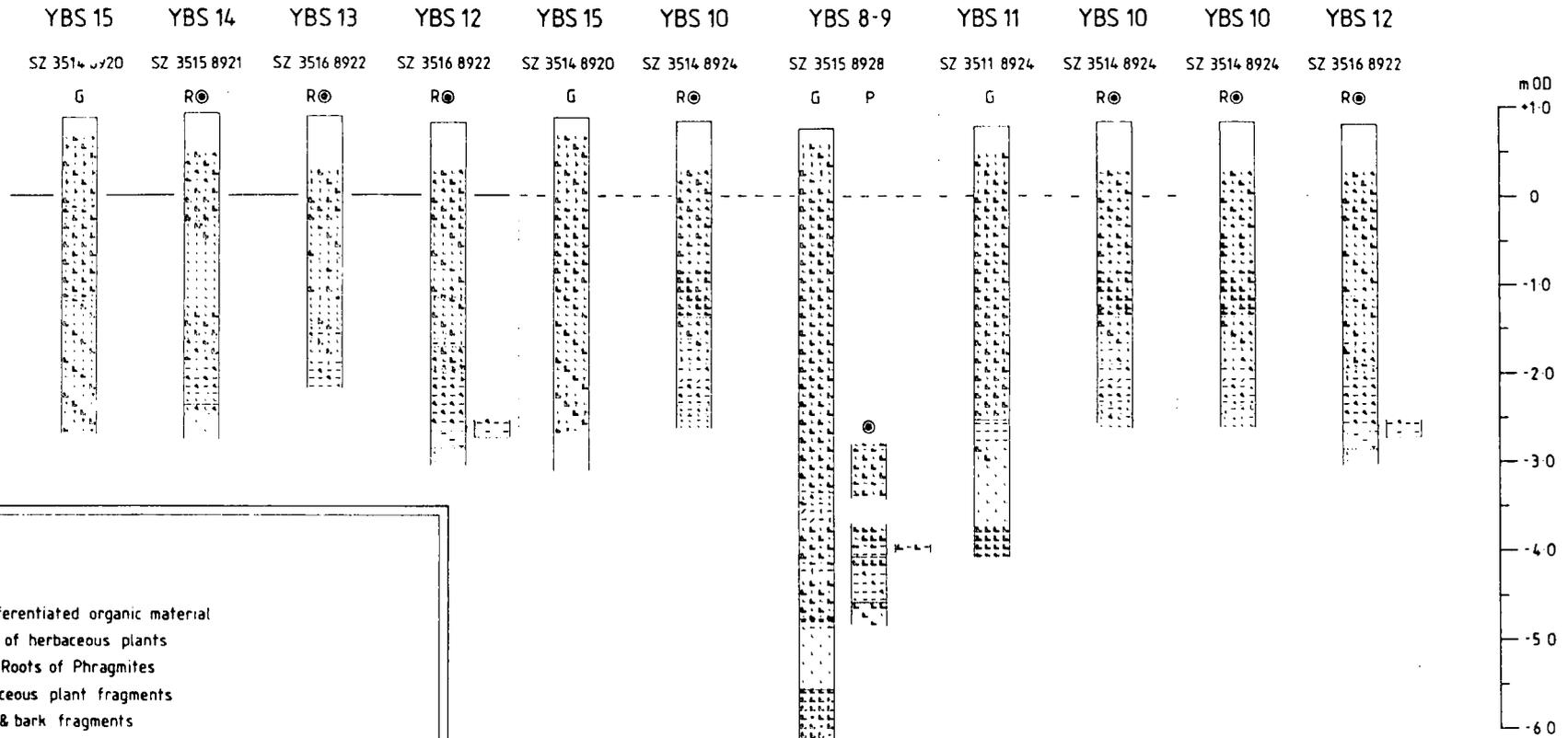
SZ 3514 8924 to SZ 3511 8924

SZ 3514 8924 to SZ 3516 8922

SZ 3516 8922 to SZ 3514 8920

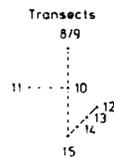
The general stratigraphy can be described as a lower and upper clastic deposit with an intercalated peat. The lower clastic deposit is found in all boreholes except YBS 13. The altitude of this ranges from

# YARMOUTH BOATYARD STRATIGRAPHY



## LEGEND

- Sh Undifferentiated organic material
- Th Roots of herbaceous plants
- Th(Phra) Roots of Phragmites
- Dh Herbaceous plant fragments
- Dl Wood & bark fragments
- As Clay
- Ag Silt
- Ga Sand
- Gg(min) Fine gravel
- Ptm Shell fragments
- Lf Iron partings
- ⊙ Sampled for macrofossils



G = Gouge sampler, R = Russian sampler  
P = Percussion corer

FIGURE 26

-2.46 m.O.D. in YBS 14 to -4.88 m.O.D. in YBS 8, and the depth varies from 5 cm in YBS 10 to 127 cm in YBS 11. This clastic band is predominantly sandy in nature, becoming more silty towards the boundary with the upper organic deposit, which overlies in all boreholes. The altitude of this organic material ranges from -1.93 m.O.D. in YBS 13 to -4.01 m.O.D. in YBS 9. Two organic bands are found in YBS 12 and YBS 9 and there are three bands in YBS 8. Again this lower peat is predominantly a woody peat although the upper peat bands show no sign of being woody.

The upper clastic deposit ranges in altitude from +0.15 m.O.D. in YBS 14 and 8 to -0.47 m.O.D. in YBS 11. The depth varies from 99 cm in YBS 10 to 344 cm in YBS 8. It is a predominantly silt-clay although a lower silty band runs through the cores YBS 12 to YBS 15. The boreholes are all overlain by a transitional band which can be correlated with a top-soil.

YBS 9, 10, 12, 13 and 14 were all sampled and taken back to the laboratory for further analyses. The detailed stratigraphy of these cores is given below.

#### The Stratigraphy of YBS 9

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
13)	-2.80 to -2.83	354 to 357	As 2, Ag 2, Lf + Nig 2+, Strf 0, Elas 0, Sicc 2+, L(s) 0 Grey silty-clay with organic staining.
12)	-2.83 to -3.09	357 to 383	As 2, Ag 2, Sh + Nig 2+, Strf 0, Elas 0, Sicc 2+, L(s) + Grey silty-clay with more organic staining.
11)	-3.09 to -3.27	383 to 401	As 2, Ag 2, Sh + Nig 2+, Strf 0, Elas 0, Sicc 2+, L(s) 0 Grey silty-clay with some organic staining.

10)	-3.27 to -3.41	401 to 415	As 3, Ag 1, Sh + Nig 2+, Strf 1, Elas 0, Sicc 2+, L(s) 0 Grey clay with less organic staining.
9)	-3.41 to -3.69	415 to 443	Not sampled.
8)	-3.69 to -3.91	443 to 465	As 3, Ag 1, Sh + Nig 2+, Strf 0, Elas 0, Sicc 2+, L(s) 0 Grey silty-clay with organic staining.
7)	-3.91 to -3.98	465 to 472	Ag 1, As 2, Sh 1, Th <sup>2</sup> (Phrag) + Nig 2+, Strf 0, Elas 0, Sicc 2+, L(s) 0 Grey transitional layer.
6)	-3.98 to -4.01	472 to 475	As 2, Sh 2, Dh + Nig 3-, Strf +, Elas 1, Sicc 2+, L(s) 0 Transitional
5)	-4.01 to -4.06	475 to 480	Sh 4 Nig 3+, Strf 1, Elas 2, Sicc 3, L(s) + Dark brown peat.
4)	-4.06 to -4.17	480 to 491	As 4, Ag +, Sh + Nig 2, Strf 0, Elas 0, Sicc 2+, L(s) 2 Clay with sharp transition.
3)	-4.17 to -4.57	491 to 531	Dh 1, Sh 3, Th(Phrag) + Nig 3+, Strf 2, Elas 2+, Sicc 3, L(s) 1+ Peat.
2)	-4.57 to -4.67	531 to 541	As 3, Ga 1, Sh +, Dh + Nig 2+, Strf 0, Elas 0, Sicc 2, L(s) 2- Grey sandy-clay.
1)	-4.67 to -4.83	541 to 556	Ga 2, As 1, Ag 1, Dh + Nig 2+, Strf 0, Elas 0, Sicc 2, L(s) 0 Orange-brown sandy layer.

Strata 2, 3, 4, 5, 6 and 7 were examined for their pollen content, strata 2, 3, 4, 5, 6, 7, 8 and 10 were looked at for diatoms and strata 1, 2, 4, 7, 8, 10, 11, 12 and 13 were tested for particle-size.

#### The Stratigraphy of YBS 10

Stratum	Height	Depth	Description
	m.O.D.	cm	
16)	+0.83	0	Topsoil

	to +0.32	to 51	
15)	+0.32 to -0.37	51 to 120	Ag 2, As 1, Dh 1, Th( <u>Phrag</u> ) + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey silt with organic staining.
14)	-0.37 to -0.59	120 to 142	As 2, Ag 2, Lf +, Dh + Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0 Blue-grey silty-clay.
13)	-0.59 to -0.70	142 to 153	Ag 2, As 1, Lf 1 Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0 Blue-grey clay with organic staining.
12)	-0.70 to -0.84	153 to 167	Ag 2, Lf 2, As + Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 0 Blue-grey sticky clay with organic staining.
11)	-0.84 to -1.36	167 to 219	As 3, Ag 1, Dh +, Dl +, Ga + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey silty-clay.
10)	-1.36 to -1.61	219 to 244	Ag 2, As 1, Dh 1, Th( <u>Phrag</u> ) +, Lf + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 1 Grey organic silt.
9)	-1.61 to -1.69	244 to 252	Ag 3, As 1, Lf +, Dh + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 1 Grey silt.
8)	-1.69 to -1.76	252 to 259	Ag 2, Sh 1, Th( <u>Phrag</u> ) 1 Nig 2+, Strf 0, Elas +, Sicc 3, L(s) + Grey organic layer - peat ball ?
7)	-1.76 to -1.87	259 to 270	Ag 2, Dh 1, Th( <u>Phrag</u> ) 1 Nig 2+, Strf 0, Elas 1, Sicc 3, L(s) + Grey organic band with <u>Phragmites</u>
6)	-1.87 to -2.03	270 to 286	Sh 2, Dh 1, Ag 1 Nig 3, Strf 0, Elas 1, Sicc 3, L(s) 1 Dark brown peat.
5)	-2.03 to -2.12	286 to 295	Sh 2, Dl 2, Dh +, Th( <u>Phrag</u> ) + Nig 3, Strf 0, Elas 1, Sicc 3, L(s) + Woody band.
4)	-2.12 to -2.36	295 to 319	Sh 2, Dh 2, Th +, Th( <u>Phrag</u> ) + Nig 3, Strf 0, Elas 1, Sicc 3, L(s) - Peat.
3)	-2.36 to -2.45	319 to 328	Dh 2, Sh 1, Ag 1, Th( <u>Phrag</u> ) + Nig 3-, Strf 0, Elas +, Sicc 3, L(s) 1 Transitional.

- 2)        -2.45     328     Ag 2, Dh 1, Sh 1, Lf +, Dl +, Th(Phrag) +  
              to        to        Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 1  
              -2.57     340     Transitional
- 1)        -2.57     340     Ag 4, Th(Phrag) +, Lf +  
              to        to        Nig 2, Strf 0, Elas 0, Sicc 3, L(s) +  
              -2.62     345     Grey silt with organic staining.

In this core strata 2, 3, 4, 5, 6, 7, 8, 9 and 10 were sampled for pollen. Strata 1, 2, 3, 6, 7, 8, 9, 10 and 11 were examined for diatoms and strata 1, 2, 3, 6, 7, 8, 9, 10 and 11 were tested for particle-size.

The Stratigraphy of YBS 12

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
18)	+0.81 to +0.31	0 to 50	Topsoil
17)	+0.31 to +0.01	50 to 80	Ag 2, As 1, Dh 1, Th( <u>Phrag</u> ) + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey organic silt.
16)	+0.01 to -0.42	80 to 123	Ag 2, As 2, Ga +, Dh +, Th( <u>Phrag</u> ) + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey silt with organic staining.
15)	-0.42 to -0.86	123 to 167	Ag 3, As 1, Lf + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey sticky silt.
14)	-0.86 to -0.99	167 to 180	Ag 3, As 1, Dh +, Dl + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey silt with organic remains.
13)	-0.99 to -1.14	180 to 195	Ag 2, As 1, Dh 1, Dl + Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) + Grey-brown organic silt.
12)	-1.14 to -1.34	195 to 215	Ag 3, As 1, Dl +, Dh + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 1 Grey organic silt.
11)	-1.34 to -1.62	215 to 243	Ag 3, As 1, Ga +, Dh +, Lf + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) + Grey clayey-silt with herbaceous remains.
10)	-1.62 to -1.70	243 to 251	Sh 2, Th <sup>2</sup> 2, Dh +, Th( <u>Phrag</u> ) + Nig 3, Strf +, Elas 1-, Sicc 2, L(s) 1 Brown peat.

9)	-1.70 to -1.94	251 to 275	Ag 2, As 1, Dh 1, Th( <u>Phrag</u> ) +, Lf + Nig 2, Strf 0, Elas +, Sicc 2, L(s) 1 Grey organic silt.
8)	-1.94 to -2.03	275 to 284	Dh 2, Ag 2, As +, Th( <u>Phrag</u> ) + Nig 3-, Strf 0, Elas +, Sicc 3, L(s) 1+ Transitional.
7)	-2.03 to -2.10	284 to 291	Sh 2, Th( <u>Phrag</u> ) 1, Dh 1 Nig 3+, Strf 0, Elas 1, Sicc 3, L(s) + Brown peat with <u>Phragmites</u> .
6)	-2.10 to -2.60	291 to 341	Sh 2, Dh 2, Th( <u>Phrag</u> ) + Nig 3, Strf 0, Elas 1+, Sicc 3, L(s) 0. Brown peat.
5)	-2.60 to -2.62	341 to 343	Sh 3, Dh 1 Nig 3, Strf 0, Elas 1, Sicc 3, L(s) 0 Dark peat
4)	-2.62 to -2.65	343 to 346	Ga 2, Sh 2, Dh +, Ag + Nig 3-, Strf 0, Elas 0, Sicc 3, L(s) + Sandy transition.
3)	-2.65 to -2.84	346 to 365	Ga 3, Ag +, Sh 1 Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 1 Sandy bed with some organic.
2)	-2.84 to -2.94	365 to 375	Ga 3, Ag 1, Dh + Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 1 Sandy-silt with some organic.
1)	-2.94 to -3.04	375 to 385	Ga 4, Lf + Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) + Sandy bedrock

At YBS 12 strata 4, 5, 6, 7, 8, 9 and 10 were sampled for their pollen content while strata 3, 7, 8, 9 and 11 were sampled for diatoms.

#### The Stratigraphy of YBS 13

<u>Stratum</u>	<u>Height</u>	<u>Depth</u>	<u>Description</u>
	m.O.D.	cm	
15)	+0.88 to +0.33	0 to 55	Topsoil
14)	+0.33 to -0.03	55 to 91	Ag 2, Th 1, As 1, Th( <u>Phrag</u> ) + Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey organic silt.

13)	-0.03 to -0.34	91 to 122	As 2, Ag 2, Part.test(moll.) +, Th( <u>Phrag</u> ) +, Th + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey silty-clay with organic remains.
12a	-0.34 to -0.72	122 to 160	Ag 3, As 1, Lf + Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0 Blue-grey silt with organic staining.
11)	-0.72 to -0.77	160 to 165	Ag 4, As +, Part.test(moll.) +, Ga + Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 1 Blue-grey silt. Silt ball ?
12b)	-0.77 to -0.89	165 to 177	Ag 3, As 1, Lf + Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 0 Blue-grey silt with organic staining.
10)	-0.89 to -0.97	177 to 185	Ag 4, Ga +, Lf + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) + Blue silt.
9)	-0.97 to -1.12	185 to 200	As 2, Ag 2, Ga +, Dh + Nig 2, Strf 0, Sicc 3, Elas 0, L(s) + Silt-clay.
8)	-1.12 to -1.21	200 to 209	Lf 1, Th 1, Ag 2, As +, Dh + Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) + Grey organic silt with black staining.
7)	-1.21 to -1.36	209 to 224	Ag 4, As +, Lf +, Dh + Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) + Blue-grey silt.
6)	-1.36 to -1.46	224 to 234	Ag 3, As 1, Dh +, Lf + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) + Grey silt.
5)	-1.46 to -1.53	234 to 241	Dh 1, Ag 2, As 1 Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 1 Organic silt.
4)	-1.53 to -1.61	241 to 249	Ag 2, Sh 2, Th( <u>Phrag</u> ) + Nig 3-, Strf 0, Elas +, Sicc 3, L(s) + Peat ball ??
3)	-1.61 to -1.84	249 to 272	Ag 3, As 1, Dh +, Th( <u>Phrag</u> ) + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) Silt.
2)	-1.84 to -1.93	272 to 281	Dh 1, Sh 2, Ag 1, Th( <u>Phrag</u> ) + Nig 3-, Strf 0, Elas 1, Sicc 3, L(s) 1 Dark organic with silt.
1)	-1.93 to -2.17	281 to 305	Sh 3, Dh 1 Nig 3+, Strf 0, Elas 1+, Sicc 3, L(s) + Peat.

At YBS 13 strata 1, 2, 3, 4, 5 and 6 were sampled for pollen and strata 2, 3, 4, 5, 6 and 7 were examined for diatoms.



The Stratigraphy of YBS 14

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
12)	+0.91 to +0.50	0 to 41	Topsoil
11)	+0.50 to +0.15	41 to 76	Ag 2, Dh 1, Dl +. As 1, Th( <u>Phrag</u> ) +, Th + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 0 Grey organic silt.
10)	+0.15 to -0.30	76 to 120	As 2, Ag 2, part.test(moll.) +, Th( <u>Phrag</u> ) +, Dh + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) + Grey silty-clay with <u>Phragmites</u> .
9)	-0.30 to -0.50	120 to 140	Ag 3, As 1, Lf +, Th + Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 1 Grey-blue silt with black banding.
8)	-0.50 to -1.32	140 to 222	Ag 4, As +, Lf + Nig 2-, Strf 0, Elas 0, Sicc 3, L(s) 1 Grey-blue sticky silt.
7)	-1.32 to -1.62	222 to 252	As 2, Ag 2, Ga +, Dh +, Lf + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) + Grey silty-clay with wood.
6)	-1.62 to -1.87	252 to 277	Dh 1, Ag 2, As 1 Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 1 Grey organic silt.
5)	-1.87 to -2.05	277 to 295	Ag 1, Sh 2, Dh 1, Th( <u>Phrag</u> ) + Nig 3, Strf 0, Elas 1, Sicc 3, L(s) 1 Transitional peat.
4)	-2.05 to -2.25	295 to 315	Sh 2, Dh 2, Th( <u>Phrag</u> ) +, Th + Nig 3, Strf 0, Elas 0, Sicc 3, L(s) 0 Peat.
3)	-2.25 to -2.36	315 to 326	Ag 4, Dh +, As + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) - Silt
2)	-2.36 to -2.46	326 to 336	Ag 2, Dh 2, Ga + Nig 2+, Strf 0, Elas 0, Sicc 3, L(s) 2 Grey transitional peaty-silt.
1)	-2.46 to -2.75	336 to 365	Ag 1, Ga 3, Dh + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 1 Bedrock.

At YBS 14 strata 2, 3, 4, 5 and 6 were sampled for their pollen content and strata 1, 2, 3, 5 and 6 for their diatoms.

### 3:3:2 Particle-size Analysis

At the Yarmouth sites, three boreholes, YBS 3, YBS 9 and YBS 10 were examined for their particle-size distribution in order to assess the validity of the Troels-Smith method of stratigraphic analyses of inorganic layers. The results of these analyses are discussed below.

#### 1) YBS 3

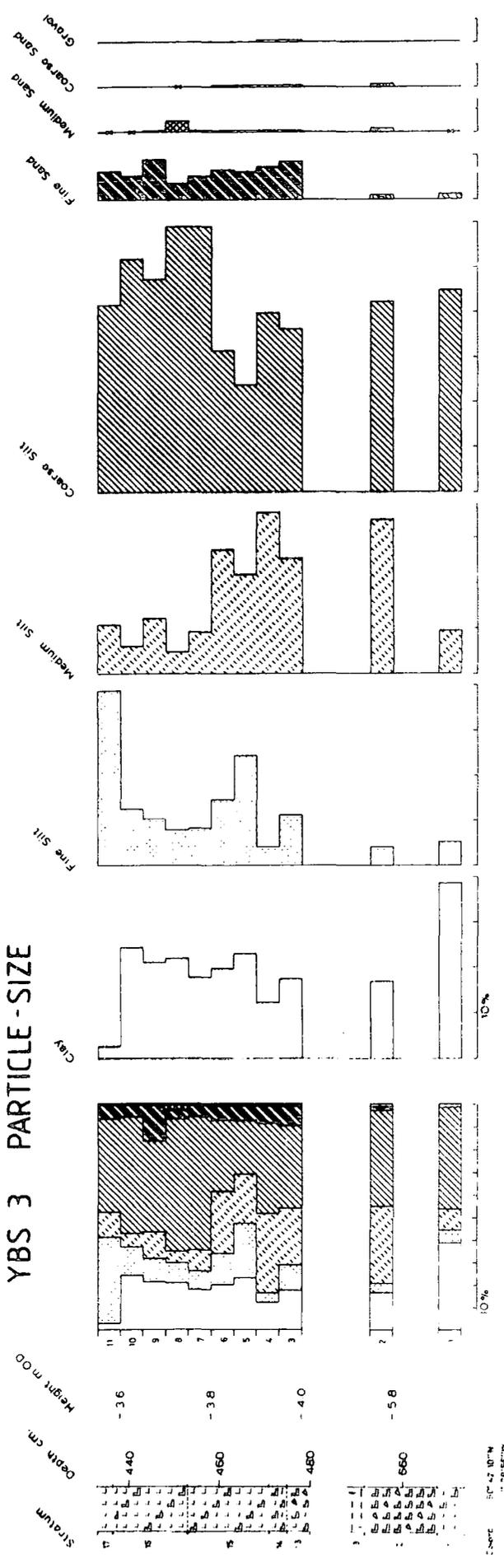
At YBS 3 six strata were sampled for their particle-size distribution; strata 1, 13, 14, 15, 16 and 17. In total ten samples were taken, one from the lower clastic deposit and nine from the upper one. The samples were chosen in order to test the validity of the description given to the cores using the Troels-Smith notation of stratigraphic analysis. The results of this analysis can be seen in Figure 27 and are tabulated below, together with the Troels-Smith classification of results.

Table 12 Particle-size Analysis of YBS 3

Sample	Altitude (m.O.D.)	%Clay	%Silt	%Sand	%Gravel
11	-3.55 to -3.60	2.5 (+)	91.1 (100)	6.4 (-)	- (-)
10	-3.60 to -3.65	24.3 (25)	70.3 (75)	5.5 (+)	- (-)
9	-3.65 to -3.70	21.1 (25)	69.7 (75)	9.3 (+)	- (-)
8	-3.70 to -3.75	21.9 (25)	71.9 (75)	6.2 (+)	- (-)
7	-3.75 to -3.80	17.8 (25)	76.8 (75)	5.5 (+)	- (-)
6	-3.80 to -3.85	19.8 (25)	73.2 (75)	7.1 (+)	- (-)
5	-3.85 to -3.90	23.0 (25)	70.1 (75)	6.9 (+)	- (-)
4	-3.90 to -3.95	12.3 (50)	79.6 (50)	7.9 (-)	0.2 (-)
3	-3.95 to -4.00	17.5 (50)	73.2 (25)	9.0 (+)	0.3 (-)
1	-5.90 to -5.95	38.7 (25)	60.2 (75)	1.2 (-)	- (-)

FIGURE 27

### YBS 3 PARTICLE-SIZE



Stratum  
Depth cm.  
Height m. O.D.

Scale 1:1000  
Date 11/25/59  
Sheet 25 of 25  
Project 60115

The results show that there is an apparent difference between the upper and lower clastic deposits. The lower clastic deposit is surprisingly finer in nature than would be expected from the results of the Troels-Smith analysis, due to its proximity to bedrock. The highest recorded clay fraction is found in sample 1 and the lowest sand fraction is also in this sample. This analysis shows that strata 13 and 14 are separate lithological units with a decrease in clay and sand from stratum 13 to stratum 14. The separation of stratum 15 from 16 is not so apparent but as the Troels-Smith notation shows, the two strata are distinct purely on a basis of the presence of organic material in stratum 15. Stratum 17 is unique with a very high silt content and a considerable drop in clay.

The results of the Troels-Smith analysis of the borehole shows that the lower clastic deposit is a clayey-silt. Once again strata 13 and 14 are shown to be separate units with stratum 13 finer in nature than stratum 14, although this is shown by an increase in silt to stratum 14 and a decrease in sand, and not by a decrease in clay. Again strata 15 and 16 are shown to be identical while stratum 17 is distinctly more silty in nature with just traces of clay.

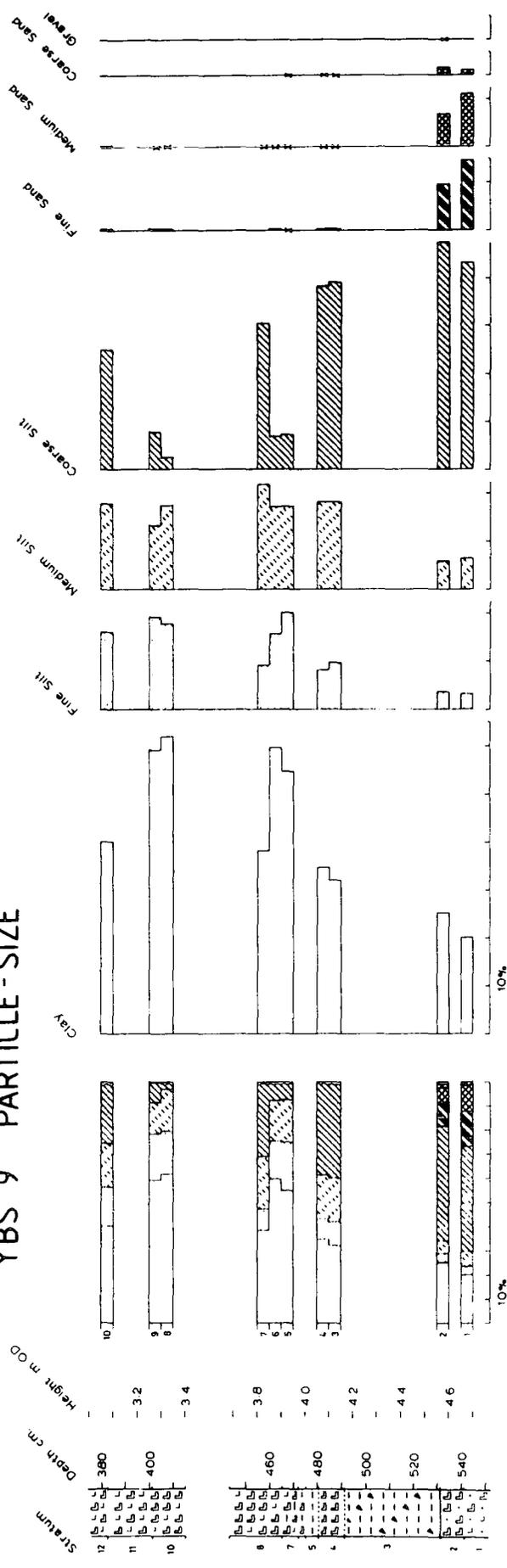
In conclusion the lithological divisions imposed using the Troels-Smith notation of stratigraphic analysis hold true when tested by particle-size analysis in most instances.

## 2) YBS 9

At YBS 9 seven strata were sampled for particle-size analysis; 1, 2, 4, 7, 8, 10, and 12. Ten samples were taken from the core, two from the lower clastic deposit and eight from the upper elastic deposits. These

FIGURE 28

# YBS 9 PARTICLE - SIZE



Coord. 50° 27' 05" N  
 1° 30' 08" W  
 Grid ref. 52 3515 8928  
 Fieldwork 801116

samples were chosen in order to identify separate lithological strata, as shown by the analysis of the core using the Troels-Smith scheme. The results of this particle-size analysis are summarised below, together with the Troels-Smith classification of the deposit, and shown in Figure 28.

Table 13 Particle-size Analysis of YBS 9

Sample	Altitude (m.O.D.)	%Clay	%Silt	%Sand	%Gravel
10	-3.05 to -3.10	40.2 (50)	59.2 (50)	0.6 (-)	- (-)
9	-3.25 to -3.30	59.0 (75)	40.5 (25)	0.5 (-)	- (-)
8	-3.30 to -3.35	61.8 (75)	37.8 (25)	0.4 (-)	- (-)
7	-3.80 to -3.85	38.2 (75)	61.5 (25)	0.3 (-)	- (-)
6	-3.85 to -3.90	59.6 (75)	39.9 (25)	0.5 (-)	- (-)
5	-3.90 to -3.95	54.9 (50)	44.8 (25)	0.3 (-)	- (-)
4	-4.05 to -4.10	34.7(100)	65.0 (+)	0.3 (-)	- (-)
3	-4.10 to -4.15	32.1(100)	67.5 (+)	0.5 (-)	- (-)
2	-4.55 to -4.60	25.2 (75)	56.7 (-)	17.4(25)	0.7(-)
1	-4.65 to -4.70	20.1 (25)	53.1 (25)	26.8(50)	- (-)

In general, these results show that the lower clastic deposit of strata 1 and 2 is much coarser than the upper clastic one. This is consistent with the high percentages of sand found in samples 1 and 2. It is interesting to note that the lower deposit also becomes finer, in particle-size, toward the intercalated organic deposit. Samples 3 and 4, immediately above the organic deposit, are more coarse in nature than the rest of the upper clastic deposit. Samples 3 and 4 are very similar in particle-size as they are taken from the same stratum. Sample 5 is taken from above the upper organic deposit and is found to be coarser than sample 6, which lies at the base of the upper clastic material. Samples 6 and 7 could be expected to show a close correlation as they are

taken from the same stratum, but this is not the case as the samples get coarser away from the organic deposit. Samples 8 and 9 are taken from the stratum which lies above the break in the stratigraphy of the core. These two samples show a similarity of results with a distinct fine nature. The last sample, number 10, shows a reversal to a dominance of silt.

When the Troels-Smith classification of the strata is examined, once again we see that samples 1 and 2 from the lower clastic deposit are distinctly different from the rest of the samples, with a high proportion of sand, although the samples become finer towards the organic deposit above. The upper clastic deposit shows a fine nature in samples 3 and 4. Sample 5 is coarser than the rest of the samples. Strata 8 and 10 appear to be identical in composition while sample 10 shows a levelling out of the particle-sizes into clay-silt.

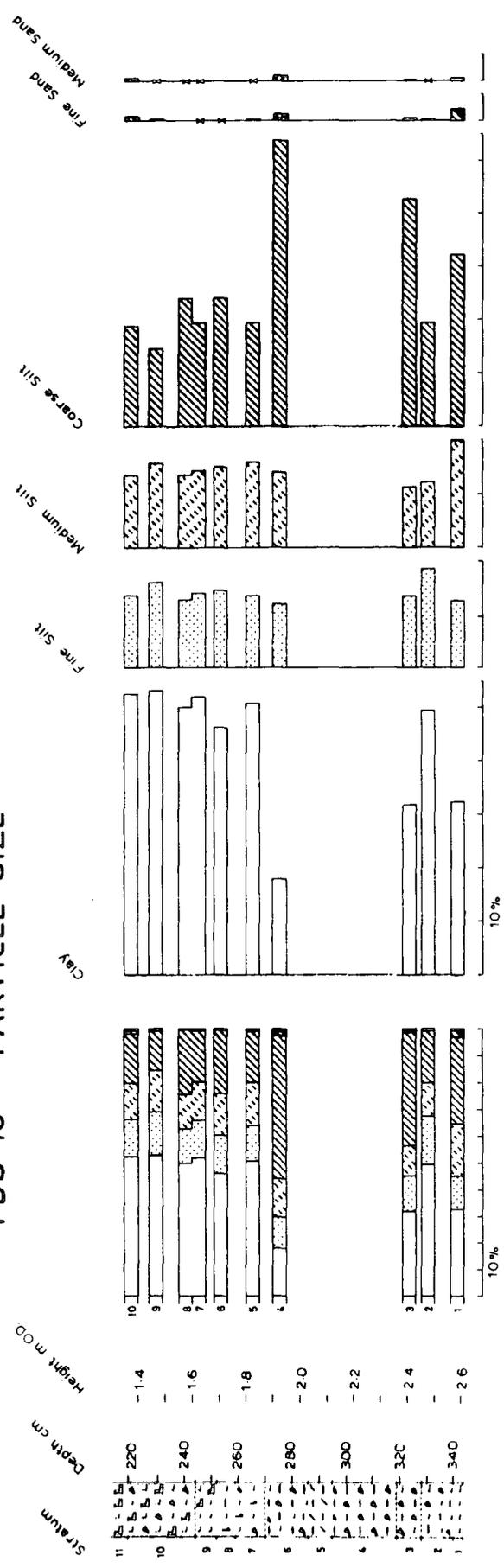
The major distinction between the two classifications of Troels-Smith and particle-size is that the particle-size method shows samples 3 and 4 to be coarser than the rest of the upper clastic deposit, but the Troels-Smith method indicates that these samples are the finest in the core. It can be concluded that YBS 9 has a coarse lower clastic deposit with a finer upper one.

### 3) YBS 10

The last core from Yarmouth to be analysed for particle-size was YBS 10. Here eight strata were examined; 1, 2, 3, 6, 7, 8, 9 and 10. Ten samples were taken from this core, three samples from the lower transitional deposit and seven from the upper transitional one. Only two pure clastic strata were sampled, 1 and 9. The results of this analysis

FIGURE 29

# YBS 10 PARTICLE-SIZE



Co-ops: 5042, 041, N  
 30, 081, W  
 Grid no.: 50, 35, 4, 852,  
 File no.: 81228

are shown below together with the Troels-Smith description, and in Figure 29.

Table 14 Particle-size Analysis of YBS 10

Sample	Altitude	%Clay	%Silt	%Sand
10	-1.35 to -1.40	52.6 (25)	46.0 (50)	1.4 (-)
9	-1.44 to -1.49	53.3 (25)	46.2 (50)	0.5 (-)
8	-1.55 to -1.60	50.0 (25)	50.0 (50)	0.1 (-)
7	-1.60 to -1.65	52.0 (25)	47.8 (75)	0.2 (-)
6	-1.68 to -1.73	46.3 (-)	53.7 (50)	0.1 (-)
5	-1.80 to -1.85	50.8 (-)	48.8 (50)	0.4 (-)
4	-1.90 to -1.95	18.1 (-)	79.8 (25)	2.2 (-)
3	-2.38 to -2.43	31.8 (-)	67.5 (25)	0.7 (-)
2	-2.45 to -2.50	49.4 (-)	50.2 (50)	0.4 (-)
1	-2.56 to -2.61	32.4 (-)	64.8(100)	2.8 (-)

These results show that the lower transitional deposit is coarser than the upper one, above the intercalated organic deposit. The highest recorded sand content is found in stratum 1. Sample 4 from stratum 6 is unique in this core with very high silt and low clay fractions. The dominance of the silt is lost in sample 5 but returns briefly in sample 6, which is the sample below the true clastic stratum of sample 7 where clay once again is dominant. Samples 8, 9 and 10 show relative uniformity with near equal parts of silt and clay. These last three samples were all taken from stratum 10.

These results of the Troels-Smith classification again show that the lower transitional deposit is coarser than that above the organic deposit. The two samples 3 and 4, bordering the organic material, show only one unit of silt. This increases to two units in the next two samples, 5 and

6, below the clastic sample 7. The latter shows an increase in silt with the introduction of clay. This clay remains through the last stratum sampled, while the silt is reduced.

The correlation between the Troels-Smith analysis and the particle-size test is very poor, although in both methods the lower samples are shown to be coarser. The largest difference is found in sample 3 where particle-size shows a high proportion of silt and clay although the Troels-Smith analysis indicates that this sample is from a stratum with a predominance of organic material and only one part silt. The disagreement between the two methods may be explained by the mixed nature of the material sampled. As mentioned previously, there are only two true clastic strata and these are thin bands of 5 cm and 9 cm.

By examining all three cores sampled, it can be seen that the core to the east of the River Yar, YBS 3, is far sandier in comparison with YBS 9 and 10, to the west of the river. There is relatively uniform dominance of silt throughout the cores but most importantly the lower clastic deposit found in all three cores is shown to be coarser than the upper clastic material.

### 3:3:3 Pollen Analyses

At Yarmouth, six boreholes were chosen in order to study their pollen content; YBS 3, YBS 9, YBS 10, YBS 12, YBS 13 and YBS 14. These cores were selected as they were the only ones with sufficient organic material for a reliable analysis.

1) YBS 3

At YBS 3 the organic deposit between the upper and lower clastic deposits was sampled for pollen. This organic deposit can be described as a herbaceous peat and consists of ten strata; 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12. Sixteen levels were sampled through these strata. The sampling interval through the main body of peat was 10 cm with an interval of 2 cm over the upper and lower transitions. These levels are 1) -651, 2) -649, 3) -647, 4) -645, 5) -640, 6) -620, 7) -600, 8) -580, 9) -560, 10) -540, 11) -520, 12) -510, 13) -504, 14) -502, 15) -500 and 16) -498 cm. Six local pollen assemblage zones (YBS 3:1 to YBS 3:6) have been identified where major changes occur in the pollen curves. These are described below. The data from this analysis can be found in Appendix IV and seen in Figure 30. The data are displayed as percentages of the total land pollen (TLP) for comparison with other sites. Data on dry-land pollen has been included for relative dating purposes.

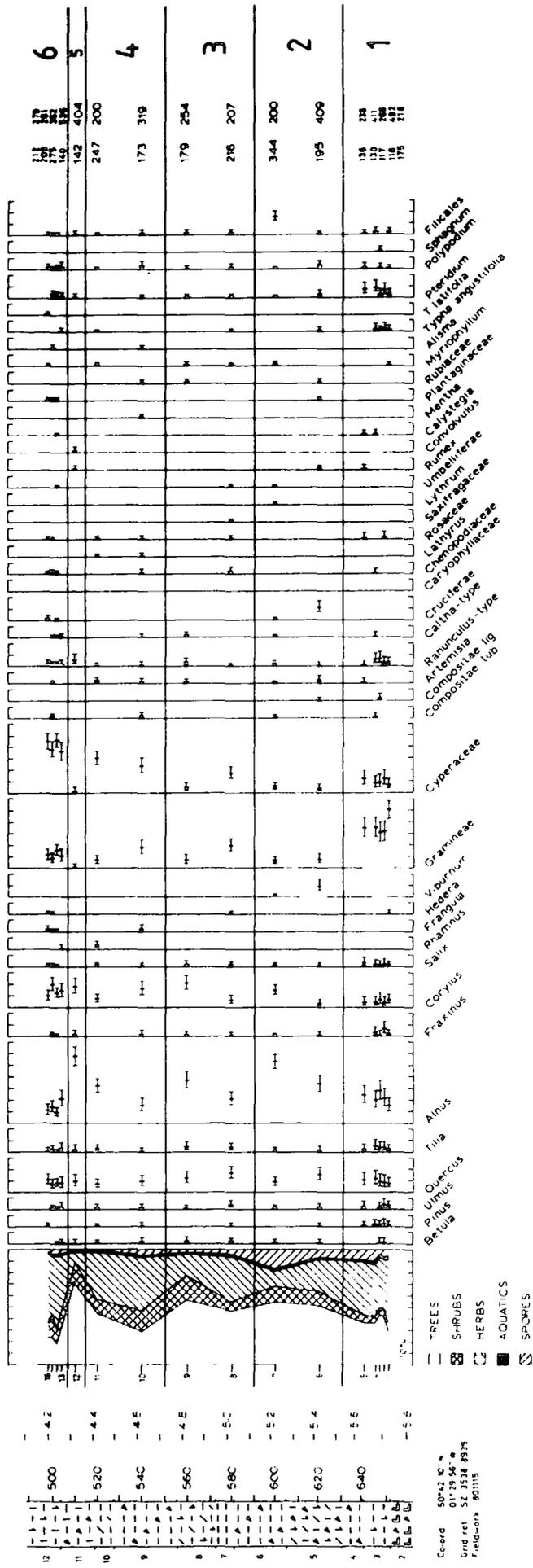
LPAZ YBS 3:1 -651 cm to ca.-630 cm

The herb pollen are dominant in this zone although they decrease to the top of the zone as trees increase. The most important tree pollen comes from Alnus with 27.9% TLP at -647 cm and Quercus with 11.7% TLP at -645 cm, both are increasing. Fraxinus pollen attains 6.5% TLP at -649 cm. Other dominant taxa are Gramineae with 50% TLP at -651 cm and Cyperaceae with 12.1% TLP at -640 cm. Corylus and Ranunculus-type pollen both have 6.3% TLP at -651 cm and -647 cm. The major dry-land tree pollen comes from Quercus with 28% of trees at -645 cm, Fraxinus with 14% of trees at -649 cm, Tilia with 12% of trees at -645 cm and Ulmus with 10% of trees at -651 cm. Sphagnum spores are only found in this zone and Calystegia pollen disappears to return

FIGURE 30

YBS 3 %Total Land Pollen

Depth cm  
Height mcs  
Stratum  
Total pollen  
Lycopodium



- Coord 50°42' N
- Grid ref 01 29 94
- Grid ref 52 3538 8934
- Field-no 80115
- Legend: TREES, SHRUBS, HERBS, AQUATICS, SPORES
- Taxa: Betula, Pinus, Quercus, Tilia, Alnus, Fraxinus, Corylus, Salix, Prunus, Fraxinus, Hedera, Viburnum, Gramineae, Cyperaceae, Compositae, Lig, Artemisia, Ranunculaceae, Caltha-type, Cruciferae, Caryophyllaceae, Chenopodiaceae, Liliaceae, Rosaceae, Saxifragaceae, Lithium, Umbelliferae, Rubeae, Convulsiaceae, Calystegia, Menyanthes, Rubiaceae, Myricaceae, Alnus, Myrica, Typha angustifolia, Pteridium, Polypodium, Sphagnum, Filicales

again at the top of the core. The concentration of Gramineae is  $40.2 \times 10^2$  grains/cc at -651 cm and Alnus has  $12.6 \times 10^2$  grains/cc at -647 cm. The upper boundary was placed where Alnus pollen increases from 24.4% TLP to 34.1% TLP, Gramineae drops from 34.9% TLP to 7.8% TLP and Cyperaceae also drop from 12.2% TLP to 3.9% TLP.

LPAZ YBS 3:2 ca.-630 cm to ca.-590 cm

Tree pollen takes over in dominance in this zone with over 50% of total pollen. Herb pollen continues to decrease to -600 cm. At this level the maximum count of spores is found. The dominant tree pollen are once again from Alnus with 53.2% TLP at -600 cm and Quercus with 15.6% TLP at -620 cm. Cruciferae pollen first appears with 11.2% TLP at -620 cm but quickly drop to 0.4% TLP at -600 cm. The rise of spores in this zone is caused by Filicales which record 16.3% TLP + Spores at -600 cm. The major dry-land tree pollen comes from Quercus with 28% of trees at -620 cm and from Ulmus and Tilia both with 3% of trees at -620 cm. Viburnum pollen is only found in this zone with 9.5% TLP at -620 cm. Cruciferae and Lythrum pollen are also only found here. The concentration of Alnus pollen reaches  $80.8 \times 10^2$  grains/cc at -600 cm while Corylus and Filicales both have concentrations in the  $20 \times 10^2$ s grains/cc. The upper boundary was marked where Alnus drops from 53.2% TLP to 21.2% TLP, Quercus pollen increases from 8.9% TLP to 16.7% TLP, Corylus pollen drops from 14.6% TLP to 6.4% TLP, Gramineae and Cyperaceae both show large increases and Filicales show a large decrease.

LPAZ YBS 3:3 ca.-590 cm to ca.-550 cm

Tree pollen is still dominant in this zone while herb pollen begins to rise to the top of the zone. The most important tree pollen is Alnus with 37.2% TLP at -560 cm and Quercus with 16.7% TLP at

-580 cm. Corylus pollen is again the dominant NAP with 20.9% TLP at -560 cm. Gramineae has 19.6% TLP at -580 cm and Cyperaceae has 17.2% TLP at -580 cm. The major dry-land tree taxa are Quercus with 34% of trees at -580 cm, Tilia with 8% of trees at -560 cm, Ulmus with 8% of trees at -580 cm and Betula with 8% of trees at -560 cm. Although Corylus pollen is the dominant NAP gramineae has the greatest concentration with  $21 \times 10^2$  grains/cc, while Corylus has  $15.4 \times 10^2$  grains/cc. Alnus has a high concentration with  $27.3 \times 10^2$  grains/cc. The upper boundary was placed where Alnus pollen decreases from 37.2% TLP to 15.4% TLP, Gramineae increase from 6.9% TLP to 17.9% TLP and Cyperaceae increase from 4.6% TLP to 23.5% TLP.

LPAZ YBS 3:4 ca.-550 cm to ca.-515 cm

At the base of this zone herb pollen is dominant but this is replaced by tree pollen at the top. Alnus pollen with 32.4% TLP at -520 cm is increasing while Quercus pollen with 9.3% TLP at -540 cm is decreasing. The other dominant taxa are Cyperaceae with 30.3% TLP at -520 cm, Gramineae with 17.9% TLP at -540 cm and Corylus with 16.1% TLP at -540 cm. The major dry-land trees are Quercus with 30% of trees at -540 cm, Tilia with 7.3% of trees at -520 cm and Betula and Fraxinus with 6% of trees at -540 cm. Mentha and Lathyrus pollen are only found in this zone. The concentration of Alnus increases from  $8.5 \times 10^2$  to  $42.3 \times 10^2$  grains/cc in this zone while Cyperaceae have a concentration of  $39.6 \times 10^2$  grains/cc at -520 cm. The upper boundary was placed where Pinus and Ulmus pollen disappear. Alnus pollen rises from 32.4% TLP to 57.9% TLP, Corylus pollen increases from 7.5% TLP to 17.9% TLP and Gramineae and Cyperaceae show very sharp decreases.

LPAZ YBS 3:5 ca.-515 cm to ca.-507 cm

Tree pollen is dominant in this zone with over 70% of total pollen.

The dominant tree taxa are Alnus with 57.9% TLP and Quercus with 9.3% TLP. Corylus pollen reaches 17.9% TLP and Ranunculus-type also show high percentages. The major dry-land tree pollen comes from Quercus with 26% of trees, Tilia with 6% of trees and Fraxinus with 4% of trees. Convolvulus pollen is only found in this zone. Although Alnus pollen reaches its highest recorded percentage in this zone, the concentration of the taxon is relatively low with  $21.8 \times 10^2$  grains/cc. The upper boundary is marked by a decrease in Alnus from 57.9% TLP to 21.3% TLP and a sharp increase in Gramineae and Cyperaceae.

LPAZ YBS 3:6 ca.-507 cm to -498 cm

Tree pollen declines sharply in this zone with a dominance of herb pollen over 50% of total pollen. The most important tree taxa are Alnus with 21.3% TLP at -504 cm and Quercus with 11.2% TLP at -498 cm. Cyperaceae are the dominant NAP with 45.4% TLP at -498 cm. Corylus pollen reaches 19.8% TLP at -500 cm and Gramineae have 15.8% TLP at -502 cm. The major dry-land tree pollen is from Quercus with 46% of trees at -498 cm and Tilia with 10% of trees at -500 cm. Typha latifolia is only found in this zone while Hedera, Frangula, Cruciferae and Calystegia pollen all reappear.

These zones can tentatively be correlated with the lithological strata of YBS 3. LPAZ YBS 3:1 can be said to represent strata 3 and 4. Herb pollen are found to be dominant at the base of this zone, while tree pollen increase to the top. This change in dominance can be explained by the change in stratigraphy from the herbaceous peat of stratum 3 to the more woody peat of stratum 4. LPAZ YBS 3:2 is a zone where tree pollen is dominant and corresponds to the mixed woody strata 5 and 6. LPAZ YBS 3:3 also shows a dominance of tree pollen with a rising importance of herb pollen to the top. This correspond to strata

7 and 8. LPAZ YBS 3:4 correlates with the upper half of stratum 9, stratum 10 and the lower parts of stratum 11. The dominant taxa changes from herb pollen at the base to tree pollen at the top. LPAZ YBS 3:5 can correlate with the upper levels of stratum 11 which has been shown to be dominated by tree pollen. The last zone, LPAZ YBS 3:6 corresponds to stratum 12, the herbaceous peat, where herb pollen is once again dominant.

In conclusion we can see that the organic material is herbaceous at the base, in stratum 3, passing into a woody peat with Alnus pollen dominant in strata 5, 6, 7 and 8. Stratum 9 is again a herbaceous peat with Cyperaceae dominant. Alnus returns to dominance in stratum 11 before Cyperaceae reappears in stratum 12.

YBS 3 was chosen to represent the Carpark site at Yarmouth as it reveals the deepest peat deposit.

Dating of the LPAZ at YBS 3.

The peat at YBS 3 ranges in altitude from -4.02 m.O.D. (-480 cm) to -5.74 m.O.D. (-652 cm). Six LPAZ were recognised and are summarised below (Table 15) with the dominant AP and NAP.

The frequency of Quercus pollen is greater than 60% of trees throughout these LPAZ, reaching 89% of trees in LPAZ YBS 3:6. The frequency of Alnus pollen is also high, over 60% of trees, reaching 81% of trees in LPAZ YBS 3:5. Tilia pollen is present throughout the LPAZ indicating an early age, probably Flandrian Chronozone II or the early part of Flandrian III. A tentative division between FII and FIII is proposed at -5.50 m.O.D. based on decreasing Ulmus values, increasing Corylus pollen and an increase in the pollen of herbaceous taxa. LPAZ YBS 3:2 to LPAZ YBS 3:6 are thought to belong to the early part of FIII as Tilia pollen is still present.

Table 15 Dating of LPAZ at YBS 3

Flandrian Chronozone	LPAZ	Altitude (m.O.D.)	Depth (cm)	Dominant life group	Dominant AP	Dominant NAP
III	Y3:6	-4.18 to -4.27	-498 to -507	Herbs	Q-A-T- U	Co-Cy- Pt-Gr
	Y3:5	-4.27 to -4.35	-507 to -515	Trees	A-Q-T- Fr	Co
	Y3:4	-4.35 to -4.70	-515 to -550	Herbs	A-Q-T- B+U+Fr	Cy-Co Gr
	Y3:3	-4.70 to -5.10	-550 to -590	Herbs & Trees	A-Q-T- U	Co-Gr Cy
	Y3:2	-5.10 to -5.50	-590 to -630	Trees	A-Q-T+ B	Fi-Co-Vi- Gr-Cr
II	Y3:1	-5.50 to -5.71	-630 to -651	Herbs	Q-A-Fr- T=U	Gr-Pt- Co-Cy

Q=Quercus, A=Alnus, T=Tilia, U=Ulmus, Fr=Fraxinus, B=Betula, Co=Corylus,  
Cy=Cyperaceae, Pt=Pteridium, Gr=Gramineae, Fi=Filicales, Vi=Viburnum,  
Cr=Cruciferae.

2) YBS 9

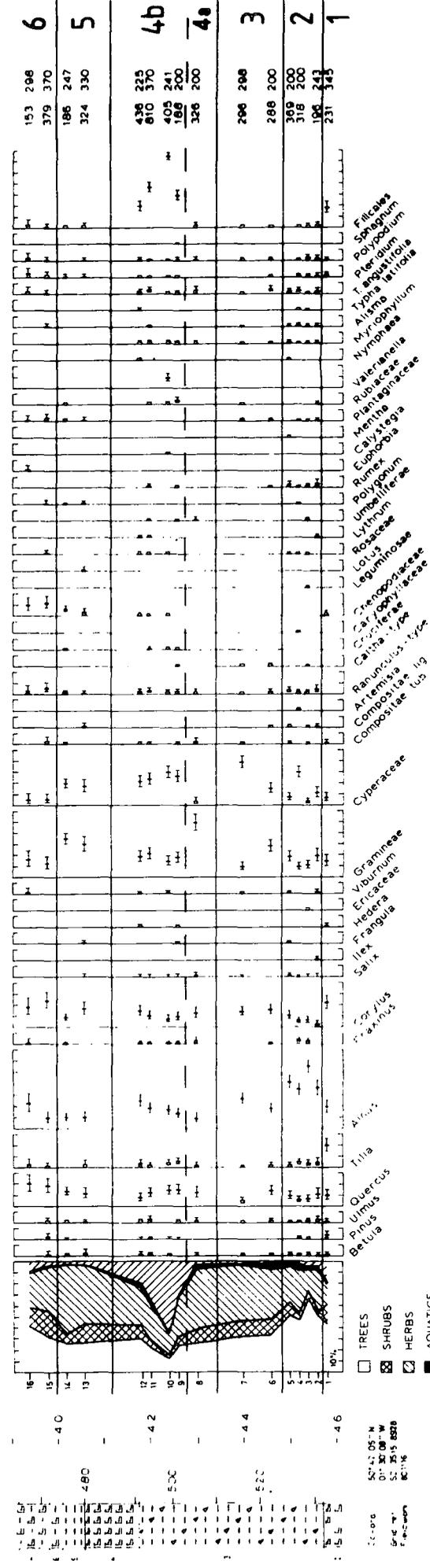
At YBS 9 six strata were sampled for their pollen content; 2, 3, 4, 5, 6 and 7. Strata 3 and 5 were organic with an intercalated clay, stratum 4. In total 16 levels were taken from these strata; 1) -532, 2) -530, 3) -528, 4) -526, 5) -524, 6) -520, 7) -514, 8) -510, 9) -500, 10) -498, 11) -494, 12) -492, 13) -480, 14) -476, 15) -472 and 16) -468 cm. In the lower peat the sampling interval was 2 cm over the lower transition with the sandy-clay. Through the main body of lower peat this interval was 6 cm and again 2 cm

FIGURE 31

# YBS 9 % Total Land Pollen

Total pollen  
L.P.2

Stratum  
Depth cm  
Height MO



at the upper transition to the clay of stratum 4. The upper strata, including the upper peat, were sampled at 4 cm intervals. The pollen sum counted at this site was 100 tree pollen where possible but where the tree pollen was scarce a total of 50 tree pollen was made. In all cases the Lycopodium marker spore count was at least 200 grains. The data recorded in this analysis can be found in Appendix IV and is graphically displayed in Figure 31. At YBS 9 six local pollen assemblage zones have been identified. LPAZ YBS 9:4 has been subdivided into two sections YBS 9:4a and YBS 9:4b on the basis of the Gramineae, Cyperaceae and Filicales curves although no changes were found within the tree pollen curves. These zones are described in detail below.

LPAZ YBS 9:1 -532 cm to ca.-531 cm.

This zone is dominated by tree pollen but also has a large proportion of spores (20.4% of total pollen). Tilia is the most important tree pollen with 19.6% TLP, Alnus is a close second with 19% TLP. NAP is dominated by Corylus pollen with 21.7% TLP, Gramineae with 14.1% TLP and Filicales is recorded to have 17.8% TLP + Spores. Hedera pollen is present here but disappears until LPAZ YBS 9:4b. The concentration of Tilia and Alnus pollen are  $11.3 \times 10^2$  grains/cc and  $11 \times 10^2$  grains/cc while Filicales is seen to have  $12.9 \times 10^2$  grains/cc. The upper boundary of this zone was drawn where Tilia pollen drops from 19.0% TLP to 4.4% TLP, Alnus pollen rises from 19% TLP to 36.3% TLP and Corylus pollen drops from 21.7% TLP to 2.2% TLP. A large drop from 17.8% TLP + Spores (TLP + S) to 1.6% TLP + S is also seen in the Filicales curve.

LPAZ YBS 9:2 ca.-531 cm to ca.-522 cm

In this zone tree pollen is still dominant but herb pollen is rising quickly. The dominant tree pollen comes from Alnus with 55.4% TLP at

-528 cm, and Quercus with 10.9% TLP at -530 cm. NAP is dominated by Cyperaceae with 29.7% TLP at 526 cm, Gramineae with 19.2% TLP at -530 cm and Corylus with 10.3% TLP at -524cm. Ericaceae pollen is only found in this zone at 528 cm as is Ilex, Artemisia, Caryophyllaceae, Leguminosae and Mentha pollen. The concentration curves show two outstanding taxa, Alnus with  $88.4 \times 10^2$  grains/cc and Cyperaceae with  $54.8 \times 10^2$  grains/cc. The upper boundary of this zone was placed where Alnus pollen drops from 41.1% TLP to 17.4% TLP, Gramineae rises from 18.3% TLP to 28.3% TLP and Cyperaceae rises from 7.2% TLP to 15.2% TLP.

LPAZ YBS 9:3 ca.-522 cm to ca.-509 cm

The dominant life group changes from tree to herb pollen in this zone. The most important tree pollen comes from Alnus with 26.8% TLP at -514 cm and Quercus with 14.1% TLP at -520 cm. Of the NAP Cyperaceae record 39.1% TLP at -514 cm, Gramineae 28.3% TLP at -520 cm and Corylus with 15.6% TLP at -520 cm. Cyperaceae pollen shows a very high concentration of  $67.3 \times 10^2$  grains/cc in this zone and perhaps suprisingly, Alnus records a concentration of  $46.1 \times 10^2$  grains/cc here. The upper boundary is marked by a rise in Quercus pollen from 5% TLP to 12.5% TLP, a fall in Alnus pollen from 26.8% TLP to 9.1% TLP, a very large increase from 9.8% TLP to 49.4% TLP in Gramineae and a corresponding large drop in Cyperaceae from 39.1% TLP to 3.4% TLP.

LPAZ YBS 9:4a ca.-509 to ca.-502

This sub-zone is characterised by a dominance of herbpollen with over 50% of total pollen. Quercus pollen becomes the most important tree pollen with 12.5% TLP while Alnus pollen has 9.1% TLP. Gramineae is the dominant non arboreal taxon with 49.4% TLP while Corylus has 12.5% TLP. As expected, Gramineae has the highest concentration with  $47.2 \times 10^2$  grains/cc.

All other curves record low concentrations. The boundary between the two sub-zones of LPAZ YBS 9:4 was drawn where Gramineae shows a large fall from 49.4% to 17.9% TLP, Cyperaceae increases from 3.4% TLP to 26.3% TLP and Filicales increases from 1.7% TLP to 29. TLP + S.

LPAZ YBS 9:4b ca.-502 cm to ca.-486 cm

Herb pollen is still dominant in this sub-zone but not by such a clear margin as recorded previously. The most important tree pollen comes from Alnus with 24.5% TLP at -492 cm and Quercus with 15.3% TLP at -500 c. The NAP is dominated by Cyperaceae with 29.7% TLP at -498 cm, Gramineae with 21% TLP at -494 cm and Corylus with 14.5% TLP at -492 cm. Filicales spores reach a maximum of 64% TLP + S at -498 cm. Cruciferae pollen first appears in this sub-zone while Calystegia and Valerianella pollen are both only recorded in this sub-zone, both at -498 cm. Valerianella pollen is recorded as being 8.8% TLP. Many species of pollen reappear here eg., Pinus, Frangula, Hedera, Chenopodiaceae, Rosaceae and Lythrum. The concentration curves show that Filicales has  $151.3 \times 10^2$  grains/cc, Cyperaceae with  $32.4 \times 10^2$  grains/cc, Gramineae with  $27 \times 10^2$  grains/cc and Alnus with  $23.1 \times 10^2$  grains/cc. The upper boundary is marked by a drop in Alnus pollen from 24.5% to 9.9% TLP, a rise in Gramineae from 18.5% TLP to 29.8% TLP and a fall in Filicales from 19.1% TLP + S to 1.6% TLP + S.

LPAZ YBS 9:5 ca.-486 cm to ca.-474 cm

This zone is dominated by herb pollen once again. The most important tree pollen comes from Quercus with 11.6% TLP at -480 cm and Alnus with 10.2% TLP at -476 cm. Of the NAP, Gramineae has 34.9% TLP at -476 cm, Cyperaceae has 19.6% TLP at -476 cm and Corylus has 16.6% TLP at -480 cm. Chenopodiaceae pollen rises to 6.2% TLP at -476 cm. Lotus pollen is only found in this zone. Gramineae records the highest concentration with

$38.1 \times 10^2$  grains/cc while Cyperaceae has  $21.4 \times 10^2$  grains/cc. The upper boundary to this zone was placed where Corylus pollen rises from 8.9% TLP to 24. TLP, Gramineae falls from 34.9% TLP to 12.3% TLP and Cyperaceae also falls from 19.6% TLP to 5.5% TLP.

LPAZ YBS 9:6 ca.-474 cm to ca.-468 cm

This zone is dominated by herb pollen at the base but tree pollen at the top. The most important tree pollen being Alnus with 22.4% TLP at -468 cm and Quercus with 20.6% TLP at -468 cm. Corylus pollen is most important NAP-type with 24% TLP at -472 cm, Gramineae has 15.9% TLP at -468 cm while Chenopodiaceae has 11.6% TLP at -472 cm. Euphorbia pollen is only found in this zone. The concentration curves are all relatively low but Corylus has the highest concentration with  $12.7 \times 10^2$  grains/cc.

These LPAZ can be tentatively correlated with the lithological strata of YBS 9. LPAZ YBS 9:1 can be correlated with stratum 2, the clastic material, which is dominated by tree pollen and also has a high record of Filicales spores. LPAZ YBS 9:2 corresponds to the lower levels of the organic material. Tree pollen is still dominant here. LPAZ YBS 9:3 corresponds to the middle levels of the organic stratum, where herb pollen first becomes dominant. LPAZ YBS 9:4a and LPAZ YBS 9:4b are still correlated with stratum 3 with dominant herb pollen. The upper level of stratum 4, the clay, and stratum 5, the peat, can be allied to LPAZ YBS 9:5 where herb pollen is still most important. LPAZ YBS 9:6 is dominated by tree pollen and corresponds to strata 6 and 7, the transitional strata.

In conclusion we can say that the basal layers of the organic stratum are woody in nature with Alnus pollen, but this passes into a herbaceous peat for the rest of the deposit with a dominance of Cyperaceae and

Gramineae pollen. The upper peat is also herbaceous in nature with Gramineae the dominant herb pollen. Above the upper peat the transitional stratum 6, is still herbaceous but with Corylus pollen as the dominant taxon. Alnus pollen returns to dominance again in stratum 7.

3) YBS 10

At YBS 10 the peat deposit together with its upper and lower transitional deposits were sampled for pollen. Nine strata were examined; 2, 3, 4, 5, 6, 7, 8, 9 and 10. The sampling interval through the main peat strata (of stratum 4 and 5) was 10 cm with an interval of 4 cm over the upper and lower transitional strata. In total 16 levels were analysed for pollen; 1) -337, 2) -333, 3) -329, 4) -325, 5) -321, 6) -317, 7) -313, 8) -303, 9) -293, 10) -283, 11) -271, 12) -267, 13) -263, 14) -253, and 16) -237 cm. A pollen sum of at least 100 trees was made at all levels except level 11 where only 50 trees were counted and 492 Lycopodium marker spores. The results of this analysis are recorded in Appendix IV and can be seen in Figure 32. Five LPAZ were recognised and are outlined below.

LPAZ YBS 10:1 -337 cm to ca.-327 cm

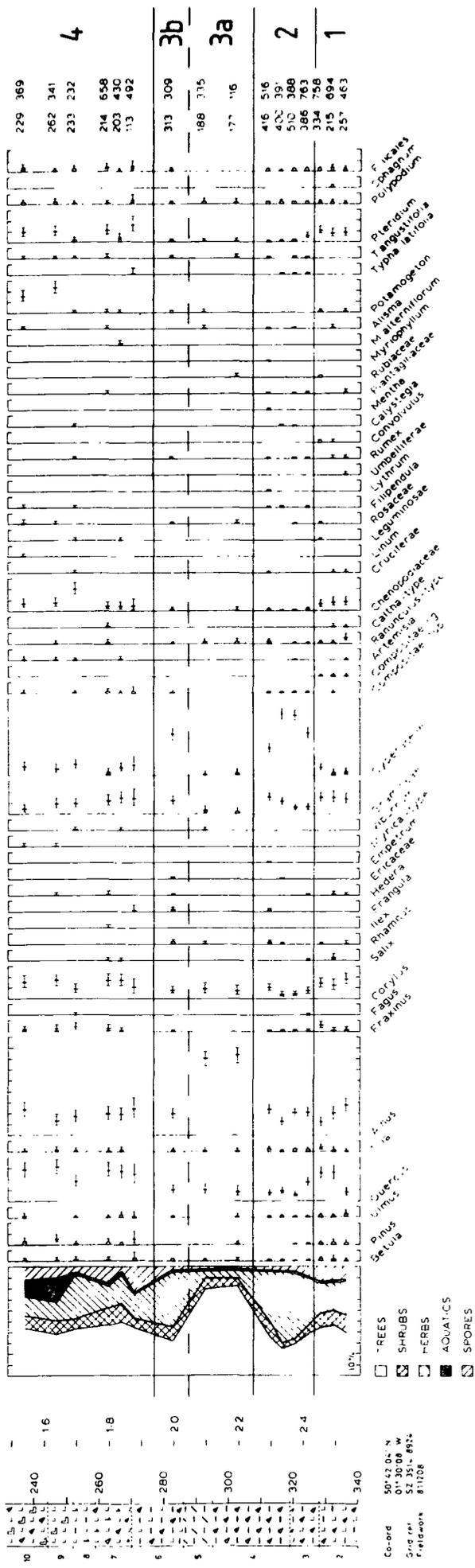
This zone is characterised by a dominance of tree pollen with decreasing herb pollen and increasing shrub pollen. The most important tree pollen being Alnus with 27.8% TLP at -337 cm and Quercus with 25.9% TLP at -333 cm. Of the NAP Corylus records 17.9% TLP at -337 cm, Gramineae has 15.1% TLP at -333 cm and -329 cm, Chenopodiaceae has 8.5% TLP at -337 cm and Pteridium has 10.5% TLP + S at -329 cm. Four species are only found in this zone, these are Compositae liguliflora, Umbelliferae, Convolvulus and Sphagnum. The concentration of pollen is relatively low with Alnus recording  $15.1 \times 10^2$  grains/cc and Quercus had  $10.9 \times 10^2$  grains/cc. The upper boundary is drawn where Quercus pollen

FIGURE 32

YBS 10 % Total Land Pollen

1942  
1941 pollen  
4

Stratum  
Depth cm  
Height m



Co-ord 50°42' 04" N  
01°30' 09" W  
Grid ref. SZ 151-8914  
Reference 01108

drops from 25.7% TLP to 17.2% TLP, Alnus pollen increases from 12.3% TLP to 21.3% TLP, Corylus pollen falls from 14.5% TLP to 7.5% TLP, Gramineae also drops from 15.1% TLP to 6.6% TLP while Cyperaceae shows a large increase from 7.4% TLP to 38.5% TLP.

LPAZ YBS 10:2 ca.-327 cm to ca.-308 cm

In this zone herb pollen becomes dominant with well over 60% of total pollen, in the middle two levels. The most important tree pollen comes from Alnus with 24.4% TLP at -313 cm and Quercus with 17.2% TLP at -325 cm. Cyperaceae records the highest percentage of NAP with 55.9% TLP at -317 cm while Gramineae has 15.8% TLP at -313 cm and Corylus has 10.6% TLP at -313 cm. Lythrum and Mentha are only found in this zone while Frangula, Ericaceae, Typha angustifolia and Typha latifolia pollen first appear. The concentration of Cyperaceae grains is high as would be expected with  $17.3 \times 10^2$  grains/cc while Alnus has  $29.7 \times 10^2$  grains/cc and Gramineae records  $13.8 \times 10^2$  grains/cc. The upper boundary to this zone is marked by a large rise in Alnus pollen from 24.4% to 76.9% TLP, a fall in Cyperaceae from 25.4% TLP to 2.3% TLP and a fall in Gramineae from 15.8% TLP to 1.7% TLP.

LPAZ YBS 10:3a ca.-308 cm to ca.-288 cm

Tree pollen once again is the dominant life group in this <sup>sub-</sup>zone with over 75% of total pollen. Herb pollen is dramatically reduced in importance here. The dominant tree pollen is Alnus with 76.9% TLP at -303 cm while Quercus has 10.5% TLP at -293 cm. Corylus is the only NAP to show any form of high representation with 9.4% TLP at -293 cm. Viburnum pollen is first found in this <sup>sub-</sup>zone. As expected Alnus pollen has a very high concentration with  $110.1 \times 10^2$  grains/cc and Quercus pollen has  $12.7 \times 10^2$

grains/cc. The upper boundary of the zone was drawn where Alnus pollen decreases rapidly to 20% TLP from 70.7% TLP, Cyperaceae increases from 1.1% TLP to 37.3% TLP and Gramineae also increases from 3.9% TLP to 12.3% TLP.

LPAZ YBS 10:3b ca.-288 cm to ca.-277 cm

Tree pollen decreases in this <sup>sub-</sup>zone and once again herb pollen becomes the dominant life group. Of the tree pollen Alnus has 20% TLP and Quercus records 10.2% TLP. Cyperaceae and Gramineae account for the increase in herb pollen in this <sup>sub-</sup>zone with 37.3% TLP and 12.3% TLP respectively. The concentration curves show Cyperaceae reach a concentration of  $41 \times 10^2$  grains/cc. Alnus has  $21.9 \times 10^2$  grains/cc, Gramineae has  $13.5 \times 10^2$  grains/cc and Quercus has  $11.3 \times 10^2$  grains/cc. The upper boundary was drawn where Pinus pollen reappears, Quercus pollen increases from 10.3% TLP to 24.7% TLP, Cyperaceae drops from 37.3% TLP to 9.4% TLP and large increases are found in Chenopodiaceae and Pteridium.

LPAZ YBS 10:4 ca.-277 cm to -237 cm

Tree pollen is once again the dominant life group in this zone and there is a very large increase in aquatic pollen in the upper two levels. Quercus is the most important tree pollen with 31.5% TLP at -247 cm and Alnus has 24.7% TLP at -271 cm. Potamogeton dominates the NAP with 23.5% TLP + Aquatics (TLP + A) at -247 cm. Chenopodiaceae records 20.6% TLP at -253 cm, Pteridium has 16.1% TLP + S at -271 cm while Corylus pollen records 15.5% TLP at -237 cm. Ilex, Myriophyllum and Linum pollen is only found in this zone. The concentration curves show Chenopodiaceae to have  $21.9 \times 10^2$  grains/cc, Quercus has  $19.5 \times 10^2$  grains/cc, Alnus has  $18.5 \times 10^2$  grains/cc and Potamogeton has  $18.2 \times 10^2$  grains/cc.

At first glance the correlation between pollen zones and lithological strata does not appear strong but when one examines the makeup of the various LPAZ some conclusions can be drawn. LPAZ YBS 10:1 can easily be correlated with stratum 2 of the stratigraphic column, which is a mixed silty-peat with a dominance of tree pollen. LPAZ YBS 10:2 corresponds to stratum 3 and the lower levels of stratum 4. This zone is dominated by herb pollen, the lower levels of stratum 4 being heavily loaded with Cyperaceae pollen. The upper levels of stratum 4, together with stratum 5 correspond to LPAZ YBS 10:3a where tree pollen is once again dominant, Alnus pollen being strongly represented at the top of stratum 4. LPAZ YBS 10:3b represents the lower part of stratum 6, a silty-peat where herb pollen is again dominant. Cyperaceae pollen reaches very high percentages again in this <sup>sub-</sup>zone. The last zone, LPAZ YBS 10:4 corresponds to the upper transitional strata 7, 8, 9 and 10 where once again tree pollen is the dominant life form. At the base of stratum 9 the clayey-silt, Chenopodiaceae pollen reaches 20.6% TLP which very high and the level above displays a large amount of Potamogeton pollen.

In conclusion we can say the lower transitional deposit is woody in nature with Alnus pollen the most important taxon. The lower level of the organic stratum 4, together with stratum 3 is herbaceous. Alnus pollen once again becomes important in the upper levels of stratum 4 and stratum 5, before herb pollen returns briefly to be dominant in stratum 6. The upper transitional strata 7, 8, 9 and 10 are all woody with Quercus the most important tree pollen.

#### 4) YBS 12

At YBS 12 seven strata were examined for their pollen content. These strata were at the base of the core where a lower sandy transitional layer passes into 59 cm of peat. Above this is another transitional deposit which



passes into 8 cm of organic material before passing into clastic deposits again. The strata sampled are 4, 5, 6, 7, 8, 9 and 10. The main organic deposit was sampled at 10 cm intervals with the transitional deposit being sampled at a closer interval. A total of 14 levels were sampled; 1) -343, 2) -341, 3) -330, 4) -320, 5) -310, 6) -300, 7) -294, 8) -288, 9) -284, 10) -278, 11) -270, 12) -260, 13) -248 and 14) -244 cm. A pollen sum of 100 trees was counted in levels 2 to 7, through the peat and 150 trees in levels 13 and 14 in the upper peat. The remaining levels were counted to 50 trees as pollen was more scarce. Data on dry-land tree pollen is based on calculations of  $\Sigma$ AP plus group and has been included for relative dating purposes. The results of this analysis can be found in Appendix IV and are displayed graphically in Figure 33. At YBS 12 five LPAZ have been recognised and are outlined below.

LPAZ YBS 12:1 -343 cm to ca.-305 cm

This first zone is dominated by herb pollen although levels 2 and 3 have tree pollen as dominant. In this zone the most important tree pollen comes from Alnus with 35.3% TLP at -341 cm. Tilia pollen has a high representation with 10.7% TLP at -343 cm. Of the NAP the most important taxa are Gramineae with 32.8% TLP at -310 cm, Corylus with 12.7% TLP at -310 cm, Cruciferae with 12.3% TLP at -343 cm and Cyperaceae with 11.5% TLP at -341 cm. The major dry-land trees are Tilia with 26% of trees at -343 cm, Quercus with 16% of trees at -341 cm and Fraxinus with 7% of trees at -320 cm. Four species are only found in this zone, these are Ilex, Cruciferae, Lythrum and Valeriana pollen. Concentrations are high with Alnus recording  $41.8 \times 10^2$  grains/cc, Gramineae with  $32.5 \times 10^2$  grains/cc and Cyperaceae has  $13.6 \times 10^2$  grains/cc. The upper boundary was placed where Alnus increases from 17.3% TLP to 47.3% TLP, Gramineae fall from 31.8% TLP to 7.1% TLP, Cyperaceae rise

from 9.5% TLP to 21.9% TLP and Typha angustifolia increases to 6% TLP + A from no previous record in the level below.

LPAZ YBS 12:2 ca.-305 cm to ca.-291 cm

This zone is characterised by a dominance of tree pollen. Alnus is the dominant tree with 53.7% TLP at -294 cm. Cyperaceae dominate the NAP with 21.9% TLP at -300 cm, while Typha angustifolia shows a relatively high record of 6% TLP + A at the same level. The major dry-land tree pollen comes from Quercus with 26% of trees at -294 cm and Tilia with 11% of trees at -310 cm. Alnus and Cyperaceae pollen record the highest concentrations with  $47.2 \times 10^2$  grains/cc and  $15.2 \times 10^2$  grains/cc. The upper boundary is marked by a fall in Alnus pollen from 53.7% TLP to 22.3% TLP, Gramineae rise from 5.6% TLP to 17.6% TLP and Cyperaceae also rise from 17.3% TLP to 33.1% TLP. Typha angustifolia fall from 5.8% TLP + A to nothing at the boundary between the two zones.

LPAZ YBS 12:3 ca.-291 cm to ca.-281 cm

Herb pollen is again dominant in this zone. The most important tree being Alnus with 22.3% TLP at -288 cm. Cyperaceae pollen is again high with 59.2% TLP at -284 cm while Gramineae has 17.6% TLP at -288 cm and at the same level Corylus pollen records 10.8% TLP. The major dry-land tree pollen comes from Quercus with 16% of trees at -288 cm and from Fraxinus and Tilia both with 8% of trees at -284 cm. The concentration of Cyperaceae is high with  $62.1 \times 10^2$  grains/cc while Alnus has  $13.8 \times 10^2$  grains/cc and Gramineae have  $11.7 \times 10^2$  grains/cc. The upper boundary is marked by a rise in Quercus from 2.2% TLP to 7.1% TLP, a rise in Corylus from 2.6% TLP to 13.5% TLP, a rise in Gramineae from 11.2% TLP to 25.6% TLP and a fall in Cyperaceae from 59.2% TLP to 18.6% TLP. Pteridium rises from 0.3% TLP+S to 5.9% TLP+S.

LPAZ YBS 12:4 ca.-281 cm to ca.-254 cm

This zone is again dominated by herb pollen. The most important tree pollen comes from Alnus with 18.7% TLP at -270 cm and Quercus with 15.9% TLP at -260 cm. Gramineae is recorded with 29.9% TLP at -270 cm, Cyperaceae and Corylus both have 18.6% TLP at -278 cm and -260 cm respectively. It is interesting to note that Chenopodiaceae pollen and Pteridium spores also have high values at -270 cm. The major dry-land tree pollen comes from Quercus with 46% of trees at -260 cm and Betula with 12% of trees at -278 cm. Potamogeton pollen is only found in this zone. The concentration curves are all relatively low, probably associated with the dearth of tree pollen in these levels as mentioned in the introduction. The upper boundary is denoted by a fall in Quercus pollen from 15.9% TLP to 6.4% TLP and a rise in Gramineae from 23.5% TLP to 33.9% TLP.

LPAZ YBS 12:5 ca.-254 cm to -244 cm

This last zone is again characterised by a dominance of herb pollen. Alnus is the most important tree pollen with 19.2% TLP at -244 cm. The NAP is dominated by Gramineae with 33.9% TLP at -248 cm and Corylus with 24.6% TLP at the same level. The major dry-land tree pollen comes from Quercus with 20.7% of trees at -248 cm, Fraxinus with 14.7% of trees at -244 cm and Betula with 10.7% of trees at -248 cm. Three species are only found in this zone, these are Ericaceae, Umbelliferae and Polygonum. Concentrations rise again here with Gramineae recording  $54.9 \times 10^2$  grains/cc while Corylus has  $39.9 \times 10^2$  grains/cc and Alnus has  $29 \times 10^2$  grains/cc.

A correlation between the pollen zones and strata in the stratigraphic column can be drawn. LPAZ YBS 12:1 can be said to correspond to the lower levels of the peat strata 5 and 6 together with

transitional stratum 4. Stratum 4 is dominated by herb pollen but the lowest levels of peat, samples 2 and 3, are dominated by tree pollen, namely Alnus. The other levels in this zone are again dominated by herb pollen in the form of Gramineae. LPAZ YBS 12:2 corresponds to the upper levels of this peat of stratum 6, where tree pollen is again dominant. Stratum 7 correlates with LPAZ YBS 12:3 where herb pollen resumes dominance with Cyperaceae pollen being very important. Above this, strata 8 and 9 correspond to LPAZ YBS 12:4 which is again dominated by herb pollen, but this time by Gramineae pollen. The last zone, LPAZ YBS 12:5 correlates with the upper peat deposit of stratum 10, where herb pollen is most important, especially Gramineae. Thus we have a core with two peat bands, the lower one being of a mixed nature being dominated by herb pollen at the upper and lower boundaries passing through tree pollen then back to herb pollen at the central levels. While the upper peat deposit is herbaceous in nature, the intercalated transitional layer is also dominated by herb pollen in the form of Gramineae.

YBS 12 was chosen to represent the Boatyard site at Yarmouth as it had two peat deposits.

#### Dating of the LPAZ at YBS 12

The upper peat at YBS 12 ranges in altitude from -1.62 m.O.D. (-243 cm) to -1.70 m.O.D. (-251 cm) and the lower peat ranges from -2.03 m. O.D. (-284 cm) to -2.62 m.O.D. (-343 cm). Five LPAZ were recognised at this borehole and are summarised below with dominant AP and NAP.

The frequency of Alnus pollen exceeds 50% of tree pollen throughout the LPAZ, while Quercus pollen exceeds 40% of tree pollen. These LPAZ are thought to belong to Flandrian Chronozone III. A tentative division into two sub-zones equivalent to the Godwin dating scheme is proposed at

-1.74 m.O.D.; this divides the LPAZ into Zone VIIb and Zone VIII. This division is based on the paucity of Tilia pollen together with a marked rise in Chenopodiaceae and Plantaginaceae in YBS 12:4 and YBS 12:5.

Table 16 Dating of LPAZ at YBS 12

Flandrian Chronozone	LPAZ	Altitude (m.O.D.)	Depth (cm)	Dominant life group	Dominant AP	Dominant NAP
III	Y12:5	-1.64 to -1.74	-244 to -254	Herbs	A-Q-Fr- B	Co-Gr
	Y12:4	-1.74 to -2.01	-254 to -281	Herbs	Q-A-B	Gr-Co- Cy-Pt
	Y12:3	-2.01 to -2.11	-281 to -291	Herbs	A-Q-T+ Fr	Cy-Co Fn-Gr
	Y12:2	-2.11 to -2.25	-291 to -305	Trees	A-Q-T- B	Cy-Ta- Co
	Y12:1	-2.25 to -2.63	-305 to -343	Herbs	A-T-Q Fr	Gr-Co

A=Alnus, Q=Quercus, Fr=Fraxinus, B=Betula, T=Tilia, Co=Corylus, Gr=Gramineae, Cy=Cyperaceae, Pt=Pteridium, Fn=Frangula, Ta=Typha angustifolia.

5) YBS 13

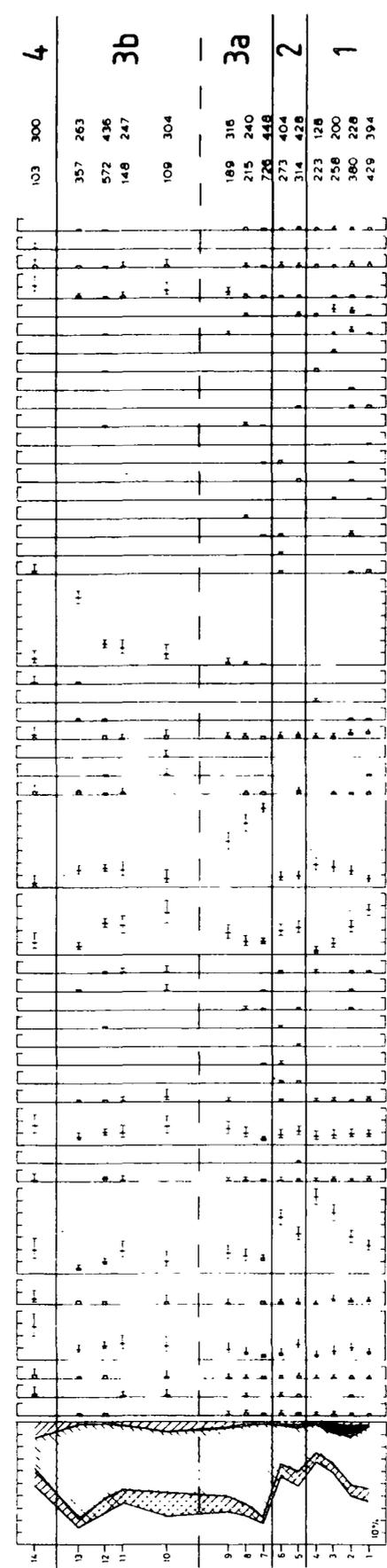
At YBS 13 the basal organic material, together with the overlying transitional deposits, were sampled for pollen. Six strata were examined; 1, 2, 3, 4, 5 and 6. In total 14 levels were taken for analysis. The sampling interval through the lower organic material was 4 cm, while over the transitional deposits this interval went up to 10 cm. These levels are

FIGURE 34

YBS 13 % Total Land Pollen

LYCOPIDIUM  
TOTAL pollen  
LPAZ  
4  
3b  
3a  
2  
1

Stratum  
Depth cm  
- 240  
- 260  
- 280  
- 300  
Height mOD  
- 14  
- 16  
- 18  
- 20



- Co-ord 59° 10' N
- Grid ref. 52 356 8972
- Field-work 811209
- Legend:
  - TREES
  - ▨ SHRUBS
  - ▧ HERBS
  - AQUATICS
  - SPORES
- Taxa List:
  - Salix
  - Rhamnus
  - Ilex
  - Fraxinus
  - Hedera
  - Ericaceae
  - Vitrum
  - Gramineae
  - Cyperaceae
  - Compositae type
  - Artemisia
  - Manuceus type
  - Cruciferae
  - Spergula
  - Chenopodiaceae
  - Rosaceae
  - Saxifragaceae
  - Lythrum
  - Umbelliferae
  - Polythrales
  - Rumex
  - Caystegia
  - Mentha
  - Plantaginaceae
  - Rubiacae
  - Myrica
  - Alisma
  - Polygonaceae
  - Polanogon
  - Typha latifolia
  - Pteridium
  - Polypodium
  - Sporopollenites
  - Filices

1) -304, 2) -300, 3) -296, 4) -292, 5) -288, 6) -284, 7) -280,  
8) -276, 9) -272, 10) -258, 11) -248, 12) -244, 13) -238 and 14) -228 cm.

The pollen sum used in this analysis was 150 trees through the lower organic material of stratum 1 and through the other levels a minimum count of 50 trees was made with over 200 Lycopodium marker grains. This total fell to 25 trees in level 10. The results of this analysis can be found in Appendix IV and in Figure 34. A total of four LPAZ have been recognised at this borehole. LPAZ YBS 13:3 has been divided into two sub-zones a and b on the basis of major changes in NAP curves but not in the arboreal curves. These zones are outlined below.

LPAZ YBS 13:1 -304 cm to ca.-290 cm

This first zone is dominated by herb pollen in the lowest level passing to a dominance of tree pollen by levels 3 and 4. There is also a relatively high proportion of aquatic pollen here. Alnus is the dominant tree pollen with 62.6% TLP at -292 cm and Quercus has 9.9% TLP at -300 cm. The NAP is dominated by Gramineae with 36.3% TLP at -304 cm and Cyperaceae has 18.2% TLP at 292 cm. Five species are only found in this zone, these are Cruciferae, Polygonaceae, Mentha, Myriophyllum and Potamogeton pollen. The concentration of Alnus pollen is very high with  $120.9 \times 10^2$  grains/cc, Gramineae has  $43 \times 10^2$  grains/cc and Cyperaceae displays  $35.3 \times 10^2$  grains/cc. The upper boundary was placed where Quercus pollen increases from 4.1% TLP to 12.7% TLP, Alnus pollen falls from 62.6% TLP to 32.4% TLP, Gramineae increases from 6.5% TLP to 22.1% TLP and Cyperaceae falls from 18.3% TLP to 9% TLP.

LPAZ YBS 13:2 ca.-290 cm to ca.-282 cm

This zone is characterised by a dominance of tree pollen exemplified by Alnus with 45.5% TLP at -284 cm and Quercus with 12.7% TLP at -288 cm.

Gramineae is the most important NAP with 22.1% TLP at -288 cm. At the same level Corylus pollen has 11% TLP and Cyperaceae has 9% TLP. In this zone Fagus, Lonicera, Ilex and Sanguisorba pollen are only found. The concentration of Alnus pollen has dropped considerably to  $33.8 \times 10^2$  grains/cc with Gramineae at  $17.4 \times 10^2$  grains/cc. The upper boundary is marked by a drop in Alnus pollen from 45.5% TLP to 12.3% TLP, a drop in Gramineae from 19.6% TLP to 10.8% TLP and a large rise in Cyperaceae from 8.3% TLP to 63.8% TLP.

LPAZ YBS 13:3a ca.-282 cm to ca.-265 cm

This sub-zone is marked by a definite preponderance of herbaceous pollen. The most important tree pollen however, is Alnus with 16.8% TLP at -272 cm. Of the NAP Cyperaceae is by far the most important with 63.8% TLP at -280 cm. Gramineae shows 17.9% TLP at -272 cm and Corylus at the same level shows 12.9% TLP. Chenopodiaceae pollen is first found here. The concentration of Cyperaceae is very high with  $114.8 \times 10^2$  grains/cc. Alnus pollen records a concentration of  $22.2 \times 10^2$  grains/cc and Gramineae has  $19.4 \times 10^2$  grains/cc. The upper boundary is shown by a rise in Gramineae pollen from 17.9% TLP to 34% TLP, a fall in Cyperaceae from 36.9% TLP to 7% TLP and a rise in Chenopodiaceae from 2.2% TLP to 9% TLP.

LPAZ YBS 13:3b ca.-265 cm to ca.-233 cm

This sub-zone also has a dominance of herb pollen and again Alnus is the most important tree pollen with 18.9% TLP at -248 cm while Quercus has 13.3% TLP at the same level. The importance of Cyperaceae is replaced by a dominance of Chenopodiaceae pollen with 55.6% TLP at -238 cm, Gramineae displays 34% TLP at -258 cm and Cyperaceae has 15.7% TLP at -244 cm. Corylus pollen is recorded with 15% TLP at -258 cm. Artemisia and Spargula pollen are only found in this zone. The concentration of Chenopodiaceae

pollen is high at  $82.9 \times 10^2$  grains/cc while Gramineae has  $37.6 \times 10^2$  grains/cc and Cyperaceae has  $22.8 \times 10^2$  grains/cc. The upper boundary is marked by a rise in Quercus pollen from 8.4% TLP to 26.9% TLP, a rise in Alnus pollen from 4.3% TLP to 19.1% TLP and a drop in Chenopodiaceae pollen from 55.6% TLP to 5.6% TLP. Large changes are also found in Corylus, Cyperaceae and Pteridium.

LPAZ YBS 13:4 ca.-233 cm to -228 cm

This zone sees the return of tree pollen as the dominant life group. The most important tree pollen being Quercus with 26.9% TLP while Alnus has 19.1% TLP. The NAP is well represented by Corylus with 15.7% TLP. Pteridium has 10.7% TLP + S, Gramineae has 10.1% TLP while Chenopodiaceae has 5.6% TLP. This zone sees the only appearance of Sphagnum spores. In general concentrations are low.

These pollen zones can be correlated with the stratigraphic column of YBS 13. LPAZ YBS 13:1 represents the lower portion of stratum 1, the organic material. The bottom level is dominated by Gramineae pollen but this is replaced by a dominance of Alnus pollen in the upper levels. This is carried on into LPAZ YBS 13.2 which correlates with the upper levels of the organic material. LPAZ YBS 13:3a can be said to represent the transitional stratum 2 where Cyperaceae pollen dominates the pollen curves. LPAZ YBS 13:3b is dominated by herb pollen and can be correlated with strata 3, 4 and 5. The upper transitional stratum 5 is shown to have a high percentage of Chenopodiaceae pollen. The last zone, LPAZ YBS 13:4 represents stratum 6, the clayey-silt which is dominated by tree pollen although not by Alnus but by Quercus. Thus we have a borehole where the basal organic material is dominated by Alnus pollen. The transitional strata above the peat is herbaceous as is the clastic material above, but Cyperaceae pollen dominates the lower levels with Gramineae pollen more important above. The

true clastic deposit above, is dominated by tree pollen in the form of Quercus.

6) YBS 14

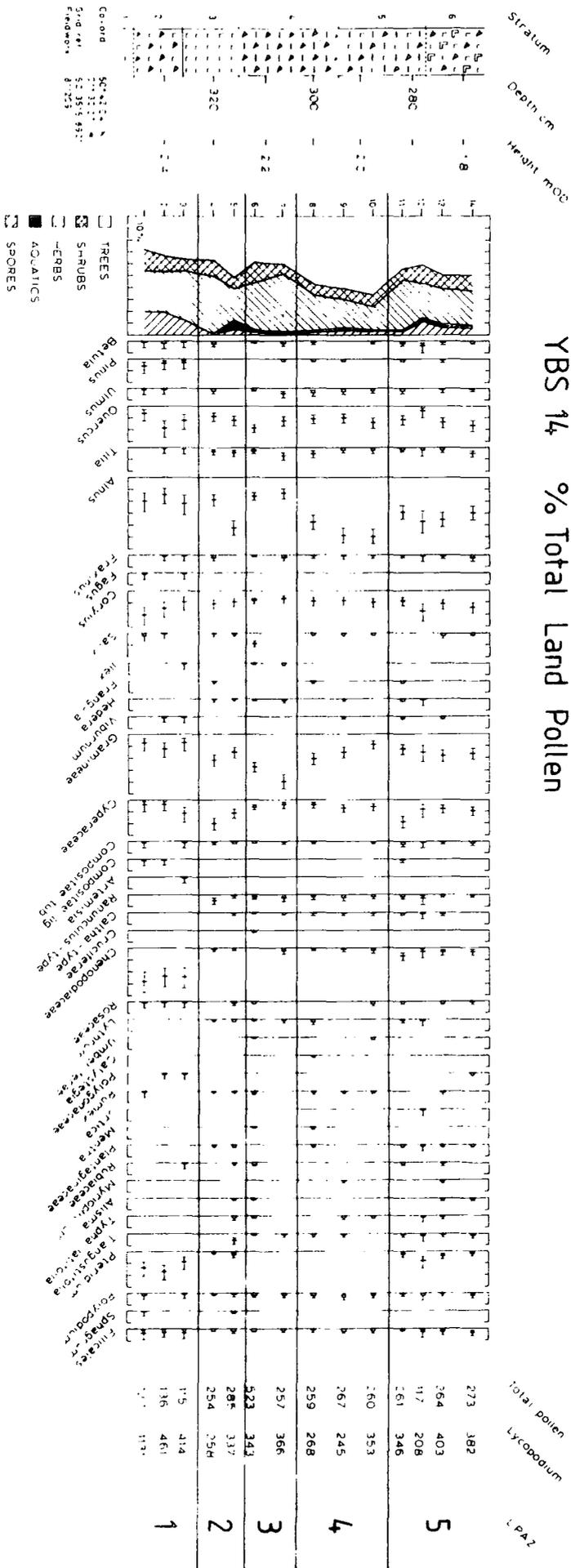
At YBS 14 the upper organic material together with upper and lower transitional deposits were sampled for pollen. Five strata were examined; 2, 3, 4, 5 and 6. In these strata 14 levels were sampled and analysed. The sampling interval being 6 cm through the organic material and 4 cm over the boundary deposits. These levels were 1) -334, 2) -330, 3) -326, 4) -320, 5) -316, 6) -312, 7) -306, 8) -300, 9) -294, 10) -288, 11) -282, 12) -278, 13) -274 and 14) -268 cm. The pollen sum for these levels was based on the number of land pollen counted as the tree pollen was too scarce for a reliable pollen sum. A count of 250 land pollen was counted for levels 4, 5, 7, 8, 9, 10, 11, 13 and 14. Level 6 was counted to 500 land pollen while the remaining levels were counted to a sum of 100 land pollen. The results of these counts can be found in Appendix IV and in Figure 35. Five LPAZ were recognised at this borehole and are described below.

LPAZ YBS 14:s1 -334 cm to ca.-323 cm

This first zone is characterised by a dominance of herb pollen with a large proportion of spores which decrease to the top of the zone. The most important tree pollen is Alnus with 22% TLP at -326 cm and Quercus with 18.4% TLP at -330 cm. The Chenopodiaceae dominate the NAP with 27.5% TLP at -334 cm. Corylus has 19.6% TLP at -334 cm and Pteridium has 16.9% TLP at -330 cm. Fagus and Artemisia pollen is only found in this zone. Concentrations are relatively low with Chenopodiaceae displaying only  $6.6 \times 10^2$  grains/cc. The upper boundary is drawn where Fagus pollen dies out, Gramineae increases from 7% TLP to 21.6% TLP, Chenopodiaceae decreases from 24% TLP to 0.8% TLP and Pteridium drops from 8.7% TLP + S to 0.4% TLP + S.

FIGURE 35

YBS 14 % Total Land Pollen



LPAZ YBS 14:2 ca.-323 cm to ca.-314 cm

This zone is dominated by herb pollen at the base but passes to tree pollen at the top. The aquatic pollen first appears here. The most important tree pollen is Alnus with 42.4% TLP at -316 cm. Gramineae and Cyperaceae are the most important NAP taxa with 21.6% TLP and 20% TLP at -320 cm. Concentrations increase in this zone. Alnus pollen has  $35.5 \times 10^2$  grains/cc, Gramineae has  $23.7 \times 10^2$  grains/cc and Cyperaceae has  $21.9 \times 10^2$  grains/cc. The upper boundary is marked by a fall in Alnus pollen from 42.4% TLP to 16.2% TLP, a rise in Gramineae from 14.8% TLP to 27.6% TLP and a rise in Salix from 0.8% TLP to 9% TLP.

LPAZ YBS 14:3 ca.-314 cm to ca.-303 cm

This zone is dominated by herbaceous pollen. The most important tree pollen is Quercus with 19% TLP at -312 cm and Alnus with 16.2% TLP at the same level. The dominant NAP is Gramineae with 39.6% TLP at -306 cm with Salix having 9% TLP at -312 cm. The concentration Gramineae is recorded as  $45.5 \times 10^2$  grains/cc while Quercus has  $31.3 \times 10^2$  grains/cc and Alnus has  $26.7 \times 10^2$  grains/cc. The upper boundary is denoted by a rise in Alnus pollen from 13.2% TLP to 37.6% TLP and a fall in Gramineae from 39.6% TLP to 20.4% TLP.

LPAZ YBS 14:4 ca.-303 cm to ca.-285 cm

This zone shows the return of trees as the dominant pollen. The dominant tree pollen is Alnus with 49.6% TLP at -288 cm while Quercus has 10.8% TLP at -300 cm. Gramineae has 20.4% TLP at -300 cm and Corylus has 9.6% TLP at -288 cm. Calystegia pollen is only found here in this zone. The concentration of Alnus pollen is found to be  $56.3 \times 10^2$  grains/cc while Gramineae has  $21.5 \times 10^2$  grains/cc. The upper boundary is marked by a fall in Alnus pollen from 49.6% TLP to

29.2% TLP, a rise in Cyperaceae from 5.6% TLP to 18.4% TLP and a rise in Chenopodiaceae from 2% TLP to 6.8% TLP.

LPAZ YBS 14:5 ca. -285 cm to -268 cm

This last zone is again characterised by tree pollen as the dominant life form. The most important tree pollen being Alnus with 37% TLP at -278 cm and Quercus with 16.4% TLP at -268 cm. Other important taxa are Cyperaceae with 18.4% TLP at -282 cm, Gramineae with 17.9% TLP at -274 cm, Corylus with 17% TLP at -278 cm. Pteridium and Chenopodiaceae also show high percentages. The concentrations are relatively low but Alnus displays a concentration of  $23.8 \times 10^2$  grains/cc.

These zones can tentatively be correlated with the stratigraphic column of YBS 14. LPAZ YBS 14:1 can be allied with stratum 2 where herb pollen is dominant although level 1 has a large proportion of Chenopodiaceae pollen. LPAZ YBS 14:2 corresponds with stratum 3, the silt below the organic material. Here a dominance of herb pollen at the base passes to tree pollen. This dominance of tree pollen is short lived as LPAZ YBS 14:3 is dominated by herbaceous pollen and correlates with the lower levels of the organic material. LPAZ YBS 14:4 is dominated by trees, although level 8 has Gramineae pollen as the most important. This zone corresponds with the upper levels of stratum 4 and the lower levels of stratum 5. The dominant tree pollen in LPAZ YBS 14:4 is Alnus. This dominance of Alnus is carried on to LPAZ YBS 14:5 which corresponds to strata 5 and 6.

In conclusion we can say that the organic deposit at YBS 14 is herbaceous with Gramineae being the dominant taxon. Above the peat the levels are dominated by Alnus pollen. The level immediately below the peat (level 5) also shows Alnus pollen as dominant. Below the peat the material is dominated by herb pollen especially Gramineae, although

Chenopodiaceae pollen is important in level 1.

### 3:3:4 Diatom Analyses

At Yarmouth the sediments from six boreholes were examined for their diatom composition. These boreholes are YBS 3, YBS 9, YBS 10, YBS 12, YBS 13 and YBS 14. Diatoms were counted from selected levels in the cores and were divided into local diatom assemblage zones (LDAZ) at each core. These analyses are outlined below and all the results are tabulated in Appendix V.

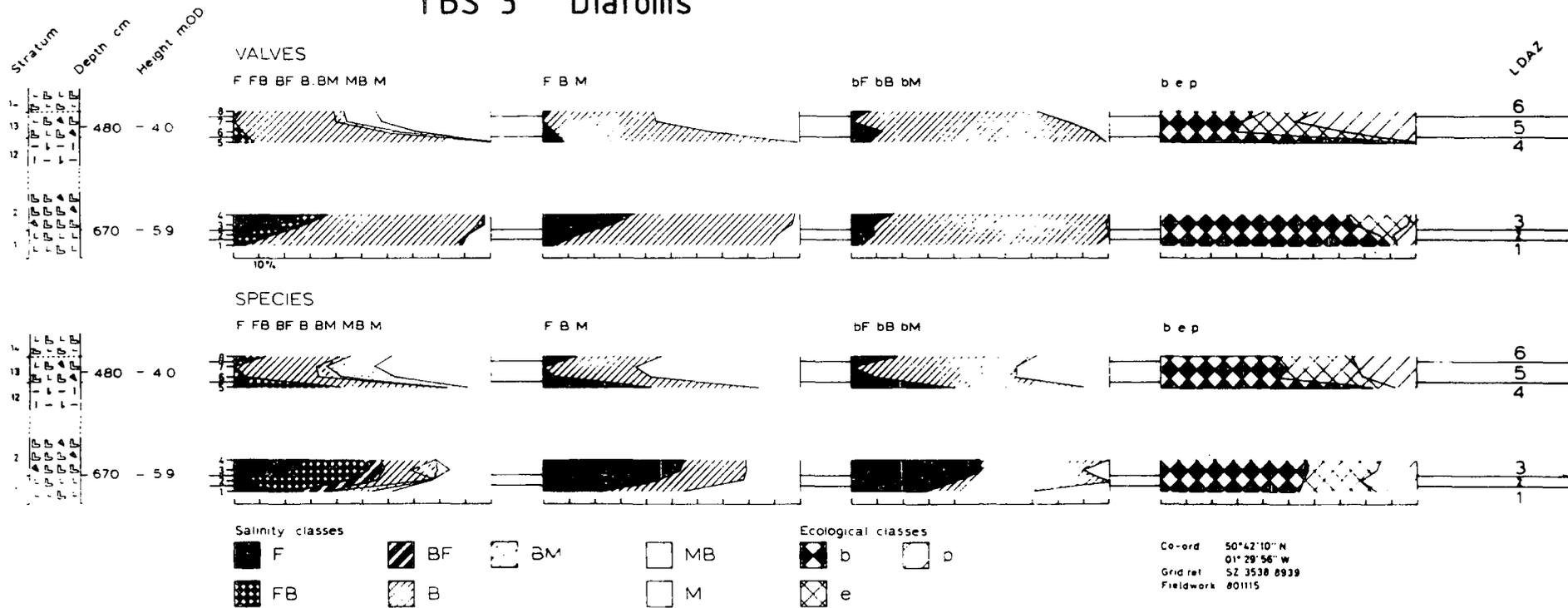
#### 1) YBS 3.

At YBS 3 the upper and lower clastic deposits were examined for their diatom content. Two strata below the peat (1 and 2) and three above the peat (12, 13 and 14) were sampled. A total of eight levels were taken in these strata 1) -673, 2) -671, 3) -669, 4) -667, 5) -483, 6) -481, 7) -479, and 8) -477 cm. Where possible a count of 200 diatom valves was made but in level 2 only 55 valves were counted, due to a dearth of diatoms at this level. The data are expressed as percentages of the total valves (TV) counted per level. Eight summary diagrams are given, as described in section 2:6:4, together with a composite diagram of the frequencies of each species identified showing 95% confidence limits. These diagrams are shown in Figures 36a and 36b.

In the following descriptions 'Freshwater' types (F) of diatoms will be taken to include both Fresh and Fresh-Brackish types; 'Brackish' types (B) will include Brackish-Fresh, Brackish and Brackish-Marine diatoms and 'Marine' types (M) will include Marine-Brackish and Marine diatoms unless otherwise stated.

FIGURE 36a

# YBS 3 Diatoms



# YBS 3 DIATOMS

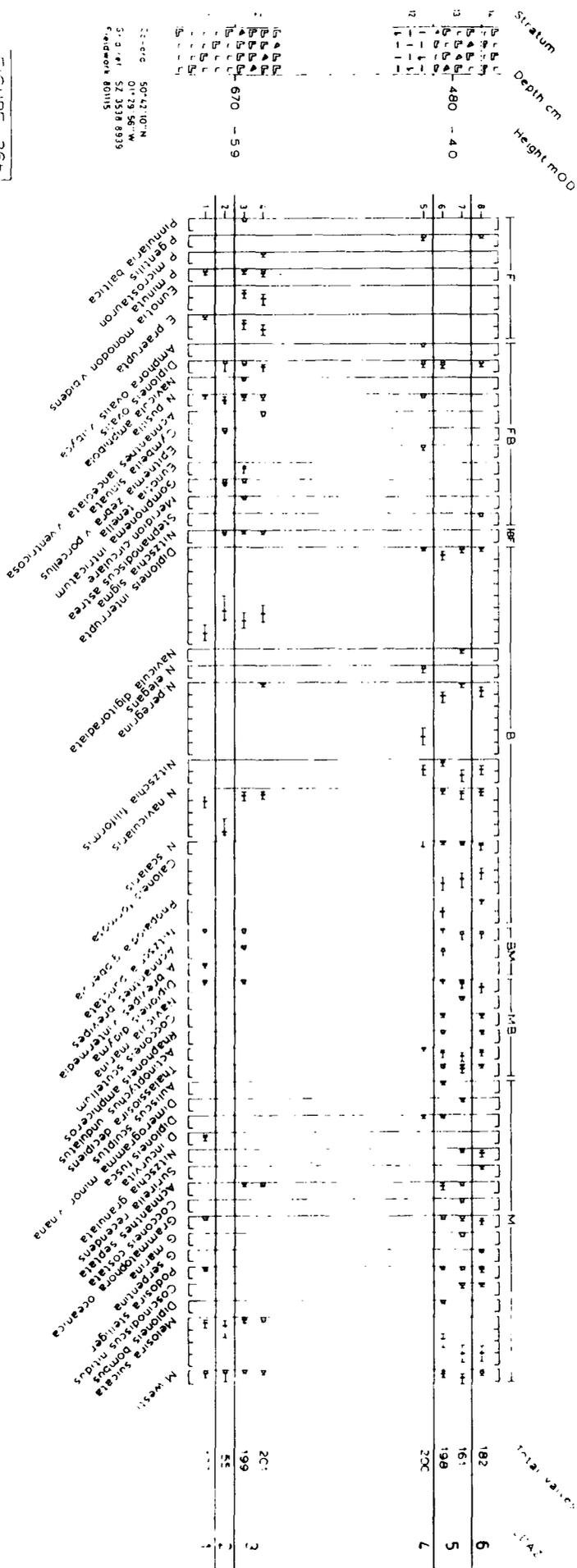


FIGURE 36C

53 species of diatoms were identified and of these 17 were freshwater, the ratio of F : B : M species being 17 : 13 : 23. A total count of 1373 diatom valves was made throughout the eight levels: the ratio of F : B : M species being 168 : 901 : 304.

There were four dominant species at this borehole; Diploneis interrupta (B b) with 398 valves, Melosira sulcata (M p) with 160 valves, Navicula peregrina (B b) with 130 valves and Caloneis formosa (B e) with 92 valves. An examination of the summary diagrams (Figure 36a) shows a clear pattern. Freshwater valves decrease in number away from the organic deposit with a corresponding increase of Marine valves in the same direction. The lower clastic deposit appears to have more of a freshwater influence than the upper clastic deposit, although Brackish valves dominate the lower levels. This pattern is also seen in the summary diagrams for species. The lower clastic deposit has a dominance of Freshwater species, replaced by a dominance of Marine species in the upper clastic deposit. Benthonic diatoms remain dominant throughout the sampled levels except in the upper levels where planktonic valves are dominant. These eight levels have been divided into six LDAZ, which are described below.

LDAZ YBS 3:1 -673 cm to ca.-672 cm

The dominant species in this zone are D.interrupta with 71.2% TV and Nitzschia navicularis (B b) with 10.7% TV. The upper boundary is placed where D.interrupta begins to decrease and N.navicularis increases. Brackish valves and species are dominant throughout this zone with 84% TV. Benthonic diatoms are the dominant life form.

LDAZ YBS 3:2 ca.-672 cm to ca.-670 cm

In this zone, the same two species are dominant; D.interrupta with 40% TV and N.navicularis with 36.4% TV. The upper boundary is placed where a large increase in Freshwater valves occurs, together with a decrease in

Marine valves. Here D.interrupta increases and N.navicularia decreases. Brackish valves are dominant although Freshwater species have the most influence. The majority of these Freshwater species are Fresh-Brackish forms.

LDAZ YBS 3:3 ca.-670 cm to -667 cm

Only one species of diatom stands out as prevalent in this zone, D.interrupta with 60.5% TV at -669 cm. Eunotia praerupta (F e) and Eunotia monodon var.bidens (F e) also reach over 10% TV, both at -667 cm. Again Brackish valves are the most numerous types but Freshwater forms dominate the species curves with over 50% of total species.

LDAZ YBS 3:4 -483 cm to ca.-482 cm

The dominant species in this zone are N.peregrina with 45% TV, Nitzschia scalaris (B b) with 34% TV and Nitzschia filiformis (b b) with 8.5% TV. The upper boundary is placed where a large increase begins in Marine diatoms, as seen in the M.sulcata curve. Freshwater types also decline here. Brackish valves are dominant in this zone but Freshwater and Brackish species attain the same percentages.

LDAZ YBS 3:5 ca.-482 cm to ca.-478 cm

In this zone the characteristic species are M.sulcata with 29.8% TV at -479 cm, C.formosa with 21% TV at -481 cm, N.filiformis with 13% TV at -479 cm, N.peregrina with 11.5% TV at -481 cm and Rhopalodia gibberula (B e) with 10.5% TV at 0481 cm. The upper boundary is drawn where the large rise in Marine species is abated and Freshwater diatoms increase again. Marine diatoms dominate this zone for the first time. Benthonic valves are no longer outstandingly dominant as there is a marked rise in planktonic valves.

LDAZ YBS 3:6 ca.-478 cm to -477 cm

This zone is dominated by M.sulcata with 30.2% TV, C.formosa with 12.1% TV, N.filiformis with 8.2% TV and N.peregrina with 7.1% TV. Marine diatoms are once again dominant here.

These zones can be correlated closely with the lithological boundaries in the core. LDAZ YBS 3:1 and LDAZ YBS 3:2 represent the clayey-silt in the lower clastic deposit, which is predominantly Brackish with increasing Freshwater influence at the top of the strata. These two zones have the same dominant species and a distinction between the two was made on the basis of changes in the D.interrupta and N.navicularis curves. LDAZ YBS 3:3 corresponds to the transitional clastic deposit below the peat where Brackish valves are still dominant but there is an increasing importance of Freshwater species. LDAZ YBS 3:4 corresponds to the upper levels of the peat deposit where Brackish valves dominate although Freshwater species attain the same proportions as Brackish species. LDAZ YBS 3:5 represents the upper transitional strata from the peat to the upper clastic deposit. This zone is predominantly Marine. The last zone LDAZ YBS 3:6 represents the silt-clay where, once again, Marine diatoms are dominant.

The lower clastic deposit was laid down in predominantly brackish conditions, whilst the upper clastic deposit was laid down under predominantly marine conditions.

## 2) YBS 9

At YBS 9 the upper and lower clastic deposits were examined for their diatom content. These deposits consisted of eight strata; 2, 3, 4, 5, 6, 7, 8 and 10. In all, 21 levels were sampled but of these only 15 in the upper clastic deposit yielded diatom valves. These levels are 1) -501, 2) -499 3) -495, 4) -493, 5) -489, 6) -485, 7) -481, 8) -479, 9) -475,

# YBS 9 Diatoms

Stratum  
Depth (m)  
Height (mOD)

## VALVES

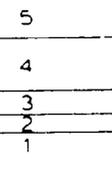
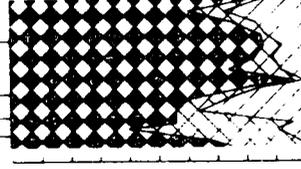
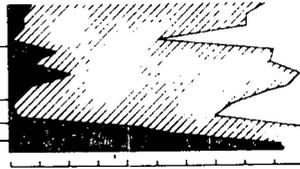
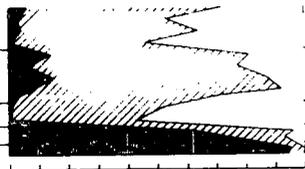
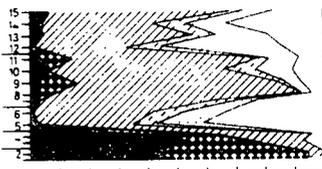
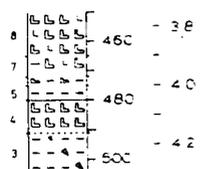
F FB BF B BM MB M

F B M

bF bB bM

b e p

LD42



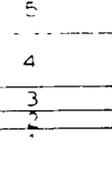
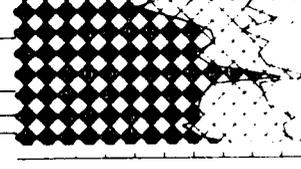
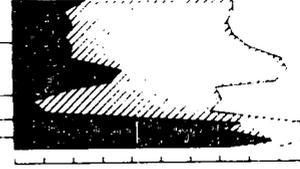
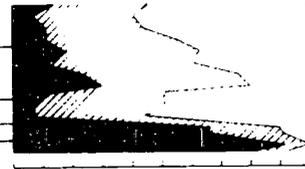
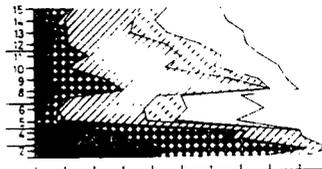
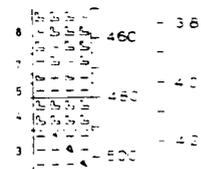
## SPECIES

F FB BF B BM MB M

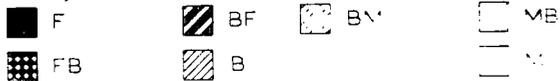
F B M

bF bB bM

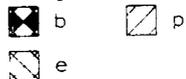
b e p



### Salinity classes



### Ecological classes



Co-ord: 50°42' 06" N  
01°40' 00" W  
Grid ref: 50 3311 4202  
Field no: 82 16



10) -471, 11) -467, 12) -463, 13) -459, 14) -455 and 15) -451 cm.

A count of roughly 200 valves was made at each level and a full record of these counts is given in Appendix V. The data are shown graphically in Figures 37a and 37b.

In this core 68 species of diatom were identified and the ratio of F : B : M was 22 : 16 : 30. In total 3035 diatom valves were identified and counted in the fifteen levels and the ratio of F : B : M was 787 : 1490 : 758.

Six dominant species were found in the core; Nitzschia navicularis (B b) with 690 valves, Navicula peregrina (B b) with 390 valves, Melosira sulcata (M p) with 298 valves, Diploneis didyma (MB b) with 192 valves, Amphora ovalis var. libyca (FB b) with 183 valves and Eunotia monodon var. bidens (F e) with 162 valves. The summary diagram for valves (Figure 37a) shows an obvious dominance of Freshwater diatoms in the lower levels. The dominance changes abruptly at -489 cm to Marine while Freshwater valves nearly disappear. This Marine dominance is shortlived and by -485 cm Brackish valves are dominant and remain so for the rest of the levels. This same pattern is seen in the species summary diagrams. Throughout the levels benthonic diatoms are dominant with fluctuating epiphytic and planktonic types.

Five assemblage zone are proposed for the data and are outlined below.

LDAZ YBS 9:1 -501 cm to ca.-497 cm

The dominant species in this zone are A.ovalis var. libyca with 40.8% TV at -499 cm, Eunotia diodon (F e) with 20.4% TV at -499 cm, Pinnularia gentilia (F b) with 19.5% TV at -501 cm, and Diploneis ovalis (FB b) with 8.3% TV at -50 cm. The upper boundary is placed where A.ovalis var. libyca declines sharply, E.monodon var. bidens rises and large changes are seen in E.diodon, D.ovalis and N.peregrina. Freshwater valves and species

dominate this zone with over 94% TV and over 80% of total species. There is a Freshwater peak of 95% TV at -499 cm and Marine diatoms are absent from this level. Benthonic life forms are dominant here.

LDAZ YBS 9:2 ca.-497 cm to ca.-491 cm

In this zone the dominant species are E.monodon var.bidens with 40.5% TV at -495 cm, N.peregrina with 27.7% TV at -493 cm, A.ovalis var.libyca with 9.2% TV at -493 cm and M.sulcata with 7% TV at -495 cm. The upper boundary is marked by a decrease in Freshwater diatoms and most noticeably by the decrease in E.monodon var.bidens. N.peregrina also shows a rapid decrease while N.navicularis and M.sulcata begin to rise. Freshwater diatoms still dominate in this zone although Brackish diatoms begin to increase in importance and Marine diatoms begin to appear. The Marine diatoms present are true Marine (M) as opposed to the Marine-Brackish diatoms of LDAZ YBS 9:1. Benthonic diatoms are again most important with increasing epiphytic types.

LDAZ YBS 9:3 ca.-491 cm to ca.-483 cm

The diatoms of this zone are dominated by M.sulcata with 28.1% TV at -489 cm, N.navicularis with 27.7% TV at -485 cm and D.didyma with 9.4% TV at -489 cm. The upper boundary is placed where N.peregrina and Nitzschia scalaris (B b) rise and N.navicularis decrease. Marine diatoms are dominant at the base of the zone but give way to Brackish diatoms at the top. Freshwater diatoms are only present in small numbers in this zone. Benthonic diatoms are once again the dominant life group here while planktonic types reach a peak of 35.9% TV at -489 cm.

LDAZ YBS 9:4 ca.-483 cm to ca.-465 cm

This zone is dominated by N.peregrina with 56.2% TV at -479 cm,

N.navicularis with 55.5% TV at -467 cm, N.scalaris with 21.3% TV at 21.3% TV at -479 cm and M.sulcata with 13.8% TV at -481 cm. D.didyma D.ovalis are also highly represented. The upper boundary is placed where Marine diatoms take over in dominance from the Brackish ones. This is shown by D.ovalis decreasing from 8.5% TV to 0.5% TV, N.navicularis decreasing from 55.5% TV to 28% TV and D.didyma increasing rapidly. Brackish valves are dominant throughout this zone, although the species curves are not so clear in their Brackish dominance. Benthonic diatoms maintain their importance here again.

LDAZ YBS 9:5 ca.-465 cm to ca.-451 cm

This last zone is characterised by N.navicularis with 58% TV at -451 cm, D.didyma with 36% TV at -463 cm and M.sulcata with 19% TV at -455 cm. Marine valves are dominant at the base of the zone but Brackish valves dominate the upper levels. The species curves are dominated by Marine diatoms.

Correlations can be drawn between the diatom zones and the lithological divisions of YBS 9. LDAZ YBS 9:1 and LDAZ YBS 9:2 represent the peat deposit of stratum 3. Here Freshwater diatoms are dominant. LDAZ 9:3 is representative of the clay stratum 4, where Marine diatoms are dominant at the base but give way to Brackish dominance at the top of the deposit. LDAZ 9:4 represents the transitional strata 5, 6, and 7. Here Brackish diatoms are the dominant types. LDAZ YBS 9:5 correlates with stratum 8, the silty-clay where Marine diatoms are most important in the lower levels of the zone but give way to Brackish ones at the top of this zone. This pattern is a repeat of LDAZ YBS 9:3. It is of interest to note that the same three species are dominant in both LDAZ YBS 9:3 and LDAZ YBS 9:5.

3) YBS 10

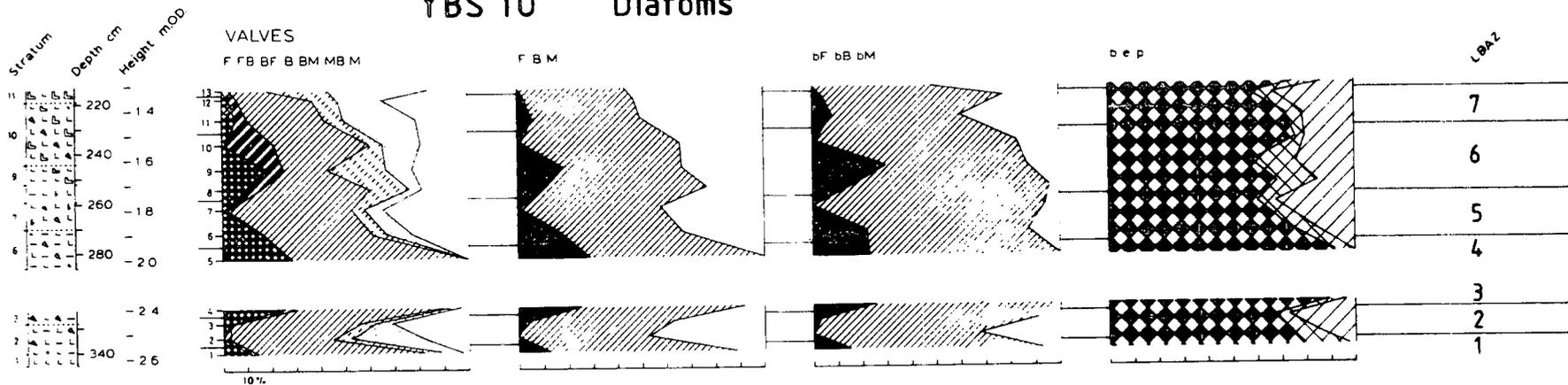
At YBS 10 the upper and lower clastic deposits were examined for their diatom content. Nine strata were examined 1, 2, 3, 6, 7, 8, 9, 10 and 11. A total of 13 levels were sampled, four from the lower clastic deposit and nine from the upper one. These levels are 1) -341, 2) -335, 3) -329, 4) -323, 5) -283, 6) -273, 7) -263 8) -255, 9) -247, 10) -237, 11) -227, 12) -219, and 13) -215 cm. A count of 200 diatom valves was made at each level and a full record can be seen Appendix V together with a graphical representation of these data in Figures 38a and 38b.

At YBS 10, 66 species of diatom were identified and the ratio of F : B : M was 20 : 19 : 27. A total of 2600 valves were identified and counted at the core and of these 247 were Freshwater, 1489 were Brackish and 864 were Marine valves.

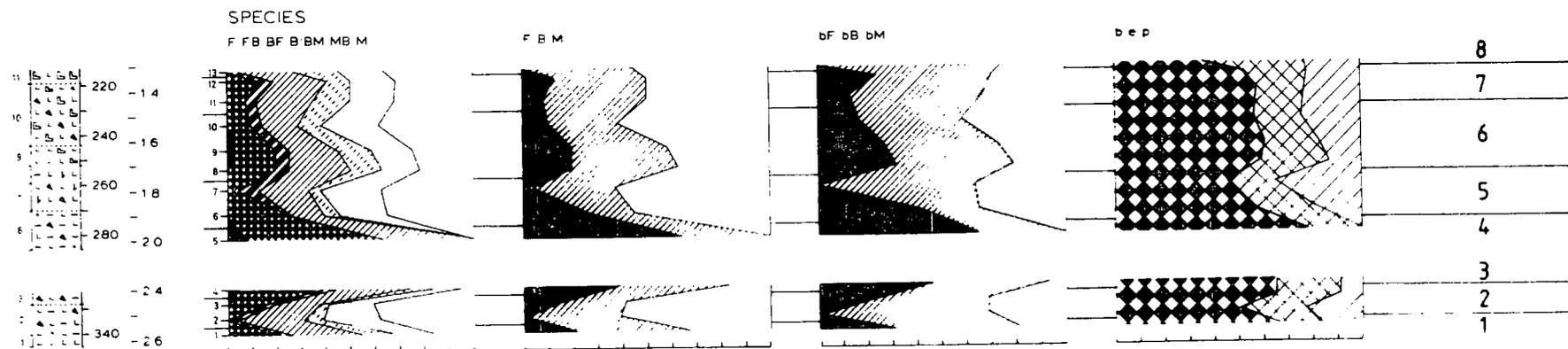
Five dominant species stand out in the counts. These are Nitzschia navicularis (B b) with 636 valves, Melosira sulcata (M p) with 311 valves, Navicula peregrina (B b) with 307 valves, Diploneis didyma (MB b) with 232 valves and Nitzschia sigma (BF b) with 103 valves. The summary diagrams for valves (Figure 38a) at YBS 10 shows that Freshwater valves increase toward the peat deposit which lies between the upper and lower clastic deposits. The Freshwater diatoms are mainly from the Fresh-Brackish group. Brackish valves remain fairly constant throughout the levels and never fall below 40% TV. Marine diatoms increase away from the peat and attain a dominant position in the upper three levels. In the summary diagrams for species the same pattern emerges; Freshwater species increase toward the peat and are dominant at level 5. The Brackish species do not show any uniform pattern, the number of species increases away from the peat. Marine species also increase in the same direction. Benthonic valves and species dominate throughout the levels.

FIGURE 38a

# YBS 10 Diatoms



## SPECIES



Salinity classes

F	BF	BM	MB
FB	B	M	

Ecological classes

b	p
e	

Location 50°42'04"N  
 01°30'04"W  
 Date 05/23/89  
 File 0811208



At YBS 10 eight assemblage zones are proposed and are outlined below.

LDAZ YBS 10:1 -341 cm to ca.-338 cm

The dominant species in this zone are N.peregrina with 26% TV, Nitzschia scalaris (B b) with 20.6% TV, Nitzschia acuminata (MB b) with 11.5% TV and M.sulcata with 10% TV. Anomoeoneis sculpta (FB b) and N.navicularis are also well represented. The upper boundary is placed where Freshwater diatoms decrease while Marine types increase. Large decreases are seen at the boundary in N.peregrina and N.scalaris, while increases are found in N.navicularis and D.didyma. Brackish diatoms are dominant in this zone although Marine types are beginning to increase in number.

LDAZ YBS 10:2 ca.-338 cm to ca.-326 cm

This zone is dominated by N.navicularis with 49% TV at -329 cm, M.sulcata with 22% TV at -329 cm and D.didyma with 21% TV at -335 cm. The upper boundary is marked by an increase in Freshwater diatoms together with a corresponding decrease of Marine ones. At this boundary there is a large rise in Diploneis ovalis (FB b) and N.peregrina, while decreases are found in N.navicularis and M.sulcata. Brackish valves are still dominant in this zone although a large increase in Freshwater species is seen at -329 cm, with a corresponding decrease in Marine diatoms at this level.

LDAZ YBS 10:3 ca.-326 cm to ca.-323 cm

Three species are characteristically dominant in this zone; N.peregrina with 42.9% TV, N.navicularis with 17.5% TV and D.ovalis with 9.5% TV. The upper boundary was artificially imposed by the break-off of sampled levels. Brackish diatoms are dominant through this zone with a large decrease of Marine types. Freshwater species have increased to 39% of total species here but the valves only account for 25% of total valves.

LDAZ YBS 10:4 -283 cm to ca.-278 cm

The dominant species in this zone are N.peregrina with 66% TV and N.scalar with 7.5% TV. The upper boundary is placed where Freshwater diatoms again begin to decline, while Marine diatoms increase. A large decrease in N.peregrina is seen at the top of this zone together with an increase in N.navicularis. Brackish valves are dominant although Freshwater diatoms dominate the species with 64% of total species. No Marine valves are found in this zone.

LDAZ YBS 10:5 ca.-278 cm to ca.-259 cm

This zone is characterised by N.navicularis with 45.5% TV at -263 cm, M.sulcata with 25% TV at -263 cm, D.ovalis with 11% TV at -273 cm and N.peregrina with 7.5% TV at the same level. The upper boundary of this zone is marked by a renewed rise in Freshwater diatoms and decreases in N.navicularis and M.sulcata. Brackish valves are dominant but Marine species out-number Brackish species here. Benthonic diatoms decrease through this zone with a rise of planktonic life forms.

LDAZ YBS 10:6 ca.-259 cm to ca.-23 cm

The species which dominate this zone are N.navicularis with 35.5% TV at -237 cm, N.sigma with 20% TV at -237 cm, M.sulcata with 17.5% TV at -247 cm, Gyrosigma acuminatum (FB b) with 10.5% TV at -247 cm and D.didyma with 10% TV at -237 cm. The upper boundary is placed where Marine diatoms become dominant and where N.sigma and N.navicularis show large decreases. An increase in D.didyma is also visible at this boundary. Brackish valves are dominant through this zone, but Marine species take over in dominance at -247 cm.

LDAZ YBS 10:7 ca.-232 cm to ca.-217 cm

This zone has three dominant species; N.navicularis with 26% TV at -219 cm, M.sulcata with 23% TV at -219 cm and D.didyma with 17.5% TV at -227 cm. The upper boundary marks the position where Freshwater diatoms die away and where a large decrease is found in N.navicularis and M.sulcata, together with a rise in Scoliopleura tumida (BM b) and D.didyma. Marine diatoms are dominant in this zone with over 50% of total valves and species. Benthonic diatoms begin declining through this zone with rising planktonic diatoms.

LDAZ YBS 10:8 ca.-217 cm to -215 cm

This last zone is dominated by D.didyma with 38% TV, S.tumida with 17.5% TV, N.navicularis with 10.5% and M.sulcata with 7.5% TV. Marine diatoms continue to increase in this zone although true Marine valves decrease.

The comparisons between diatom assemblage zones and lithological boundaries in this core are not so clear as in the other boreholes at this site. LDAZ YBS 10:1 corresponds with the lower clastic stratum of silt where Brackish diatoms are dominant. LDAZ YBS 10:2 can be identified with the transitional stratum 2 of silt-peat, where Brackish diatoms are once again dominant. LDAZ YBS 10:3 clearly shows an increasing Freshwater influence of species with Brackish dominance of valves. This zone can be correlated with the silty-peat transitional stratum 3. LDAZ YBS 10:5 and LDAZ YBS 10:6 can be compared with the upper transitional strata 6 and 7. Although Brackish valves are still dominant in these zones the species are dominated by Marine diatoms. LDAZ YBS 10:7 shows a Marine dominance and corresponds to the upper transitional stratum 10. The last zone, LDAZ YBS 10:8 can be identified with the upper silty-clay which is Marine in composition.

Thus we have a core with upper and lower transitional strata of a Brackish type topped by a clearly Marine silty-clay.

4) YBS 12

At YBS 12 the upper and lower clastic deposits were analysed for their diatom content. Five strata 3, 7, 8, 9, and 11 were examined but only the upper four strata provided sufficient diatoms for reliable counts. In all, 11 levels were sampled and the eight in the upper clastic deposit were used in this analysis. These levels are 1) -284, 2) -278, 3) -270, 4) -260, 5) -254, 6) -240, 7) -230, and 8) -220 cm. A count of 200 diatom valves was made wherever possible, but only 166 valves were counted at level 7 and 73 at level 8. The results are presented in Appendix V and the data are displayed graphically in Figures 39a and 39b.

At YBS 12, 53 species of diatoms were identified and of these 12 were recorded as Freshwater, 14 were Brackish and 27 were Marine species. A total of 1442 valves were counted in this core and 62 were Freshwater, 952 were Brackish and 428 were Marine valves.

Four species of diatoms were dominant in the counts. These were Nitzschia navicularis (B b) with 566 valves, Melosira sulcata (M p) with 143 valves, Navicula peregrina (B b) with 136 valves and Diploneis didyma (MB b) with 96 valves.

The summary diagram for valves (Figures 39a) shows that in general, Freshwater valves decrease away from the peat with a corresponding increase in Marine valves in the same direction. However, in the species summary diagram, the pattern is not so clear. Freshwater species decrease away from the peat but the Marine species tend to increase to the middle levels and then decrease upward. Benthonic diatoms are dominant throughout the levels.

# YBS 12 Diatoms

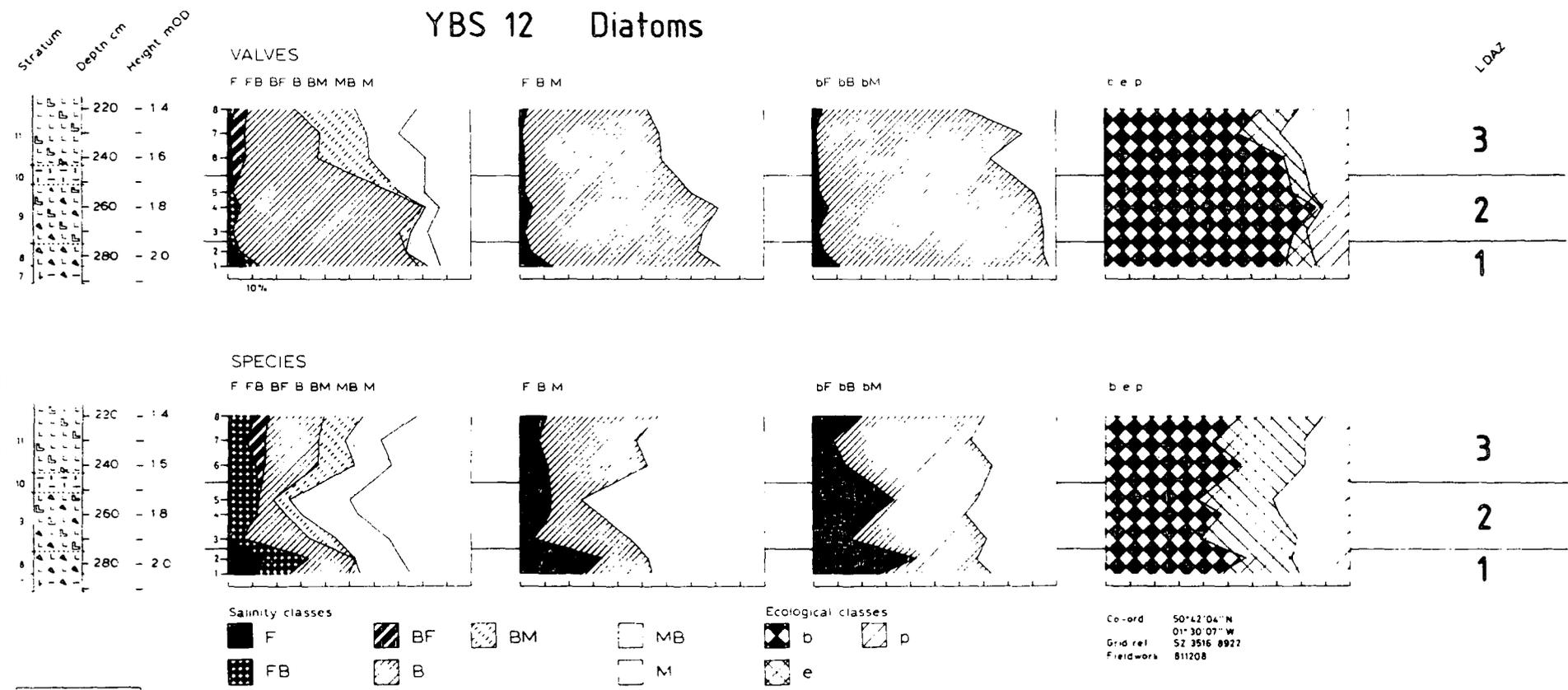


FIGURE 29a



Three assemblage zones were recognised at YBS 12 and are outlined below.

LDAZ YBS 12:1 -284 cm to ca.-274 cm.

The dominant species in this zone are N.peregrina with 48% TV at -284 cm, N.navicularis with 35% TV at -278 cm and Nitzschia circumscuta (B b) with 19% TV at -278 cm. Other species with relatively high percentages are M.sulcata and Diploneis smithi (MB e). The upper boundary of this zone is placed where Freshwater diatoms begin to decrease and where N.peregrina and N.circumsuta show large decreases with an increase in N.navicularis. Brackish valves are dominant although the species curves are dominated by Marine types. Many Freshwater species die out above this zone.

LDAZ YBS 12:2 ca.-274 cm to ca.-247 cm.

The species dominating this zone are N.navicularis with 74.5% TV at -260 cm and M.sulcata with 8% TV at -254 cm. The upper boundary is placed in the upper peat where Marine valves increase at the expense of the Brackish valves, as shown by the increase in D.didyma and the decrease in N.navicularis. Brackish valves are dominant although Marine types are again dominant in the species curves.

LDAZ YBS 12:3 ca.-247 cm to -220 cm.

This last zone is dominated by D.didyma with 20.5% TV at -220 cm, N.navicularis with 18.5% TV at -240 cm, M.sulcata with 18.1% TV at -230 cm and Scoliopleura tumida (BM b) with 16.4% TV at -220 cm. Once again the same pattern is found with dominant Brackish valves and Marine species which decrease upward.

The zones of diatoms correspond to the lithological boundaries.

LDAZ YBS 12:1 is identified with the lower transitional stratum above the

peat. LDAZ YBS 12:2 corresponds to the upper transitional stratum and LDAZ YBS 12:3 to the upper clastic deposit of clayey-silt.

5) YBS 13

At YBS 13 the upper clastic deposit was examined for its diatom content. Six strata were sampled 2, 3, 4, 5, 6 and 7 and 12 levels were extracted 1) -278, 2) -270, 3) -264, 4) -258, 5) -252, 6) -244, 7) -238 8) -234, 9) -230, 10) -226, 11) -222 and 12) -218 cm. A count of 200 valves was made at each level and the results are tabulated in Appendix V. The data are shown graphically in Figures 40a and 40b.

At YBS 13 58 species of diatoms were found. Of these 14 species were Freshwater, 16 Brackish and 28 Marine types. A total of 2386 valves were identified and counted and 74 valves were Freshwater, 1429 were Brackish and 883 were Marine.

At this borehole five species were found to be dominant. These were Nitzschia navicularis (B b) with 668 valves, Diploneis didyma (MB b) with 446 valves, Navicula peregrina (B b) with 331 valves, Melosira sulcata (M p) with 202 valves and Caloneis formosa (B e) with 135 valves. The summary diagram for valves (Figure 40a) indicates a general decrease in Freshwater valves upward from the peat with a corresponding increase in Marine valves. This pattern is broken at -238 cm where a large increase in Brackish valves is recorded and this is due to an increase in the frequency of N.peregrina and a drop in M.sulcata. Benthonic valves are dominant throughout the levels. The summary diagrams for species show the same pattern of decreasing Freshwater species away from the peat with increasing Brackish species in the same direction. The pattern for Marine species is not so clear; there is a general decrease in the number of Marine species away from the peat. Again benthonic species are dominant.

# YBS 13 Diatoms

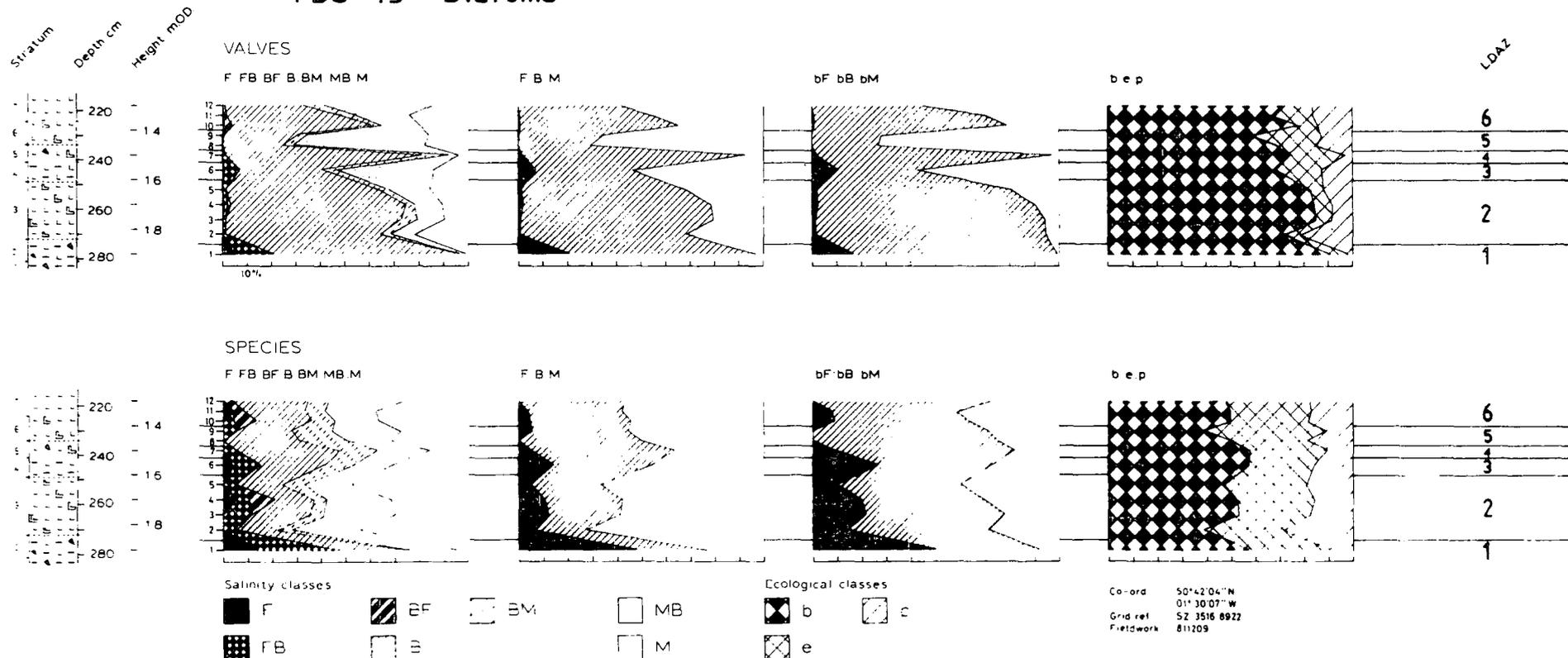


FIGURE 40a



Six assemblage zones are applied to the data at YBS 13 and are outlined below.

LDAZ YBS 13:1 -278 cm to ca.-274 cm

There are two dominant species in this zone, N.peregrina with 66.7% TV and Amphora ovalis var.libyca (FB b) with 7.4% TV. The upper boundary is placed where Marine diatoms begin to rise sharply and Freshwater diatoms decrease from 10 to 3. This is indicated by the increase of species and the rise of M.sulcata. Brackish valves are dominant in this zone, with Freshwater types dominating the species curve.

LDAZ YBS 13:2 ca.-274 cm to ca.-248 cm

The dominant species found in this zone are N.navicularis with 64.5% TV at -258 cm, Rhaphoneis amphicerus (MB (b) e) with 51.6% TV at -264 cm, D.didyma with 19.5% TV at -252 cm, Nitzschia circumscuta (B b) with 14% TV at -270 cm and M.sulcata with 11% TV at -270 cm. The upper boundary marks where Brackish valves decrease with rising Marine valves. A large decrease of N.navicularis is seen at the boundary accompanied by an increase in C.formosa and D.didyma. Brackish valves are again dominant but the species are dominated by Marine types.

LDAZ YBS 13:3 ca.-248 cm to ca.-241 cm

Four species dominate this zone, D.didyma with 37.5% TV, C.formosa with 15.5% TV, N.peregrina and M.sulcata with 9% TV each. The upper boundary is placed where Freshwater diatoms decrease again and where a very sharp increase in Brackish diatoms is found, as shown by N.peregrina. Marine diatoms decrease as shown by D.didyma and M.sulcata. Marine diatoms are, however, dominant in this zone.

LDAZ YBS 13:4 ca.-241 cm to ca.-236 cm

This zone is dominated by N.peregrina with 57% TV, C.formosa with 8% TV and Achanthes brevipes var.intermedia with 7% TV. The upper boundary is marked by a decrease in Brackish diatoms and an increase in Marine ones. This is shown by D.didyma and M.sulcata. Brackish diatoms are dominant again here.

LDAZ YBS 13:5 ca.-236 cm to ca.-228 cm

In this zone the species which dominate are D.didyma with 50% TV at -234 cm, C.formosa with 16.7% TV at -230 cm, M.sulcata with 13.6% TV at -234 cm and N.navicularis with 7.3% TV at -230 cm. The upper boundary is placed where Brackish valves increase with decreasing Marine valves. This increase in Brackish valves is seen by the increase in N.navicularis and the decrease in Marine valves is shown by D.didyma. Marine diatoms are once again dominant here.

LDAZ YBS 13:6 ca.-228 cm to ca.-218 cm

This last zone is dominated by N.navicularis with 49.3% TV at -226 cm, D.didyma with 38% TV at -218 cm, M.sulcata with 12.5% TV at -227 cm and C.formosa with 8.5% TV at -218 cm. Brackish valves dominate the upper levels and the species are dominated by Marine diatoms throughout.

A close correlation exists between the diatom zones and the lithological strata of YBS 13. LDAZ YBS 13:1 represents the upper transitional stratum 2, from the peat below to the clastic deposit above. The only Freshwater influence is seen in the species with valves being dominated by Brackish types. LDAZ YBS 13:2 clearly coincides with stratum 3, the clayey-silt. Here the Brackish valves are still dominant but the species are dominated by Marine diatoms. LDAZ YBS 13:3 corresponds with stratum 4 which is a

transitional peaty layer where Marine diatoms dominate. Stratum 5 coincides with the Brackish zone LDAZ YBS 13:4. LDAZ YBS 13:5 represents the clayey-silt of stratum 6 where Marine diatoms are dominant. The last zone LDAZ YBS 13:6 represents the upper stratum 7 of silt where Marine valves at the base give way to Brackish ones in the upper levels and Marine diatoms dominate the species. LDAZ YBS 13:5 and LDAZ YBS 13:6 have the same dominant species.

#### 6) YBS 14

At YBS 14 the upper and lower clastic deposits were sampled for their diatoms. Five strata were examined; 1, 2, 3, 5 and 6, and 15 levels sampled. In these 15 levels the diatom counts were very poor. Only 5 levels yielded a count of around 100 valves; 2) -350, 3) -346, 6) -332, 7) -328 and 8) -324 cm. These levels were in the lower clastic deposits. 7 other levels; 1) -354, 4) -342, 5) -338, 9) -320, 10) -316, 11) -284 and 13) -272 cm yielded very low counts and level 12) -276 cm yielded no diatoms. These low counts give rise to large fluctuations on the frequency diagrams and so calculations used for the analyses and for the graphical display of the data are based on percentages calculated from the total number of valves (% V) counted over only 10 levels; level 1 to level 10. This method is different to that used at the other boreholes, namely calculations based on the number of valves counted per level. The 95% confidence limits are not shown on the diagram due to the large fluctuations of numbers.

At YBS 14, 57 species were identified and of these 18 species were Freshwater, 17 Brackish and 22 Marine. A total of 629 valves were counted over the 10 levels; 154 were Freshwater, 280 were Brackish and 195 were Marine.

Four dominant species were picked out from this borehole, Navicula peregrina (B b) with 147 valves, Diploneis didyma (MB b) with 88 valves,

# YBS 14 DIATOMS

Wavelength  
Depth cm  
Height m/Litt

## VALVES

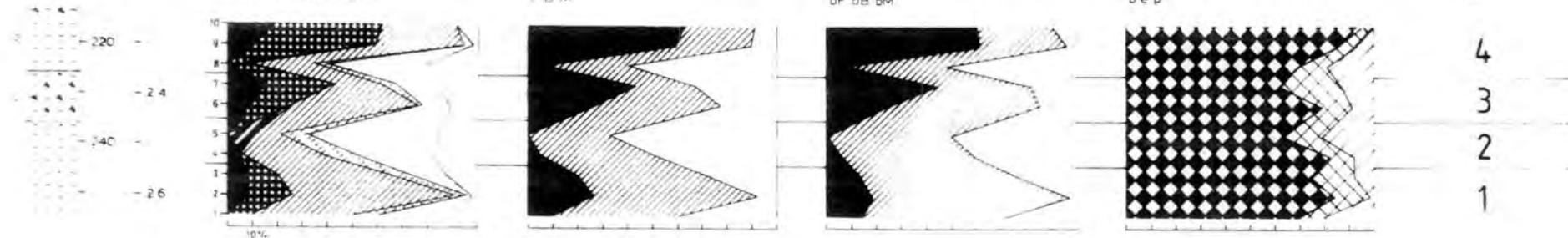
F FB BF B BM MB M

F B M

bF bB bM

b e p

LOA2



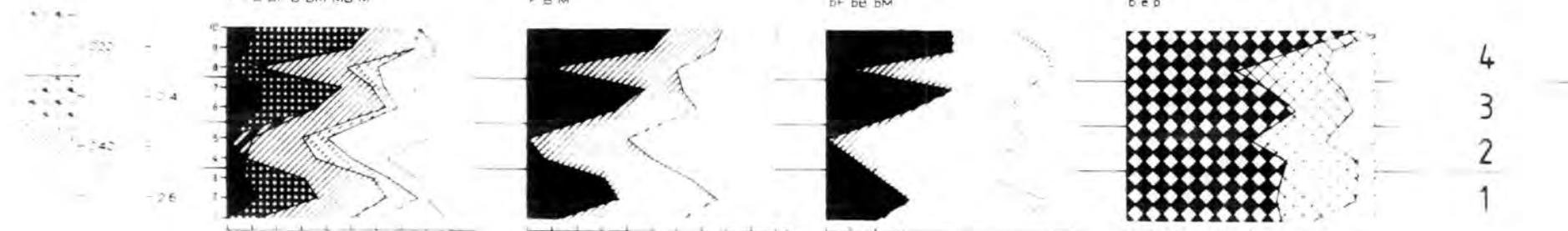
## SPECIES

F FB BF B BM MB M

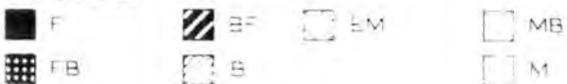
F B M

bF bB bM

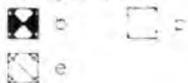
b e p



### Salinity classes



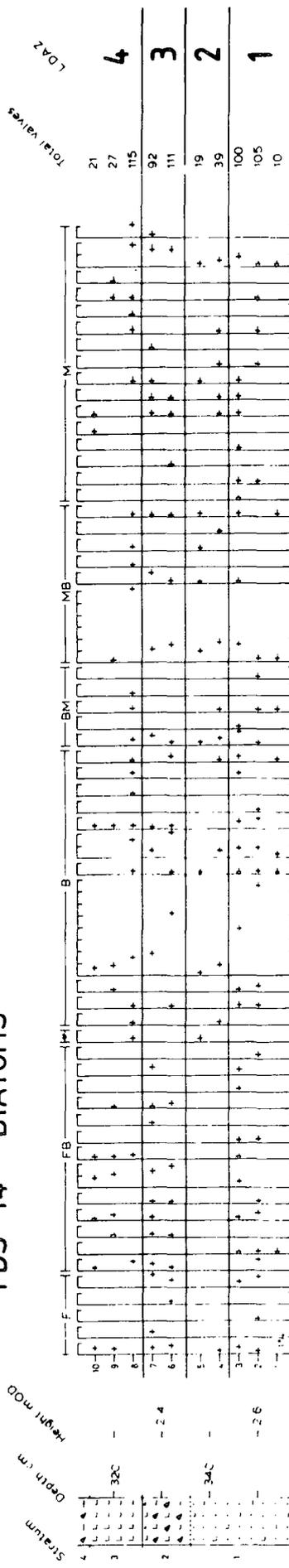
### Ecological classes



Co-ord 50°42 04 N  
01°30 07 W  
Date: 52 1515 89/1  
F. Midway 81/09

10%

# YBS 14 DIATOMS



- M. westi*
- Melosira sulcata*
- Diploetes bombus*
- C. nitidus*
- Cocconeoskelus apiculatus*
- Pogonitina stelliger*
- Plagiogramma rufum*
- Grammatonema oceanica*
- Trachymenion aspersa*
- Surirella laetosa*
- N. parvifurcata*
- Nitzschia gracilis*
- Diploetes carinata*
- Actinocyclus incurvatus*
- Rhynchocylus sinuatus*
- Cocconeis smithi*
- Cocconeis scutellum*
- Diploetes didyma*
- A. brevipes*
- Acinanthus ventermedia*
- Scolopiresura tumida*
- N. punctata*
- Rhopileta v. constricta*
- Caloneis gibberula*
- Acinanthus formosa*
- Acinanthus delicaltula*
- N. scalaris*
- Nitzschia circumscissa*
- N. progerina*
- N. elegans*
- Nitzschia digitoradiata*
- Diploetes interrupta*
- Nitzschia sigma*
- G. longipes*
- G. intricatum*
- G. constrictum*
- Gomphonema angustatum*
- Gomphonema tenella*
- Eunotia aspera*
- Cymbella maior*
- Pinnularia*
- N. pusilla*
- Nitzschia*
- Nitzschia dicens*
- Diploetes ovata*
- Amphora v. videns*
- E. monodon*
- E. gracilis*
- Eunotia exigua*
- Stauroneis*
- Pinnularia*

Nitzschia navicularis (B b) with 42 valves and Melosira sulcata (M p) with 41 valves. A full record of these counts is given in Appendix V and the data displayed graphically in Figures 41a and 41b.

The summary diagram for valves (Figure 41a) shows no general trends which stand out in the curves. Freshwater valves tend to increase toward the peat while Brackish and Marine valves decrease. Benthonic valves dominate the levels. The summary diagrams for species show much the same pattern although Brackish species tend to remain more subdued through the levels.

At YBS 14 four separate assemblage zones are recognised. These are described below.

LDAZ YBS 14:1 -354 cm to ca.-344 cm

The dominant species in this zone are N.peregrina with 7.5%  $\Sigma V$  at -350 cm, D.didyma with 1.5%  $\Sigma V$  at -346 cm, and Nitzschia punctata (BM b) with 1.1%  $\Sigma V$  at 346 cm. The upper boundary is placed where Freshwater diatoms decrease after a peak at -350 cm and where Marine diatoms begin to rise. A large change is seen in the N.peregrina curve. This zone is dominated by Brackish diatoms.

LDAZ YBS 14:2 ca.-344 cm to ca.-335 cm

This zone is dominated by Diploneis didyma with 1.7%  $\Sigma V$  at -342 cm. The upper boundary is marked by a rise in Freshwater diatoms together with a decrease in Marine types. N.peregrina shows a large rise at this boundary, together with N.navicularis. This zone is dominated by Marine diatoms as shown by the composition of the valves and species.

LDAZ YBS 14:3 ca.-335 cm to ca.-326 cm

The species which dominate this zone are N.peregrina with 5.2%  $\Sigma V$  at

-332 cm, N.navicularis with 2.1%  $\Sigma V$  at -332 cm, Pinnularia maior with 1.8%  $\Sigma V$  at -332 cm, D.didyma with 1.5%  $\Sigma V$  at -332 cm and M.sulcata with 1.4%  $\Sigma V$ . The upper boundary is drawn where Freshwater diatoms decline before rising again and where Marine diatoms increase. At this boundary D.didyma shows a very large increase. The zone is dominated by Brackish valves at the base but this gives way to a dominance of Freshwater valves at the top of the zone. Freshwater types dominate the species.

LDAZ YBS 14:4 ca.-326 cm to -316 cm

This last zone is dominated by D.didyma with 6.2%  $\Sigma V$  at -324 cm, M.sulcata with 1.8%  $\Sigma V$  at -324 cm, N.peregrina and N.navicularis both with 1.5%  $\Sigma V$  at -324 cm. P.maior is also highly represented in the upper levels of this zone. Marine valves dominate the lowest levels but are replaced by Freshwater valves in the upper levels of the zone. Likewise, Brackish species dominate the lowest level but the upper level is dominated by Freshwater species.

Although the counts at levels 11 and 13 were too small to be reliable, it is interesting to note that Freshwater diatoms have disappeared from the upper level 13, and that both levels are dominated by Brackish diatoms.

These zones can be correlated with the lithological column of YBS 14. LDAZ YBS 14:1 is representative of the lower part of stratum 1, the silty-sand, where Brackish diatoms are dominant. LDAZ YBS 14:2 corresponds to the upper levels of this stratum, where the dominance has changes to Marine types. At stratum 2, the lower transitional layer is represented by LDAZ YBS 14:3 where Brackish valves are dominant at the base but the rest of the zone is Fresh in nature. The last zone, LDAZ YBS 14:4

corresponds to the silt stratum 3, below the peat. Here Freshwater types are dominant in the upper levels but Marine and Brackish types dominate the lower levels.

### 3:4 Pett Level

#### 3:4:1 Stratigraphy

The site known as Pett Level in this study is located to the south-west of Pett Level in East Sussex. It is situated at Cliff End, where a tract of submerged forest outcrops on the foreshore (Fig. 42).

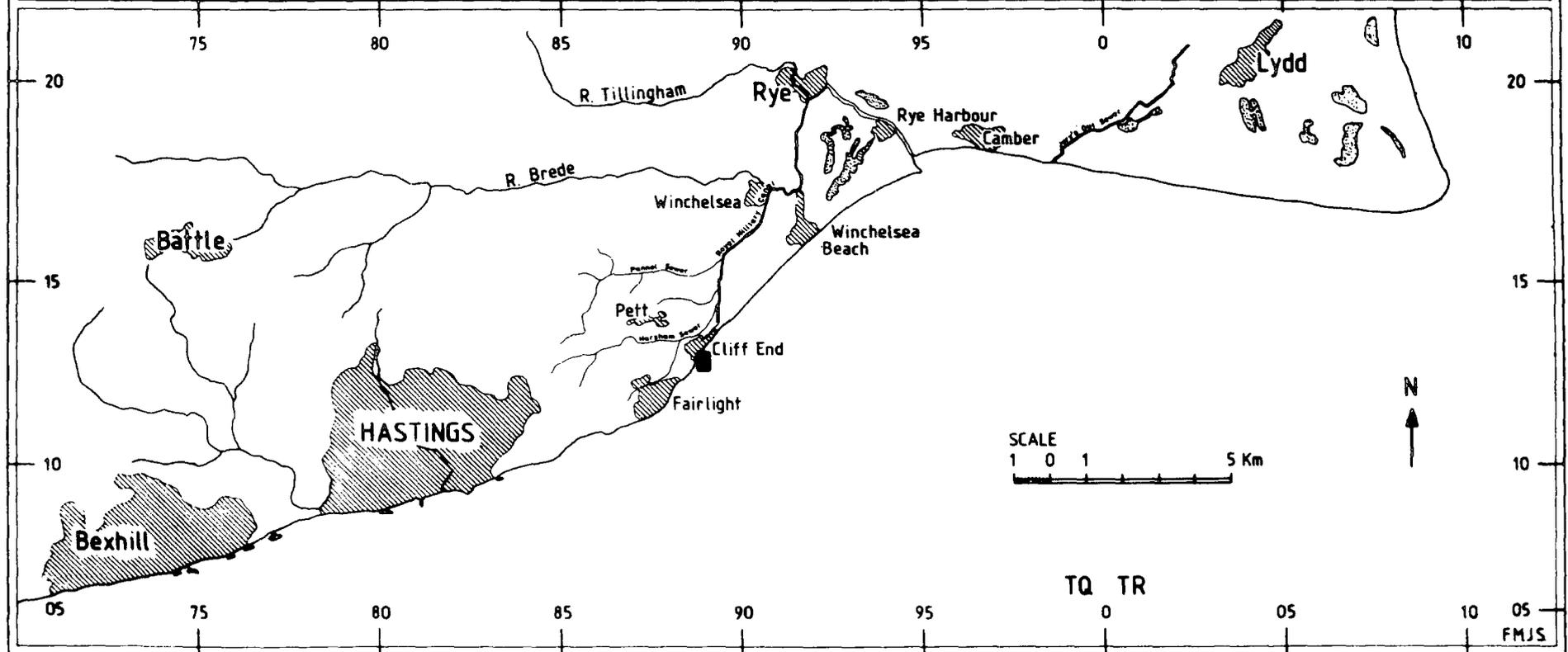
A series of seven sampling sites (Figure 43) were put down in a straight line out from the shingle barrier at the top of the beach: TQ 8903 1331 to TQ 8912 1327. Five pits were dug at Pett 1, Pett 2, Pett 3, Pett 4 and Pett 5 with samples taken from the pit sides of Pett 1, Pett 2 and Pett 3 and monolith samples from Pett 4 and Pett 5. Pett 1a and Pett 2a were taken adjacent to Pett 1 and Pett 2 using a Gouge sampler. The monolith sample of Pett 5 was taken at a first site visit at TQ 8904 1332. The ground level at this site varies in altitude from + 0.03 m.O.D. at Pett 4 to - 1.35 m.O.D. at Pett 1.

The stratigraphy of the Pett Level site can be seen in Figure 44. In general the stratigraphy can be described as two clastic horizons with two intercalated peats. This holds true for all sample sites except Pett 4 and Pett 5 which will be dealt with separately.

The lower clastic deposit is found in Pett 1a and Pett 2a, the deepest sites and ranges in altitude from - 2.29 m.O.D. at Pett 1a to - 2.58 m.O.D. at Pett 2a and has the greatest depth of 21 cm at Pett 1a. It is a silty-clay at both boreholes. In Pett 1a this clastic deposit passes into 3 cm of transitional deposit. The lower organic deposit is only found in Pett 1a and Pett 2a with a sharp lower boundary zone.

# PETT LEVEL SITE

FIGURE 42



# PETT LEVEL BOREHOLES

FIGURE 43

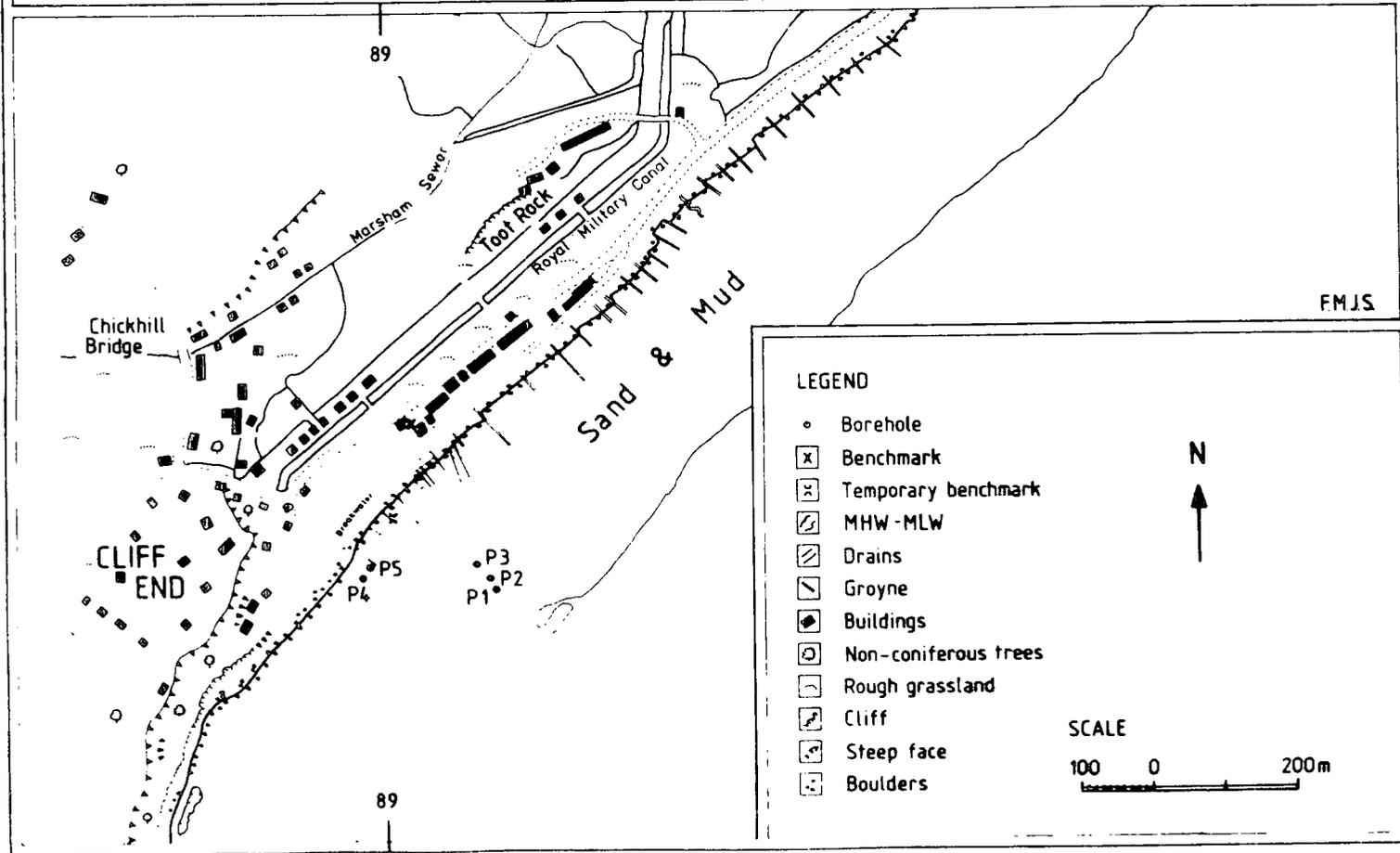
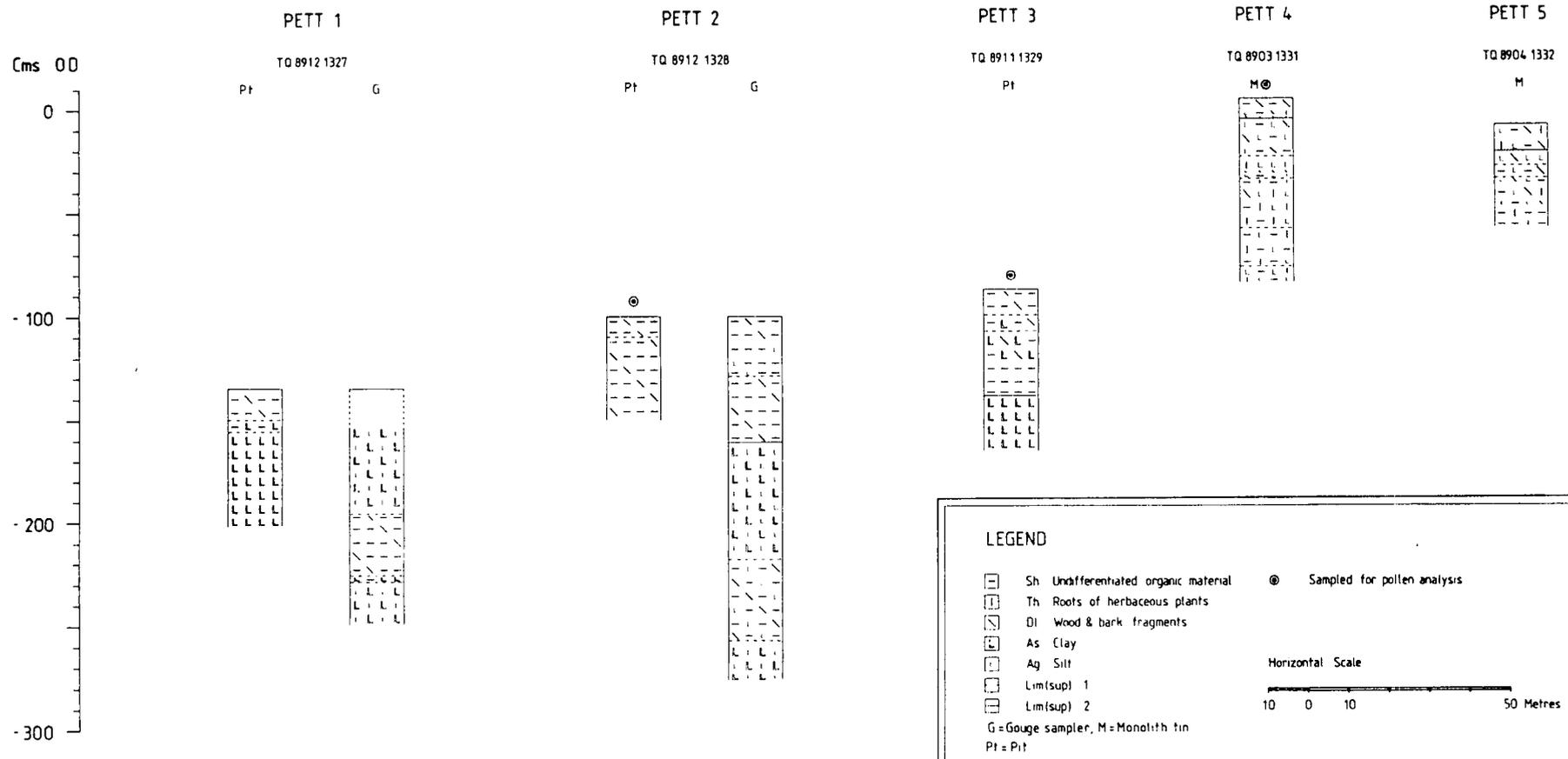


FIGURE 44

# PETT LEVEL STRATIGRAPHY



FMJS

This deposit ranges in altitude from - 1.96 m.O.D. at Pett 1a to - 2.19 m.O.D. at Pett 2a. It reaches a greatest depth of 39 cm in Pett 2a. The composition of this material varies in the two boreholes from a pure organic material in Pett 1a with wood fractions, to a similar material but with a silt fraction in Pett 2a. This organic deposit passes into the upper clastic deposit with a sharp boundary zone. The upper clastic deposit is found in Pett 1, Pett 1a, Pett 2a and Pett 3. It varies in altitude from - 1.40 m.O.D. at Pett 3 to - 1.62 m.O.D. at Pett 2a and has the greatest depth of 57 cm at Pett 2a. The composition of this deposit takes two forms; the silty-clay, found in the lower clastic deposit is again found in Pett 1a and Pett 2a while a pure clay is found in Pett 1 and Pett 3. In Pett 1, Pett 2a and Pett 3 this passes into the upper organic material with a very sharp boundary zone. The upper organic material is found in all but Pett 2. It varies in altitude from - 0.89 m.O.D. at Pett 3 to - 1.35 m.O.D. at Pett 1 but it must be remembered that the top of this deposit is not found in any of the sample sites. Its greatest depth is found at Pett 2a where 61 cm were recovered. In the main it is the same composition as the lower organic deposit, namely a peat with a wood fraction. Transitional horizons with clastic material are found within this peat at Pett 2a and Pett 3.

At Pett 4, 89 cm of material were recovered in monolith tins. This material can not be regarded as a reliable record of the true chronologically, stratified sequence as it has been disturbed by the action of live mollusca. Four pure organic layers were found at altitudes of + 0.03 m.O.D., - 0.06 m.O.D., - 0.32 m.O.D. and - 0.36 m.O.D. The rest of the core is predominantly silty-peat. At Pett 5, one pure organic deposit was found at an altitude of - 0.50 m.O.D. with a depth of 10 cm, but the rest of the core was mixed due to the live mollusca.

Three boreholes were used for further analyses; these are Pett 2, Pett 3 and Pett 4. The detailed stratigraphy of these cores is outlined below.

1) The Stratigraphy of Pett 2.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
3)	-1.01 to -1.11	0 to 10	Sh 3, D1 1 Nig 3+, Strf 0, Elas 3, Sicc 3, L(s) ? Brown peat.
2)	-1.11 to -1.23	10 to 22	Sh3, D1 1, As + Nig 3-, Strf 0, Elas 2, Sicc 3, L(s) 1 Transitional
1)	-1.23 to -1.51	22 to 50	Sh 3, D1 1 Nig 3+, Strf 0, Elas 3, Sicc 3, L(s) ? Brown peat

All the strata of this core were sampled for pollen analyses.

2) The Stratigraphy of Pett 3.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
5)	-0.89 to -1.01	0 to 15	Sh 3, D1 1, As + Nig 3, Strf 0, Elas 2, Sicc 3, L(s) ? Dark mixed woody-peat
4)	-1.01 to -1.09	15 to 20	Sh 2, D1 1, As 1 Nig 2+, Strf 0, Elas 1, Sicc 3, L(s) 1 Transitional
3)	-1.09 to -1.24	20 to 35	Sh 1, D1 1, As 2 Nig 2, Strf 0, Elas +, Sicc 3, L(s) 1 Clay with wood.
2)	-1.24 to -1.40	35 to 51	Sh 4, D1 + Nig 3+, Strf 0, Elas 2, Sicc 3, L(s) ? Brown peat.
1)	-1.40 to -1.67	51 to 78	As 4, Sh + Nig 2, Strf 0, Elas 0, Sicc 3, L(s) 2+ Clay.

Strata 2, 3, 4 and 5 were sampled for pollen analyses.

3) The Stratigraphy of Pett 4.

<u>Stratum</u>	<u>Height</u> m.O.D.	<u>Depth</u> cm	<u>Description</u>
14)	+0.03 to -0.03	0 to 6	Dl 2, Sh 2, Th + Nig 3+, Strf 1, Elas 2, Sicc 3, L(s) ? Dark brown woody-peat with monocots + wood.
13)	-0.03 to -0.06	6 to 10	Sh 1, Th 1, Dl 1, Ag 1 Nig 3, Strf 2, Elas 1, Sicc 3, L(s) Monocot remains laminated in silt penetrated by wood and molluscs.
12)	-0.06 to -0.07	10 to 11	Dl 4 Nig 4, Strf 0, Elas 1, Sicc 3, L(s) 3 Wood.
11)	-0.07 to -0.18	11 to 21	Sh 1, (Dl + Th) 1, Ag 2 Nig 2+, Strf 2, Elas 1, Sicc 3, L(s) 3 <u>Juncus fusca</u> , <u>Rubus</u> , <u>Carex schorotea</u> + fungal sclerotae at 12 cm. <u>Alisma</u> at 17 cm.
10)	-0.18 to -0.25	21 to 28	Dl 1, Sh 2, Ag 1 Nig 3-, Strf 1, Elas 1, Sicc 3, L(s) + Organic silt with <u>Carex</u> seed, <u>Alisma</u> and sedge fruits. <u>Juncus</u> .
9)	-0.25 to -0.32	28 to 35	Dl 1, Tl 1, Ag 3, Th +, As + Nig 2+, Strf 2, Elas 0, Sicc 3, L(s) 1 Silt with very laminated wood and monocot bits.
8)	-0.32 to -0.34	35 to 37	Wood
7)	-0.34 to -0.36	37 to 39	Sh 1, Tl 1, Ag 2, Dl + Nig 3, Strf 1+, Elas 1, Sicc 3, L(s) 0 Transitional
6)	-0.36 to -0.39	39 to 42	Sh 2, Tl 2, Ag +, Th + Nig 3+, Strf 1, Elas 1, Sicc 3, L(s) 1 Brown peat.
5)	-0.39 to -0.47	42 to 50	Dl 1, Th 1, Ag 2, As + Nig 2+, Strf 2, Elas 0, Sicc 3, L(s) ? Bark, monocots + <u>Carex</u> . Very laminated organic/silt.
4)	-0.47 to -0.60	50 to 63	Tl 2, Sh 1, Ag 1, Th +, As + Nig 2, Strf 1, Elas 0, Sicc 3, L(s) + Grey silty-peat with wood + laminated.
3)	-0.60 to -0.78	63 to 81	Sh 2, Tl 1, Ag 1, Th + Nig 3+, Strf 1, Elas 1+, Sicc 3, L(s) 1 <u>Eupatorium cannabinum</u> seed, woody peat + herbs.

- |    |       |    |   |
|----|-------|----|---|
| 2) | -0.78 | 81 | Sh 1, Tl 1, Ag 2, Th +.                 |
|    | to    | to | Nig 2, Strf 1, Elas +, Sicc 3, L(s) 1.  |
|    | -0.83 | 86 | Grey peaty-silt.                        |
| 1) | -0.83 | 86 | Sh 1, Tl 1, Ag 2, Th +.                 |
|    | to    | to | Nig 2+, Strf 1, Elas +, Sicc 3, L(s) +. |
|    | -0.86 | 89 | Dark transitional peaty-silt.           |

Strata 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 were sampled for pollen.

### 3:4:2 Pollen Analyses

Three pits at Pett Level were sampled for their pollen content. These were Pett 2, Pett 3, and Pett 4. In all cases the upper organic deposit was investigated. The results of these analyses are outlined and discussed below.

#### 1) Pett 2

At Pett 2 all three strata were sampled for their pollen. Nine levels were taken through this organic material at 5 cm intervals except for levels 1 and 2 which were taken at 10 cm intervals. These levels were taken at the following depths through the pit; 1) -50, 2) -40, 3) -30, 4) -25, 5) -20, 6) -15, 7) -10, 8) -5 and 9) 0 cm. A pollen sum of 500 land pollen was counted throughout this analysis, as any count based on arboreal pollen was deemed as unreliable due to the predominance of Alnus pollen in the pit. The results of this analysis can be seen graphically in Figure 45 and are tabulated in Appendix IV. The data are expressed as a percentage of the total land pollen (TLP). Two LPAZ were recognised at Pett 2 and are outlined below.

LPAZ P2:1 -50 cm to ca.-35 cm.

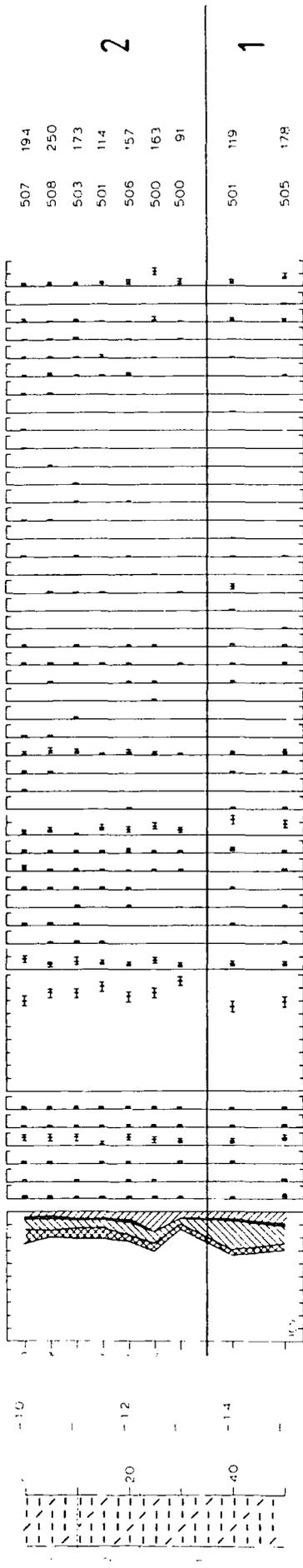
Tree pollen dominates this first zone although there is a relatively high presence of herb pollen. Alnus is the most important type of tree pollen with 68.6% TLP at - 50 cm with Quercus represented

FIGURE 45

PETT LEVEL 2 % Total Land Pollen

1942  
Lycodium  
Total pollen

Stratum  
Depth (m)  
Height (m)



50°53'13"N  
00°41'20"E  
Grid ref. TO 4912 078  
Fieldwork 870977

TREES  
 SHRUBS  
 HERBS  
 AQUATICS  
 SPORES

by 5.6% TLP at the same level. The NAP is dominated by Cyperaceae pollen with 11.8% TLP at - 40 cm while Filicales spores show 7.6% TLP + S at - 50 cm. Potentilla-type, Lythrum, Calystegia and Alisma pollen are only found in this first zone. Alnus pollen has a concentration of  $294.3 \times 10^2$  grains/cc at - 40 cm while Cyperaceae have  $53.1 \times 10^2$  grains/cc at the same level. Again at - 40 cm Umbelliferae pollen have a concentration of  $20.7 \times 10^2$  grains/cc and at the same level Corylus has a concentration of  $19.8 \times 10^2$  grains/cc. The upper boundary of this zone was drawn where tree pollen increases with rising Alnus pollen and where herb pollen decreases shown by a significant decrease in Cyperaceae and Umbelliferae pollen.

LPAZ P2:2 ca.-35 cm to 0 cm.

Tree pollen again dominates this zone with Alnus showing a record of 85.4% TLP at - 30 cm. The NAP is dominated by Cyperaceae pollen with 7.4% TLP at - 25 cm and Corylus with 8.0% TLP at 0 cm. A rise of spores is seen at - 25 cm with an increase in Filicales to 11.8% TLP + S. Alnus has the greatest concentration with  $512.4 \times 10^2$  grains/cc at - 30 cm while the peak of spores at - 25 cm records a concentration of Filicales of  $48.3 \times 10^2$  grains/cc.

We can see that the pit at Pett 2 has Alnus pollen dominating the tree pollen throughout the levels while the NAP is dominated by Cyperaceae and Corylus pollen. The two LPAZ of Pett 2 have been tentatively dated using the pollen evidence.

Dating of LPAZ at Pett 2

The peat at Pett 2 was found between altitudes of - 1.51 m.C.D. and - 1.01 m.O.D. Two LPAZ were identified and are summarised below with their major characteristics.

Table 17 Dating of LPAZ at Pett 2

Flandrian Chronozone	LPAZ	Altitude m.O.D.	Depth cm	Dominant life group	Dominant AP	Dominant NAP
III	P2:2	-1.01 to -1.36	0 to -35	Trees	A-Q	Cy-Co-Ra-Fi
	P2:1	-1.36 -1.51	-35 to -50	Trees	A-Q-B	Cy-Um-Co

A=Alnus, Q=Quercus, B=Betula, Cy=Cyperaceae, Co=Corylus, Ra=Ranunculus-type, Fi=Filicales and Um=Umbelliferae.

The frequency of tree pollen exceeds 60% of all pollen in LPAZ P2:1 and is over 70% of all pollen in LPAZ P2:2. These LPAZ are thought to belong to Flandrian Chronozone III, which is dated from 5010 ± 80 BP (West 1970).

2) Pett 3

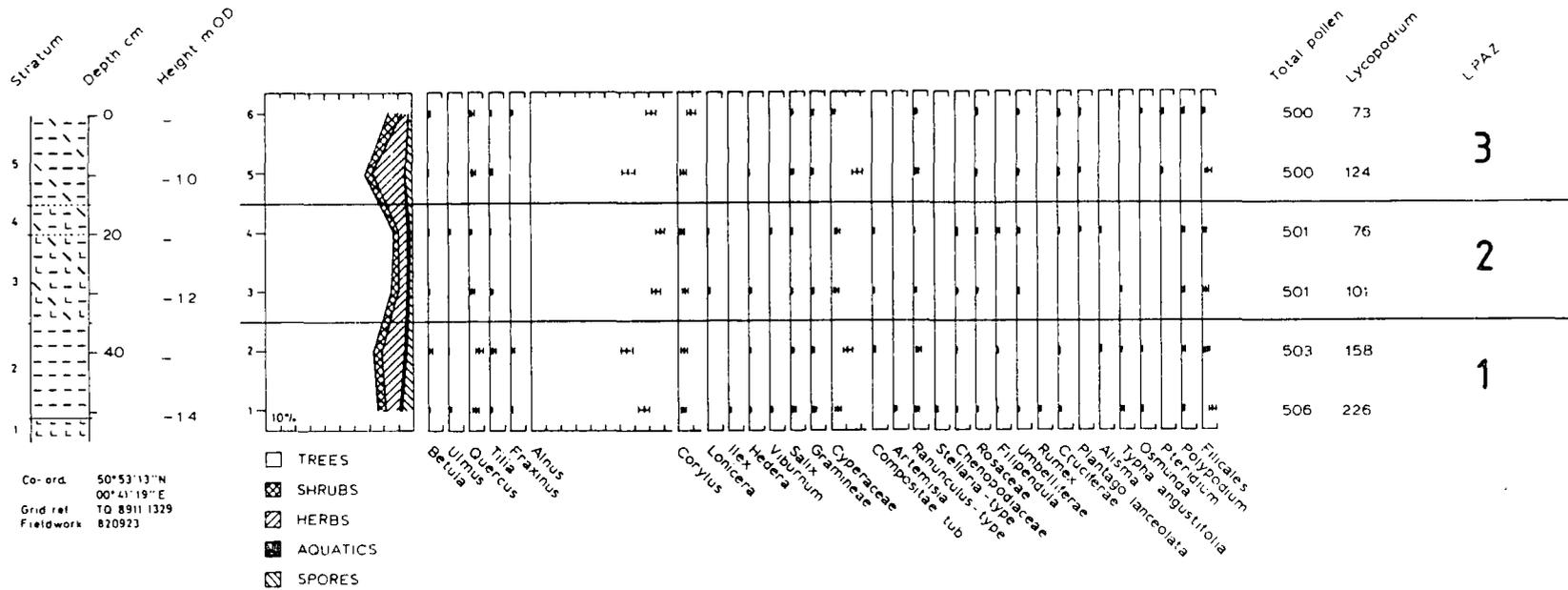
At Pett 3, strata 2, 3, 4 and 5 were sampled for their pollen content. These strata range from pure organic material in strata 2 and 5 to mixed silty-peat in strata 3 and 4. Six levels were taken in this pit at 10 cm intervals. These levels are 1) -50, 2) -40, 3) -30, 4) -20, 5) -10 and 6) 0 cm. A pollen sum of 500 land pollen was counted throughout the levels. Calculations of these data were expressed as a percentage of total land pollen (TLP) and the results can be seen in Figure 46 and are tabulated in Appendix IV. Three LPAZ were recognised at Pett 3 and are outlined below.

LPAZ P3:1 -50 cm to ca.-45 cm.

This first LPAZ is dominated with tree pollen with over 70% of all pollen and also a relatively high presence of herb pollen. Alnus is the dominant tree pollen with 76.6% TLP at - 50 cm while Quercus has 6.8% TLP at - 40 cm. The NAP is dominated by Cyperaceae pollen

FIGURE 46

### PETT LEVEL 3 % Total Land Pollen



Co-ord. 50°53'13"N  
00°41'19"E  
Grid ref TD 8911 1329  
Fieldwork 820923

- TREES
- ▣ SHRUBS
- ▤ HERBS
- AQUATICS
- ▦ SPORES

Betula  
Ulmus  
Quercus  
Fraxinus  
Alnus  
Corylus  
Lonicera  
Ilex  
Hedera  
Viburnum  
Salix  
Gramineae  
Cyperaceae  
Artemisia  
Compositae tub  
Ranunculaceae  
Stellaria-type  
Chenopodiaceae  
Rosaceae-type  
Filipendula  
Umbelliferae  
Rutaceae  
Cruciferae  
Plantago  
Alisma  
Typha lanceolata  
Osmunda  
Typha angustifolia  
Pteridium  
Polypodium  
Filicales

with 11.2% TLP at - 40 cm while Filicales has 7.0% TLP + Sp at - 50 cm. Four species are only found in this LPAZ. These are Ilex, Artemisia, Stellaria-type and Rumex. Alnus pollen records the highest concentration with  $228.2 \times 10^2$  grains/cc at - 40 cm. The highest NAP concentration is shown by Cyperaceae pollen with  $39.2 \times 10^2$  grains/cc at the same level and Filicales has a concentration of  $19.0 \times 10^2$  grains/cc at - 50 cm. The upper boundary was placed where tree pollen begins to increase and herb pollen decreases. At this boundary a rise in Alnus pollen is seen from 65.2% TLP to 85.4% TLP while Quercus pollen decreases from 6.8% TLP to 2.4% TLP and Fraxinus pollen temporarily disappears. Cyperaceae pollen also decreases from 11.2% TLP to 3.2% TLP.

LPAZ P3:2 ca.-45 cm to ca.-15 cm.

This LPAZ is again dominated by tree pollen with over 80% of all pollen, and decreasing herb pollen. Alnus pollen again dominates the tree pollen with 88.4% TLP at - 20 cm. The NAP is very low with Corylus pollen recording 4.4% TLP at - 30 cm and Cyperaceae with 4.2% TLP at - 20 cm. Lonicera pollen is only found in this LPAZ. The concentration of Alnus pollen is again high with  $663 \times 10^2$  grains/cc at - 20 cm. Cyperaceae pollen show a concentration of  $31.5 \times 10^2$  grains/cc at - 20 cm and at - 30 cm Corylus pollen has  $24.2 \times 10^2$  grains/cc. The upper boundary is marked by a decrease in tree pollen with a corresponding rise of herb pollen, and the dying away of aquatic pollen. Alnus decreases from 88.4% TLP to 66.6% TLP, Cyperaceae records a rise from 4.2% TLP to 18.8% TLP and Filicales rise from 1.8% TLP+SP to 4.8% TLP+Sp.

LPAZ P3:3 ca.-15 cm to 0 cm.

Tree pollen dominates this last LPAZ with a peak of herb pollen at - 10 cm. Alnus pollen dominates the tree pollen with 85.3% TLP at

0 cm while Quercus pollen has 3.4% TLP at - 10 cm. The NAP is dominated by Cyperaceae pollen with 18.8% TLP at - 10 cm, Corylus pollen has 9.2% TLP at 0 cm and Filicales has 4.8% TLP + Sp at - 10 cm. Pteridium spores are only found in this zone while Viburnum, Compositae tubuliflora, Chenopodiaceae, Filipendula, Alisma and Typha angustifolia all die out in this zone. Concentration of Alnus pollen is again high with  $616.5 \times 10^2$  grains/cc at 0 cm. Cyperaceae pollen has a concentration of  $84.6 \times 10^2$  grains/cc at - 10 cm, Corylus has  $69 \times 10^2$  grains/cc and Filicales has  $22.5 \times 10^2$  grains/cc at - 10 cm.

The pit at Pett 3 is dominated by tree pollen throughout the levels with two peaks of herb pollen at - 40 cm and - 10 cm. LPAZ P3:1 can be said to correlate with the lower organic stratum 2 where Alnus is the dominant tree pollen and Cyperaceae dominate the NAP. The transitional peaty-silt of stratum 3 and silty-peat of stratum 4 correspond with LPAZ P3:2 where Alnus again dominates the tree curves and where Corylus and Cyperaceae pollen dominate the NAP. The upper organic stratum 5 correlates with LPAZ P3:3 where Alnus pollen dominates the trees and where Cyperaceae pollen shows a peak of NAP at - 10 cm. The three LPAZ of Pett 3 have been tentatively dated using the pollen evidence.

#### Dating of LPAZ at Pett 3

At Pett 3 a lower and upper peat was found between altitudes of - 1.40 m.O.D. to - 1.24 m.O.D. and - 1.01 m.O.D. to - 0.89 m.O.D. Three LPAZ were identified and are summarised below with their major characteristics.

Table 18 Dating of LPAZ at Pett 3

Flandrian Chronozone	LPAZ	Altitude m.O.D.	Depth cm	Dominant life group	Dominant AP	Dominant EAP
III	P3:3	-0.89 to -1.01	0 to -15	Trees	A-Q	Cy-Co-Fi
	P3:2	-1.01 to -1.34	-15 to -45	Trees	A	Co-Cy
	P3:1	-1.34 to -1.39	-45 to -50	Trees	A-Q	Cy-Fi-Co

A=Alnus, Q=Quercus, Cy=Cyperaceae, Co=Corylus, Fi=Filicales.

Tree pollen dominates all of these LPAZ and reaches up to 87.7% of all pollen at - 20 cm. These LPAZ are thought to belong to Flandrian Chronozone III which is dated from 5010 ± 80 BP (West 1970).

3) Pett 4

At Pett 4 thirteen strata were sampled for their pollen content; strata 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14. These included the pure organic strata 6, 8 and 12 together with the mixed inorganic and organic strata. The sampling interval varied from 8 cm to 1 cm depending on the stratigraphic boundaries imposed on the core by the Troels-Smith analysis. In total 22 levels were taken for analysis from this site. These are 1) -84, 2) -82, 3) -80, 4) -74, 5) -70, 6) -66, 7) -60, 8) -56, 9) -52, 10) -46, 11) -41, 12) -40, 13) -38, 14) -36, 15) -31, 16) -25, 17) -17, 18) -13, 19) -10, 20) -8, 21) -5 and 22) -1 cm. In all cases a pollen sum of 500 land pollen was counted. The data are displayed in Figure 47 in the form of %total land pollen (TLP). The results are tabulated in Appendix IV. Seven LPAZ are recognised at this pit and are outlined below.



LPAZ P4:1 -84 cm to ca.-81 cm.

Tree pollen dominates this first LPAZ with Alnus recording 70.2% TLP at - 84 cm. The NAP is dominated by Cyperaceae with 9.6% TLP at - 84 cm, Corylus with 8% TLP at - 82 cm and Salix with 7.4% TLP at the same level. Succisa pollen is only found in this zone. Alnus records a high concentration of  $330.5 \times 10^2$  grains/cc while Cyperaceae have  $45.2 \times 10^2$  grains/cc at the same level of - 84 cm and again at - 84 cm Corylus pollen records a concentration of  $32 \times 10^2$  grains/cc. The upper boundary is drawn where Alnus pollen rises from 64.8% TLP to 80.2% TLP and decreases in Salix and Cyperaceae pollen are seen.

LPAZ P4:2 ca.-81 cm to ca.-58 cm.

Tree pollen declines through this LPAZ with rising herb pollen. Alnus dominates the tree pollen with 80.2% TLP at - 80 cm. The NAP is dominated by Cyperaceae with 20.2% TLP at - 60 cm while Salix has 15.4% TLP at - 60 cm and is rising through this zone. Corylus pollen has 14.2% TLP at the same level. Fagus pollen first appears in this LPAZ while Lonicera and Myriophyllum pollen are only found here. The concentration of Alnus pollen is  $335.7 \times 10^2$  grains/cc at - 80 cm. Cyperaceae pollen has a concentration of  $58.5 \times 10^2$  grains/cc at - 60 cm and at the same level Salix pollen has  $44.6 \times 10^2$  grains/cc. The upper boundary of this zone is marked by an increase in Alnus pollen from 19% TLP to 49.6% TLP and where decreases are seen in Corylus, Gramineae and Cyperaceae pollen.

LPAZ P4:3 ca.-58 cm to ca.-43.5 cm.

Again tree pollen dominates this third zone at the base although the top levels are dominated by shrub and herb pollen. Alnus pollen records 61.3% TLP at - 52 cm. The NAP is dominated by Salix with

19.4% TLP at - 56 cm and Cyperaceae with 17.6% TLP at - 46 cm. The concentration of pollen decreases overall in this LPAZ with Alnus recording  $142.1 \times 10^2$  grains/cc at - 46 cm, Cyperaceae with  $56.8 \times 10^2$  grains/cc at the same level and at - 56 cm Salix has a concentration of  $53.5 \times 10^2$  grains/cc. The upper boundary was placed where there is an increased rise of Alnus pollen from 44% TLP to 79.2% TLP with a decrease in Gramineae pollen from 9.8% TLP to 1.4% TLP and in Cyperaceae from 17.6% TLP to 2.0% TLP.

LPAZ P4:4 ca.-43.5 cm to ca.-33.5 cm.

This LPAZ shows the peak of tree pollen with over 84% of all pollen at - 38 cm. Alnus pollen has a peak of 84.2% TLP at - 40 cm. The record of NAP is very low throughout this zone. Calystegia and Pilularia species are only found in this LPAZ. Alnus pollen records a concentration of  $1034.6 \times 10^2$  grains/cc at - 36 cm while Filicales has a concentration of  $55.5 \times 10^2$  grains/cc at - 38 cm. Corylus has  $55.2 \times 10^2$  grains/cc at - 36 cm and at - 40 cm Betula has a concentration of  $53.4 \times 10^2$  grains/cc. The upper boundary is marked by the beginnings of a decline in tree pollen with Alnus falling from 82.4% TLP to 60.6% TLP and rises in Corylus, Gramineae and Cyperaceae pollen.

LPAZ P4:5 ca.-33.5 cm to ca.-21 cm.

This zone shows a decrease of tree pollen with a corresponding rise of herb pollen. Alnus pollen has a record of 60.6% TLP at - 31 cm. The NAP is dominated by Cyperaceae pollen with 25.5% TLP at - 25 cm, Salix pollen with 12.8% TLP at the same level and again at - 25 cm Corylus pollen has 10.8% TLP. The concentration of Alnus pollen has dropped to  $428 \times 10^2$  grains/cc at - 31 cm while Cyperaceae records a concentration of  $96.4 \times 10^2$  grains/cc at - 25 cm and at

- 31 cm Corylus pollen has a concentration of  $60.7 \times 10^2$  grains/cc. The upper boundary was drawn where there is a renewed rise of Alnus pollen from 29.3% TLP to 42.7% TLP and also a rise of Salix pollen from 12.8% TLP to 25.1% TLP and where Cyperaceae fall from 25.5% TLP to 4.4% TLP.

LPAZ P4:6 ca.-21 cm to ca.-11.5 cm.

This zone is dominated by NAP in the form of herb and shrub pollen. The tree pollen decreases to a minimum at - 13 cm. Alnus is the most important tree pollen with 42.7% TLP at - 17 cm. The NAP is dominated by Salix with 32.2% TLP at - 13 cm, Gramineae have 15% TLP at - 13 cm and Typha angustifolia has a peak of 10.8% TLP + Aq at the same level. Centaurea pollen is only found in this zone, while the first record of Glaux pollen is here. The concentration of Alnus pollen is  $322.4 \times 10^2$  grains/cc at - 17 cm and at the same level Salix has a concentration of  $189.8 \times 10^2$  grains/cc and Gramineae has  $90.4 \times 10^2$  grains/cc at the same level. The upper boundary is marked by a renewed rise of tree pollen with Alnus rising from 18.8% TLP to 45.6% TLP, Salix pollen falls from 32.2% TLP to 21% TLP and decreases are also recorded in Gramineae and Cyperaceae pollen.

LPAZ P4:7 ca.-11.5 cm to -1 cm.

This last LPAZ sees a large rise of shrub pollen. The trees are dominated by Alnus pollen with 48.6% TLP at - 8 cm. Salix dominates the NAP with 48.8% TLP at - 5 cm. Cyperaceae records 13.8% TLP at - 1 cm and Gramineae has 8% TLP at - 10 cm. Convolvulus pollen is only found in this last zone. The concentration of Alnus pollen is  $343.5 \times 10^2$  grains/cc at - 10 cm while Salix records a high concentration of  $250.7 \times 10^2$  grains/cc at - 5 cm. The concentrations of Gramineae and Cyperaceae are  $60.3 \times 10^2$  grains/cc at - 10 cm and at - 5 cm the

latter has  $57.5 \times 10^2$  grains/cc.

These LPAZ show a record of changing vegetation types closely associated with the strata of Pett 4. LPAZ P4:1 correlates with stratum 2 which is a transitional peaty-silt bed where Alnus dominates the tree pollen and where Corylus and Cyperaceae dominate the NAP. LPAZ P4:2 can be said to correspond to the silty-peat of stratum 3 where tree pollen is most important and to the base of stratum 4 where NAP is more important in the form of Cyperaceae and Salix pollen. The top levels of stratum 4 and stratum 5 correspond to LPAZ P4:3, here tree pollen is again dominant and Salix is the most important NAP. LPAZ P4:4 clearly shows the peak of tree pollen corresponding to the wood stratum 8, where there is little evidence of NAP. The peaty-silt of stratum 9 is dominated by tree pollen while the silty-peat of stratum 10 is shown to be dominated by NAP in the form of Cyperaceae and Salix pollen. LPAZ P4:6 can be correlated with stratum 11 and is dominated by NAP with Salix the most important species. At LPAZ P4:7 there is a change of dominance from NAP to tree pollen at the base corresponding to stratum 12, which is a bed of wood; the upper levels of this LPAZ are dominated by NAP.

It is obvious that Pett 4 displays the most complex of patterns of local vegetational change at the Pett Level site and as previously mentioned this is thought to be due to the action of live mollusca, which have disturbed the sample site. As a result this pit has not been dated using the pollen evidence, although it would of been useful to represent the uppermost organic deposit of the site.

3:5 Browndown

3:5:1 Stratigraphy

The core at Browndown was taken by the Civil Engineering Department at Portsmouth Polytechnic. This core, Browndown 13/14 53, was taken using a type of Percussion corer from the sea-bed off the coast from Gosport in Stokes Bay (Figure 48) (SZ 585 985). The sampled material consists of four one metre sections:-

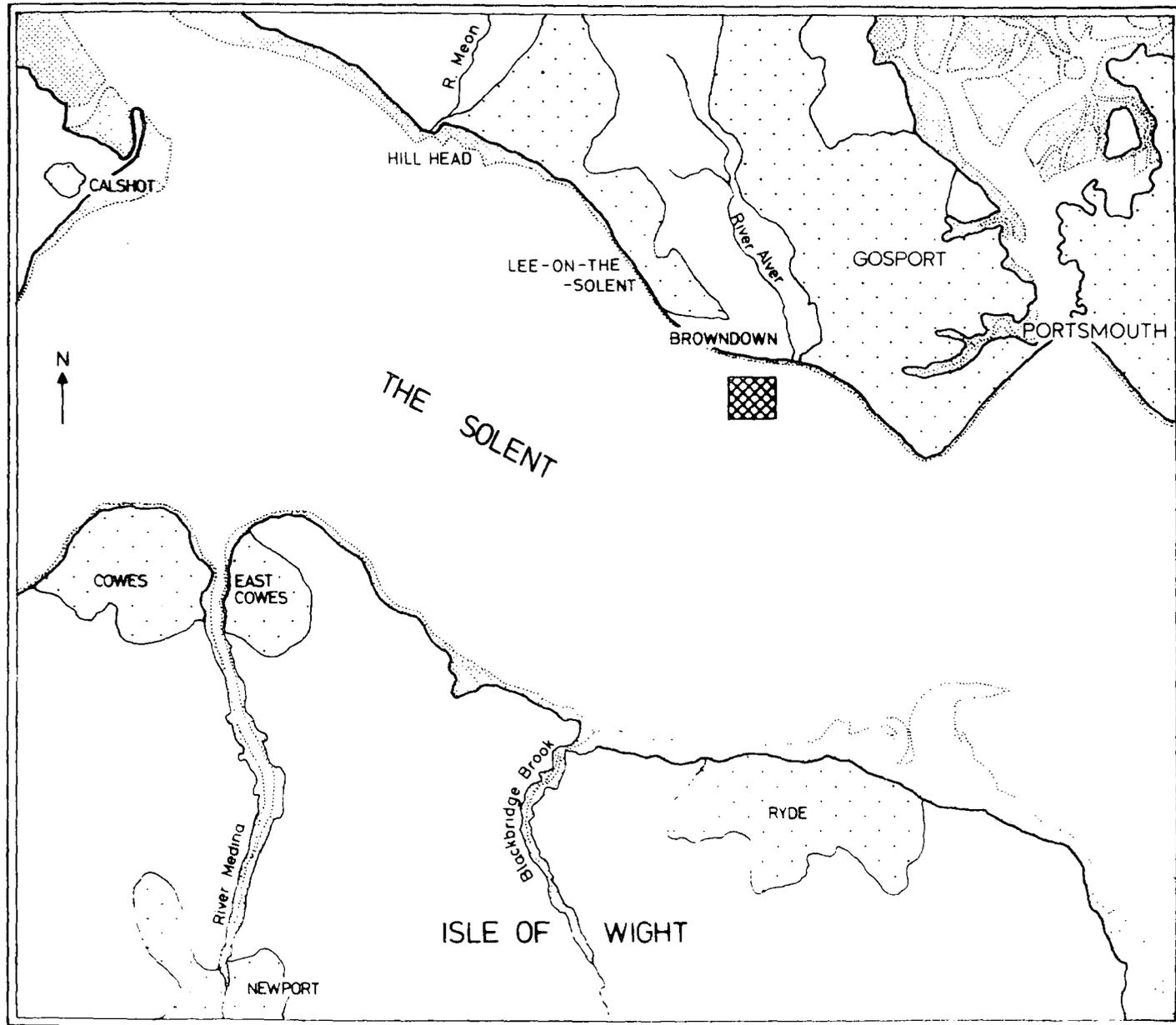
- Tube 26 -9.4 m.O.D. to -10.4 m.O.D.
- " 27 -10.2 m.O.D. to -11.2 m.O.D.
- " 28 -11.2 m.O.D. to -12.2 m.O.D.
- " 36 -18.8 m.O.D. to -19.8 m.O.D.

The indication of depth, in centimetres, from the top of the core is given with the sea-bed, at -5.5 m.O.D. taken as the top of the core.

The stratigraphy of this core at Browndown can be divided into four sections and is seen in Figure 49. The basal strata consist of a sandy deposit 42.5 cm deep. Above this lies the only organic material found in Browndown 13/14 53. This organic deposit is not a pure peat but mainly a transitional peaty-silt bordering stratum 6, which is a silty-peat with a depth of 12 cm, at an altitude of -19.2 m.O.D. Above the organic deposit, approximately 9.26 m of mixed clays and silts are found with no definite trends apparent within the strata. The last type of material found at this borehole is coarser than the mixed silts and clays and is a sandy deposit becoming coarser towards the top of the sampled material. The detailed stratigraphy of this borehole is given below.

The Stratigraphy of Browndown 13/14 53

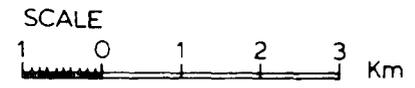
Stratum	Altitude	Depth	Description
29	-9.4	390	Ag 1, Ga 3, Part.test.(moll.) +
	to	to	Nig 1+, Strf 0, Elas ?, Sicc 4, L(s) 0
	-9.6	408	Light grey silty-sand with <u>Ostrea</u>



# THE BROWNDOWN SITE

FIGURE 48

-  BROWNDOWN SITE
-  HWM / LWM.
-  SAND & MUD
-  URBAN AREA



FMJS.

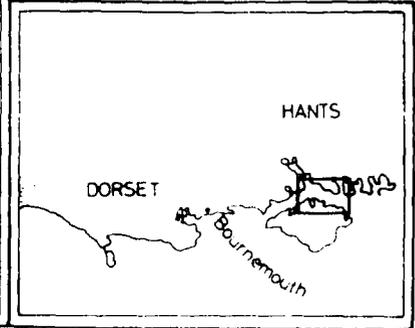
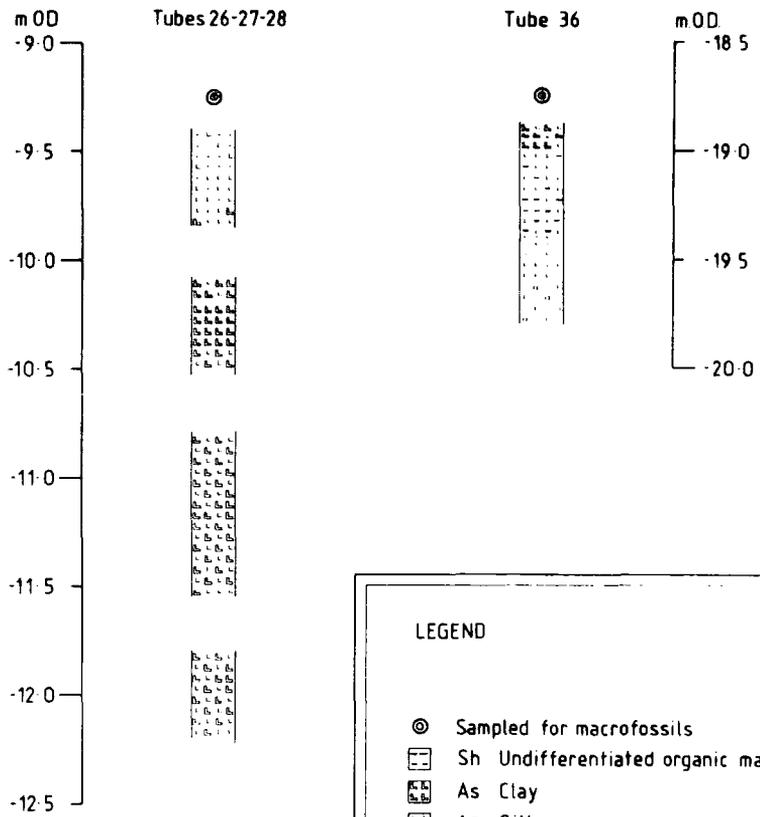


FIGURE 49

### BROWNDOWN 13/14 53 STRATIGRAPHY



FMJS

#### LEGEND

- ⊙ Sampled for macrofossils
- ▬ Sh Undifferentiated organic material
- ▒ As Clay
- ⋯ Ag Silt
- Ga Sand
- ◻ Gg(min) Fine gravel

28	-9.6 to -9.7	408 to 424	Ag 3+, Ga 1-, As +, Part.test.(moll.) + Nig 1+, Strf 0, Elas ?, Sicc 4, L(s) 0 Light sandy-silt with whole <u>Ostrea</u>
27	-9.7 to -9.9	424 to 435	Ag 3, As 1, Part.test.(moll.) + Nig 1+, Strf 0, Elas ?, Sicc 4, L(s) 0 Light clayey-silt with parts and shells
26	-9.9 to -10.1	435 to 457	Not sampled
25	-10.1 to -10.2	457 to 468	Ag 1-, As 3+, Part.test.(moll.) + Nig 3, Strf 0, Elas ?, Sicc 4, L(s) 0 Dark grey transitional clay. Flame of silty-clay and shell fragments.
24	-10.2 to -10.4	468 to 491	As 4, Ag +, Sh + Nig 3-, Strf 0, Elas ?, Sicc 4, L(s) 0 Dark grey clay and organic staining
23	-10.4 to -10.5	491 to 503	As 2, Ag 2, Ga +. Sh + Nig 3-, Strf 0, Elas ?, Sicc 4, L(s) 0 Dark grey clay-silt and organic remains
22	-10.5 to -10.8	503 to 529	Not sampled
21	-10.8 to -10.9	529 to 539	Ag 2, As 2 Nig 2-, Strf 0, Elas ?, Sicc 4, L(s) 0 Light grey clay-silt
20	-10.9 to -11.1	539 to 562	Ag 2, As 2, Sh +, Lf + Nig 2, Strf 0, Elas ?, Sicc 4, L(s) 0 Dark grey clay-silt and organic stains
19	-11.1 to -11.2	562 to 570	Ag 1+, As 3-, Sh +. Lf + Nig 2, Strf 0, Elas ?, Sicc 4, L(s) 0 Silty-clay and great organic staining
18	-11.2 to -11.5	570 to 602	As 2, Ag 2, Sh +, Lf + Nig 1+, Strf 1-, Elas ?, Sicc 4, L(s) 0 Light grey silt-clay and charcoal FeO <sub>2</sub> Clay balls present
17	-11.5 to -11.6	602 to 605	Ag 3-, As 1+ Nig 1+, Strf 0, Elas ?, Sicc 4, L(s) 0 Light clayey-silt
16	-11.6 to -11.8	605 to 630	Not sampled
15	-11.8 to -11.9	630 to 639	Ag 2-, As 2+, Sh + Nig 1, Strf 0, Elas ?, Sicc 4, L(s) 0 Silt-clay and organic remains

14	-11.9 to -12.0	639 to 646	As 3+, Ag 1-, Sh + Nig 2, Strf 2, Elas ?, Sicc 4, L(s) 0 Dark grey silty-clay and charcoal, wood and organic staining
13	-12.0 to -12.2	646 to 666	Ag 2-, As 2+, Sh +, Lf + Nig 2-, Strf 2, Elas ?, Sicc 4, L(s) 0 Grey silt-clay, transitional and silt bands
12	-12.2 to -12.2	666 to 670	Ag 3, As 1, Sh +, Lf + Nig 2-, Strf 1, Elas ?, Sicc 4, L(s) 0 Grey clayey-silt and charcoal remains
11	-12.2 to -18.9	670 to 1338	Not sampled
10	-18.9 to -18.9	1338 to 1342	As 2, Ag 2, Sh +, Gg(min) + Nig 1-, Strf 1+, Elas ?, Sicc 4, L(s) 0 Light clay-silt and dark organic stains
9	-18.9 to -19.01	1342 to 1351	Ag 1, As 3, Sh +, Th + Nig 2, Strf 2+, Elas ?, Sicc 4, L(s) 0 Grey silty-clay transitional and organic
8	-19.01 to -19.06	<del>1351</del> to 1356	Ag 3+, Sh 1-, Th + Nig 3-, Strf 3, Elas ?, Sicc 4, L(s) 0 Light grey peaty-silt
7	-19.06 to -19.2	1356 to 1370	Ag 3, Sh 1, Th + Nig 3, Strf 2+, Elas ?, Sicc 4, L(s) 0 Grey peaty-silt and dark banding
6	-19.2 to -19.3	1370 to 1382	Ag 1, Sh 3, Ga +, Lf + Nig 3+, Strf 3+, Elas ?, Sicc 4, L(s) 0 Dark silty-peat, rusty stains
5	-19.3 to -19.4	1382 to 1388	Ag 2-, Sh 2, Gg(mag) +, Ga + Nig 3, Strf +, Elas ?, Sicc 4, L(s) 0 Dark transitional, nodules of chalk
4	-19.4 to -19.4	1388 to 1391	Ga 2, Ag 2, Sh + Nig 2, Strf 0, Elas ?, Sicc 4, L(s) 0 Transitional silt-sand and organic
3	-19.4 to -19.5	1391 to 1401	Ga 3-, Ag 1, Lf +, Gg(min) +, Sh + Nig 2, Strf 0, Elas ?, Sicc 4, L(s) 0 Silty-sand and nodules of chalk
2	-19.5 to -19.6	1401 to 1412	Ag 3-, As 1+, Gg(mag) +, Sh + Nig 2, Strf 0, Elas ?, Sicc 4, L(s) 0 Sandy-silt and chalk and flint, organic stain
1	-19.6 to -19.8	1412 to 1430	Ga 2-, Ag 1+, Gg(min) 1, Gg(mag) + Nig 2, Strf 0, Elas ?, Sicc 4, L(s) 0 Silty-sand and chalk and flint nodules.

Pollen samples were taken from strata 5, 6, 7, 8 and 9. All the strata with the exceptions of 11, 12, 16, 17, 22 and 26 were sampled for diatom analyses and particle-size samples were taken from strata 1, 2, 3, 4, 5, 8, 9, 10, 24, 25, 27, 28 and 29.

3:5:2 Particle-size Analyses

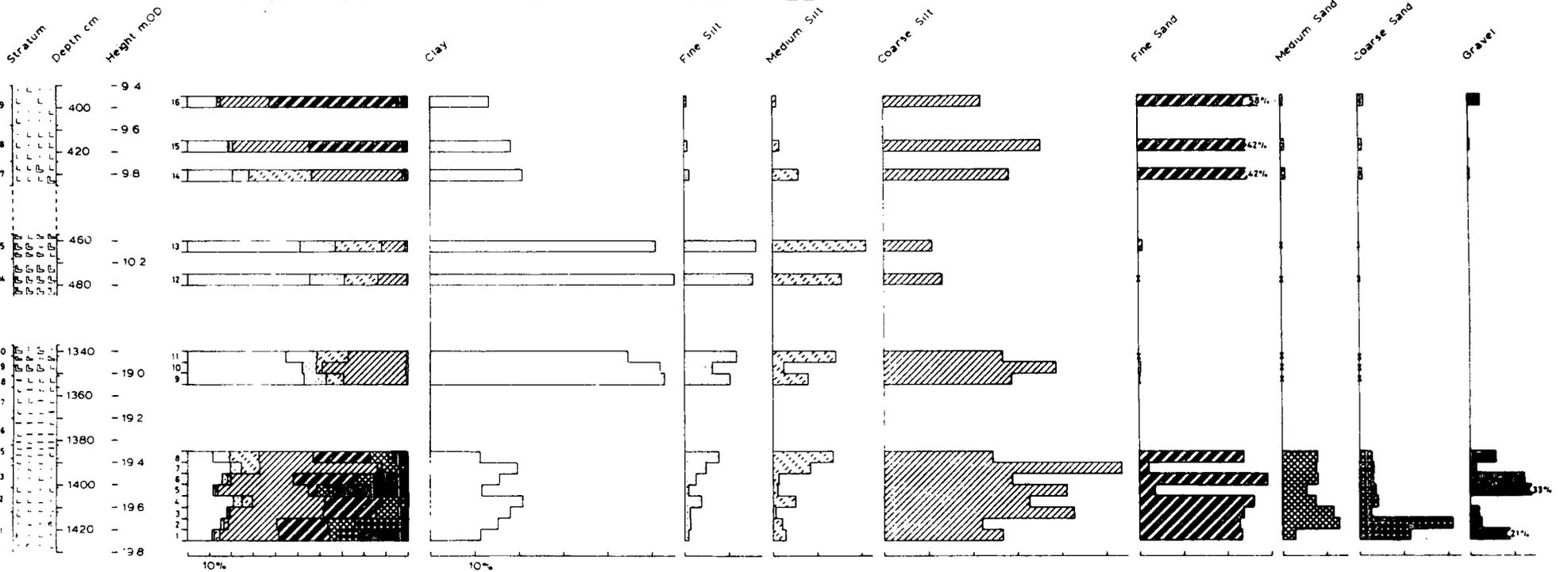
Samples for particle-size analyses at Browdown were taken from the clastic deposits bordering the organic material in Tube 36 and from the clastic material in Tube 26, at the top of the sampled material. In total 16 samples were tested and the results are summarised below, and seen in Figure 50.

Table 19 Particle-size Analysis of Browdown 13/14 53

Sample	Altitude (m.O.D.)	% Clay	% Silt	% Sand	% Gravel
16	-9.45 to -9.50	13.2 (-)	23.6 (25)	60.2 (15)	2.9 (-)
15	-9.65 to -9.70	18.1 (+)	37.2 (75)	44.5 (25)	0.3 (-)
14	-9.78 to -9.83	20.8 (25)	34.8 (75)	44.0 (-)	0.4 (-)
13	-10.10 to -10.15	50.9 (75)	48.0 (25)	1.1 (-)	- (-)
12	-10.25 to -10.30	55.4 (100)	44.4 (+)	0.3 (-)	- (-)
11	-18.90 to -18.95	44.5 (50)	55.4 (50)	0.1 (-)	- (-)
10	-18.95 to -19.00	51.9 (75)	47.6 (25)	0.5 (-)	- (-)
9	-19.00 to -19.05	52.8 (-)	46.8 (75)	0.5 (-)	- (-)
8	-19.35 to -19.40	11.3 (-)	45.8 (50)	37.1 (50)	6.0 (-)
7	-19.40 to -19.45	19.6 (-)	66.6 (25)	12.7 (75)	1.2 (+)
6	-19.45 to -19.50	15.4 (-)	32.8 (25)	39.8 (75)	12.0 (+)
5	-19.50 to -19.55	11.6 (-)	43.2 (75)	12.5 (25)	32.7 (+)
4	-19.55 to -19.60	20.7 (-)	41.6 (75)	37.8 (25)	- (+)
3	-19.60 to -19.65	17.8 (-)	44.1 (25)	36.2 (50)	2.0 (25)
2	-19.65 to -19.70	15.3 (-)	25.5 (25)	56.8 (50)	2.5 (25)
1	-19.70 to -19.75	11.3 (-)	30.3 (25)	37.8 (50)	20.7 (25)

FIGURE 50

# BROWNDOWN 13/14 53 PARTICLE-SIZE



Grid ref. SZ 585985

The results outlined above display a few trends. The lower clastic material of samples 1 to 8, below the organic material in Tube 36, has a definite high proportion of sand and overall is a very coarse deposit with a representative proportion of gravel also present. In general this lower clastic material can be described as a sandy-silt, although clay is also present. The clastic deposit above the organic material of Tube 36, loses the gravel component and only traces of sand are present, this can be described as a silt-clay. In Tube 26, again a pattern of different sediments can be seen. Below the break in stratigraphy, the material is a silt-clay, similar to the material above the organic strata in Tube 36. Above this break, the strata become more coarse with high proportions of sand and low clay. This can be described as a silty-sand. Turning now to the samples taken from the same strata we see that no clear pattern is evident. Samples 1, 2 and 3 were taken from stratum 1, samples 4 and 5 from stratum 2 and samples 6 and 7 from stratum 3. We can see that this is not apparent in the results.

The results of the Troels-Smith analyses of the stratigraphy of Browdown 13/14 53 corresponds quite well with the particle-size tests carried out on the core. Again it is apparent that the clastic material below the organic deposit in Tube 36, is of a coarse nature and can indeed be described as a sandy-silt. The clastic material above the organic strata shows the same loss of coarse components and is composed of clays and silts alone. Again in Tube 26, below the break in stratigraphy, the strata are similar to the silts and clays of Tube 36, and above this break the deposits become much coarser in nature. Thus we can see a close correlation between the two analyses of the stratigraphy of Browdown using particle-size and stratigraphic analyses.

### 3:5:3 Pollen Analysis

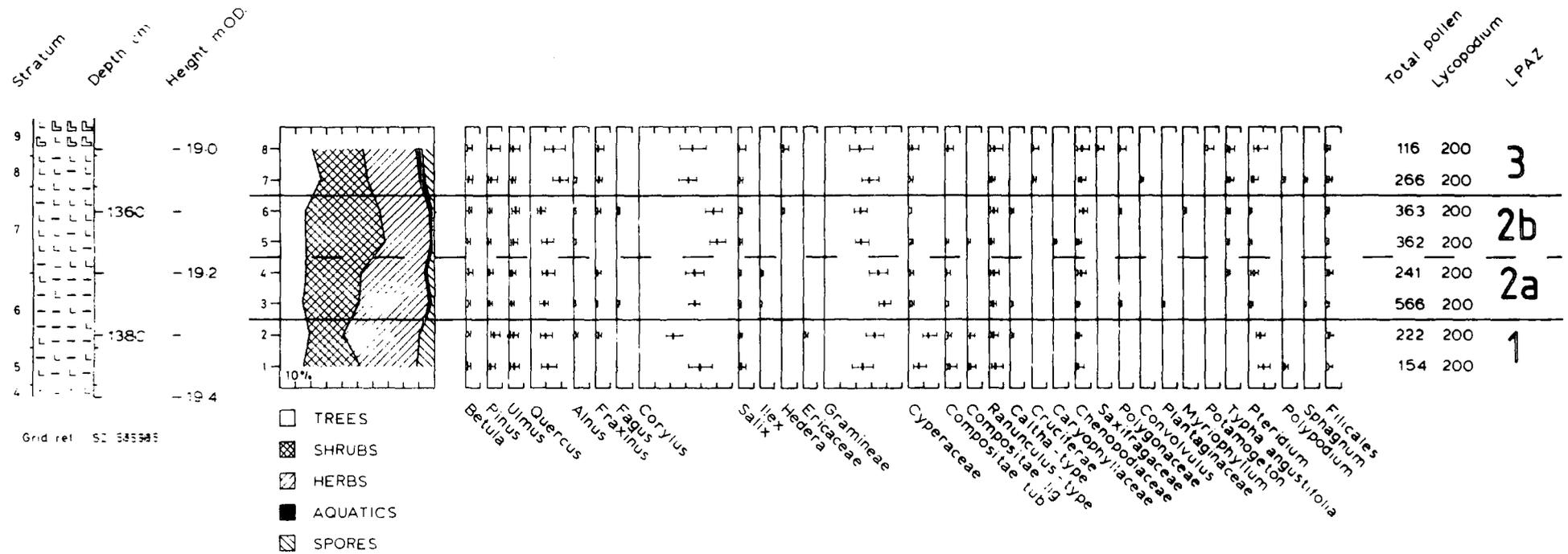
Organic material was only found in Tube 36 of Browndown 13/14 53. The samples for pollen analyses were taken from strata 5, 6, 7, 8 and 9. Eight levels were sampled at 5 cm intervals; 1) -1385, 2) -1380, 3) -1375, 4) -1370, 5) -1365, 6) -1360, 7) -1355 and 8) -1350 cm. A pollen sum counted to 200 Lycopodium spores was made at each level. The results of these counts are calculated as a percentage of the total land pollen (TLP) and are tabulated in Appendix IV, being displayed in Figure 51. Three LPAZ have been recognised in this core and are outlined below. LPAZ B 36:2 has been subdivided into two on the basis of changes in the NAP. The dry-land pollen data are based on calculations of percentage trees plus group and are used for relative dating purposes.

LPAZ B 36:1 -1385 cm to ca.-1378 cm.

This first zone is dominated by herb pollen. The most important tree pollen is Quercus with 11% TLP at - 1385 cm and Pinus with 5.4% TLP at - 1380 cm. The NAP is dominated by Corylus with 39.6% TLP at - 1385 cm. Gramineae has 32.4% TLP at - 1380 cm while Cyperaceae has 13.5% TLP at the same level, and at - 1385 cm Pteridium show 9.7% TLP + Sp. The major dry-land pollen comes from Quercus with 65.4% AP at - 1385 cm, Pinus with 25% AP at - 1380 cm and from Ulmus with 19.2% AP at - 1385 cm. Ericaceae are only found here. Concentrations are generally low throughout with Gramineae having  $19.5 \times 10^2$  grains/cc at - 1380 cm, Corylus has  $16.5 \times 10^2$  grains/cc at - 1385 cm, Cyperaceae has  $8.1 \times 10^2$  grains/cc at - 1380 cm and at the same level Quercus has  $5.9 \times 10^2$  grains/cc although the greatest record of Quercus pollen in this LPAZ is found at - 1385 cm. The upper boundary of this

FIGURE 51

# BROWNDOWN 13/14 53 % Total Land Pollen



first zone is placed where tree pollen decreases and also spores begin to decrease. Here Pinus pollen falls from 5.4% TLP to 1.8% TLP, Corylus increases from 22.5% TLP to 35.9% TLP, Cyperaceae drop from 13.5% TLP to 2% TLP and Pteridium also fall from 7.7% TLP + S to 1.4% TLP + S.

LPAZ B 36:2a ca.-1378 cm to ca.-1367 cm

This sub-zone is characterised by a dominance of herb pollen with the first appearance of aquatic pollen. Quercus is still the most important tree with 11.3% TLP at -1370 cm. Gramineae are the most important NAP with 39.3% TLP at -1375 cm while at -1370 cm Corylus has 36.3% TLP. The major dry-land tree pollen comes from Quercus with 61.4% T at -1370 cm and Ulmus with 13.5% T at -1375 cm. Here the first Fagus, Ilex, Plantaginaceae, Typha angustifolia and Sphagnum are seen. Concentrations have risen here and Gramineae have  $59.9 \times 10^2$  grains/cc at -1375 cm, Corylus has  $54.8 \times 10^2$  grains/cc at the same level and again at -1375 cm Quercus has  $14.1 \times 10^2$  grains/cc. The division between the two subzones is marked by a rise of Corylus from 36.3% TLP to 50.8% TLP, a fall in Gramineae from 34.5% TLP to 23.9% TLP and a decrease in Pteridium from 3.5% TLP + S to 0.6% TLP + S.

LPAZ B 36:2b ca.-1367 cm to ca.-1357 cm

Shrub pollen dominate for the first time in this sub-zone, and spores decline to a minimum. Quercus is again the most important tree pollen with 11.1% TLP at -1365 cm. Corylus is now the dominant NAP with 50.8% TLP at -1365 cm and at the same level Gramineae have 23.9% TLP while at -1360 cm Chenopodiaceae rise to 5.3% TLP. The major dry-land trees are Quercus with 64.5% T at -1365 cm, Ulmus with 24.2% T at -1360 cm and Betula with 14.5% T at -1360 cm. Hedera, Caryophyllaceae and Myriophyllum pollen are only found in this sub-zone. Concentrations are again high with Corylus showing  $49.6 \times 10^2$  grains/cc. Gramineae has

$23.3 \times 10^2$  grains/cc and Quercus has  $10.9 \times 10^2$  grains/cc. The upper boundary to this sub-zone is placed where tree pollen begins to increase as do spores and aquatic pollen. At this boundary Quercus rises from 7.0% TLP to 19.3% TLP and Corylus decreases from 48.3% TLP to 31.7% TLP.

LPAZ B 36:3 ca. -1357 cm to -1350 cm

This last zone sees the return of herb pollen as the dominant life form, although tree pollen is at its maximum presence. Quercus is the most important AP although it has fallen to 34.8% TLP at -1350 cm, Gramineae has 29.3% TLP at -1355 cm and Pteridium rises to 7.4% TLP + Sp at -1350 cm. The major dry-land tree pollen comes from Quercus with 65% T at -1355 cm and from Pinus with 14.8% T at -1350 cm. Four species are only found in this zone and these are Cruciferae, Saxifragiaceae, Convolvulus and Potamogeton. The concentrations in this zone are low with Corylus having  $22.2 \times 10^2$  grains/cc, Gramineae having  $20.6 \times 10^2$  grains/cc and Quercus with  $13.6 \times 10^2$  grains/cc.

These zones correspond quite well with the lithological boundaries of the core. LPAZ B 36:1 represents stratum 5 and the lower level of stratum 6, where herb pollen is the dominant life group with Quercus the most important tree pollen and Corylus the most important NAP. LPAZ B 36:2a corresponds to the upper levels of stratum 6. Again herb pollen is most important with Quercus the dominant tree pollen but Gramineae now being the dominant NAP. Aquatic pollen first appears at the boundary between strata 6 and 7. LPAZ B 36:2b represents stratum 7 where shrub pollen is the dominant life form with Quercus and Corylus the most abundant tree pollen and NAP. The last zone can be said to represent stratum 8 where again herb pollen dominates together with Quercus and Corylus. To summarise: this core is dominated by herb pollen except in stratum 7 where shrub pollen

becomes more important. Quercus is the most important tree pollen throughout the levels and Corylus the most important NAP except in stratum 6 where Gramineae are dominant. Aquatic pollen is only found above stratum 6, in the upper transitional peaty-silt.

Dating of LPAZ at Browndown 13/14 53.

The organic deposit found at Browndown ranges in altitude from - 19.01 m.O.D. at - 19.38 m.O.D. and it is the deepest organic deposit found in this study. Four LPAZ are recognised and are outlined below with their major characteristics.

Table 20 Dating LPAZ at Browndown 13/14 53.

Flandrian Chronozone	LPAZ	Altitude m.O.D.	Depth cm	Dominant life group	Dominant AP	Dominant NAP
Id	B 36:3	-19.0 to -19.1	-1350 to -1357	Herb	Q-P	Co-Gr-Pt
	B36:2b	-19.1 to -19.2	-1357 to -1367	Shrub	Q-U-B	Co-Gr
	B36:2a	-19.2 to -19.3	-1367 to -1377	Herb	Q-U	Co-Gr-Pt
	B 36:1	-19.3 to -19.4	-1377 to -1385	Herb	Q-P-U	Co-Gr- Pt-Cy

Q=Quercus, P=Pinus, U=Ulmus, B=Betula, Gr=Gramineae, Pt=Pteridium and Cy=Cyperaceae.

Tree pollen is very low throughout the levels of Browndown 13/14 53 with a dominance of shrub and herb pollen shown by Corylus and Gramineae pollen. These LPAZ are thought to belong to the late part of Flandrian Chronozone I, probably Zone Id before the rise of tree pollen. This Chronozone has been dated from 8196 ± 150 to 7107 ± 120 BP (West 1970).

The expansion of Corylus pollen being complete, together with the presence of Quercus pollen in large quantities and the relatively poor representation of Alnus pollen indicates a correlation with Godwin's Zone VIb which is post 8,000 BP.

### 3:5:4 Diatom Analyses

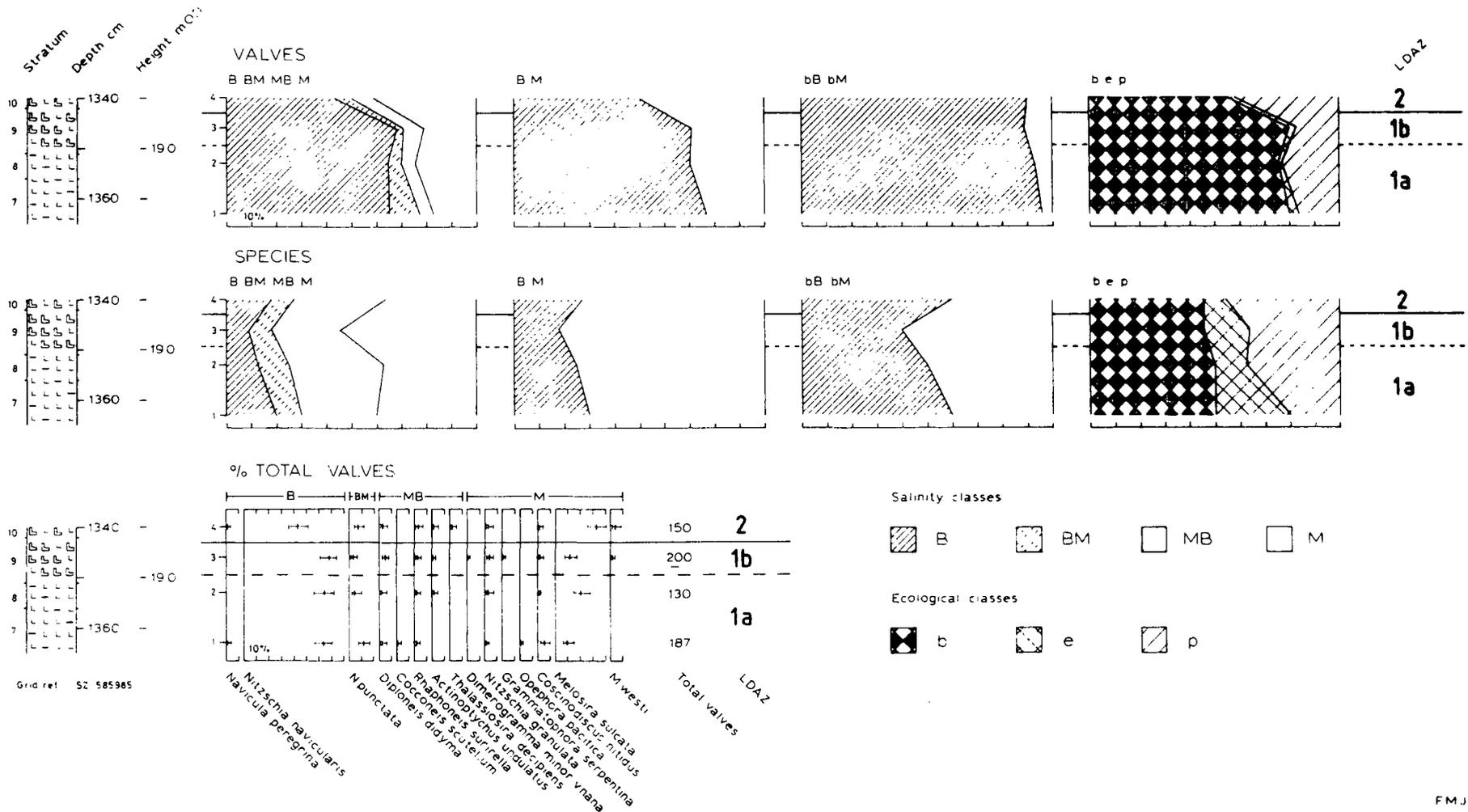
At Browndown 13/14 53, nearly all the strata were sampled for their diatom content (see section 3:5:1). A total of 31 samples were taken but of these, only 15 yielded enough diatoms for a representative count. These levels were taken at 10 cm intervals from the upper levels of the organic material and the upper clastic deposit of Tube 36, the whole of Tube 28 and the lower clastic deposit, below the stratigraphic break, in Tube 26. The levels are 1) -1363, 2) -1353, 3) -1346, 4) -1340, 5) -665, 6) -655, 7) -645, 8) -635, 9) -595, 10) -585, 11) -575, 12) -488, 13) -478, 14) -468 and 15) 460 cm. A count of 200 diatom valves was aimed at but this was rarely achieved due to the paucity of diatom valves present in the levels. A record of these counts is given in Appendix V and can be seen in Figures 52 and 53. For ease of description and interpretation, these data have been drawn up on two graphs; the first represents the diatoms of Tube 36 (Figure 52) and the second the diatoms of Tubes 28 and 26 (Figure 53). These will be analysed separately and the information obtained from these analyses will be compared at the end of this section.

#### 1) Browndown 13/14 53 Tube 36.

In Tube 36 of Browndown 13/14 53, four levels were examined for their diatom content as described above. A total of just 15 species of diatom

FIGURE 52

# BROWNDOWN 13/14 53 - Tube 36 DIATOMS



were identified in this tube and none of these were Fresh types. 12 species were Marine and 3 were Brackish. The four levels yielded 667 diatom valves and of these 215 were Marine and 452 were Brackish. Thus we see that although there are more Marine species present in tube 36 the greatest number of valves are Brackish types.

There are three dominant species; Nitzschia navicularis (B b) with 404 valves, Melosira sulcata (M p) with 121 valves and Nitzschia punctata (BM b) with 45 valves. The summary diagram (Figure 52) shows relatively constant features. Overall Brackish valves dominate throughout the levels, although these decrease to the top of the levels. These valves are dominated by benthonic types. The species are dominated by Marine types and although the benthonic species are not as abundant, they do dominate the levels. Planktonic species increase to the top of the levels. These levels have been segregated into two local assemblage zones which are described below. LDAZ B:1 has been subdivided into two sub-zones.

LDAZ B:1a -1363 cm to ca.-1349.5 cm

Three species dominate this first sub-zone; N.navicularis with 64.6% of total valves (TV) at -1353 cm, N.punctata with 11.8% TV at -1363 cm and M.sulcata with 20.8% TV at -1353 cm. The upper boundary is placed where Marine species begin to increase. The sub-zone is dominated by Brackish valves and Marine species. Benthonic types dominate both valves and species. Planktonic species increase to -1353 cm.

LDAZ B:1b ca.-1349 cm to ca.-1343 cm

This sub-zone is dominated by N.navicularis with 68% TV and M.sulcata with 12.5% TV. The upper boundary to this sub-zone is marked by a decrease of N.navicularis from 68% TV to 42.7% TV, a rise in M.sulcata from 12.5% TV to 33.3% TV. At this boundary Marine valves begin a rise together with a

rise of Brackish species. Again we see that Brackish valves but Marine species dominate this sub-zone, while benthonic valves and species are the most important life forms.

LDAZ B:2 ca.-1343 cm to -1340 cm

This zone is again dominated by N.navicularis with 42.7% TV, M.sulcata with 33.3% TV and N.punctata with 6.7% TV. Brackish valves are again dominant but Marine valves are rising. Marine species are the most important but the life form diagram shows that benthonic Brackish types are dominant. Benthonic types dominate this zone although planktonic types are on the increase.

These zones agreed well. with the lithological divisions of this tube. LDAZ B:1a corresponds to strata 7 and 8. LDAZ B:1b reflects the diatoms of stratum 9 while LDAZ B:2 can be said to represent stratum 10.

2) Browndown 13/14 53 Tubes 28 and 26

In tubes 28 and 26, 11 levels were examined for their diatom content. These levels have been described at the beginning of this section.

A total of 29 species have been identified in these levels. The ratio of F : B : M was 3 : 5 : 21. In all, 1302 diatom valves were counted and again the F : B : M ratio was 49 : 597 : 656. We can see that Marine valves and species are the dominant types throughout these levels.

Three species were identified as being dominant; these are Nitzschia navicularis (B b) with 506 valves, Melosira sulcata (M p) with 328 valves and Diploneis didyma (NB b) with 148 valves. Looking at the summary diagram for valves (Figure 53) we see that Marine valves dominate at the base of Tube 28, up to -655 cm but above this Brackish valves are most important up to -575 cm. It is interesting to note that

# BROWNDOWN 13/14 53-Tubes 26 & 28 DIATOMS

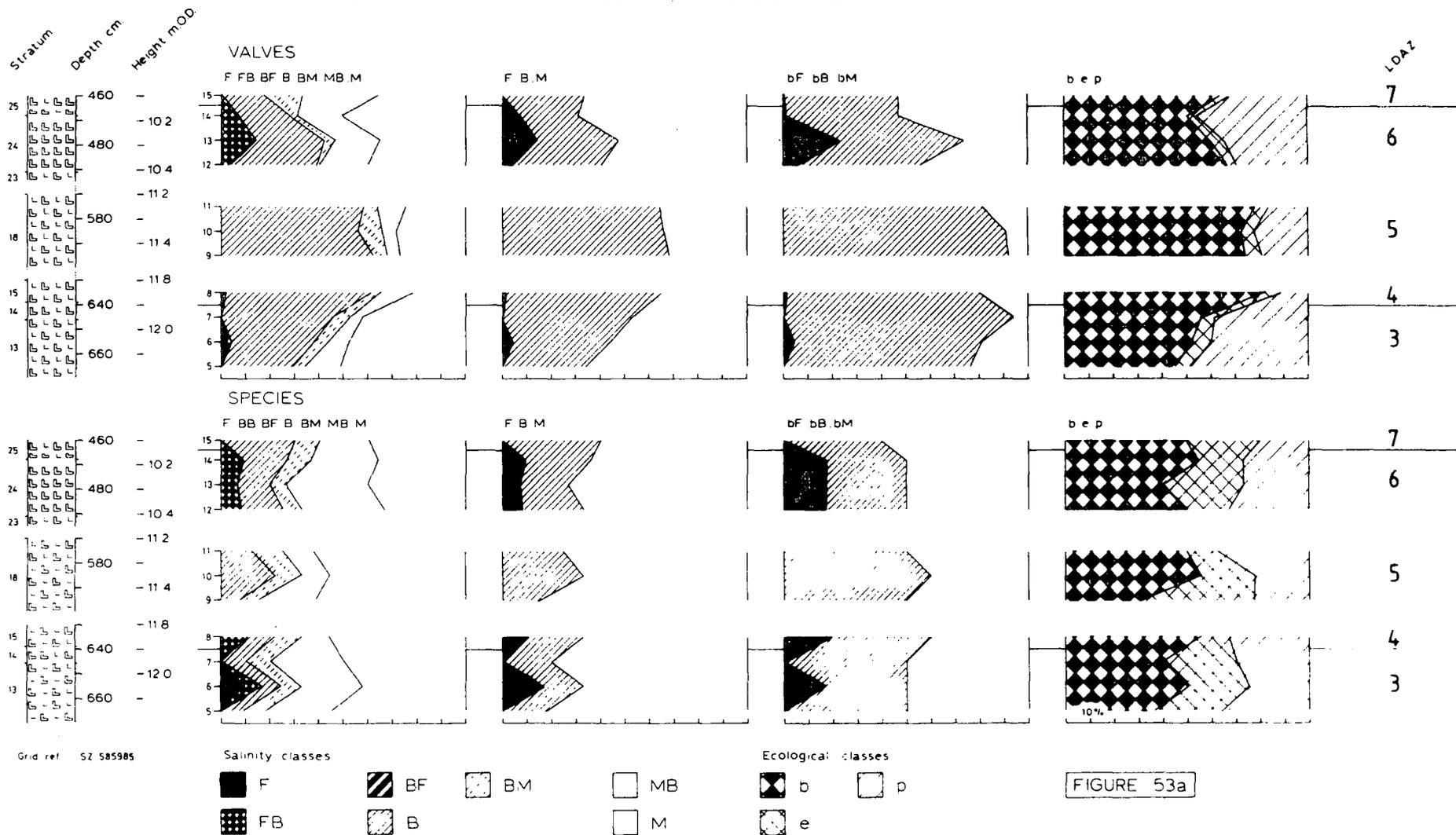
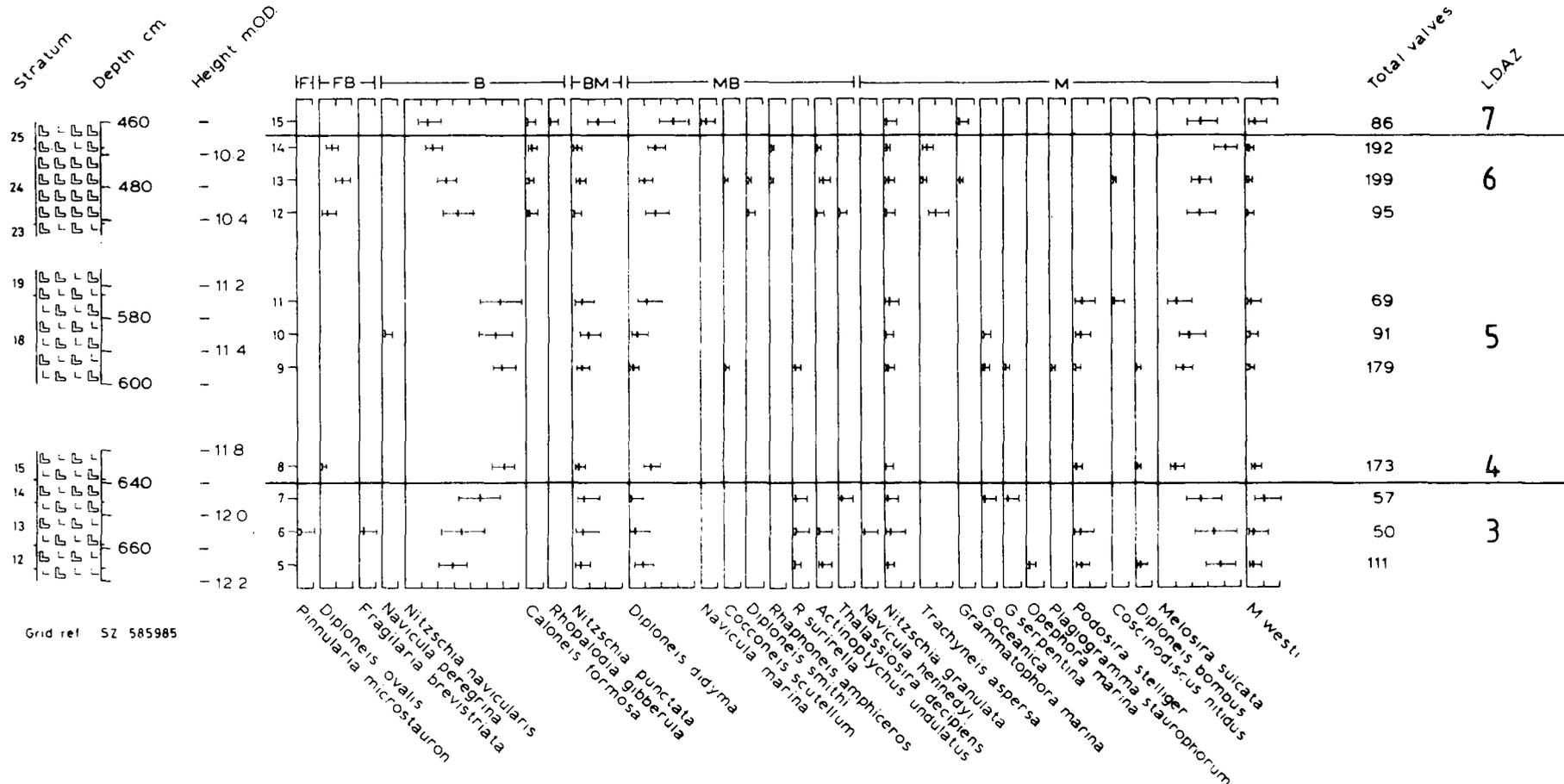


FIGURE 53b

# BROWNDOWN 13/14 53 - Tubes 26 & 28 DIATOMS



the levels of Tube 28 are all dominated by benthonic Brackish types. Tube 26 has Marine valves as the dominant forms throughout the levels. Fresh valves are found below the stratigraphic break in Tube 28 and also in Tube 26. Benthonic valves dominate the life form diagrams. Marine species are dominant throughout all the levels analysed here as are benthonic forms.

These data have been divided into five local assemblage zones of diatoms. Some of the zone boundaries are imposed by the nature of the sampled material where breaks in the stratigraphic record occur. These zones are described below.

LDAZ B:3 -665 cm to ca.-640 cm

This zone has four dominant species: N.navicularis with 45.6% TV at -645 cm, M.sulcata with 37.8% TV at -665 cm, Melosira westi (M p) with 10.5% TV at -645 cm, and D.didyma with 9% TV at -665 cm. The upper boundary is marked by a rise in D.didyma from 1.8% TV to 13.9% TV and a fall in M.sulcata from 26.3% TV to 10.4% TV. This zone is characterised by a dominance of Marine valves at the base which changes to a dominance of Brackish valves at the top. Fresh valves are only important at -655 cm. The species are dominated by Marine types with constant Brackish species and fluctuating Fresh species. Benthonic types dominate the valves and species.

LDAZ B:4 ca.-640 cm to -635 cm

This zone has three dominant species; N.navicularis with 60.1% TV, D.didyma with 13.9% TV and M.sulcata with 10.4% TV. The upper boundary is artificially imposed by the break in the stratigraphic record of the core. Brackish valves dominate this zone but Marine species are present in the greatest numbers. Benthonic valves and species are most important with decreasing planktonic valves and decreasing epiphytic species.

LDAZ B:5 -595 cm to -575 cm

This zone is dominated by N.navicularis with 61.5% TV at -595 cm, M.sulcata with 19.8% TV at -585 cm, D.didyma with 11.6% TV at -575 cm and Nitzschia punctata (BM b) with 9.9% TV at -585 cm. No Fresh species are found in this zone. Brackish valves dominate throughout with a slight increase of Marine valves to the top of the zone. Marine species are the most important here. Benthonic valves dominate but benthonic and epiphytic are equal at the base of the zone before benthonic species become dominant at the top of the zone.

LDAZ B:6 -488 cm to ca.-464 cm

Five species are very important in this zone; M.sulcata with 42.2% TV at -468 cm, N.navicularis with 32.6% TV at -488 cm, D.didyma with 17.2% TV at -468 cm, Diploneis ovalis (FB b) with 14.1% TV at -478 cm and Trachyneis aspersa (M b) with 10.5% TV at -488 cm. The upper boundary is marked by a rise in N.punctata from 3.1% TV to 16.3% TV, a fall in M.sulcata from 42.2% TV to 26.7% TV, here also D.ovalis dies out and Fresh diatoms decrease. Marine valves and species are dominant in this zone although Fresh valves show a peak at -478 cm. Benthonic valves and species are most important with planktonic valves increasing to the top of the zone.

LDAZ B:7 ca.-464 cm to -460 cm

This last zone is dominated by D.didyma with 27.9% TV, M.sulcata with 26.7% TV, N.punctata with 16.3% TV and N.navicularis with 14% TV. Marine valves and species dominate, with a dying out of Fresh diatoms. The valves and species are dominated by benthonic types with a decrease of planktonic types and an increase of epiphytic species.

These zones correspond well with the lithological strata of the core. LDAZ B:3 corresponds to strata 13 and 14 where N.navicularis is the dominant species. Marine species are the most important here but the valves are dominated by Marine types at the base passing to Brackish types at the top. LDAZ B:4 correlates with stratum 15, again N.navicularis is the dominant species with a dominance of Brackish valves and Marine species. The zone LDAZ B:5 can be said to represent stratum 18. The only difference between this zone and LDAZ B:4 is that the former zone has no Fresh diatoms. LDAZ B:6 corresponds to stratum 24 where M.sulcata is the most important species and the valves and species are both dominated by Marine types. The last zone represents stratum 25 where D.didyma is the most important species and again the valves and species are dominated by Marine types.

When the two diatom analyses of Tube 36 and Tubes 28 and 26 are examined we see that up to LDAZ B:6, N.navicularis is the dominant species and the zones are all dominated by Brackish valves and Marine species. The upper two zones, 6 and 7, have M.sulcata and D.didyma as the dominant species with Marine valves and species as most important. Thus we see that Brackish diatoms are most important in Tubes 36 and 28 but Tube 26 shows a dominance of Marine diatoms.

C H A P T E R 4

FLANDRIAN SEA-LEVEL CHANGES ON THE SOUTH COAST

4:1 REVIEW OF LITERATURE

There are very few studies of Flandrian sea levels which are concerned with the South Coast region of Britain. As a result of this, literature dealing directly with sea-level studies and indirectly by pollen analyses are dealt with in this review. The information on pollen studies has been included when the stratigraphic position of organic material is relevant to sea-level studies. All sites mentioned in this review can be located in Figure 2.

4:1:1 Review of Literature on Sea-Level Studies.

There are a number of factors that explain the few studies dealing directly with sea-level fluctuations on the South Coast. A deficit of summer precipitation along the South Coast hinders the development of blanket bogs and of peat and thus limits the availability of sites that can be used to reconstruct past environmental conditions. The South-East of England was beyond the limits of the last glaciation and so no major glacial features were eroded in which sediments could accumulate. The geological nature of the South of England is such that the major rock types are of a calcareous nature. These are alkaline which is detrimental to pollen preservation. The long history of man's occupation in the region has led to the cutting of what peat there was, and enclosure and farming have resulted in oxidation of what peat survived. Nevertheless, organic material has survived in valleys where it has been buried by colluvium and in the flood plains.

A number of authors in the Nineteenth Century encountered features associated with past sea levels. James (1847) noted forest layers exposed in excavations at Portsmouth Dockyard at altitudes of - 0.6 m.O.D. and - 4.1 m.O.D. which were overlain by a blue, silty-clay. Lyell (1853) describes the coastal Flandrian succession of deposits along the South Coast. Meyer (1870) again noted the presence of a blue clay at Portsmouth with an intercalated deposit of roots and trees in situ between - 5 m.O.D. and - 5.3 m.O.D. Reid (1893) discovered organic horizons at Stone in Hampshire and in the same year Shore (1893) noted gravels overlain by estuarine mud deposits in the southern part of Southampton Water.

Lewis and Balchin (1940) studied storm ridges at Dungeness and used them as indicators of past sea levels. They noted that Drew (1864, in Lewis & Balchin op. cit.) had recorded the levels of older storm ridges at 6' (1.8 m) below that of present-day storm ridges, but he had ascribed these to variations in tidal range and not to sea levels. The study made by Lewis and Balchin showed that sea level was 5' to 6' (1.5 to 1.8 m) lower in Roman Times, approximately the same as present in the Thirteenth Century and 1' (0.3 m) lower in the Eighteenth Century and that the annual average rate of advance of the Dungeness foreshore was ca. 8' to 11' / year (2.7 to 3.6 m/year).

Godwin, Suggate and Willis (1958) found freshwater peat overlain by marine clays at Lower Hamworthy (SZ 005 902) at an altitude of - 11.5 m.O.D. which was quoted as being aged  $7340 \pm 110$  BP (Q 181). Infact the date of Q 181 as quoted in Radiocarbon (19 ) is  $9298 \pm 100$  BP at an altitude of - 12.8 m.O.D. This has led to great confusion in subsequent literature where the earlier date has been quoted.

Gilbertson (1967) was one of the first to do a detailed study of sea-level changes on the South Coast. Two sites in Dorset at Coldharbour River (SY 897 894) and Keyworth Farm (SY 939 891) were investigated. The results of the analyses of deposits at these two sites led to the conclusions that ca. 7340 BP the sea level was - 11.4 m.O.D. There followed a period of rising sea level to - 0.9 m.O.D. by ca. 5500 BP, which was followed by a fall of sea level to - 4.8 m.O.D. by ca. 3800 BP. Finally the sea level rose to its present position by ca. 2500 BP.

Devoy (1972) carried out a study of sea-level fluctuations at the Western River Yar (SZ 3485 8927) on the Isle of Wight and at Southsea (SZ 6505 9866). Stratigraphic analyses of these boreholes showed that peat growth began ca. 4750 BP, indicating a marine transgression at this time. The peak of sea level was reached by ca. 5500 BP with an altitude of - 3 m.O.D. which was followed by a fall to - 5 m.O.D. at ca. 4500 BP. A less rapid transgression of sea level ensued from ca. 3500 BP to reach - 1 M.O.D. by ca. 2500 BP.

Hodson and West (1972) worked on deposits at Fawley (SU 477 026). The thickest (3.35 m) and best developed bed of peat at Fawley is found above a succession of freshwater clays. The upper part of the peat is dated as  $3689 \pm 120$  BP (Q 831) at an altitude of - 2.7 m.O.D. The authors found more than 7 m of sediment had been deposited on a surface which has been submerged to - 7 m.O.D. since  $6366 \pm 124$  BP (Q 834); the average rate of submergence being given as 1 cm/100 years. The sea is first thought to have entered Southampton Water early in the Flandrian before ca. 6366 BP.

Poole Harbour was the area examined by Byrne (1975). Two sites at The Moors (SY 95 87) and Slepe Moor (SY 95 86) were analysed. At Slepe Moor the analysis of borehole sediments showed an abrupt truncation of peat growth at - 1.03 m.O.D., dated to ca. 6500 BP, which could be indicative of a transgressive period of sea level. A sea level of ca. - 0.45 m.O.D. was given at ca. 5000 BP. Evidence from The Moors site shows a fall of sea level to ca. - 2 m.O.D. by ca. 3800 BP followed by a transgressive episode ca. 2500 BP when sea level was at or just above present level. The final transgression at this site had receded by ca. 1300 BP.

Dyer (1975) worked on the ancient 'River Solent'. He found evidence of a sea level at - 6 m.O.D. ca. 7500 BP and at ca. 3500 BP the sea level was - 2 m.O.D.

Shephard-Thorn reviewed the data available on the Quaternary of the Weald area. Terrestrial periods were stated as being 10,000 to 8000 BP, 6000 to 3000 BP and 3000 to 1500 BP. These are very generalised periods based on few <sup>14</sup>C dates and give no clear indications of sea-level movement. This review was compiled in 1975.

Cunliffe (1980) published a preliminary report on the evolution of Romney Marsh. He proposed that during the early Flandrian transgression of sea level a wide, shallow bay was created between Fairlight and Hythe which eventually silted-up into a lagoonal environment with a protective sand bar - The Midley Sand - to seaward. A shingle spit formation began to accumulate on the seaward side of The Midley Sand. Various periods of rising and falling sea level are recorded in the marsh sediments behind the barrier including the deposition of a 'forest layer' of Oak and Birch, dated 3340 ± 92 BP (NPL 24) and 3020 ± 94 BP (NPL 23). The shingle barrier was breached

ca. 1550 ± 120 BP (NPL 25).

The course of sea-level movement in S. Britain was reviewed by Jones (1981) during the Flandrian. He postulated that during the early Flandrian sea level rose from below - 100 m.O.D. ca 14,000 BP to - 20 m.O.D. ca. 8000 BP. The sea advanced quickly up the English Channel and through the Strait of Dover by ca. 9600 BP with a final separation of Britain from mainland Europe by ca. 8600 BP, the present shoreline configuration of Southern England being attained ca. 6000 BP.

Jennings and Smyth (1982a) studied the South Coast sites of Langney Point (TQ 64 01), Lottbridge Drove (TQ 61 01) and Coombe Haven (TQ 77 09) and compared them to the study made by Jones (1981) at The Vale of Brooks. These authors state that a peat deposit at Langney Point is found between altitudes of - 27.1 m.O.D. and - 27.0 m.O.D. and is dated from 9510 ± 75 BP (SRR 380) to 8760 ± 75 BP (SRR 379). The authors believe this peat accumulated landward of a coastal barrier during the early rise of Flandrian sea level. The barrier was transgressed by the sea by 8760 ± 75 BP. At The Vale of Brooks an extensive peat deposit was recognised with intercalated clay layers and is overlain by silts and sands which have been identified as having a marine origin (Jones op. cit.). The authors assume the intercalated clays are the result of breaching of a coastal barrier. Thus at The Vale of Brooks a transgressive overlap is postulated at 3190 ± 125 BP at an altitude of - 2.3 m.O.D. due to a breaching of a coastal barrier. This paper initiated a lively debate between various authors in the following years.

Burrin (1982) worked at The Vale of Brooks, Littlehampton (TQ 62 02), Shoreham (TQ 20 06) and Cuckmere Haven (TQ 51 97). At The Vale of Brooks a freshwater deposit of silty-clay with peat intercalations and

freshwater shells overlies the marine silts and sands above the peat found by Jennings and Smyth (op. cit.). The peat itself is described as 'generally discontinuous' with interbedded silty-clays. It is suggested that these silty-clays are due to fluvial processes and not to barrier breaching. The peat deposit at Langney Point is given an altitude range of - 24.8 m.O.D. to - 28.3 m.O.D. in the present paper and the author concludes that no evidence of offshore barriers has been found on the coastal margins of the Southern Weald.

Jennings and Smyth (1982b) reply to the preceding paper by re-emphasising a number of points from their previous paper (1982a), including the possibility of barrier breaching at the Langney Point site. Evidence is given from particle-size, pollen and macrofossil analyses of the deposit overlying the peat at The Vale of Brooks.

The debate is continued by Burrin (1983) where he says that there is a possibility of 'an environment protected to some degree by offshore barriers or spits' but also adds that evidence for this type of environment is not present at The Vale of Brooks.

A paper by Carter (1982) elucidates the process of barrier breaching and shows where such events may be expected. In this paper the author states that caution should be observed when identifying a breaching process in a vertical sediment sequence. It is shown that breaching usually occurs from the landward side of the barrier by seepage, which is seen in the sedimentary sequence as disturbed layers together with erosional contacts and channels, as the lag on level drops. This is followed by a return to lacustrine facies as the barrier reforms. If the barrier is over-topped from the seaward the sediment record will reveal rapid alterations of sediment types near the barrier with less marked evidence further from the barrier.

In 1982 the final report from the IGCP Project 61 was published concerning sea-level movement over the past 15,000 years. A paper by Devoy (1982) analysed the geological evidence for Holocene sea-level movement in South-East England using 55 sea-level indicator points gathered since 1950 and subjected to statistical tests in order to elucidate a sea-level curve for South-East England. The results show that levels above - 30 m.O.D. were inundated by marine conditions after ca. 9300 BP with a rapidly rising sea level. At ca. 4500 BP to ca. 3000 BP the sea-level curve levels out showing either a stillstand or a reduction in the rate of sea-level rise. From ca. 3000 BP to the present day the effects of man together with a deterioration of climatic conditions and a greater freshwater input into estuarine zones is observed, whilst sea level continues to rise to above + 0.5 m.O.D. by ca. 1700 BP. The data points show the course of sea-level rise to contain alterations of speed and direction producing an oscillating sea-level curve for South-East England.

Flemming (1982) used multiple-regression analyses on 143 sea-level index points and produced a predicted sea-level curve and a map showing the rates of vertical isostatic displacement in the United Kingdom. This showed South-East England is an area of vertical isostatic uplift compared to the generally accepted view that this area is undergoing vertical displacement. This anomaly was explained by the lack of data points for this region.

Eddison et al (1983) studied the occurrence of offshore shingle barriers along the Sussex Coast. Shingle barriers are thought to have accumulated at the end of the main Flandrian Transgression by the action of predominantly north-east littoral drift. By ca. 5300 BP the barriers were well developed and peat accumulation began off Cliff End, in East Sussex. Two radiocarbon dates for submerged forest

deposits at Pett Level are given; an in situ tree trunk is dated  $5205 \pm 105$  BP (IGS-C14/55) while the soil below the trunk is dated  $5300 \pm 100$  BP (IGS-C14/56). Low level shingle and sand has been located at Broomhill (TQ 987 184) at - 1 m.O.D. and at + 2 m.O.D. which could be dated ca. 5500 BP to ca. 4000 BP.

Eddison (1983) continued to discuss barrier beaches in the area east of Fairlight and the mechanisms of shingle movement in the area. The low level shingle of Broomhill is thought to be evidence of a very early barrier dating from when sea level was more than 4 m below present. It is postulated that the Dungeness shingle formation accumulated outside this early barrier. It is also suggested that barriers have been in existence in this area for most of the last 6000 years.

Further ideas on the origins of Langney Point were given in Jennings and Smyth (1985). In this paper three sea-level index points are recognised; at - 25.94 m.O.D. there is a positive tendency of sea level noted, at - 24.82 m.O.D. there is a regressive contact and at - 24.7 m.O.D. there is a transgressive contact which is dated as  $8770 \pm 50$  BP (SRR 2452). At - 14.2 m.O.D. an accumulation of sand particles with related marine Foraminifera and Cstracoda indicate the over-running of a sand barrier at the site and at - 3.7 m.O.D. the sand is replaced by shingle deposits. It is thought that the accumulation of the Crumbles Shingle, in the area, may have initiated the formation of peat on Willington Levels (TQ 61 01) dated  $3750 \pm 40$  BP (SRR 2455) to  $3390 \pm 40$  BP (SRR 2454).

#### 4:1:2 Review of Literature on Pollen Studies.

The first detailed study of submerged peat deposits along the South Coast was by Godwin and Godwin (1940) at Southampton. The

conclusions from this work was that a marine transgression affected levels of - 1.83 m.O.D. after Godwin's Zone VII. Following this work Godwin (1940) used data from the whole of the British Isles to conclude that the greater part of the 'North Sea Transgression' took place between Zone V and Zone VII. Analyses of peat beds in Swansea Bay at - 54' C.D., separated by marine silts, revealed that a rapid transgression occurred in the latter half of Zone VI at a rate of 4.5'/100 years, whereas higher peat beds at - 5' O.D. were dated to Zone VII showing that the pace of this sea-level movement had slowed by the end of Zone VIc and may have been interrupted by a marine regression. In this paper Godwin mentions that transgression rates vary from region to region, due to isostatic movements of the land and sea, and that more research was needed at that time on the subject of sea-level fluctuations.

Seagrief (1959) began a series of pollen studies from Southern England beginning with a study at Wareham in Dorset, and Nursling in Hampshire. At Wareham (SY 923 892) he found a peat over 300 cm thick which ranged in age from Godwin's Zone IV to Zone VII. He noted possibilities of valley flooding to levels of + 1.22 m.O.D. before peat growth was initiated. At Nursling (SZ 356 158) the peat deposit was 380 cm thick and ranged in age from Zone III to Zone VIb. The greatest accumulation of peat was in the Pre-Boreal and Boreal. Pinus pollen was found in Zone III, IV and V which is an early age for this species at this site. Fagus pollen was also found from the early part of the Atlantic.

The second of this series of pollen diagrams from the South of England was by Seagrief (1960) at Crane's Moor. The greatest record at this site is of peat growth from Godwin's Zone V to Zone VIIa at Sphagnum Bog, but accumulation at Flush Bog began in Zone IV. Again

the evidence points to an early and rapid accumulation of peat in Pre-Boreal and Boreal times and also Pinus and Fagus pollen are recorded early.

The third of this series of analyses was at Elstead, in Surrey by Seagrief and Godwin (1960). Here pollen analyses showed Zone III to be dominated by Fagus pollen and Zones IV, V and VI were dominated by Pinus pollen, which is again an early record for this species.

Godwin (1962) investigated two sites in Kent. At Frogholt (TR 176 375) a peat deposit from + 52.25 m.O.D. to + 50.90 m.O.D. was found to have fluvial origins. This peat was underlain by sands and overlain by a blue clay. The organic deposit was dated from ca. 2980 BP to ca. 2490 BP. The Wingham site revealed a detrital mud with organic remains from + 3.3 m.O.D. to + 1.6 m.O.D. and is underlain by silty-clay and is overlain by a fine mud and clay. This whole deposit has been dated from ca. 3650 BP to ca. 1750 BP, and shows a decrease in Tilia pollen at ca. 3150 BP and the presence of Fagus pollen from an Early Bronze Age. This site also revealed evidence of an increase in water-logging after 'Neolithic A' which could be the result of a rise in sea level.

Barber (1975) carried out a preliminary investigation into the pollen record at Church Moor (SU 247 069) in the New Forest. At this site 250 cm of peat were analysed showing peat accumulation began in the Boreal with more Quercus pollen present than would be expected, together with a great spread of Fagus pollen and Ilex pollen in the upper levels of the peat. The Atlantic boundary is thought to be pre- 7450 BP.

The Poole Harbour area was chosen by Haskins (1978) for a detailed pollen investigation. A number of sites around the Harbour

were examined including Luscombe (SZ 047 895), Morden A (SY 916 912), Morden B (SY 924 892), East Stoke (SY 864 866), The Moors (SY 949 865), Rempstone (SY 983 843) and Godlingstone (SZ 01 83). It was found that Fagus pollen was present in the Boreal and that Pinus pollen persisted throughout the Flandrian Stage.

Watson (1980) published a preliminary report on pollen analyses at Rims Moor in Dorset (SY 814 922). Peat had accumulated at the site to a depth of 18 m since the Early Flandrian and showed a total regeneration of the forest cover after the 'Elm decline'.

Thorley (1981) worked on a site in The Vale of Brooks at Lewes (TQ 413 092). Here Alder-carr peats were truncated by marine and fluviatile clays. Peat growth was considered to be very rapid in the early stages of the marine transgression at the site.

Scaife (1982) worked on two sites on the Isle of Wight; at Gatcombe (SZ 502 858) and Munsley Bog (SZ 526 825). These sites showed pollen records from Godwin's Zone III to present. The humified peat deposit found at Gatcombe is dated as 9970  $\pm$  50 BP (SRR 1433) which is underlain by a sandy-silt. Continuous records of Quercus pollen and Alnus pollen are recorded from ca. 9970 BP. From 6385  $\pm$  50 BP (SRR 1339) no Tilia or Fraxinus pollen is found on the Isle of Wight. Scaife argues that the Betula and Pinus pollen found in Zone III is of long distance origins as compared to Seagrief (1959) who concluded that these species were present at the sites. Scaife points out that this could be thought to be true as the data were calculated as a percentage of the tree pollen, instead of as a percentage of the total land pollen, and thus tree pollen will be over-represented.

Watson (1982) published a report on his earlier work at Rimsmoor together with pollen records from sites at Winchester (SU 486 799), Snelsmore (SU 463 704) and Amberley (TQ 037 145). At Winchester the pollen record dates from the Boreal to the present day with an 'Elm decline' date of  $5630 \pm 90$  BP (HAR 4342). At Rimsmoor the peat records pollen from the Late Boreal to the present with an 'Elm decline' date at  $5150 \pm 70$  BP (HAR 3919) to  $4690 \pm 70$  BP (HAR 3920). Here peat accumulation was at a rate of ca. 26 cm/100 years.

Although not many of these studies are relevant to the evaluation of past sea levels, they have been used in this work for dating purposes. The present study has no radiocarbon dates available and so it must rely on other dates available from different authors and sites. These dates have been used in the following section to construct a relative chronology of pollen zones on the South Coast of England.

#### 4:2 RELATIVE CHRONOLOGY OF SOUTH COAST POLLEN ZONES

As already mentioned above, a number of sites on the South Coast have been worked on with regard to vegetational changes during the Flandrian Stage. These include buried peats at Southampton (Godwin 1940), Wareham, Nursling and Crane's Moor (Seagrief 1959, 1960), Elstead (Seagrief & Godwin 1960), Yarmouth and Southsea (Devoy 1972), Church Moor (Barber 1975), S.E. Dorset (Haskins 1978), Lewes (Thorley 1981), Rimsmoor (Watson 1982) plus two sites on the Isle of Wight, Munsley and Gatcombe (Scaife 1982). The latter four authors plus Devoy (1972) have dated pollen zone boundaries and these together with the generally accepted dated pollen zone boundaries of Godwin (1940) and West (1970) are outlined in Table 21.

Table 21 Dated LPAZ Boundaries from the South Coast.

GODWIN 1940	WEST 1970	DEVOY 1972	HASKINS 1978	THORLEY 1981	WATON 1982	SCAIFE 1982
VIII A-B-Q-Fg			I P-B H Q-A			GTW 11 A-B-Q-P
2500 VIIb A-Q-T	F III Q-A		2950 G Q-A-Fg F U-Q-A		NAP	GTW 10 A-Q-B-Fg GTW 9 A-Q-B-T
5000 5500 VIIa A-Q-U-T	5010±80 F II Q-U-A	4500 4750	4950 E A-T-P-B	5670	4690±70 5150±70 AP	GTW 8 A-Q-U-T
7500 VI P-Co	7107±120 F Id P-Co-U		6979 D Q-U-P-B			6385±50 GTW 7 Q-P-U
9000 V Co-B-P	8196±150 F Ic Co-P		8950 C P-Q(U)			GTW 6 P-Q-B
9500 IV B-P	8880±170 F Ib B-P-Co		9650 B P-B			GTW 5 B-P-Q
10500 III Sa	9798±200 F Ia B-P-J		10250 A B-P			GTW 4 P-B-A

A=Alnus, Q=Quercus, B=Betula, T=Tilia, P=Pinus, U=Ulmus, Fg=Fagus, J=Juniperus, Co=Corylus and Sa=Salix.

Discrepancies arise in the dates of the LPAZ boundaries. The beginning of Flandrian Chronozone II (Godwin's Zone VI/VIIa) is seen to range from 6385 ± 50 BP (SRR 1339) at Gatcombe on the Isle of Wight to ca. 6979 BP (SRR 789) at Poole, a maximum of 714 years, while the 'Elm decline' boundary, which corresponds to the beginning of F III varies over 1260 years from ca. 4500 BP at Southsea to ca. 5670 BP at Lewes. Thus we can see that dating the LPAZ at the sites in this study is rather complex and in most cases

dates are taken from the closest dated diagram to the site: Thus the dates for The Moors site and the Studland Heath site are taken from Haskins (1978), the dates for the Yarmouth site are taken from Devoy (1972) and Scaife (1982), the Fett Level dates are from Thorley (1981) and the dates for Browdown are taken straight from West (1970) as there is no dated diagram close to the site.

#### 4:3 ANALYSES OF INDICATORS OF SEA-LEVEL MOVEMENT FROM SITES STUDIED

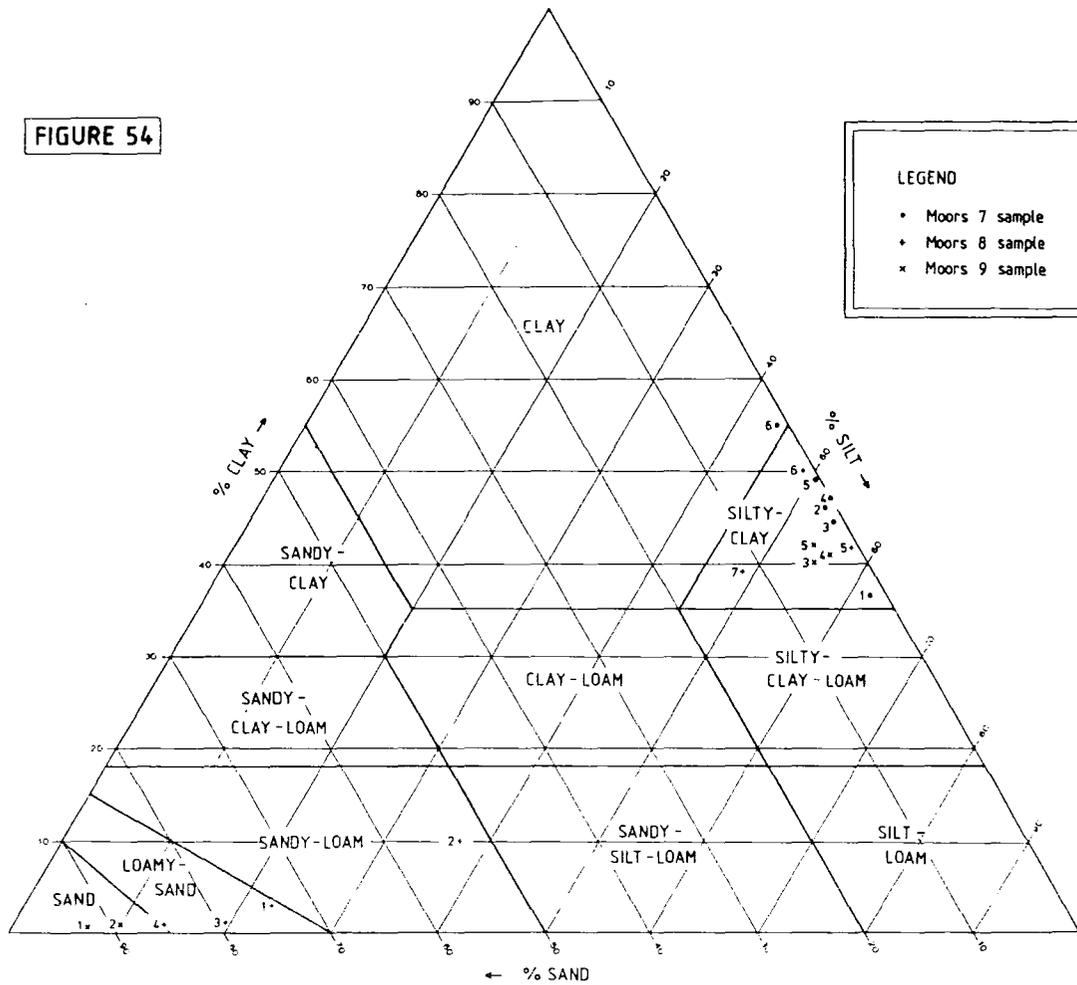
##### 4:3:1 The Moors Site

At The Moors site there is evidence for one period of biogenic sedimentation and one period of minerogenic sedimentation (Figure 8). These sediments are thought to have accumulated during the Flandrian Age and lie on a bedrock of Bagshot Beds of Eocene Age.

The organic horizons, of the site, lie above this bedrock and are found in all boreholes. The altitude of the lower contact of these deposits varies from - 2.39 m.O.D. to - 0.46 m.O.D. and the thickness ranges from 13 cm to 176 cm with increasing thickness to the landward of the site. The upper contact of these peats is taken where predominantly organic sediments are replaced by predominantly clastic deposits. This contact varies in altitude from - 1.11 m.O.D. to - 0.04 m.O.D. The minerogenic deposit is found in all boreholes above the peat and accumulated during the Flandrian Age, continuing to accumulate probably until Roman Times when the site was drained by an extensive system of dykes. The upper contact is with the top-soil of the site and varies from - 0.34 m.O.D. to + 0.12 m.O.D. The minerogenic material was divided into two facies in the particle-size and field analyses; a lower coarser silt and clay (Ag 2, As 2) and an upper finer silty-clay (Ag 1, As 3).

# THE MOORS - PARTICLE-SIZE

FIGURE 54



LEGEND

- Moors 7 sample
- + Moors 8 sample
- x Moors 9 sample

The particle-size analyses of the three boreholes M 7, M 8 and M 9 at The Moors site (Section 3:1:2) has been summarised in Figure 54. These analyses reveal that although the field analyses divided the deposit into a silt and clay and a silty-clay, the particle-size analyses (B.S. 1377, 1967) shows the minerogenic deposit to be a silty-clay, using the Soil Survey of England and Wales terminology, but these analyses also reveal that there is a fining of the sediment up through the deposit i.e. M 7:2 and M 7:3 are coarser than M 7:4, M 7:5 and M 7:6. These sediments indicate deposition in a relatively higher energy environment above the peat which passes into deposition in a lower energy environment above.

Pollen analyses were carried out at M 7 and M 10. At M 7, (Figure 12) the analysis of pollen revealed a series of changes in the local environmental conditions. A lower wet Alder carr fen environment is indicated with Alnus pollen dominant and Betula and Quercus pollen also recorded at the site (LPAZ M7:1). Gramineae, Frangula, Ranunculus-type, Caltha-type and Rubiaceae (probably Galium-type) pollen are found here which are indicative of a damp fen environment. Major changes in the pollen spectra are found at the top of the organic material where pollen of increasingly inter-tidal conditions is present in the form of Chenopodiaceae, Caryophyllaceae, Myriophyllum and Compositae species (LPAZ M7:2b). At M 10 (Figure 13) the pollen analysis revealed a sequence of semi-terrestrial peat growth with Alder carr (LPAZ M10:1) giving way to an herbaceous peat in the top levels. The pollen taxa indicate a change-over from Alder carr to a more open environment with a rise of Gramineae (LPAZ M10:2-5) and Cyperaceae (LPAZ M10:3-5) together with the increase in saltmarsh taxa such as Chenopodiaceae and Compositae (LPAZ M10:5) and a rise in aquatic pollen. Thus

although sediments with a high proportion of organic matter were recorded above - 0.95 m.O.D. (ca. 32 cm) in M 10, the pollen data indicate that marine influenced minerogenic sedimentation was underway before full marine conditions were recorded at the site, ie. the change-over at the site was transitional.

Diatom analyses were performed at M 7, M 8, M 9 and M 10 (Section 3:1:4). One must take care when interpreting the results from the diatom diagrams as it will be seen that major changes in the lifestyle diagrams are the result of a change in perhaps just a single species ie. at M 8 (Figure 15a) the change to a dominance of Marine valves in LDAZ M8:3 is caused by the rise in the frequency of Melosira sulcata (Figure 15b). Thus it is only possible to say that the diatom analyses of The Moors site indicates that the environment was predominantly Brackish/Marine when the diatoms were deposited in the minerogenic material.

The particle-size analyses of The Moors site suggests the minerogenic layers were deposited first in a relatively higher energy environment with coarser sedimentation and later in a lower energy environment with finer sedimentation. The sequence of deposits found at The Moors, a basal peat topped by a minerogenic stratum, could be explained by the rise of water level at the site leading to the truncation of peat growth and the deposition of Brackish/Marine sediments above. This sedimentary environment could be the result of a rise of sea level in the environment causing an increase in the level of the local water-table with subsequent deposition of minerogenic deposits as the water inundated the site. This type of deposition at the site could be expected if a coastal barrier, protecting the site, was breached, such as the spit formation at the entrance to Poole Harbour. This would allow the rapid inundation of

The Moors by marine water from the English Channel replacing the more brackish water of the harbour. If this was the case then erosion of the top levels of the peat could be expected in some boreholes, particularly nearer the breaching point, with a rapid truncation of peat growth and the deposition of marine sediments, with sharp lithological boundaries. The stratigraphic sequences seen in Figure 8 show that in each borehole the peat is overlain by a transitional biogenic-minerogenic deposit with no evidence of a rapid truncation of peat growth. The pollen and diatom analyses also show no evidence of barrier breaching in the immediate vicinity. The pollen analyses at The Moors shows increasing water-logging and marine influence at the site in the upper levels of peat, shown by the saltmarsh and aquatic pollen types. This sequence is seen in both M 7 and M 10 where wet Alder carr vegetation is replaced by open water taxa and saltmarsh species. The diatom analyses reveals only the presence of predominantly Brackish/Marine water above the peat. Although the microfossil evidence at The Moors site suggest no rapid inundation by marine conditions it is perhaps worth noting that the site is well sheltered from the entrance to Poole Harbour by the Arne Peninsula and it is also rather far, ca. 9 km, to receive immediate inundating if the spit at the entrance was breached. If we assume a breach ca. 9 km away, instead of a rapid truncation of peat growth we would expect a more gentle transition to marine conditions at The Moors, which could explain the lack of erosional horizons above the peat yet also explain the fining of the minerogenic deposit as the estuary silted up following the re-establishment of quieter sedimentation behind a re-aligned barrier. The Studland Heath site is closer to the harbour entrance, ca. 2 km, and although it is also partially sheltered by the South Haven Peninsula we could expect to

find other evidence at this site if there was a breaching of the spit formation at the entrance to Poole Harbour. This idea will be discussed further.

The beginning of marine sedimentation at The Moors site is thought to have begun during early Flandrian Chronozone III, which starts ca. 5000 BP (West 1970) and covers Godwin's Zone VIIb, which has been assigned time limits of ca. 5500/5000 BP to ca. 2500 BP (Godwin 1940). In the Poole Harbour region Haskins (1978) has assigned time limits of ca. 4950 BP to ca. 2950 BP for this zone.

Thus at The Moors site we have indications of positive tendencies of sea-level movement with a range of altitude from - 1.11 m.O.D. to - 0.04 m.O.D. and dating from the range of ca. 4950 BP to ca. 2950 BP.

#### 4:3:2 The Studland Heath Site

At Studland Heath there is evidence of one episode of biogenic sedimentation of a very limited extent laterally, and one period of minerogenic deposition thought to have accumulated during the Flandrian Age. The biogenic material lies above the bedrock of Bagshot Beds of Eocene Age.

The altitude of the lower contact between the peat and the bedrock varies from + 0.02 m.O.D. to - 0.72 m.O.D. The thickness of this peat ranges from 17 cm to 103 cm. Again the upper contact of the peat is taken to be where predominantly organic sediments are replaced by predominantly clastic sediments. This contact varies in altitude from + 0.11 m.O.D. to + 0.56 m.O.D.. The minerogenic material at this site has a rather complex configuration and has been described in Section 3:2:1.

Pollen analyses were carried out at SH 4b and SH 4h. At SH 4b (Figure 21) the pollen spectra from the peat levels indicate the presence of an Oak-Alder carr with abundant Gramineae pollen (LPAZ SH 4b:1-3). This was probably quite an acid environment locally shown by the pollen of Ericaceae and the spores of Sphagnum. At the top of the organic deposit, the pollen analysis revealed some evidence for the presence of saltmarsh conditions with Chenopodiaceae and Plantaginaceae pollen, also open water taxa like Potamogeton and reedswamp taxa such as Typha latifolia (LPAZ SH 4b:4). At SH 4h (Figure 22) the peat is predominantly shrubby in nature with high Corylus and Ericaceae values (LPAZ SH 4h:1-2). The rise in Gramineae pollen (LPAZ SH 4h:3a-3b) together with an increase in the frequencies of Alnus and Quercus pollen indicates a change to more damp Oak-Alder carr environment. A change to saltmarsh conditions is reflected in the vegetation of the silty-sand (LPAZ SH 4h:4) where Chenopodiaceae, Compositae and Plantaginaceae pollen are all present. There are however no aquatic pollen present here but this could be due to probable erosion of the top levels of peat as the lithological boundary between the peat and minerogenic material is very sharp. At the borehole SH 4h, above + 0.19 m.O.D. (ca. 134 cm) the strata are minerogenic but pollen analysis revealed that saltmarsh taxa were present thus indicating that marine influenced sedimentation was in progress at Studland Heath before fully marine conditions were prevalent.

No particle-size analyses or diatom analyses were performed at Studland Heath but the field analyses of the sediments showed that at SH 4b a transitional silty-peat is found above the organic material which passes into a silty-sand (Ag 1, Ga 3) at + 0.62 m.O.D. and above to a finer sand-silt (Ag 2, Ga 2) before graduating to an organic clayey-silt (Th 1, As 1, Ag 2). At SH 4h the organic deposit

is sharply delimited from a thin band of silty-sand (Ag 1, Ga 3) at + 0.19 m.O.D. passing upward into a coarser gravel-sand (Ga 2, Gg(min) 2) and finally to a finer organic sandy-silt (Th 1, Ga 1, Ag 2).

These deposits could indicate deposition occurred first in a higher energy environment and later in a lower energy environment. The Studland Heath site is close to the entrance of Poole Harbour, ca. 2 km, and if we are to postulate a hypothetical spit formation across the entrance was breached at some time, then the evidence of this event should be seen in the boreholes of Studland Heath (Figure 20). The transect from SH 1 to SH 8 shows clearly that a lower predominantly sandy deposit is found in all boreholes, which is overlain by a finer natured deposit of clays and silts, except at SH 1 and SH 2. This could be the result of deposition in a higher energy environment, such as following the breaching of a protective barrier, followed by deposition in a lower energy environment, as the estuary silted up. The second transect from SH 4a to SH 4h shows that at SH 4 and SH 4h there is a rapid truncation of peat growth with a sharp upper lithological boundary, being replaced by minerogenic material. This pattern is not however found at SH 4a and SH 4b where transitional material lies above the peat. Thus at Studland Heath we have evidence of encroaching marine conditions, indicated by the saltmarsh taxa and open water taxa of pollen, but locally the change to marine sedimentation is characterised by some erosional horizons and high energy sedimentation. The minerogenic deposits show a lack of homogeneous layers but this is to be expected if the site were close to a mobile spit environment.

The beginning of marine sedimentation at Studland Heath is thought to have been during Flandrian Chronozone III (Godwin's

Zone VIIb) which is dated from ca. 5000 BP (West 1970) and dated by Haskins (1978) from ca. 4950 BP to ca. 2950 BP.

Thus at the Studland Heath site we have evidence of a positive tendency of sea-level movement between ca. 4950 BP and ca. 2950 BP within a range of altitude from + 0.11 m.O.D. to + 0.56 m.O.D.

#### 4:3:3 The Yarmouth Site

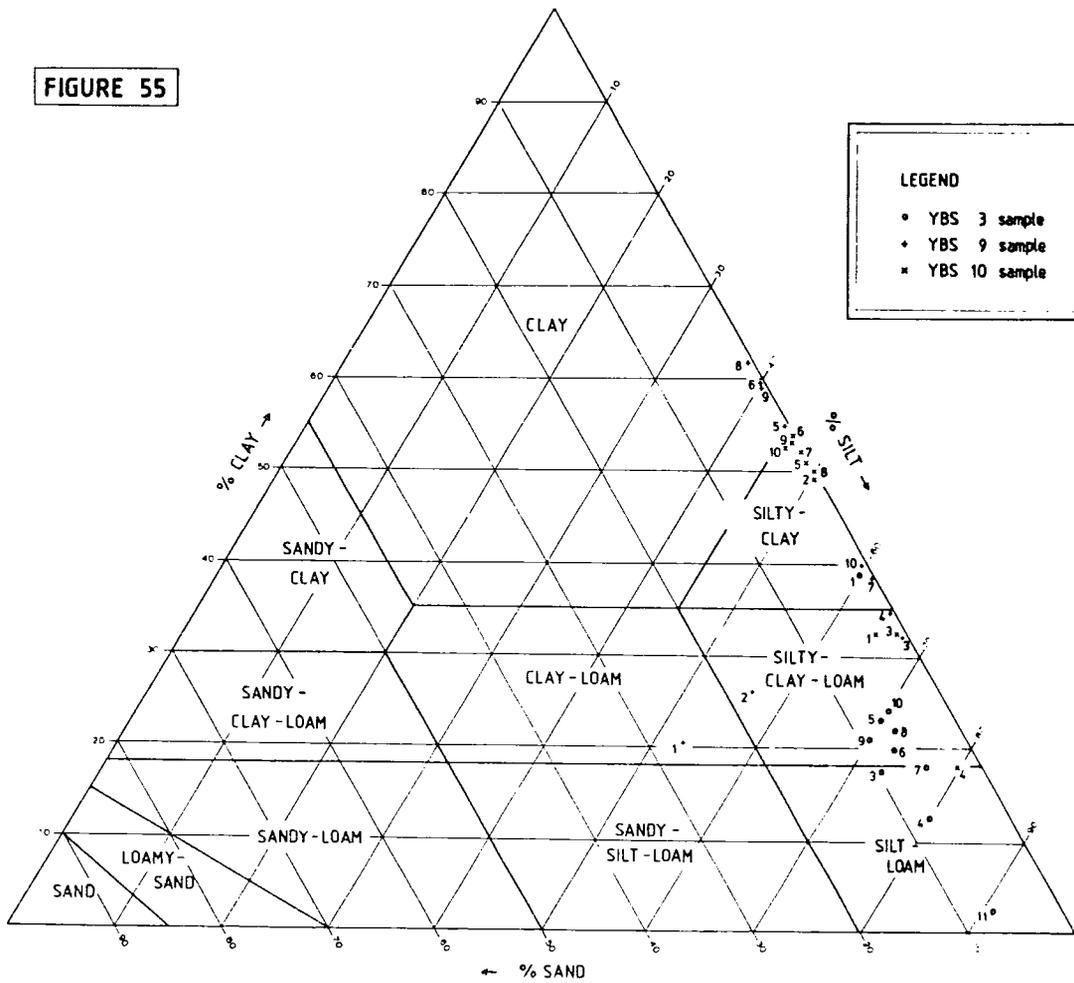
The Yarmouth site was subdivided in Section 3:3 into Yarmouth Carpark and Yarmouth Boatyard to facilitate the discussion of the deposits; this scheme will be continued here and the site discussed as a whole at the end of this section.

At Yarmouth Carpark the stratigraphic diagram (Figure 25) shows a single period of biogenic sedimentation together with two periods of minerogenic sedimentation. These deposits are all thought to have accumulated during the Flandrian Age and lie on a bedrock of Headon Beds, which are Oligocene in age.

The lower minerogenic deposit is only found at YBS 2 and YBS 3, and consists of silts and clays. The upper contact of this material ranges in altitude from - 6.55 m.O.D. to - 5.74 m.O.D. Biogenic material is found only at YBS 1, YBS 2 and YBS 3, although transitional peaty-clastic strata are found in YBS 5, YBS 6 and YBS 7. The true organic material reaches a depth 248 cm at YBS 2. The upper contact of this peat with a clay and silt deposit above, varies in altitude from - 3.55 m.O.D. to - 4.07 m.O.D. The upper minerogenic deposit is found in all boreholes and consists in the main of silts and clays with a lower sandy band at YBS 5, YBS 6 and YBS 7 and an upper sandy band in all boreholes except YBS 7. Shell remains were located in all boreholes in the upper minerogenic deposit.

# YARMOUTH - PARTICLE-SIZE

FIGURE 55



The borehole YBS 3 was the only one to the east of the River Yar to be examined for microfossils. The field analysis of the strata (Section 3:3:1) showed that the lower minerogenic deposit was a clayey-silt and that the upper minerogenic deposit was also a clayey-silt. The particle-size analysis (Section 3:3:2) is summarised in Figure 55 and also seen in Figure 27 (B.S. 1377; 1967). The lower minerogenic deposit is shown to be a silty-clay according to Soil Survey of England and Wales terminology while above the peat the deposit is a silt-loam which passes into a silty-clay loam and to a coarser silt-loam at the top of the borehole. The pollen analysis of YBS 3 (Section 3:3:3) revealed a series of LPAZ indicative of a greatly fluctuating water level at the site (Figure 30). The base of the peat contains an herbaceous pollen flora, which could be a swamp carr environment shown by Salix and Typha angustifolia pollen (LPAZ YBS 3:1) with local stands of Oak-Alder scrub woodland. This gives way to a drying out of the site with a predominance of Alder scrub woodland (LPAZ YBS 3:2), although Cruciferae and Lythrum pollen could indicate localised reedswamp conditions together with high Myriophyllum pollen values indicating open water conditions. Further drying out at the site is recognised in LPAZ YBS 3:3, with Alder scrub woodland and no indications of wetland conditions. This reverts back to swamp carr conditions (LPAZ YBS 3:4) with Rhamnus and Frangula pollen showing fen peat. The Mentha and Lathyrus pollen found here together with the fen peat indicators confirm this view. Again a drying out of the site is seen above this swamp carr with the reappearance of Alder-Oak scrub woodland (LPAZ YBS 3:5). The Gramineae and Cyperaceae pollen die back dramatically here together with all shrub pollen except Corylus. The top levels of peat show swamp conditions (LPAZ YBS 3:6) with the expansion of saltmarsh taxa like Chenopodiaceae and Plantaginaceae and an expansion of aquatic

pollen. The diatom analysis at YBS 3 (Section 3:3:4) showed the lower minerogenic deposit to be predominantly Brackish in nature (Figure 36a) with increasing Fresh diatoms towards the lower contact with the peat above. The upper minerogenic deposit is shown to be predominantly Brackish/Marine with decreasing Freshwater influence away from the peat deposit.

There are two periods of minerogenic sedimentation recognised at Yarmouth Carpark. The lower phase of clastic deposition is thought to have accumulated ca. 6385 BP (Scaife 1982) in a brackish environment. This was followed by a period of peat accumulation within an age range from post ca. 6385 BP (Godwin 1940). The final phase of clastic sedimentation is thought to be post ca. 2500 BP with indicators of marine conditions at the site seen in the particle-size, pollen and diatom analyses.

Thus at Yarmouth Carpark there is evidence of a negative tendency of sea-level movement with an altitude range of - 6.55 m.O.D. to - 5.74 m.O.D. and dated from post ca. 6385 BP. This is followed by a positive tendency of sea-level movement with an altitude range of - 4.07 m.O.D. to - 3.55 m.O.D. and dating from pre ca. 2500 BP.

At Yarmouth Boatyard the stratigraphic analyses (Figure 26) revealed a more complex pattern of strata. There appears to have been two main periods of biogenic accumulation; the lower period being equivalent in altitudinal range to the biogenic deposit of Yarmouth Carpark, and a possibility of three periods of minerogenic deposition. The biogenic and minerogenic deposits are all thought to have accumulated during the Flandrian Stage and lie on a bedrock of Headon Beds of Oligocene age.

The lowest minerogenic deposit is only found at YBS 8 and YBS 9 where it consists of silts, clays and sands. The upper contact of this deposit is with biogenic material and varies in altitude from - 4.88 m.O.D. to - 4.57 m.O.D. The lower biogenic deposit is observed at YBS 8 and YBS 9 and the upper contact of this peat varies in altitude from - 3.98 m.O.D. to - 3.50 m.O.D., it being overlain in both boreholes by silts and clays. At YBS 8, three peat bands are seen and at YBS 9, two peats were observed. Both boreholes display intercalated silts and clays. A second minerogenic deposit is thought to be in evidence at YBS 10 through to YBS 14 and consists predominantly of silts and sands. The upper contact of this deposit with the peat above varies in altitude from - 2.80 m.O.D. to - 2.25 m.O.D. A possible second period of biogenic accumulation is observed at YBS 10, YBS 11, YBS 12, YBS 13 and YBS 14. The upper contact, with clastic material, varies in altitude from - 2.53 m.O.D. to - 1.62 m.O.D. No upper biogenic material is found at YBS 15. The uppermost minerogenic deposit at Yarmouth Boatyard is found at all boreholes and consists of silty-clays but a band of lower silt runs through cores YBS 12 to YBS 15, which are closest to the River Yar. Evidence of shell remains found at Yarmouth Carpark are also present at YBS 13, YBS 14 and YBS 15.

Microfossil analyses were carried out at YBS 9, YBS 10, YBS 12, YBS 13 and YBS 14. The particle-size analyses of YBS 9 and YBS 10 have been summarised in Figure 55. The field analysis of YBS 9 (Section 3:3:1) showed a fining of the particle-size of the strata towards the base of the lower peat deposit, from a silty-clayey-sand to a sandy-clay. The intercalated minerogenic stratum between the peats is a pure clay and above the upper peat, the field analysis showed a silty-clay stratum. The particle-size analysis (Section 3:3:2)

of this borehole also revealed a fining of the particle-size towards the contact with the lower peat. According to the Soil Survey of England and Wales terminology, this is a clay loam passing to a silty-clay loam. The intercalated stratum is revealed as a silty-clay loam which passes into a silty-clay below the upper peat. Above this upper peat the strata are a mix of silty-clays and clays. At YBS 10 the field analysis showed the lowest minerogenic deposit to be predominantly silty with a pure silt at the base of the borehole. This lowest stratum was shown to be a silty-clay loam in the particle-size analysis fining to a silty-clay and above to a silty-clay loam just below the peat. Above the peat of YBS 10 the field analysis showed a suite of silts but the particle-size analysis showed a silty-clay loam immediately above the peat passing to a series of silty-clays above. Pollen analyses were carried out at YBS 9, YBS 10, YBS 12, YBS 13 and YBS 14 (Section 3:3:3). Each borehole revealed a sequence of changing vegetational environments reflecting fluctuations in the local water level at the site. At YBS 9 (Figure 31) the base of the peat showed a dry scrub Alder woodland (LPAZ YBS 9:1). This passed into a wetter Alder fen with local open water aquatics shown by the pollen of Myriophyllum and the reedswamp taxa such as Typha angustifolia and Typha latifolia (LPAZ YBS 9:2). Conditions at the site dried out in LPAZ YBS 9:3 where Alder-Oak carr is the dominant vegetation type. The Alder-Oak woodland died back in LPAZ YBS 9:4a with an expansion of open habitat vegetation. Below the clay of stratum 4, the vegetation reflected a damp Alder carr fen with increasing saline conditions at the site shown by the pollen of Chenopodiaceae and Compositae tubuliflora (LPAZ YBS 9:4b) and reedswamp taxa such as Cruciferae, Lythrum and Valerianella. This rise in water level continued on above the clay into a second upper biogenic

stratum where Chenopodiaceae and Plantaginaceae pollen expand (LPAZ YBS 9:5). Above this upper peat the pollen indicate a wet Alder-Oak fen with increasing marsh pollen of Chenopodiaceae and Plantaginaceae (LPAZ YBS 9:6) showing the proximity of marshes to the site. The beginning of peat growth at YBS 9 is thought to have been after ca. 6385 BP and the 'Elm decline' is recognised at - 4.57 m.O.D. and dated using the Devoy (1972) dates of ca. 4750/4500 BP. The end of peat growth at the borehole is not dated. At YBS 10 a sequence of fluctuating water levels is reflected in the pollen analysis of the site (Figure 32). The lowest levels of peat revealed an Oak-Alder fen with Chenopodiaceae and Plantaginaceae pollen showing evidence of localised marsh conditions (LPAZ YBS 10:1) and open water with the pollen of Potamogeton. Above this the vegetation reflects the drying out at the site with Alder-Oak scrub (LPAZ YBS 10:2) and localised swamp carr conditions shown by the pollen of Rhamnus, Frangula and Mentha. This drying out continues into LPAZ YBS 10:3a where there is an expansion of Alder woodland with some localised open water conditions reflected by the pollen of Potamogeton and fringing reedswamps with Typha angustifolia pollen. The drying out is carried on into LPAZ YBS 10:3b with a dying back of Alder and more open habitat vegetation expanding in the form of Gramineae and Cyperaceae pollen. The top levels of peat showed a rise in the local water level at the site and the expansion of saltmarsh taxa of Chenopodiaceae and Compositae (LPAZ YBS 10:4) and open water aquatic pollen of Potamogeton and Typha angustifolia. The pollen analysis of YBS 10 showed that peat growth began ca. 4750/4500 BP (after Devoy 1972). At an altitude of - 1.94 m.O.D. a date of ca. 2500 BP is tentatively recognised by the re-establishment of Pine pollen and the continuous Fraxinus curve. The pollen analysis of the borehole YBS 12 revealed a series of alternating water levels

(Figure 33). The base of the lowest peat deposit is herbaceous in nature with indications of a very wet environment, probably reedswamp (LPAZ YBS 12:1) shown by the pollen of aquatic species together with Cruciferae, Lythrum, Valeriana and Salix. This passed into a drier zone of woody peat (LPAZ YBS 12:2) which is probably a scrub Alder-Oak woodland with localised reedswamp communities shown by the pollen of Cyperaceae and Typha angustifolia. The upper levels of the lower peat are drier in nature with Alder-Oak carr (LPAZ YBS 12:3) although Frangula pollen is present indicating moist soil conditions. The transitional deposit between the two peats is again predominantly herbaceous with Chenopodiaceae, Potamogeton and Compositae species of pollen (LPAZ YBS 12:4) which could indicate saltmarsh environments with swamp conditions and stands of Oak-Alder scrub woodland. The upper peat deposit is herbaceous with very low aquatic pollen present (LPAZ YBS 12:5) which indicates a return to carr conditions and Alnus becomes the dominant tree pollen. At YBS 12 peat growth is thought to have been initiated from ca. 4750/4500 BP. At - 1.74 m.O.D. a date of ca. 2500 BP is assumed where Tilia pollen declines and Fraxinus pollen expands. The pollen analysis of YBS 13 (Figure 34) showed that the base of the peat has indicators of a damp Alder fen environment with Rubiaceae, Jramineae, Ranunculus-type and Caltha-type pollen, together with open water taxa of Typha angustifolia and Potamogeton (LPAZ YBS 13:1). This environment dried out above to an Alder carr with less aquatic pollen (LPAZ YBS 13:2). The first indications of a rising water level are seen in LPAZ YBS 13:3a where the vegetation is Alder fen with rising water levels indicated by the pollen of Chenopodiaceae, Plantaginaceae and Compositae species together with high Cyperaceae values. The rise of water level is

carried on into LPAZ YBS 13:3b where a peak of Chenopodiaceae pollen occurs just below the clayey-silt of stratum 6. The top level analysed in this core showed a drying out at the site with Oak-Alder scrub woodland and no aquatic pollen (LPAZ YBS 13:4), but higher water levels are maintained still, shown by the Chenopodiaceae pollen. The peat growth at YBS 13 is thought to have been initiated ca. 4750/4500 BP with the Tilia decline recognised at - 1.94 m.O.D. and dated at ca. 2500 BP, seen by the decline of Tilia pollen and the expansion of herb pollen. The end of peat growth is not dated.

The final core at Yarmouth Boatyard to be analysed for pollen is YBS 14 (Figure 35). The bottom levels are found in a transitional peat-silt which revealed an Alder-Oak fen vegetation with high local water levels shown by Chenopodiaceae and Compositae pollen (LPAZ YBS 14:1) but no aquatic pollen is present. The pure silt of stratum 3, found below the peat deposit, showed indications of damp Alder fen with a decrease of saltmarsh taxa and rising aquatic pollen (LPAZ YBS 14:2). The base of the true peat showed vegetation of reedswamp conditions with Gramineae, Cruciferae and Lythrum pollen (LPAZ YBS 14:3) and localised Alder-Oak scrub and open water habitats with Salix and Typha angustifolia pollen. The transitional material above the peat showed a drying out of the environment with Alder carr vegetation (LPAZ YBS 14:4). The bottom of the upper minerogenic deposit revealed an environment of Alder fen with marsh conditions shown by Chenopodiaceae, Plantaginaceae and Compositae species (LPAZ YBS 14:5) and open water taxa of Typha angustifolia and Myriophyllum. At YBS 14 the peat growth is thought to have been initiated from ca. 4750/4500 BP but again the end of peat growth is not dated. Diatom analyses at Yarmouth Boatyard were performed at YBS 9, YBS 10, YBS 12, YBS 13 and YBS 14. At YBS 9 the diatom

diagram (Figure 37a) showed a Freshwater influence at the top of the lower peat which changes to a Brackish environment in the intercalated clay and upper peat and to a more Brackish/Marine environment in the upper clastic deposit. At YBS 10 (Figure 38a) the minerogenic material below the peat was shown to be influenced by Brackish/Marine waters while above the peat there was a strong Freshwater influence with Brackish conditions and no Marine diatoms present. The transitional material above the peat was predominantly Brackish/Marine changing to a more Marine environment of deposition in the clayey-silt of the upper minerogenic material. At YBS 12 (Figure 39a) the lower minerogenic deposit did not yield any diatoms but the upper minerogenic deposit showed signs of being predominantly Brackish/Marine. The diatoms of YBS 13 (Figure 40a) showed Fresh/Brackish influences above the peat deposit which changed to a Brackish/Marine environment in the upper minerogenic deposit. YBS 14 was the last core at Yarmouth Boatyard to be analysed (Figure 41a). The lower silty-sand was shown to be predominantly Brackish/Marine while the pure silt below the peat was Freshwater/Brackish in nature. The lower peat showed a strong Freshwater influence.

At the Yarmouth site the stratigraphic configuration of the boreholes together with the microfossil analyses leads to at least two possible explanations for sediment accumulation: The site could display two separate peat layers indicating the possibility of three periods of positive sea-level tendency. As an alternative hypothesis the peat deposit could be synchronous across the site leading to the assumption that there are two periods of positive sea-level tendency at the site.

The altitudinal differences of the peat deposits at Yarmouth

indicate a division into two separate peat accumulation phases with the peats of YBS 1, YBS 2, YBS 3, YBS 8 and YBS 9 accumulating before the peats of YBS 10, YBS 11, YBS 12, YBS 13 and YBS 14. If this were the case the relative dating of the peat deposits should indicate distinctly separate phases of growth. Although the peats of YBS 3 and YBS 9 are thought to begin after ca. 6385 BP, a date of ca. 4750/4500 BP is recognised throughout the seven cores analysed. Thus peat growth seems to have been synchronous across the site.

The peats of Yarmouth all display evidence of fluctuating water levels in their vegetation. At YBS 3, three periods of predominantly rising water levels are seen at - 5.71 m.O.D., - 4.70 m.O.D. and - 4.18 m.O.D. At YBS 9, two of these phases are recognised at - 4.57 m.O.D. and - 4.27 m.O.D. which correspond well with the altitude of the upper two phases at YBS 3 although the dates do not correspond, but this could be due to compression of the borehole samples from YBS 9. In the cores YBS 10 to YBS 14, two periods of rising water level are seen in each core, at the base of the peat and at the top of the peat. The altitudes of these two events correspond well and give a mean altitude of - 2.44 m  $\pm$  0.20 m.O.D. for the lowest rise of water level and a mean altitude of - 1.97 m  $\pm$  0.03 m.O.D. for the upper event. At YBS 12 and YBS 13 a further drying out of the site is observed above the upper rise of water level. The date of the lower water level rise is thought to be ca. 4750/4500 BP and there is evidence at YBS 10 and YBS 13 that the upper rise dates from ca. 2500 BP with an increase in saltmarsh taxa indicating the onset of fully marine conditions at the site. The diatom analyses of the boreholes indicate that the lowest minerogenic deposit found at YBS 3, YBS 10 and YBS 14 are related to

changes in the water level at the site and are not bedrock deposits as first assumed. Above the upper peat at both the Yarmouth Carpark and Boatyard, shell fragments were recorded in the strata. These deposits can be related to the shelly silty clay which Devoy (1972) found above the peat deposits at Yarmouth and which he assumed to indicate estuarine conditions and fluctuating water levels at the site. The boreholes taken by Devoy show evidence of peat growth corresponding in altitude to the lower peat found in the present study together with peat growth corresponding to the upper peat of Yarmouth Boatyard. At one borehole in the Devoy study (YB 2) the peat growth has an altitudinal range from - 4.75 m.O.D. to - 2.15 m.O.D. which spans the altitudinal range from Yarmouth Boatyard and Carpark. Devoy also finds evidence of peat growth at much lower altitudes, - 5.75 m.O.D., - 6.25 m.O.D. and - 9.85 m.O.D. than found in the present study. Devoy shows peat growth began ca. 4750/4500 BP and ends ca. 3750/3250 BP. A series of boreholes taken by the Wimpey Company (1973) close to the northern edge of the Carpark site showed peat growth from altitudes of - 3.10 m.O.D., - 4.05 m.O.D. and - 6.80 m.O.D. which again correspond with the lowest peats found in the present study.

At Yarmouth this work has shown that peat accumulation at the site is synchronous. The altitude differences between the peats is thought to be the result of the topography of the sites and could also explain the lack of biogenic sediments at YBS 4, YBS 5, YBS 6, YBS 7 and YES 15, where a rise in the land surface would not allow the accumulation of peat material. At Yarmouth the evidence presented suggests initiation of peat growth after ca. 6385 BP as a result of a drop in the local water level at the site. This early growth is seen in YES 3 and YES 9. Peat deposits continued to

accumulate in these boreholes and by ca. 4750/4500 BP growth was initiated at YBS 10, YBS 12, YBS 13 and YBS 14. A drying out of the site is recognised in all boreholes with a renewed rise in the local water level at ca. 2500 BP. The change-over to minerogenic sedimentation post dates ca. 2500 BP and varies greatly in altitude from - 4.07 m.O.D. at YBS 2 to - 1.62 m.O.D. at YBS 12. The microfossil evidence indicates this upper minerogenic deposition was during marine conditions at the site.

Thus at the Yarmouth site we see that there is a rather complex history of sea-level movements. Two phases of positive sea-level tendency are recognised and one period of negative sea-level tendency. Due to the topographical configuration of the site, the altitudinal range of these events varies considerably. The first period of positive sea-level tendency is dated prior to ca. 6385 BP with an upper contact ranging in altitude from - 6.55 m.O.D. to - 4.57 m.O.D. This is followed by a period of negative sea-level tendency which is dated from ca. 6385 BP to ca. 2500 BP. This phase involved a series of fluctuating local water levels at the site which are recorded in the pollen spectra. The second phase of positive sea-level tendency is dated post ca. 2500 BP with an altitude range of - 4.07 m.O.D. to - 1.62 m.O.D. when fully marine conditions were experienced at the Yarmouth site.

#### 4:3:4 The Pett Level Site

At Pett Level in Sussex there is evidence for two major periods of minerogenic sedimentation together with two main periods of biogenic sedimentation (Figure 44). These deposits are thought to have accumulated during the Flandrian Age and lie on a bedrock of Cretaceous Ashdown Sands and Fairlight Clays.

The lowest minerogenic deposit is found at Pett 1a and Pett 2a. In both boreholes it occurs as a clay plus silt. It is not possible to state the altitude of the lower contact of this deposit as it was found at the bottom of the boreholes. The upper contact is with a biogenic horizon and varies in altitude from - 2.58 m.O.D. to - 2.26 m.O.D. The lowest biogenic material found at Pett Level is only present at Pett 1a and Pett 2a and is a woody peat with traces of silt at Pett 2a. The upper contact of this peat varies in altitude from - 2.19 m.O.D. to - 1.96 m.O.D. and is seen to possess a sharp lithological boundary in both cases. The upper minerogenic deposit is found at Pett 1, Pett 1a, Pett 2a and Pett 3 and varies from a pure clay at Pett 1a and Pett 3 to a silt plus clay at Pett 1a and Pett 2a. Again it is difficult to determine the lower contact altitude as the deposit was not reached at Pett 1 and Pett 3. The upper contact of the minerogenic deposit is with a peat at Pett 1, Pett 2a and Pett 3 and varies in altitude from - 1.62 m.O.D. to - 1.40 m.O.D. The upper biogenic horizon is found at Pett 1, Pett 2, Pett 2a and Pett 3 and has a very sharp lower lithological contact at Pett 2a and Pett 3. The upper contact of this peat is at ground level as it is exposed on the foreshore. It varies from - 1.35 m.O.D. to - 0.89 m.O.D. A transitional zone of silty-peat is found between altitudes of - 1.14 m.O.D. to - 1.30 m.O.D. at Pett 2a and between - 1.01 m.O.D. to - 1.24 m.O.D. at Pett 3. At Pett 4 no clear minerogenic and biogenic strata can be discerned but the presence of predominantly biogenic sediments showed that peat accumulation at the site continued to an altitude of + 0.03 m.O.D. although it must be remembered that erosion by wave action is occurring at the present day.

Pollen analyses (Section 3:4:2) were carried out at Pett 2, Pett 3

and Pett 4, all these analyses revealed that Alnus pollen is present at the site in very great numbers indicating that the site can be described as having a vegetation of Alder fen with localised communities indicative of other habitat conditions. It is these localised communities that will be described in the following section remembering that they occur as a background to the predominant Alder fen of Pett Level.

At Pett 2 (Figure 45) the pollen of the bottom levels of peat revealed an Alder carr environment (LPAZ P2:1) with localised swamp conditions shown by the pollen of Lythrum, Alisma and Frangula. This passes into a wetter environment (LPAZ P2:2) with the expansion of Alnus pollen. The top levels of peat showed an increase in damp conditions at the site with localised damp fen habitats shown by the pollen of Frangula, Mentha and Rubiaceae together with rising water levels and marsh conditions with Plantaginaceae, Artemisia, Compositae liguliflora and high Cyperaceae pollen. Localised open water conditions are seen in the pollen of Myriophyllum and Potamogeton. At Pett 3 (Figure 46) the pollen analysis showed a sequence of differing vegetation communities reflecting fluctuating water levels at the site. The base of the peat (LPAZ P3:1) has pollen indicators of high water levels with marsh taxa of Chenopodiaceae, Artemisia and Compositae tubuliflora together with high Cyperaceae pollen values. This passes into an environment of expanding Alnus pollen (LPAZ P3:2) and marsh indicators of Chenopodiaceae, Compositae tubuliflora and Plantaginaceae pollen. The top levels of peat revealed a drier environment (LPAZ P3:3) of Alder carr with an expansion of Corylus pollen and the dying back of aquatic pollen together with less marsh pollen indicators. At Pett 4 the biogenic and minerogenic strata were examined for their pollen content

(Figure 47). The lowest levels of the material revealed a damp fen environment (LPAZ P4:1) with the pollen of Rhamnus, Frangula, Cruciferae and Ranunculus-type. This environment is carried on above (LPAZ P4:2) with open water conditions reflected at the site by the pollen of Potamogeton and Myriophyllum, together with local reedswamp conditions shown by Lythrum, Cruciferae, Typha angustifolia and Typha latifolia pollen. These conditions are carried on to LPAZ P4:3 with Alisma and Potamogeton pollen indicating open water conditions, with marsh communities shown by the pollen of Compositae species, Artemisia, Chenopodiaceae and Plantaginaceae. A drying out of the site is experienced above (LPAZ P4:4) with no open water taxa. Wetter conditions return with an increase in the water level of the site (LPAZ P4:5) shown by the pollen of Cyperaceae and damp fen conditions. Saltmarsh taxa expand in LPAZ P4:6 with Compositae species, Artemisia, Chenopodiaceae and Plantaginaceae pollen and open water indicators of Alisma and Potamogeton pollen. The upper levels of material show localised reedswamp (LPAZ P4:7) with Lythrum, Typha angustifolia and Typha latifolia pollen.

At Pett Level there appears to be evidence for two periods of positive sea-level tendency together with two periods of negative sea-level tendency. Evidence for the first phase of positive sea-level tendency lies at the base of Pett 1a and Pett 2a where minerogenic sediments are found. The change-over from marine to terrestrial facies occurs over an altitude range of - 2.58 m.O.D. to - 2.29 m.O.D. No dates are available for this phase. This is followed by a period of negative sea-level tendency, seen at Pett 1a and Pett 2a when peat accumulated. No dates are available for this period but the change-over from terrestrial to marine facies occurs within an altitude range of - 2.19 m.O.D. to - 1.96 m.O.D. and has

a sharp lithological boundary. The second phase of positive sea-level tendency is seen at Pett 1, Pett 1a, Pett 2a and Pett 3. The change to terrestrial facies occurs over an altitude range of - 1.62 m.O.D. to - 1.40 m.O.D. and appears to have occurred rapidly as the lithological boundary is very sharp at both Pett 2a and Pett 3, but this could be due to subaerial erosion of the top levels of the minerogenic material. The change-over is dated ca. 5670 BP (after Thorley 1981) and represents the end of the positive phase of sea-level tendency. The following period of peat accumulation is dated from ca. 5670 BP to post ca. 2500 BP (Godwin 1940) and represents a period of negative sea-level tendency.

Thus at the Pett Level site two periods of positive sea-level tendency are recognised. The first of these phases occurs prior to ca. 5670 BP with the change-over to terrestrial facies occurring over an altitude range of - 2.58 m.O.D. to - 2.29 m.O.D. The second phase of positive sea-level tendency at Pett level covers an altitude range of - 2.19 m.O.D. to - 1.96 m.O.D. and ended ca. 5670 BP.

#### 4:3:5 The Browndown Site

The borehole material supplied from Browndown revealed only one period of biogenic accumulation within a sequence of minerogenic deposits of Flandrian Age.

The predominantly organic material, found at Browndown 13/14 53, was recovered between altitudes of - 19.38 m.O.D. and - 19.20 m.O.D. This was a silty-peat which lies above a silt-sand and passes through a peaty-silt before true minerogenic deposits are reached at - 19.01 m.O.D. Above the biogenic material, 9.26 m of mixed clays and silts were recognised with a sandy deposit at the top of

the borehole sample from - 9.74 m.O.D. to - 9.40 m.O.D.

The particle-size analysis (Section 3:5:2) of this core (Figure 50) showed that below the organic strata, the deposit is a sandy-silt loam while above the organic strata there are silty-clays. The upper sandy deposit noted in the field analysis is recognised in the particle-size analysis as a sandy-silt loam passing into a sandy loam above. Pollen analysis was performed on the organic material and the results can be seen in Figure 51. A number of different vegetation communities were observed. The base of the organic material indicates the presence of a relatively dry scrub Oak woodland (LPAZ B 36:1) with local heathland habitats shown by the pollen of *Ericaceae* and the spores of *Pteridium*. This scrub woodland passes into a wetter carr environment with *Plantaginaceae* and *Typha angustifolia* pollen (LPAZ B 36:2a). Above this is a shrubby fen swamp environment with increasing *Chenopodiaceae* and *Myriophyllum* pollen (LPAZ B 36:2b). The upper levels of organic material are indicative of a wet swamp with *Saxifragiaceae* and *Potamogeton* pollen (LPAZ B 36:3) and the rise of *Chenopodiaceae* pollen which is indicative of saltmarsh conditions at the site. The diatom analysis of the brown-down core showed that above the organic deposit, no Freshwater diatoms were recovered in Tube 36, but only Brackish and Marine types (Figure 52) but in the mixed clays and silts of Tubes 26 and 28 (Figure 53a) Freshwater diatoms do appear.

The change-over from biogenic to minerogenic sedimentation is taken at an altitude of - 19.20 m.O.D. and has been dated as ca. 7100 BP (after West 1970). This change-over was gradual and is reflected in the pollen records by a gradual transition to marine

conditions at the site. Thus at Browdown 13/14 53 we have indications of a positive phase of sea-level movement with an altitude of - 19.20 m.O.D. and has been dated in the range from ca. 8190 BP to ca. 7100 BP.

#### 4:4 REGIONAL SYNTHESIS OF EVIDENCE FOR SEA-LEVEL MOVEMENT FROM SITES STUDIED.

In this section it is proposed to treat the South Coast on a regional basis and to assess the environmental changes within these regions before an attempt is made to identify changes within the depositional environment over the whole South Coast. Three regions have been delimited; The Poole Harbour Region will include data from The Moors Site and the Studland Heath Site. The Solent Region will include the Yarmouth Site together with the Browdown Site and the Sussex Region will deal with data from the Pett Level Site.

##### 4:4:1 The Poole Harbour Region (Figure 1).

A number of features is common to The Moors Site and Studland Heath Site: They are both situated to the west of The Arne Peninsula and the South Haven Peninsula respectively, and as such are protected from the entrance to Poole Harbour. Both sites are underlain by a bedrock of Eocene Bagshot Beds. The two sites also display one period of minerogenic deposition and a single period of biogenic accumulation. The Moors Site has suffered disturbance by the actions of man in the form of drainage for land management and the construction, to the north of the site, of a sea defence. The Studland Heath Site has also had a disturbed history but not at the hands of man. The site lies on the west of South Haven Peninsula which is a mobile spit environment undergoing morphological changes

during its history.

At The Moors Site there is evidence of peat accumulation dating within the age range ca. 4950 BP to ca. 2950 BP, which shows a sequence of changing environmental conditions from damp Alder carr to saltmarsh conditions upwards through the peat. This peat is overlain firstly by a coarse silt and clay which passes into a finer silty-clay. The altitude of the lower contact of this minerogenic material varies from + 1.11 m.O.D. to - 0.04 m.O.D.

At the Studland Heath Site there is also evidence of peat accumulation within the age range of ca. 4950 BP to ca. 2950 BP, which shows the local vegetation changing from a damp Oak-Alder carr to a more intertidal environment with saltmarsh taxa present. The peat, which is of a very limited lateral extent, is overlain by a predominantly silty-sand deposit and upwards to a finer sand and silt. The altitude range of the lower contact of the minerogenic material is from + 0.11 m.O.D. to + 0.56 m.O.D.

It has already been suggested that these lithological sequences are the result of a rise of sea level in the local area, perhaps accompanied by a breaching of a barrier across the entrance to Poole Harbour. If this was the case, it would explain the coarser sedimentation above both peat deposits, indicative of a higher energy environment, followed by a lower energy deposition with a finer particle-size fraction as displayed at both sites. This minerogenic material is seen to be Brackish/Marine in nature by the diatom analyses at The Moors Site. As previously suggested, had such a breach occurred the Studland Heath Site would register the change of depositional environment more clearly than at The Moors Site (Carter 1982), which is some 7 km further away from the harbour entrance.

This can be seen in the tidal range at both sites; at The Moors Site the range of Spring Tides is 1.5 m while at Studland Heath this range is 1.7 m. At Studland Heath there is evidence of the truncation of peat growth with a sharp lithological boundary within the sedimentary sequence, as would be expected with a sudden inundation of the site. At The Moors the change-over from biogenic to minerogenic sedimentation is more transitional in nature with no sharp breaks in the lithological sequence. This change-over is marked at a higher altitude at Studland Heath, from + 0.11 m.O.D. to + 0.56 m.O.D. compared to - 1.11 m.O.D. to - 0.04 m.O.D. at The Moors Site.

Thus the upper minerogenic material at both sites is thought to have been deposited synchronously as the result of the breaching of a barrier across the entrance to Poole Harbour, in the age range from ca. 4950 BP to ca. 2950 BP, resulting in the inundation of the sites by marine conditions.

#### 4:4:2 The Solent Region (Figure 1).

The Yarmouth and Browdown Sites are over 27 km apart but are treated together. Both sites are located on the margins of the Solent; the Yarmouth Site is on the shore of the Isle of Wight while the Browdown Site is on the north-east shore. The deepest records of peat in this study are found in this region. The tidal conditions of the Solent are very complex with a double peak of high water and of Spring Tides. At Yarmouth the range of Spring Tides is 2.5 m while at Browdown it is 3.6 m.

At the Browdown Site a single phase of positive sea-level tendency is recognised at an altitude of - 19.2 m.O.D. and has been

dated in the range from ca. 8190 BP to ca. 7100 BP.

The Yarmouth Site reveals a stratigraphic sequence of strata with a complex history of deposition. At Yarmouth Carpark two periods of minerogenic sedimentation were recognised with one period of biogenic accumulation. At Yarmouth Boatyard there is a possibility of three periods of minerogenic sedimentation together with two periods of biogenic accumulation. It has already been shown (Section 4:3:3) that the biogenic accumulation was synchronous over the whole site, although peat accumulation began later at Yarmouth Boatyard. Thus at the Yarmouth Site we have evidence of the initiation of peat growth after ca. 6385 BP at YBS 3 and YBS 9, in the altitude range of - 6.55 m.O.D. to - 4.57 m.O.D. This accumulation of biogenic sediments continued and by ca. 4750/4500 BP peat growth was initiated at YBS 10, YBS 12, YBS 13 and YBS 14, within an altitude range of - 2.80 m.O.D. to - 2.25 m.O.D. The pollen spectra reveal a drying out at the site with a range of altitude from - 2.44 m.O.D. to - 2.03 m.O.D., recognised at YBS 10, YBS 12, YBS 13 and YBS 14 followed by a renewed rise of the local water level dated ca. 2500 BP at an altitude of - 1.97 ± 0.03 m.O.D. This rather prolonged phase of biogenic accumulation was followed by a period of minerogenic deposition post-dating ca. 2500 BP with an altitude range of - 4.07 m.O.D. to - 1.62 m.O.D.

Thus at the Yarmouth Site there is evidence of an early phase of positive sea-level tendency before ca. 6385 BP, this being followed by a period of negative sea-level tendency with a lower contact altitude varying from - 6.55 m.O.D. to - 4.57 m.O.D. and dating in the range from ca. 6385 BP to ca. 2500 BP. A renewed rise of water level at the site is seen during this negative phase of sea-level

tendency at ca. 2500 BP with an altitude of  $- 1.97 \pm 0.03$  m.O.D. The last period of positive sea-level tendency is seen across the site with an altitude range of  $- 4.07$  m.O.D. to  $- 1.62$  m.O.D. and has been dated post ca. 2500 BP.

At the Yarmouth and Browdown Sites there is evidence of a change of depositional environment in the upper minerogenic deposit. Coarse bands of silts and sands run through the boreholes at Yarmouth and an upper sandy deposit is seen at Browdown. These horizons would indicate deposition in an higher energy environment, which is probably due to local tidal regimes or to channel development at the sites. There is no evidence for the abrupt truncation of peat growth at either site as both sites display a gradual transition to minerogenic sedimentation from biogenic accumulation. This shows that marine inundation at the sites was gradual occurring over a relatively long period of time.

The Solent Region displays evidence of at least three periods of positive sea-level tendency but the events at Yarmouth and Browdown cannot be linked temporally. The first phase of positive sea-level tendency is seen at Browdown at an altitude of  $- 19.2$  m.O.D. and has been dated in the range from ca. 8190 BP to ca. 7100 BP. The second phase of positive sea-level tendency is recognised at Yarmouth and is thought to be before ca. 6385 BP. This is followed by a period of negative sea-level tendency with an altitude range of  $- 6.55$  m.O.D. to  $- 4.57$  m.O.D. and is dated in the range from ca. 6385 BP to ca. 2500 BP. A possible shortlived phase of higher water level is seen at Yarmouth at  $- 1.97 \pm 0.03$  m.O.D. and is dated ca. 2500 BP. The last phase of positive sea-level tendency is recognised with an altitude range of  $- 4.07$  m.O.D. to  $- 1.62$  m.O.D.

and is dated from after ca. 2500 BP.

#### 4:4:3 The Sussex Region (Figure 1).

This region covers a great areal extent, stretching from Selsey Bill eastwards along the South Coast towards Kent. To facilitate discussion this region will be sub-divided into The West Sussex Region and The East Sussex Region; the two being divided in the vicinity of Beachy Head. The West Sussex Region contains no site studied in this present work but the Pett Level Site is located in the East Sussex Region.

The Pett Level Site is found on the foreshore south of Cliff End. This site has submerged forest deposits exposed on the foreshore, which are being eroded by wave action at the present time. At Pett Level there is evidence of two periods of positive sea-level tendency together with two periods of negative sea-level tendency. The first phase of positive sea-level tendency is thought to have occurred prior to ca. 5670 BP with the change-over to terrestrial facies occurring over an altitude range of - 2.58 m.O.D. to - 2.26 m.O.D. The second phase of positive sea-level tendency covers an altitude range from - 2.19 m.O.D. to - 1.96 m.O.D. and is thought to have ended ca. 5670 BP. This phase revealed a sharp lithological boundary at the change-over from terrestrial to marine facies, which indicates sudden inundation of the site by marine conditions. This could be due to a very rapidly rising sea level or to the over-running of an offshore protective barrier at the site, although there is no evidence of the latter possibility in the field analyses of the strata. The end of this phase of positive sea-level tendency also discloses a sharp lithological boundary which could represent a sudden fall of sea level, the building up of a protective coastal barrier or subaerial erosion of the facies by wave action at the site.

It is clear that within each region, local factors play an important part in the fluctuations of sea levels. This is especially true where offshore barriers are assumed to have been present at the sites. Evidence of barrier development in the present study was only found at The Moors Site and the Studland Heath Site. Cunliffe (1980) and Eddison et al. (1983) note the development of a barrier system from Fairlight to Hythe but no positive indications of this barrier were found in the lithological sequences at the Pett Level Site.

Each region has a distinct topography: The Poole Harbour Region is a sheltered harbour environment. The Solent Region is a semi-exposed estuarine environment and the Sussex Regions are exposed environments on the shore of the English Channel. It is therefore not feasible to make further correlations between events of sea-level tendencies found in separate regions, although a few trends do seem apparent (Figure 57) especially from ca. 6500 BP to the present day.

The evidence presented would support the theory of an oscillating sea-level curve during the Flandrian Age, but the data is too imprecise to actually plot a curve to show these trends.

#### 4:6 FUTURE RESEARCH NEEDS

There is a need for further investigations of sea-level tendencies on the South Coast of England and for dating the limits of the positive sea-level tendencies.

The South Coast of England is very densely populated with a great number of industrial complexes on coastal sites, including power stations such as the one at Dungeness. Tooley (1979) points out the problems involved with coastal locations of industry and

settlements in North West England but on the South Coast the problem is more serious. There is a need for future research on return periods of flood events so that adequate coastal protection can be provided for industrial and urban sites on the South Coast of England.

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A P P E N D I X I

## Laboratory Schedule for Pollen Analysis.

Stages 1:2, 1:4 and 1:5 should be applied to peats. Gyttjas and lake marls may require the addition of stages 1:1 and 1:3 in strict order.

- 1:1 Solution of Carbonates and Disaggregation.  
Add 1 tablet of Lycopodium to  $\frac{1}{2}$  cc of material.
- 1:11 Add cold HCL (10% solution) until effervescence stops. Stir.
- 1:12 Centrifuge. Decant.
- 1:2 Evacuation of Alkali-soluble Organic Compounds.
- 1:2:1 Add KOH almost filling tube. Stir.
- 1:2:2 Heat in boiling water, 30 minutes. Stir occasionally.
- 1:2:3 Decant through sieve (mesh 180 microns). Wash residue.
- 1:2:4 Centrifuge and wash until supernatant liquid unstained.
- 1:3 Hydrofluoric Digestion of Siliceous Material.
- 1:3:1 Add HF to residue. Stir well,  $\frac{1}{2}$  fill tube.
- 1:3:2 Heat in boiling water until sediment dispenses and stratified sediment appears - 1 hour.
- 1:3:3 Stir. Centrifuge. Decant.
- 1:3:4 Add HCL (10% solution). Heat in boiling water 3 - 5 minutes.
- 1:3:5 Centrifuge. Decant. Wash with distilled water. Stir. Centrifuge. Decant.
- 1:4 Acetylation. Evacuation of Unaltered Lignin and Cellulose.
- 1:4:1 Add Glacial acetic acid. Stir. Centrifuge. Decant.
- 1:4:2 Add Acetylation mixture. Stir well. 1:9 conc  $H_2SO_4$  - Acetic anhydride.
- 1:4:3. Heat in boiling water - 1 minute. Stir occasionally. Top up with glacial acetic.
- 1:4:4 Centrifuge. Decant.
- 1:4:5 Add glacial acetic. Stir. Centrifuge. Decant 1x.
- 1:4:6 Add distilled water. Stir. Centrifuge. Decant 2x.

1:5 Staining

1:5:1 Add Tertiary Butyl. Alcohol. Centrifuge. Decant.

1:5:2 1 ml Tert. Butyl. Alcohol + 2 drops safranin solution into small vials. Centrifuge. Decant.

1:5:3 Add silicone fluid same volume as sample. Stir. Plug with cotton wool.

A P P E N D I X II

## Laboratory Schedule for Diatom Analysis.

- 2:1 Place 1 cm<sup>3</sup> material in 150 ml. Pyrex beaker.
- 2:2 Add 30% solution of H<sub>2</sub>O<sub>2</sub>
- 2:3 Leave overnight. If reaction not already complete, heat gently until effervescence stops (with samples containing a lot of organic matter more H<sub>2</sub>O<sub>2</sub> may be necessary).
- 2:4 Place one drop of diatom mixture on a cover slip (22 x 22 mm) with five drops of distilled water.
- 2:5 Place cover slip on a hot plate and evaporate liquid.
- 2:6 Place a small amount of Microps 163 mountant on a microscope slide and heat gently.
- 2:7 Invert microscope coverslip onto microscope slide and cool.

A P P E N D I X 111

## Laboratory Schedule for Particle-size Analysis.

- 3:1 Pretreatment of Soil
- 3:1:1 A sample of 30 g is weighed ( $W_a$ ) and placed in the 650 ml conical Flask.
- 3:1:2 Add 50 ml of distilled water and boil until the volume reduces to 40 ml.
- 3:1:3 Cool then add 75 ml of hydrogen peroxide and leave to stand over night.
- 3:1:4 Gently heat to reduce volume to 30 ml.
- 3:1:5 Filter the mixture through a Büchner funnel washing through with warm water.
- 3:1:6 Transfer damp soil on filter paper to an evaporating dish using a jet of distilled water.
- 3:1:7 Place evaporating dish in oven and dry at 105 - 110°C.
- 3:1:8 Weigh evaporating dish ( $W_b$ ).
- 3:2 Dispersion of Soil
- 3:2:1 Add 25 ml of sodium hexametaphosphate solution and 25 ml of distilled water.
- 3:2:2 Gently warm and transfer to dispersion cup and agitate for 15 minutes with mechanical mixer.
- 3:2:3 Transfer mixture to 75  $\mu$ m sieve placed on a reciever and wash through using distilled water.
- 3:2:4 The sieved suspension material is transferred to a graduated sedimentation tube and volume of liquid is made up to 500 ml with distilled water.
- 3:2:5 The material remaining on 75  $\mu$ m sieve is oven dried at 105 - 110°C.
- 3:2:6 Dried material is re-sieved on 2 mm, 600  $\mu$ m, 210  $\mu$ m and 75  $\mu$ m and material remaining on each sieve is weighed ( $W_g$ ,  $W_c$ ,  $W_m$  and  $W_f$ ).

3:3 Sedimentation

- 3:3:1 25 ml of sodium hexametaphosphate solution is added to 500 ml distilled water to act as a control.
- 3:3:2 All the sedimentation tubes are transferred to a constant temperature bath.
- 3:3:3 Shake sedimentation tube and at same time set stop watch.
- 3:3:4 Samples from each tube are taken at intervals of 4 mins., 5 sec.; 46 mins.; and 6 hrs., 54 mins.
- 3:3:5 Weight of solid material in each sample is determined after oven drying over night.

3:4 Calculations

Calculations for the analyses are found in the Methods of Testing Soils for Civil Engineering Purposes handbook (British Standard 1377 : 1967) on pages 69 and 70.

A P P E N D I X IV

POLLEN COUNTS

Moors 7

Moors 10

Studland Heath 4b

Studland Heath 4h

YBS 3

YBS 9

YBS 10

YBS 12

YBS 13

YBS 14

Pett Level 2

Pett Level 4

Browdown 13/14 53

Moors 7; Pollen Counts

Co-ord. 50° 40' 56" N  
02° 05' 41" W

Grid ref. SY 9491 8702  
Fieldwork 800622.

Level		8	7	6	5	4	3	2	1
Height	M.O.D.	-0.70	-0.72	-0.77	-0.87	-0.97	-1.07	-1.17	-1.19
Depth	cm.	-93	-95	-100	-110	-120	-130	-140	-142
Betula		13	5	3	14	10	16	15	25
Pinus		-	-	1	-	-	1	-	1
Ulmus		1	-	3	17	5	9	6	5
Quercus		12	15	13	55	61	58	30	12
Tilia		-	-	1	8	4	6	-	-
Alnus		21	27	25	54	63	55	96	106
Fraxinus		-	3	4	2	7	5	3	1
Fagus		3	-	-	-	-	-	-	-
Corylus		84	67	66	252	259	98	64	55
Salix		-	-	1	-	2	3	1	1
Frangula		-	-	-	-	-	-	1	-
Ericaceae		26	53	9	24	43	23	11	12
Viburnum		2	-	-	-	-	-	-	-
Gramineae		48	27	41	119	143	127	59	43
Cyperaceae		4	4	-	4	3	4	4	4
Compositae tub.		3	-	-	-	-	-	3	2
Compositae lig.		5	-	-	-	-	-	1	-
Artemisia		-	-	-	-	-	-	1	-
Ranunculus-type		10	24	12	15	18	3	3	2
Caltha-type		-	-	-	2	3	2	1	-
Caryophyllaceae		-	1	-	-	-	-	-	-
Chenopodiaceae		2	-	-	-	-	-	-	-
Cruciferae		1	1	1	1	-	-	-	-
Rosaceae		4	3	-	3	-	2	-	-
Saxifragaceae		1	-	-	-	-	-	-	-
Lythrum		1	-	-	-	-	-	1	2
Umbelliferae		1	-	-	-	-	-	-	1
Polygonaceae		1	1	-	-	-	2	2	1
Plantaginaceae		1	2	1	-	-	-	-	-
Rubiaceae		-	-	-	-	-	-	-	2
Myriophyllum		1	-	-	-	-	-	-	-
Pteridium		8	17	13	4	6	4	24	23
Polypodium		1	2	-	2	4	1	1	-
Sphagnum		69	168	61	159	108	96	45	18
Filicales		1	-	-	2	2	1	-	-
Lycopodium		348	273	264	355	260	248	245	371
Total land pollen		244	233	181	570	621	414	302	275

Level	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height M.O.D.	-0.23	-0.33	-0.43	-0.53	-0.63	-0.73	-0.83	-0.93	-0.98	-1.06	-1.53	-1.63	-1.73	-1.83	-1.93
Depth	-60	-70	-80	-90	-100	-110	-120	-130	-135	-143	-190	-200	-210	-220	-230
Betula	7	1	2	2	3	10	6	5	8	4	6	23	16	261	36
Pinus	2	1	2	4	3	-	-	2	1	-	1	-	-	1	-
Ulmus	-	-	2	3	-	-	1	1	-	1	4	7	5	7	9
Quercus	4	8	4	5	8	8	6	6	5	27	12	51	23	26	20
Tilia	-	-	1	-	-	-	-	-	-	-	-	1	136	6	7
Alnus	10	13	10	9	9	7	10	11	10	12	24	63	91	402	76
Fraxinus	2	1	4	-	1	-	1	-	1	4	2	5	-	6	1
Fagus	-	1	-	2	1	-	1	-	-	2	1	-	-	1	-
Corylus	15	14	15	27	32	21	61	37	154	282	154	142	118	166	132
Salix	1	4	1	-	1	1	1	-	1	2	4	6	-	10	1
Rhamnus	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
Ilex	-	2	2	-	-	-	-	1	-	-	1	-	1	1	-
Hedera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ericaceae	7	5	5	6	11	10	31	20	25	6	11	70	978	34	42
Ulex	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Graminae	52	78	35	33	52	29	45	42	66	118	70	343	181	155	206
Cyperaceae	12	7	13	18	19	13	24	15	11	6	25	8	3	7	2
Compositae tub.	8	9	10	5	3	2	2	6	-	-	1	1	6	1	-
Compositae lig.	5	7	3	5	4	8	4	6	-	-	7	-	5	1	-
Artemisia	1	1	1	1	1	-	-	1	-	-	-	-	-	-	-
Ranunculus type	4	2	2	1	4	3	1	-	3	7	1	14	9	8	1
Caltha type	1	1	-	-	-	-	-	-	1	-	-	2	1	1	-
Caryophyllaceae	-	-	1	-	-	-	-	-	-	1	1	-	6	4	-
Chenopodiaceae	11	1	2	1	2	1	3	11	3	6	1	1	-	-	1
Cruciferae	1	-	-	-	-	-	2	-	-	1	-	-	-	-	-
Leguminosae	-	-	-	1	-	1	-	-	1	-	2	24	302	12	2
Rosaceae	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-
Saxifragaceae	-	-	-	-	-	-	-	-	-	1	1	-	33	1	-
Lythrum	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Umbelliferae	-	-	-	-	-	-	-	-	-	-	-	-	100	1	1
Polygonum	2	2	1	-	2	-	-	-	-	1	1	-	-	-	-
Rumex	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-
Urtica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantaginaceae	2	4	13	2	5	2	3	3	2	1	3	1	10	35	1
Rubiaceae	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-
Nymphaea	-	-	-	-	-	1	-	-	-	1	1	-	-	-	1
Myriophyllum	1	3	-	-	-	-	-	-	-	-	1	-	-	-	1
Potamogeton	2	-	3	1	2	5	1	5	3	-	1	-	2	-	-
Typha lat.	-	-	-	-	-	-	-	-	-	-	1	-	5	-	-
Pteridium	7	3	7	2	2	5	6	8	6	9	11	16	-	7	8
Polypodium	-	-	1	3	0	2	1	3	-	1	2	2	3	2	1
Sphagnum	6	3	3	3	11	10	28	22	44	50	43	330	11	25	13
Filicales	6	-	4	5	2	5	3	5	1	1	5	-	7	50	-
Lycopodium	457	250	302	316	308	337	337	377	202	273	322	383	200	200	231

Co-ord 50° 39' 43" N  
01° 58' 63" W

Grid ref. SZ 0230 8480  
Fieldwork 820804.

Level	11	10	9	8	7	6	5	4	3	2	1
Height M.O.D.	+0.31	+0.21	+0.11	+0.01	-0.09	-0.19	-0.29	-0.39	-0.49	-0.59	-0.69
Depth cm.	-130	-140	-150	-160	-170	-180	-190	-200	-210	-220	-230
Betula	2	4	5	5	3	3	7	9	-	5	4
Pinus	8	3	8	7	2	7	1	-	1	-	1
Ulmus	7	4	9	7	-	1	3	1	6	8	4
Quercus	16	12	43	51	30	54	29	24	43	50	59
Tilia	-	1	1	3	-	3	3	4	4	4	2
Alnus	15	25	32	26	13	31	6	12	19	28	30
Fraxinus	2	1	-	1	2	1	1	-	2	5	-
Fagus	-	-	2	-	-	-	-	-	-	-	-
Corylus	56	53	106	111	38	116	56	95	96	129	90
Salix	-	-	3	-	1	2	1	-	3	2	-
Ilex	-	-	-	-	-	-	1	-	-	-	-
Hedera	1	1	-	-	-	-	1	2	1	-	-
Calluna	44	43	103	116	29	101	12	20	77	232	66
Erica-type	-	7	14	23	6	15	-	2	22	20	5
Myrica	-	-	-	1	-	-	-	-	-	-	-
Viburnum	-	-	-	-	-	1	-	-	-	-	-
Gramineae	35	37	52	44	42	63	101	54	53	61	107
Cyperaceae	11	8	17	6	2	8	4	3	2	3	2
Compositae tub.	-	-	-	3	-	1	-	-	1	-	1
Compositae lig.	1	-	1	-	-	-	-	1	-	-	-
Artemisia	-	-	1	-	-	1	-	-	-	-	-
Ranunculus-type	2	2	1	2	-	3	3	1	-	1	1
Caltha-type	-	-	-	1	-	-	-	2	-	-	-
Chenopodiaceae	1	-	2	3	-	2	-	-	2	1	-
Cruciferae	-	-	-	-	3	1	-	-	-	-	-
Rosaceae	-	2	2	-	-	1	1	-	2	1	-
Filipendula	2	-	-	1	1	-	2	1	5	2	2
Polygonaceae	-	1	-	-	-	-	-	-	-	-	-
Rumex	-	-	-	-	1	-	-	-	-	-	-
Plantaginaceae	1	-	-	-	-	-	-	-	-	-	-
Plantago lanc.	1	8	4	7	1	1	1	-	2	1	-
Plantago media.	-	-	4	5	1	2	-	-	1	-	1
Valerianella	-	-	3	-	-	-	-	-	-	-	-
Succisa	-	-	-	-	1	-	-	-	-	-	-
Potamogeton	2	-	-	-	-	-	-	-	-	-	-
Typha latifolia	1	-	-	-	-	-	-	-	-	-	-
Pteridium	7	9	12	9	8	19	4	3	5	4	5
Polypodium	2	1	5	2	1	1	2	1	-	-	3
Sphagnum	58	120	147	121	44	97	53	56	39	53	66
Filicales	-	1	1	2	-	2	1	1	-	2	-
Lycopodium	367	520	361	377	441	291	283	327	358	297	243

Studdland Heath 4b Pollen Counts

Studland Heath 4h; Pollen Counts

Co-ord 50° 39' 43" N  
01° 58' 03" W

Grid ref. SZ 0230 8480  
Fieldwork 820804

Level	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height m.O.D.	+0.20	+0.19	+0.18	+0.17	+0.16	+0.14	+0.12	+0.10	+0.08	+0.06	+0.05	+0.04	+0.03	+0.02	0.0
Depth cm	-133	-134	-135	-136	-137	-139	-141	-143	-145	-147	-148	-149	-150	-151	-153
Betula	4	6	12	9	14	19	24	21	20	19	14	6	6	8	4
Pinus	1	3	9	4	-	1	15	10	9	40	57	30	38	55	68
Ulmus	3	9	20	18	18	32	22	29	41	18	31	27	18	6	1
Quercus	16	42	55	63	65	52	65	60	58	53	46	11	12	6	1
Tilia	1	3	8	5	11	5	7	2	-	3	-	-	-	-	-
Alnus	22	31	41	48	38	37	15	27	21	14	2	-	1	-	1
Fraxinus	2	5	5	3	4	4	2	1	1	3	-	1	-	-	-
Fagus	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Corylus	54	95	200	158	177	164	197	204	202	262	338	227	213	269	77
Salix	1	2	3	-	4	5	-	2	1	2	-	-	-	-	-
Frangula	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Hedera	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Ericaceae	(27)	(38)	(71)	(62)	(53)	(41)	(45)	(48)	(41)	(33)	(48)	(56)	(88)	(164)	(80)
Calluna	22	34	59	48	37	33	32	44	39	29	46	-	-	-	-
Erica-type	5	4	12	14	16	8	13	4	2	4	2	-	-	-	-
Gramineae	33	110	100	158	109	101	95	84	76	73	58	15	8	4	1
Cyperaceae	4	9	2	10	14	4	4	1	5	2	-	1	2	-	1
Compositae tub.	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Compositae lig.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Artemisia	2	-	1	-	1	-	-	-	-	-	1	1	-	-	-
Ranunculus-type	4	4	1	4	5	-	4	3	3	2	1	-	1	-	-
Caltha-type	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Chenopodiaceae	2	1	1	-	-	-	-	2	-	1	-	-	-	-	-
Cruciferae	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-
Leguminosae	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Rosaceae	1	1	-	-	-	1	1	-	1	-	1	-	1	-	-
Filipendula	1	3	2	3	3	2	2	3	6	1	3	-	-	-	-
Potentilla-type	1	3	-	2	-	2	-	-	-	-	-	-	-	-	-
Umbelliferae	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercurialis	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Rumex	1	-	-	-	-	2	-	1	-	-	-	-	-	-	-
Stachys-type	-	-	1	2	-	1	-	-	-	-	-	-	-	-	-
Plantago lanc.	3	-	-	1	1	-	1	1	-	2	1	-	1	-	-
P.maj/med.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pteridium	5	2	6	9	7	5	9	4	2	5	1	-	-	-	-
Polypodium	1	2	3	1	1	3	2	2	-	-	2	-	1	-	-
Sphagnum	30	97	247	178	189	194	148	188	204	194	186	57	37	6	-
Filicales	-	2	1	2	-	3	-	2	1	-	1	-	3	1	3
Lycopodium	185	158	23	40	29	25	-	-	-	-	118	25	86	179	344

Studland Heath 4h Pollen Counts

Co-ord. 50° 42' 10" N  
01° 29' 50" W

Grid ref. S2 3538 8939  
Fieldwork 801115

Level	16	15	14	13	12	11	10.	9	8	7	6	5	4	3	2	1
Height M.O.D.	-5.71	-5.69	-5.67	-5.65	-5.60	-5.40	-5.20	-5.00	-4.80	-4.60	-4.40	-4.10	-4.06	-4.04	-4.02	-4.00
Depth cm.	-651	-649	-647	-645	-640	-620	-600	-580	-560	-540	-520	-490	-486	-484	-482	-480
Betula	-	-	1	1	1	2	3	4	4	4	2	-	-	1	1	-
Pinus	1	-	-	-	-	1	1	-	1	-	1	1	2	1	2	2
Ulmus	-	2	2	3	-	4	2	1	8	3	3	3	-	2	4	5
Quercus	23	13	21	11	13	17	15	21	34	25	28	13	14	10	9	12
Tilia	2	5	1	5	3	8	1	8	8	4	3	3	6	4	4	4
Alnus	24	28	24	30	81	78	25	64	43	149	61	30	24	31	23	24
Fraxinus	-	2	1	-	2	-	3	2	2	1	2	-	4	1	7	3
Corylus	21	39	32	20	25	18	26	36	13	41	6	5	5	7	4	10
Salix	1	1	1	-	-	3	1	3	3	3	1	4	2	1	2	2
Rhamnus	-	-	-	1	-	9	-	-	-	-	-	-	-	-	-	-
Frangula	4	1	2	-	-	-	4	-	-	-	-	-	-	-	-	-
Hedera	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Viburnum	-	-	-	-	-	-	-	-	-	2	17	-	-	-	-	-
Gramineae	24	17	41	15	1	17	29	12	40	18	14	43	42	34	34	80
Cyperaceae	93	75	120	51	2	73	38	8	35	16	7	15	10	10	13	11
Compositae tub.	-	3	-	-	-	-	3	-	-	2	-	-	1	-	-	-
Compositae lig.	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-
Artemisia	-	1	-	-	-	6	2	2	-	1	6	1	-	-	-	-
Ranunculus-type	5	3	5	3	8	2	2	6	1	6	2	1	7	7	3	5
Caltha-type	-	1	1	1	-	-	1	3	-	1	-	-	1	-	-	-
Cruciferae	3	-	1	-	-	-	-	-	-	1	20	-	-	-	-	-
Chenopodiaceae	1	3	3	-	-	-	2	-	6	-	-	-	1	-	-	-
Lathyrus	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
Rosaceae	1	1	-	-	-	2	1	-	2	-	-	2	-	-	2	-
Saxifragaceae	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Lythrum	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Umbelliferae	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-
Rumex	-	-	-	-	1	-	-	-	-	-	2	1	-	-	-	-
Convolvulus	-	-	-	-	2	0	0	0	-	-	-	-	-	-	-	-
Calystegia	-	-	1	-	-	-	-	-	-	-	-	1	1	-	-	-
Mentha	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Plantaginaceae	1	1	2	-	-	-	-	1	2	-	2	-	-	-	-	-
Rubiaceae	-	-	-	-	-	-	1	2	-	-	2	-	-	-	-	-
Myriophyllum	1	-	-	-	-	3	-	2	1	5	-	-	-	-	-	1
Alisma	-	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Typha angustifolia	-	-	-	1	-	1	-	-	1	-	2	-	3	1	3	3
Typha latifolia	1	-	-	-	-	-	-	-	-	-	6	10	-	-	-	-
Pteridium	-	7	6	2	1	-	1	1	2	2	6	10	12	3	7	6
Polypodium	4	1	5	4	-	1	6	1	4	1	7	2	-	1	-	1
Sphagnum	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Filicales	1	1	2	-	1	1	3	3	4	55	1	1	3	-	-	4
Lycopodium	279	261	362	536	404	200	319	254	207	200	409	238	411	266	492	216

YBS 3 Pollen Counts

XXII

Level	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height M.O.D.	-3.94	-3.98	-4.02	-4.06	-4.18	-4.20	-4.24	-4.26	-4.30	-4.40	-4.46	-4.50	-4.52	-4.54	-4.56	-4.58
Depth cm.	-468	-472	-476	-480	-492	-494	-498	-500	-504	-514	-520	-524	-526	-528	-530	-532
Betula	-	2	4	5	4	3	1	-	1	2	2	3	2	4	1	2
Pinus	-	3	2	-	1	1	1	1	-	-	-	-	4	2	-	7
Ulmus	-	2	3	1	3	9	-	3	3	2	5	1	2	6	5	2
Quercus	22	27	51	21	20	33	40	42	22	16	39	25	20	20	20	18
Tilia	3	2	-	5	9	5	11	15	3	2	5	5	16	11	8	36
Alnus	24	14	38	18	61	48	45	37	16	85	48	108	118	163	66	35
Fraxinus	1	-	2	-	2	1	2	2	5	-	1	-	12	7	-	-
Corylus	19	35	33	30	36	27	20	26	22	44	43	27	19	18	4	40
Salix	-	-	-	1	1	2	1	2	2	1	-	3	1	2	1	-
Ilex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Frangula	-	-	-	1	-	-	-	1	-	-	-	1	-	-	-	-
Hedera	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	1
Ericaceae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Viburnum	1	-	-	-	1	-	2	-	-	1	-	1	-	-	2	-
Gramineae	17	18	130	54	46	56	40	49	87	31	78	48	31	32	35	26
Cyperaceae	5	8	73	31	53	63	84	72	6	124	42	19	101	10	20	12
Compositae tub.	-	4	2	-	1	1	-	2	4	2	-	2	-	1	-	2
Compositae lig.	-	-	-	2	-	-	-	-	-	-	1	2	-	1	1	-
Artemisia	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
Ranunculus type	3	8	5	1	5	8	5	6	3	2	6	9	6	5	8	-
Caltha type	-	-	-	-	-	-	-	1	-	1	3	-	-	1	-	-
Cruciferae	-	-	1	-	-	2	1	1	-	-	-	-	-	-	-	-
Caryophyllaceae	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Chenopodiaceae	10	17	23	6	2	1	1	-	-	-	-	-	-	-	-	3
Leguminosae	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Lotus	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Rosaceae	-	1	-	-	2	1	1	-	-	-	-	1	1	1	-	-
Lythrum	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	-
Umbelliferae	-	-	-	-	-	1	-	1	2	-	-	-	-	3	-	-
Polygonum	-	1	1	1	-	-	-	-	-	-	-	-	1	-	-	-
Rumex	-	-	-	-	-	3	-	1	-	-	1	7	1	4	7	-
Euphorbia	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calystegia	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Mentha	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Plantaginaceae	1	4	3	2	-	-	-	-	-	3	2	-	1	1	1	-
Rubiaceae	-	-	1	-	-	1	2	11	-	1	-	-	-	-	1	-
Valerianella	-	-	-	-	-	-	25	-	-	-	-	-	-	-	-	-
Nymphaea	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-
Myriophyllum	-	-	-	-	2	3	3	2	1	1	1	3	1	2	1	2
Alisma	-	1	-	-	-	1	-	-	-	1	-	2	6	3	1	-
Typha latifolia	-	-	-	-	2	-	-	-	-	-	-	-	2	1	-	-
Typha angustifolia	2	1	-	-	5	10	1	3	6	1	13	6	12	1	4	-
Pteridium	4	3	5	1	1	1	5	3	-	-	2	-	4	3	2	4
Polypodium	3	1	-	1	4	1	2	6	2	3	3	-	2	9	3	2
Sphagnum	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Filicales	3	1	2	3	60	153	516	116	3	3	1	-	2	5	3	41

Co-ord. 50° 42' 04" N  
01° 30' 08" W

Grid ref. SZ 3514 8924  
Fieldwork 811208

Level	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height M.O.D.	-1.54	-1.64	-1.70	-1.80	-1.84	-1.88	-2.00	-2.10	-2.20	-2.30	-2.34	-2.38	-2.42	-2.46	-2.50	-2.54
Depth cm.	-237	-247	-253	-263	-267	-271	-283	-293	-303	-313	-317	-321	-325	-329	-333	-337
Betula	1	2	4	2	-	2	2	1	1	3	4	1	2	5	4	2
Pinus	5	10	3	4	1	5	-	-	1	-	-	2	3	4	4	4
Ulmus	2	-	1	1	5	1	2	-	1	4	4	2	1	4	1	8
Quercus	48	56	40	51	52	21	31	19	13	32	37	30	60	73	48	18
Tilia	1	3	3	2	3	-	4	2	1	12	3	10	7	12	3	2
Alnus	40	24	38	35	37	21	60	128	113	97	50	102	74	35	38	62
Fraxinus	3	5	10	5	2	-	1	-	-	2	2	3	2	17	2	4
Fagus	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-
Corylus	26	31	20	30	33	9	24	17	11	42	16	23	26	41	23	40
Salix	-	-	-	1	1	-	-	-	-	-	-	-	2	-	5	-
Rhamnus	-	-	-	-	-	-	7	1	-	9	2	-	-	1	-	2
Ilex	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Frangula	-	-	-	-	-	1	7	-	-	6	-	-	-	-	-	-
Hedera	-	1	-	2	-	-	1	-	-	-	-	-	1	-	2	1
Eriaceae	-	-	-	-	-	-	2	-	-	0	1	1	-	-	-	-
Empetrum	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Myrica	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viburnum	-	-	2	-	1	-	-	1	-	-	-	-	-	-	-	-
Gramineae	8	17	21	22	28	12	37	7	3	63	45	30	23	43	28	30
Cyperaceae	14	11	23	5	14	8	112	2	4	101	215	262	134	21	5	8
Compositae tub.	1	-	1	2	1	1	2	-	-	2	2	5	2	-	1	1
Compositae lig.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
Artemisia	2	1	1	-	2	-	-	-	-	-	-	1	-	-	-	1
Ranunculus type	-	1	-	3	-	-	1	3	2	10	-	2	1	3	1	12
Caltha type	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	1
Chenopodiaceae	12	14	45	8	9	4	5	-	1	6	1	4	5	19	15	19
Cruciferae	-	-	1	-	-	-	-	-	-	1	-	-	-	-	1	2
Linum	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leguminosae	-	-	1	-	1	-	-	-	-	-	-	-	-	1	-	-
Rosaceae	2	1	-	-	-	-	1	-	1	-	-	1	-	1	-	-
Filipendula	1	-	1	-	-	-	-	-	-	1	1	-	1	-	-	-
Lythrum	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Umbelliferae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Rumex	-	-	1	-	-	-	1	-	-	1	-	1	1	-	1	2
Convolvulus	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-
Calystegia	-	-	1	-	-	-	-	-	-	-	1	1	-	-	-	-
Mentha	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Plantago lanc.	-	-	-	1	-	-	-	-	-	1	-	1	2	-	-	3
Rubiaceae	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-
M. alterniflorum	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Alisma	1	-	-	1	-	-	-	1	-	1	-	2	-	-	2	-
Potamogeton	31	55	1	1	1	1	1	1	-	-	-	-	-	4	-	2
Typha latifolia	-	-	-	-	-	1	-	-	-	-	1	1	1	-	-	-
Typha angustifolia	1	1	1	2	-	-	2	-	1	2	-	4	1	-	-	-
Pteridium	18	21	5	23	8	18	3	1	1	2	4	7	23	35	17	22
Polypodium	3	5	2	2	-	4	3	4	2	5	9	6	5	5	3	2
Sphagnum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Filicales	7	2	6	8	1	5	4	-	-	7	2	9	8	6	7	6
Lycopodium	369	341	232	658	430	492	309	335	116	516	391	388	763	758	694	463

TBS 10 Pollen Counts

XXIV

Co-ord. 50° 42' 04" N  
01° 30' 07" W

Grid ref. SY 9491 8702  
Fieldwork 811208

Level	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height M.O.D.	-1.64	-1.68	-1.80	-1.90	-1.98	-2.04	-2.08	-2.14	-2.20	-2.30	-2.40	-2.50	-2.61	-2.63
Depth cm.	-244	-248	-260	-270	-278	-284	-288	-294	-300	-310	-320	-330	-341	-343
Betula	8	16	3	-	6	-	-	2	1	2	4	-	-	-
Pinus	-	-	1	1	1	-	1	1	-	1	-	-	-	-
Ulmus	2	5	-	1	1	1	1	-	1	5	3	3	-	-
Quercus	25	31	23	19	11	7	8	8	11	26	10	13	16	5
Tilia	6	8	2	3	2	4	3	2	6	11	7	5	6	13
Alnus	86	75	19	25	27	34	33	87	80	49	69	75	77	32
Fraxinus	22	15	2	1	2	4	2	-	1	6	7	3	1	-
Juglans	-	-	-	-	-	-	2	-	-	-	-	1	-	-
Corylus	83	119	27	23	21	8	16	10	15	36	15	27	22	10
Salix	2	2	-	-	2	-	-	-	-	-	1	-	1	5
Ilex	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Frangula	1	-	1	-	-	11	-	-	-	1	1	-	-	-
Hedera	-	1	-	1	-	1	-	2	1	1	2	-	1	1
Ericaceae	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Viburnum	-	-	1	-	-	-	-	1	-	-	-	1	-	3
Gramineae	149	164	34	40	40	35	26	9	12	90	65	64	58	28
Cyperaceae	33	15	8	6	29	186	49	28	37	27	25	20	25	6
Compositae tub.	-	-	1	-	-	1	2	1	1	-	2	1	1	1
Compositae lig.	1	1	-	-	-	-	-	-	-	-	-	1	-	-
Artemisia	-	-	6	-	-	-	-	-	-	-	-	-	-	-
Ranunculus	20	21	9	4	10	20	4	4	2	19	8	8	3	2
Caltha	-	-	1	2	1	1	-	-	-	1	-	-	-	-
Cruciferae	-	-	-	-	-	-	-	-	-	-	-	-	-	15
Chenopodiaceae	1	1	2	6	3	1	-	-	-	-	4	1	-	-
Leguminosae	-	1	-	-	-	-	-	-	-	-	-	-	1	-
Rosaceae	1	4	3	1	-	-	-	-	1	1	-	-	-	-
Lythrum	-	-	-	-	-	-	-	-	-	4	1	-	2	-
Umbelliferae	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Rumex	-	-	-	-	-	-	-	1	-	1	-	-	1	-
Calystegia	-	-	-	-	-	-	5	-	-	-	1	-	-	-
Plantaginaceae	2	1	2	1	-	-	1	1	-	-	-	-	1	-
Rubiaceae	-	2	-	-	-	-	1	1	-	1	-	-	-	-
Valeriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myriophyllum	-	1	4	-	-	-	1	-	-	-	-	-	-	-
Alisma	-	-	1	0	1	-	-	-	-	-	-	-	1	-
Potamogeton	-	-	-	2	1	-	-	-	-	-	-	5	-	-
Typha latifolia	-	-	-	-	2	-	-	-	3	-	-	-	-	-
Typha angustifolia	-	-	-	-	-	-	-	10	11	-	5	7	4	2
Pteridium	2	1	5	10	10	1	1	-	-	1	2	1	-	1
Polypodium	2	2	-	1	3	4	2	4	4	3	1	5	4	2
Sphagnum	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Filicales	-	-	1	5	-	-	-	1	2	-	2	2	3	-
Lycopodium	322	324	430	366	426	325	260	200	299	300	307	255	200	484

YBS 12 Pollen Counts

KXV

Co-ord. 50° 42' 04" N  
01° 30' 07" W

Grid ref. SZ 3516 8922  
Fieldwork 811209

Level	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height M.O.D.	-1.40	-1.50	-1.56	-1.60	-1.70	-1.84	-1.88	-1.92	-1.96	-2.00	-2.04	-2.08	-2.12	-2.16
Depth cm.	-228	-238	-244	-248	-258	-272	-276	-280	-284	-288	-292	-296	-300	-304
Betula	-	1	3	-	-	1	3	3	4	1	1	2	2	1
Pinus	2	-	-	1	1	-	1	-	3	1	-	-	1	-
Ulmus	2	1	7	-	1	1	1	3	1	5	1	2	2	4
Quercus	24	29	65	19	11	15	13	20	14	38	9	17	33	27
Tilia	4	4	7	-	2	2	-	8	4	6	1	10	10	14
Alnus	17	15	55	27	10	30	30	88	121	97	137	116	100	95
Fraxinus	1	-	13	2	-	1	2	3	3	1	1	3	2	9
Fagus	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Picea	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Corylus	14	22	58	14	15	23	20	31	22	33	15	18	30	36
Salix	-	1	3	1	4	1	-	-	1	-	1	2	1	8
Lonicera	-	-	-	-	-	-	-	-	1	1	-	-	-	-
Rhamnus	-	-	-	-	-	-	-	2	3	-	-	-	-	-
Ilex	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Frangula	-	-	2	-	-	-	-	-	1	-	-	-	-	-
Hedera	-	-	-	-	-	-	1	1	-	1	-	-	1	-
Ericaceae	-	1	-	-	1	-	-	2	-	-	-	-	1	-
Viburnum	-	-	2	1	1	-	-	-	1	-	1	-	1	2
Gramineae	9	24	145	34	34	32	22	77	52	66	7	21	76	150
Cyperaceae	3	48	88	20	7	66	108	455	22	27	40	38	44	27
Compositae tub.	2	6	1	2	-	-	1	6	-	9	-	1	1	5
Compositae lig.	-	-	1	-	1	-	-	-	-	-	-	-	-	1
Artemisia	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Ranunculus-type	3	-	9	1	2	3	3	7	7	8	4	4	15	22
Caltha-type	-	1	2	-	-	-	-	-	-	-	-	-	1	1
Cruciferae	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Spergula	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodiaceae	5	193	98	20	9	4	1	1	-	-	-	-	-	-
Rosaceae	2	-	-	-	-	-	-	-	1	-	-	-	1	5
Sanguisorba	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Lythrum	-	-	-	-	-	-	-	3	1	-	-	-	8	-
Umbelliferae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Polygonaceae	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Rumex	-	-	-	-	-	-	-	-	-	2	-	-	1	-
Calystegia	-	-	-	-	-	-	-	2	2	-	-	-	1	-
Mentha	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Plantaginaceae	-	-	2	-	-	-	2	1	-	-	-	-	-	-
Rubiaceae	-	-	-	-	-	-	-	-	-	1	-	-	2	4
Myriophyllum	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Alisma	-	-	1	-	-	-	-	-	-	-	1	-	-	-
Potamogeton	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Typha latifolia	-	-	1	-	-	1	-	-	-	-	-	1	14	1
Typha angustifolia	-	-	-	-	-	-	1	-	-	5	1	15	16	1
Pteridium	11	8	4	3	7	9	2	6	1	2	-	1	2	2
Polypodium	2	1	3	2	2	-	2	2	5	5	1	1	9	9
Sphagnum	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Filicales	-	1	2	-	-	-	1	5	1	3	1	3	3	3
Lycopodium	300	263	436	247	304	316	240	448	404	428	128	200	228	394

Co-ord 50° 42' 04" N  
01° 30' 07" W

Grid ref. SZ 3515 8921  
Fieldwork 811209

Level	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height m.O.D.	-1.76	-1.84	-1.88	-1.92	-1.98	-2.04	-2.10	-2.16	-2.22	-2.26	-2.30	-2.36	-2.40	-2.44
Depth cm	-268	-274	-278	-282	-288	-294	-300	-306	-312	-316	-320	-326	-330	-334
Betula	1	2	4	4	1	-	2	4	3	-	5	1	2	1
Pinus	-	2	-	1	-	1	1	1	-	-	-	3	4	6
Ulmus	2	3	-	5	4	6	9	11	5	-	5	-	1	1
Quercus	41	33	4	29	35	25	27	31	95	30	22	12	20	6
Tilia	12	4	2	3	6	5	13	17	16	11	8	1	1	-
Alnus	74	85	37	73	124	122	94	33	81	106	47	22	16	20
Fraxinus	6	2	1	1	2	3	2	6	3	-	6	1	1	-
Fagus	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Corylus	34	26	17	21	24	20	21	16	41	23	27	9	16	20
Salix	1	4	-	-	1	2	1	-	45	2	3	-	1	2
Ilex	-	-	-	-	-	-	-	1	1	-	-	1	-	-
Frangula	-	-	-	1	-	-	1	-	-	-	3	-	-	-
Hedera	-	-	1	1	-	1	-	3	2	1	2	-	-	-
Viburnum	-	1	-	1	-	1	-	1	-	-	-	1	1	+
Gramineae	40	43	15	31	21	37	51	99	138	37	54	7	13	7
Cyperaceae	23	18	8	46	14	17	10	10	31	28	50	11	4	4
Compositae tub.	3	1	1	5	1	-	1	1	3	1	2	1	-	1
Compositae lig.	-	-	-	2	-	-	-	-	-	-	-	-	1	-
Artemisia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus-type	1	1	3	3	4	6	4	7	11	2	12	-	-	-
Caltha-type	-	1	1	1	2	1	2	1	1	1	-	-	-	-
Chenopodiaceae	8	8	3	17	5	2	1	6	-	1	2	24	26	28
Cruciferae	-	-	-	-	-	-	-	-	4	-	-	-	-	-
Rosaceae	2	1	-	1	4	-	-	-	1	3	-	1	1	1
Lythrum	-	-	1	2	-	-	5	2	2	1	1	-	-	-
Umbelliferae	-	-	-	-	1	-	-	-	1	-	-	-	-	-
Euphorbia	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Polygonaceae	1	-	-	-	-	-	-	-	-	-	-	1	1	-
Rumex	-	2	-	-	1	1	2	-	9	1	1	-	-	1
Calystegia	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Mentha	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Plantago lanc.	1	1	1	1	-	-	1	-	-	1	1	-	-	-
Rubiaceae	-	2	-	1	-	-	-	-	6	1	-	1	-	-
Myriophyllum	-	1	-	-	-	1	-	-	-	-	-	-	-	-
Alisma	1	1	-	-	-	-	-	-	3	1	-	-	-	-
Typha latifolia	-	2	1	-	1	2	-	-	3	4	-	-	-	-
T. angustifolia	4	2	2	2	-	2	2	2	2	15	-	-	-	-
Pteridium	4	9	9	6	-	-	-	-	-	7	1	10	23	17
Polypodium	5	2	2	2	5	8	4	3	10	3	1	1	-	2
Sphagnum	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Filicales	9	7	3	1	4	4	3	2	5	4	1	4	4	5
Lycopodium	382	403	208	346	353	245	268	366	343	337	258	414	461	1131

YBS 14 Pollen Counts

XXVII

Co-ord. 50° 53' 13" N  
00° 41' 20" E

Grid ref. TQ 8912 1328  
Fieldwork 820922

Level	9	8	7	6	5	4	3	2	1
Height m.O.D.	-1.01	-1.06	-1.11	-1.16	-1.21	-1.26	-1.31	-1.41	-1.51
Depth cm	0	-5	-10	-15	-20	-25	-30	-40	-50
<i>Betula</i>	10	8	5	3	3	6	2	3	14
<i>Pinus</i>	1	-	1	-	1	1	-	-	2
<i>Ulmus</i>	2	2	-	1	3	-	1	3	-
<i>Quercus</i>	30	31	31	6	32	18	15	17	28
<i>Tilia</i>	1	1	2	2	10	4	3	5	6
<i>Alnus</i>	350	379	379	402	368	381	427	327	344
<i>Fraxinus</i>	6	1	5	3	2	1	7	2	2
<i>Corylus</i>	40	19	32	27	21	35	18	22	21
<i>Salix</i>	15	5	4	7	3	1	1	-	4
<i>Ilex</i>	-	1	3	1	-	-	-	-	1
<i>Frangula</i>	4	3	1	-	-	-	-	1	-
<i>Hedera</i>	-	-	1	-	1	-	-	-	2
<i>Viburnum</i>	2	1	2	6	1	-	-	1	-
Gramineae	8	5	4	3	11	4	2	14	6
Cyperaceae	14	18	4	30	23	37	20	59	44
Compositae tub.	-	-	-	-	1	-	-	1	1
Compositae lig.	1	-	-	-	-	-	-	-	-
<i>Artemisia</i>	1	2	-	-	-	-	-	1	1
Ranunculus-type	7	10	15	1	12	7	2	6	14
Caltha-type	1	1	-	-	-	-	-	-	-
Cruciferae	-	-	1	-	-	-	-	-	-
Caryophyllaceae	-	-	-	-	-	1	-	-	-
Chenopodiaceae	-	1	-	-	1	2	-	1	-
Rosaceae	2	1	1	2	1	-	1	5	3
<i>Filipendula</i>	1	-	2	-	1	1	-	6	4
Potentilla-type	-	-	-	-	-	-	-	-	1
<i>Lythrum</i>	-	-	-	-	-	-	-	1	-
Umbelliferae	-	1	1	2	-	-	1	23	-
<i>Polygonum</i>	-	-	-	-	-	1	-	-	-
<i>Rumex</i>	3	-	2	-	3	-	-	1	2
<i>Calystegia</i>	-	-	-	-	-	-	-	1	-
<i>Mentha</i>	1	1	-	-	-	-	-	-	-
<i>Plantago lanc.</i>	-	-	3	-	2	-	-	-	-
<i>Plantago maj/med.</i>	-	-	1	-	-	-	-	-	-
<i>Galium</i>	-	1	-	-	-	-	-	-	-
<i>Myriophyllum</i>	1	-	1	-	-	-	-	-	-
<i>M.verticillatum</i>	1	-	-	-	-	-	-	-	-
<i>Alisma</i>	-	-	-	-	-	-	-	1	-
<i>Potamogeton</i>	1	1	-	-	-	-	-	-	-
<i>Typha angustifolia</i>	4	7	2	1	6	-	-	-	5
<i>Osmunda</i>	5	3	3	8	2	1	-	2	-
<i>Pteridium</i>	2	1	5	-	1	-	1	-	-
<i>Polypodium</i>	6	1	7	3	5	14	1	10	8
<i>Sphagnum</i>	-	-	-	-	-	1	-	-	2
Filicales	6	9	9	13	20	69	20	18	42
<i>Lycopodium</i>	194	250	173	114	157	163	91	119	178

Pett Level 2 Pollen Counts

Pett Level 3; Pollen Counts

Co-ord. 50° 53' 13" N  
00° 41' 19" E

Grid ref. TQ 8911 1329  
Fieldwork 820923

Level	6	5	4	3	2	1
Height m.O.D.	-0.89	-0.99	-1.09	-1.19	-1.29	-1.39
Depth cm.	0	-10	-20	-30	-40	-50
Betula	5	4	2	3	11	5
Ulmus	-	1	2	-	-	3
Quercus	11	17	3	12	34	22
Tilia	1	4	2	4	12	2
Alnus	411	333	442	427	326	383
Fraxinus	2	-	-	-	6	2
Corylus	46	20	11	22	21	16
Salix	1	6	1	2	6	12
Lonicera	-	-	1	1	-	-
Ilex	-	-	-	-	-	1
Hedera	-	1	-	1	1	1
Viburnum	-	-	1	-	-	1
Gramineae	3	3	-	2	4	9
Cyperaceae	7	94	21	16	56	22
Compositae tub.	-	-	1	3	1	-
Artemisia	-	-	-	-	-	1
Ranunculus-type	5	10	1	3	16	9
Stellaria-type	-	-	-	-	-	1
Chenopodiaceae	-	-	1	1	2	1
Rosaceae	4	3	6	2	-	4
Filipendula	-	-	-	-	2	-
Umbelliferae	1	1	2	1	-	2
Rumex	-	-	-	-	-	1
Cruciferae	2	2	2	-	2	2
Plantaginaceae	1	1	1	-	-	-
Alisma	-	-	1	-	1	-
Typha angustifolia	-	-	-	1	2	6
Osmunda	5	-	-	-	1	2
Pteridium	2	1	-	-	-	-
Polypodium	5	-	4	5	5	3
Filicales	4	25	9	14	19	38
Total Lycopodium	73	124	76	101	158	226

Browndown 13/14 53; Pollen Counts

Grid ref. SZ585 985

Level	8	7	6	5	4	3	2	1
Height m.O.D.	-19.00	-19.05	-19.10	-19.15	-19.20	-19.25	-19.30	-19.35
Depth cm.	-1350	-1355	1360	-1365	-1370	-1375	-1380	-1385
Betula	1	5	9	5	5	9	3	1
Pinus	4	10	6	4	4	10	12	3
Ulmus	3	6	15	12	5	12	7	5
Quercus	17	50	25	40	27	52	22	17
Alnus	-	1	1	1	-	1	1	-
Fraxinus	2	5	4	-	3	3	3	-
Fagus	-	-	1	-	-	1	-	-
Corylus	39	82	172	183	87	202	50	61
Salix	1	2	2	5	1	3	1	2
Ilex	-	-	-	-	1	1	-	-
Hedera	1	-	1	-	-	-	-	-
Ericaceae	-	-	-	-	-	-	2	-
Gramineae	26	76	83	86	83	221	72	37
Cyperaceae	3	3	2	5	3	11	30	10
Compositae tub.	2	-	-	1	3	5	3	5
Compositae lig.	-	-	-	1	-	-	5	3
Ranunculus-type	5	5	13	8	9	17	6	7
Caltha-type	-	-	1	-	-	2	1	-
Cruciferae	1	2	-	-	-	-	-	-
Caryophyllaceae	-	-	-	1	-	-	-	-
Chenopodiaceae	5	11	19	8	9	7	4	3
Saxifragaceae	1	-	-	-	-	-	-	-
Polygonum	1	-	1	-	-	3	-	-
Convolvulus	-	1	-	-	-	-	-	-
Plantaginaceae	-	-	-	-	-	1	-	-
Myriophyllum	-	-	2	-	-	-	-	-
Potamogeton	2	-	-	-	-	-	-	-
Typha angustifolia	2	6	2	2	1	-	-	-
Pteridium	9	10	3	2	9	8	19	17
Polypodium	-	2	-	-	-	-	-	1
Sphagnum	-	1	-	-	-	1	-	-
Filicales	1	5	1	2	5	3	5	2
Lycopodium	200	200	200	200	200	200	200	200

Browndown 13/14 53 Pollen Counts

A P P E N D I X V

DIATOM COUNTS

Moors 7

Moors 8

Moors 9

Moors 10

YBS 3

YBS 9

YBS 10

YBS 12

YBS 13

YBS 14

Browdown 13/14 53

Moors 7; Diatom Counts

Co-ord 50° 40' 56" N  
02° 05' 41" W

Grid ref. SY 9491 8702  
Fieldwork 800622

Level	6	5	4	3	2	1
Height m.O.D.	-0.15	-0.27	-0.42	-0.60	-0.67	-0.70
Depth cm.	-38	-50	-65	-83	-90	-93
<i>Fragilaria construens</i> v.bid	-	-	-	-	1	-
<i>F.lapponica</i>	1	-	-	-	1	-
<i>F.virescens</i> v.elliptica	-	-	1	3	4	1
<i>Diploneis ovalis</i>	-	1	-	2	-	-
<i>Navicula gracilis</i>	-	-	-	1	-	-
<i>Nitzschia sigma</i>	-	-	-	4	-	-
<i>Cocconeis pediculus</i>	1	-	-	3	3	3
<i>Diploneis interrupta</i>	1	2	1	1	2	2
<i>Navicula digitoradiata</i>	-	-	1	5	8	-
<i>N.peregrina</i>	2	9	2	14	7	-
<i>Nitzschia navicularis</i>	49	54	82	76	66	79
<i>Surirella ovalis</i>	-	-	-	1	4	-
<i>S.striatula</i>	-	-	-	-	-	1
<i>Caloneis formosa</i>	-	8	1	17	10	7
<i>Rhopalodia gibberula</i>	1	-	1	1	1	-
<i>Nitzschia punctata</i>	24	20	16	11	17	22
<i>Achnanthes brevipes</i>	-	-	-	1	-	-
<i>Diploneis didyma</i>	3	-	2	2	3	2
<i>Navicula marina</i>	-	-	-	1	-	2
<i>Cocconeis scutellum</i>	4	2	3	6	4	5
<i>Diploneis smithi</i>	5	4	1	-	-	-
<i>Rhaphoneis amphiceros</i>	1	1	-	-	1	-
<i>R.surirella</i>	-	-	-	-	1	-
<i>Actinoptychus undulatus</i>	3	1	4	-	-	-
<i>Thalassiosira decipiens</i>	-	1	-	1	1	2
<i>Auliscus sculptus</i>	1	1	1	1	1	3
<i>Dimerogramma minor</i>	3	-	-	1	-	1
<i>D.minor</i> v.nana	8	2	4	2	8	6
<i>Gyrosigma littorale</i>	-	-	-	-	2	-
<i>Navicula lyra</i>	-	-	-	1	-	-
<i>Nitzschia granulata</i>	2	5	9	6	10	32
<i>Achnanthes septata</i>	-	-	-	1	7	-
<i>Cocconeis costata</i>	-	-	3	2	1	-
<i>Grammatophora marina</i>	6	-	1	-	4	1
<i>G.oceanica</i> v.macilenta	9	-	5	-	4	2
<i>Opephora marina</i>	-	-	-	3	-	-
<i>O.pacifica</i>	-	-	1	1	3	1
<i>Plagiogramma staurophorum</i>	2	1	-	-	1	3
<i>Podosira stelliger</i>	-	-	-	2	-	-
<i>Coscinodiscus nitidus</i>	-	-	1	3	6	-
<i>C.perforatus</i> v.pavillardii	-	-	1	-	-	1
<i>Diploneis bombus</i>	-	-	-	2	2	3
<i>Melosira sulcata</i>	74	87	59	19	19	19
<i>M.westi</i>	1	-	-	-	-	1
Total valves	201	199	200	194	202	199

Moors 8; Diatom Counts

Co-ord 50° 40' 57" N  
01° 05' 41" W

Grid ref. SY 9491 8707  
Fieldwork 800622

Level	4	3	2	1
Height m.O.D.	-0.30	-0.40	-0.50	-0.60
Depth cm.	-50	-60	-70	-80
<i>Pinnularia microstauron</i>	2	-	-	-
<i>Fragilaria lapponica</i>	5	-	1	1
<i>F.virescens v.elliptica</i>	-	-	2	-
<i>Diploneis ovalis</i>	4	-	-	-
<i>Gomphonema constrictum</i>	-	-	1	-
<i>Cocconeis pediculus</i>	-	1	2	2
<i>Diploneis interrupta</i>	20	1	-	3
<i>Navicula digitoradiata</i>	-	1	1	5
<i>N.peregrina</i>	16	1	1	2
<i>Nitzschia navicularis</i>	11	79	90	95
<i>Caloneis formosa</i>	-	1	2	2
<i>Rhopalodia gibberula</i>	-	-	1	1
<i>Nitzschia punctata</i>	4	15	18	17
<i>Achnanthes brevipes</i>	-	-	1	1
<i>Diploneis didyma</i>	-	5	6	5
<i>Navicula abrupta</i>	1	1	-	-
<i>N.marina</i>	103	-	1	3
<i>Cocconeis scutellum</i>	3	-	6	1
<i>Diploneis smithi</i>	17	6	1	1
<i>Rhaphoneis amphiceros</i>	-	1	-	-
<i>Actinoptychus undulatus</i>	-	-	2	1
<i>Thalassiosira decipiens</i>	-	-	4	2
<i>Auliscus sculptus</i>	-	-	2	-
<i>Dimerogramma minor v.nana</i>	-	6	-	1
<i>Nitzschia granulata</i>	-	3	12	6
<i>Cocconeis discoides</i>	-	-	4	-
<i>Grammatophora marina</i>	-	1	2	2
<i>G.oceanica v.macilentata</i>	-	4	-	1
<i>Opephora marina</i>	-	1	1	-
<i>Plagiogramma staurophorum</i>	-	2	-	-
<i>Coscinodiscus nitidus</i>	1	-	1	2
<i>Melosira sulcata</i>	14	69	39	45
<i>M.westi</i>	-	2	1	-
Total valves	201	200	202	199

Moors 9; Diatom Counts

Co-ord 50° 41' 01" N  
02° 05' 41" W

Grid ref. SY 9491 8717  
Fieldwork 800622

Level	1	2
Height m.O.D.	-0.61	-0.71
Depth cm.	-27	-37
<i>Fragilaria virescens</i> v. <i>elliptica</i>	-	1
<i>Diploneis ovalis</i>	-	1
<i>Opephora martyi</i>	-	3
<i>Diploneis interrupta</i>	9	4
<i>Navicula digitoradiata</i>	1	-
<i>N. peregrina</i>	1	1
<i>Nitzschia navicularis</i>	19	65
<i>Caloneis formosa</i>	1	-
<i>Nitzschia punctata</i>	31	29
<i>Diploneis didyma</i>	3	3
<i>Navicula abrupta</i>	-	1
<i>N. forcipata</i>	-	3
<i>Cocconeis scutellum</i>	-	6
<i>Diploneis smithi</i>	-	1
<i>Actinoptychus undulatus</i>	-	2
<i>Auliscus sculptus</i>	5	5
<i>Dimerogramma minor</i>	1	-
<i>D. minor</i> v. <i>nana</i>	-	5
<i>Nitzschia granulata</i>	1	4
<i>Trachyneis aspersa</i>	1	-
<i>Achnanthes septata</i>	-	1
<i>Cocconeis discoides</i>	-	2
<i>Grammatophora marina</i>	1	4
<i>G. oceanica</i> v. <i>macilentata</i>	1	5
<i>Plagiogramma staurophorum</i>	3	1
<i>Podosira stelliger</i>	3	1
<i>Coscinodiscus apiculatus</i> v. <i>ambigua</i>	1	-
<i>C. nitidus</i>	1	1
<i>Melosira sulcata</i>	50	49
<i>M. westi</i>	2	3
Total valves	135	201

## Moors 10; Diatom Counts

Co-ord 50° 41' 04" N  
02° 05' 41" WGrid ref. SY 9491 8727  
Fieldwork 800622

Level	8	7	6	5	4	3	2	1
Height m.O.D.	-0.22	-0.22	-0.42	-0.52	-0.62	-0.72	-0.82	-0.92
Depth cm.	-60	-70	-80	-90	-100	-110	-120	-130
<i>Navicula lacustris</i>	-	-	-	1	-	-	-	1
<i>Pinnularia microstauron</i>	-	-	-	-	-	-	1	-
<i>Cymbella affinis</i>	-	-	-	-	-	-	1	-
<i>Fragilaria atomis</i>	-	-	-	-	-	-	1	-
<i>F. construens</i>	-	-	-	-	-	-	2	-
<i>F. construens v. venter</i>	2	6	4	-	-	-	2	-
<i>F. lapponica</i>	-	1	2	-	-	-	-	1
<i>F. schulzi</i>	-	-	-	1	-	-	2	-
<i>F. virescens v. elliptica</i>	-	-	-	8	1	1	6	-
<i>Amphora ovalis v. libyca</i>	-	1	-	2	-	-	6	-
<i>Diploneis ovalis</i>	-	-	-	2	2	1	1	2
<i>Navicula gracilis</i>	1	1	-	-	-	-	1	-
<i>N. menisculus</i>	-	-	-	1	1	-	2	-
<i>N. pupula</i>	-	-	-	-	-	1	1	2
<i>Cymbella aspera</i>	-	-	-	1	-	-	-	-
<i>C. sinuata</i>	-	-	-	1	-	-	-	-
<i>Eunotia tenella</i>	-	-	-	1	-	-	1	-
<i>Fragilaria brevistriata</i>	-	-	-	1	-	1	3	-
<i>Gomphonema longicoepe v. subol.</i>	-	-	-	-	-	-	-	1
<i>Opephora martyi</i>	-	-	1	1	-	3	6	1
<i>Meridion circulare</i>	-	-	-	1	-	-	-	-
<i>Nitzschia sigma</i>	-	-	-	-	-	-	1	1
<i>N. tryblionella v. levidensis</i>	1	4	-	-	-	-	-	-
<i>Cocconeis pediculus</i>	1	3	7	5	2	2	7	3
<i>Diploneis interrupta</i>	1	1	-	1	2	10	2	2
<i>Navicula digitoradiata</i>	1	2	3	1	-	1	-	2
<i>N. peregrina</i>	5	1	-	2	1	2	4	-
<i>Nitzschia navicularis</i>	21	4	5	2	8	16	34	39
<i>Achnanthes brevipes v. parvula</i>	-	-	1	-	-	-	-	-
<i>A. delicatula</i>	-	1	-	-	-	-	-	-
<i>Caloneis formosa</i>	4	1	1	1	-	2	12	3
<i>Rhopalodia gibberula</i>	1	3	6	2	-	-	-	-
<i>Nitzschia punctata</i>	10	38	38	34	16	12	14	9
<i>Achnanthes brevipes</i>	-	-	2	1	-	1	-	-
<i>A. brevipes v. intermedia</i>	-	3	-	-	-	-	-	-
<i>Diploneis didyma</i>	17	2	6	3	4	2	5	1
<i>Navicula abrupta</i>	-	-	-	1	-	1	2	8
<i>N. forcipata</i>	-	1	1	-	-	-	-	2
<i>N. humerosa</i>	-	-	-	-	1	-	-	-
<i>N. marina</i>	1	-	1	-	-	1	2	5
<i>Cocconeis scutellum</i>	9	16	18	21	2	8	10	3
<i>C. scutellum v. stauroformis</i>	-	-	1	-	-	-	-	-
<i>G. speciosa</i>	-	-	5	4	-	-	-	1
<i>Diploneis smithi</i>	7	1	-	1	2	3	3	8
<i>Rhaphoneis amphiceros</i>	-	-	-	-	-	1	2	-
<i>R. surirella</i>	-	-	1	-	1	-	1	-
<i>Actinoptochus undulatus</i>	1	2	2	-	-	3	2	-
<i>Thalassiosira decipiens</i>	1	2	4	8	-	-	2	-
<i>Auliscus sculptus</i>	-	3	2	6	3	1	6	3
<i>Dimerogramma marinum</i>	-	1	-	-	-	-	-	-
<i>D. minor</i>	-	1	-	-	-	2	-	-
<i>D. minor v. nana</i>	10	13	11	9	5	7	4	9
<i>Gyrosigma littorale</i>	-	-	1	-	-	-	-	-
<i>Navicula lyra</i>	-	-	1	-	-	-	-	-
<i>Nitzschia granulata</i>	-	-	-	2	-	2	3	2
<i>N. panduriformis</i>	-	-	2	1	-	-	-	-
<i>Surirella fastuosa</i>	-	1	-	1	-	-	-	-
<i>Trachyneis aspersa</i>	-	2	2	3	-	-	-	-
<i>Biddulphia aurita</i>	-	1	-	-	-	-	-	-
<i>Cocconeis costata</i>	-	6	3	-	-	-	-	-
<i>C. discloides</i>	-	-	3	1	-	-	-	2
<i>Grammatophora marina</i>	2	2	7	6	1	2	4	1
<i>G. oceanica v. macilentata</i>	5	19	24	14	4	5	5	6
<i>G. serpentina</i>	1	1	1	-	-	-	-	-
<i>Opephora pacifica</i>	1	1	6	7	-	-	7	-
<i>Plagiogramma staurophorum</i>	-	3	1	-	-	1	-	-
<i>Podosira stelliger</i>	-	-	-	-	-	-	-	1
<i>Coccinodiscus nitidus</i>	1	-	1	4	-	1	3	-
<i>Diploneis bomboideus</i>	1	-	1	-	-	-	-	-
<i>Diploneis bombus</i>	2	1	-	1	1	-	-	-
<i>Melosira sulcata</i>	92	52	23	39	43	47	33	41
<i>M. westi</i>	2	-	2	1	2	2	1	1
Total valves	201	201	198	198	102	142	205	155

YBS 10; Diatom Counts

Coord. 50° 42' 04" N  
01° 30' 08" W

Grid ref. SZ 3514 8924  
Fieldwork 811208

Level	13	12	11	10	9	8	7	6	5	4	3	2	1
Height m.O.D.	-1.32	-1.36	-1.44	-1.54	-1.64	-1.72	-1.80	-1.90	-2.00	-2.40	-2.46	-2.52	-2.58
Depth cm.	-215	-219	-227	-237	-247	-255	-263	-273	-283	-323	-329	-335	-341
<i>Eunotia monodon</i> v. <i>bidens</i>	-	-	-	-	1	-	-	-	3	4	-	-	-
<i>Amphora ovalis</i> v. <i>libyca</i>	-	-	-	-	-	-	-	1	12	9	-	-	1
<i>Anomoeoneis sculpta</i>	-	-	-	-	-	3	-	-	-	1	-	-	17
<i>Cymatopleura elliptica</i>	-	-	-	-	-	-	-	2	-	-	-	-	-
<i>Diploneis ovalis</i>	-	2	-	-	2	3	-	22	-	19	2	-	-
<i>D.ovalis</i> v. <i>oblongella</i>	-	-	2	1	-	-	-	1	2	9	-	-	-
<i>Jyrosigma acuminatum</i>	-	-	9	-	21	-	-	-	-	-	-	-	4
<i>J.attenuatum</i>	-	1	-	-	-	-	-	-	-	-	-	-	-
<i>Navicula cincta</i>	-	-	-	-	9	8	-	-	-	-	-	-	-
<i>N.dicephala</i>	-	1	-	-	-	-	-	-	-	-	-	-	-
<i>N.gracilis</i>	-	-	-	-	-	-	-	-	-	1	-	-	-
<i>N.graciloides</i>	-	1	-	1	1	1	-	-	8	-	-	-	-
<i>N.pusilla</i>	-	-	-	-	1	3	-	-	3	4	-	-	1
<i>N.rhyncocephala</i>	-	-	-	-	-	-	-	-	5	-	-	-	-
<i>Pinnularia maior</i>	-	-	-	-	-	-	-	3	2	-	-	-	-
<i>P.viridis</i>	-	-	-	-	-	-	-	2	10	3	1	-	-
<i>Surirella amoricana</i>	-	-	-	-	-	-	-	1	-	-	1	-	-
<i>Gomphonema intricatum</i>	-	-	-	-	-	-	-	2	12	1	1	-	-
<i>Gyrosigma scalproides</i> v. <i>eximia</i>	-	-	-	-	1	-	-	-	-	-	-	-	-
<i>Nitzschia sigma</i>	5	6	9	40	13	10	2	-	-	8	1	5	4
<i>Cocconeis pediculus</i>	-	1	-	-	-	2	1	-	-	-	-	-	-
<i>Diploneis interrupta</i>	4	1	2	-	-	3	1	-	-	-	3	1	6
<i>Navicula digitoradiata</i>	-	-	-	-	-	3	2	-	-	-	-	1	4
<i>N.elegans</i>	-	-	-	-	1	-	-	-	3	1	-	-	-
<i>N.peregrina</i>	-	4	1	2	4	19	7	15	119	73	3	6	54
<i>Nitzschia circumscuta</i>	-	-	-	-	1	1	-	10	-	2	2	1	-
<i>N.navicularis</i>	21	52	46	71	19	51	91	62	5	36	98	67	17
<i>N.scalar</i>	2	2	2	-	1	4	-	-	15	6	-	2	30
<i>Surirella crumena</i>	-	1	-	-	-	-	-	-	-	-	-	-	-
<i>S.striatula</i>	-	-	-	-	-	-	1	-	-	-	-	-	-
<i>Caloneis formosa</i>	3	1	7	5	6	5	-	1	-	1	1	7	15
<i>Rhopalodia gibberula</i>	2	1	5	-	4	1	-	-	1	1	-	-	10
<i>Diploneis aestuarii</i>	-	-	2	-	2	-	-	-	-	-	-	-	-
<i>Nitzschia punctata</i>	6	14	2	8	15	6	10	8	2	1	11	7	1
<i>Scoliopleura tumida</i>	35	4	11	3	9	13	-	-	-	-	-	9	8
<i>Achnanthes brevipes</i>	1	-	-	-	5	11	-	-	-	-	-	-	-
<i>A.brevipes</i> v. <i>intermedia</i>	7	2	1	-	16	3	-	3	-	4	-	-	4
<i>Diploneis didyma</i>	76	21	35	20	9	2	3	4	-	6	7	42	7
<i>Navicula marina</i>	-	1	8	1	-	-	2	-	-	-	-	3	-
<i>Nitzschia acuminata</i>	-	2	12	3	2	1	-	1	-	-	-	-	3
<i>Cocconeis scutellum</i>	2	2	1	-	2	2	1	2	-	2	-	1	-
<i>C.speciosa</i>	-	-	-	-	-	1	-	-	-	-	-	-	-
<i>Diploneis smithi</i>	-	-	-	-	-	-	-	10	-	-	1	3	7
<i>Rhaphoneis amphiceros</i>	1	-	-	1	1	-	3	-	-	-	2	-	-
<i>R.surirella</i>	-	-	-	-	-	-	-	1	-	-	1	2	-
<i>Actinoptychus undulatus</i>	3	9	2	5	5	4	5	3	-	2	3	6	1
<i>Thalassiosira decipiens</i>	-	1	1	-	3	-	1	-	-	-	-	-	-
<i>Dimerogramma minor</i>	-	-	1	-	-	-	-	1	-	-	1	-	-
<i>Diploneis fusca</i>	-	-	-	-	-	-	-	8	-	-	1	-	-
<i>Nitzschia granulata</i>	-	-	-	-	1	-	1	3	-	-	-	1	-
<i>N.panduriformis</i>	-	1	1	1	1	1	-	1	-	-	3	-	-
<i>Surirella fastuosa</i>	1	-	-	-	1	-	-	-	-	-	-	-	1
<i>Trachyneis aspersa</i>	-	1	-	1	1	1	1	-	-	-	-	1	-
<i>Cocconeis britannica</i>	-	-	-	-	-	-	-	-	-	-	1	-	-
<i>Diploneis weissflogi</i>	-	-	-	-	-	-	-	-	-	-	-	3	-
<i>Grammatophora oceanica</i> v. <i>mac</i>	1	9	1	1	-	8	6	1	-	-	1	3	-
<i>G.serpentina</i>	-	1	-	1	-	-	1	1	-	-	2	-	-
<i>Podocira stelliger</i>	5	2	-	3	3	1	2	-	-	-	2	3	-
<i>Rhabdonema minutum</i>	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Coscinodiscus apiculatus</i>	2	2	2	-	2	1	4	1	-	-	-	1	-
<i>C.nitidus</i>	1	1	1	-	1	-	1	5	-	-	1	1	-
<i>Diploneis bombus</i>	-	5	-	1	-	-	-	2	-	-	2	6	1
<i>Melosira sulcata</i>	15	46	25	28	35	24	50	22	-	6	44	14	2
<i>M.westi</i>	6	2	11	3	1	1	3	1	-	-	4	4	1
Total valves	200	200	200	200	200	200	200	200	200	200	200	200	200

YBS 10 Diatom Counts

Level	8	7	6	5	4	3	2	1
Height m.O.D.	-1.40	-1.50	-1.60	-1.74	-1.80	-1.90	-1.98	-2.04
Depth cm.	-220	-230	-240	-254	-260	-270	-278	-284
<i>Pinnularia gentilis</i>	-	-	-	-	-	-	3	5
<i>P.microstauron</i>	-	-	-	-	-	-	1	-
<i>Eunotia diodon</i>	-	-	-	-	-	-	1	2
<i>E.monodon v.bidens</i>	-	-	-	-	-	-	1	8
<i>Amphora ovalis v.libyca</i>	1	-	1	2	-	-	1	7
<i>Anomoeoneis sculpta</i>	-	-	-	-	-	-	1	-
<i>Diploneis ovalis</i>	1	-	2	2	9	4	-	-
<i>Navicula pusilla</i>	-	1	-	-	1	-	1	4
<i>Cymbella aspera</i>	-	-	-	-	-	-	-	-
<i>C.ehrenbergii</i>	-	1	-	-	-	-	-	-
<i>Eunotia tonella</i>	-	-	1	-	-	-	-	-
<i>Gomphonema intricatum</i>	-	-	-	-	-	-	-	1
<i>Meridion circulare</i>	-	-	-	-	-	-	1	-
<i>Nitzschia sigma</i>	4	9	11	-	-	-	-	-
<i>Cocconeis pediculus</i>	-	1	-	-	-	-	-	-
<i>Navicula digitoradiata</i>	-	1	13	-	-	-	-	1
<i>E.elegans</i>	-	-	1	-	-	-	-	-
<i>E.peregrina</i>	1	4	3	-	-	4	28	96
<i>Nitzschia circumscuta</i>	-	1	-	-	2	6	38	4
<i>E.navicularis</i>	5	29	37	132	149	125	70	19
<i>E.scalaris</i>	-	4	1	-	-	-	-	9
<i>Caloneis formosa</i>	7	12	4	-	-	1	3	-
<i>Rhopalodia gibberula</i>	1	-	-	-	-	1	-	1
<i>Nitzschia punctata</i>	5	6	9	4	2	8	-	-
<i>N.punctata v.constricta</i>	-	-	1	-	-	-	-	-
<i>Scolioptleura tumida</i>	12	23	29	-	-	-	-	-
<i>Achnanthes brevipes v.int.</i>	1	3	3	-	-	1	-	7
<i>Diploneis didyma</i>	15	11	36	13	8	7	4	2
<i>Navicula lyroides</i>	-	-	1	-	-	-	-	-
<i>N.marina</i>	-	-	-	-	-	-	1	-
<i>Achnanthes longipes</i>	-	-	-	-	-	-	-	1
<i>Cocconeis acutellam</i>	1	-	-	-	-	-	-	-
<i>Diploneis smithi</i>	1	1	1	3	1	2	16	4
<i>Rhaphoneis amphiceros</i>	-	-	-	3	1	1	-	-
<i>Actinoptychus undulatus</i>	2	9	9	3	2	4	3	2
<i>Thalassiosira decipiens</i>	-	1	-	-	-	-	-	1
<i>Diploneis crabro</i>	1	1	-	-	-	-	-	-
<i>D.fusca</i>	-	-	-	-	-	-	1	-
<i>D.incurvita</i>	1	-	2	-	-	1	-	-
<i>Navicula inflexa</i>	-	-	-	-	-	-	-	1
<i>N.latisema</i>	-	-	-	-	1	-	-	-
<i>Nitzschia granulata</i>	-	1	1	1	2	-	2	-
<i>N.panduriformis</i>	-	-	-	-	-	-	-	1
<i>Cocconeis costata</i>	-	1	1	-	-	3	-	-
<i>Diploneis weissflogi</i>	-	1	-	-	-	-	-	-
<i>Grammatophora oceanica</i>	-	-	3	4	2	-	-	-
<i>G.serpentina</i>	-	3	-	3	-	2	-	-
<i>Rhabdonoma minutum</i>	-	1	-	-	-	-	-	0
<i>Plagiogramma staurophorum</i>	-	-	-	-	-	-	-	1
<i>Podosira stelliger</i>	1	4	1	2	1	-	1	-
<i>Coccinodiscus nitidus</i>	-	-	1	2	8	12	8	1
<i>Diploneis bambus</i>	-	1	2	7	2	-	1	-
<i>Melosira sulcata</i>	13	30	25	16	7	15	17	20
<i>M.vesti</i>	-	6	1	3	3	3	-	2
Total valves	73	166	200	200	201	200	202	200

YBS 13 Diatom Counts

Co-ord. 50° 42' 04" N  
01° 30' 07" W

Grid ref. SZ 3516 8922  
Fieldwork 811209

Level	12	11	10	9	8	7	6	5	4	3	2	1
Height m.O.D.	-1.30	-1.34	-1.38	-1.42	-1.46	-1.50	-1.56	-1.64	-1.70	-1.76	-1.82	-1.90
Depth cm.	-218	-222	-226	-230	-234	-238	-244	-252	-258	-264	-270	-278
<i>Navicula lacustris</i>	-	1	-	-	-	-	-	-	-	-	-	-
<i>Pinnularia gentilis</i>	-	-	-	-	-	-	1	-	1	-	-	4
<i>Eunotia gracilis</i>	-	-	-	-	-	-	-	-	-	-	-	1
<i>E.monodon v.bidens</i>	-	-	-	-	-	-	-	-	-	-	-	4
<i>Amphora ovalis v.libyca</i>	-	-	-	-	-	-	-	-	-	-	-	15
<i>Anomoeoneis sculpta</i>	-	-	-	-	-	-	-	-	-	1	-	1
<i>Cymatopleura elliptica</i>	-	-	-	-	-	-	11	3	3	1	2	5
<i>Diploneis ovalis</i>	-	-	-	-	-	3	1	-	-	-	-	3
<i>Navicula pusilla</i>	-	-	-	-	-	-	-	-	-	-	-	3
<i>N.rhyncocephala</i>	-	-	-	-	-	-	1	-	-	-	-	-
<i>Surirella americana</i>	-	-	1	-	-	-	-	-	-	-	-	4
<i>Eunotia tenella</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Fragilaria brevistriata</i>	-	-	-	1	-	-	-	-	-	-	-	3
<i>Gomphonema angustatum</i>	-	-	-	-	-	-	-	-	1	-	-	-
<i>Nitzschia sigma</i>	2	2	4	-	-	-	-	-	1	-	-	-
<i>N.tryblionella</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cocconeis pediculus</i>	-	-	3	-	-	-	-	-	-	-	-	-
<i>Diploneis interrupta</i>	3	5	-	-	4	5	2	-	-	1	-	-
<i>Navicula digitoradiata</i>	5	7	4	11	9	7	5	1	-	-	-	1
<i>N.elegans</i>	-	-	-	-	-	-	-	-	-	-	-	7
<i>N.peregrina</i>	6	2	9	1	3	114	18	12	11	10	9	136
<i>Nitzschia circumscuta</i>	-	-	-	-	-	-	-	-	-	22	28	-
<i>N.navicularis</i>	30	67	100	14	13	3	7	109	129	103	90	3
<i>N.scalaris</i>	1	-	1	-	-	1	3	-	-	-	-	5
<i>Surirella striatula</i>	-	-	-	-	-	3	-	-	-	-	-	-
<i>Caloneis formosa</i>	17	11	1	32	20	16	31	3	4	-	-	-
<i>Rhopalodia gibberula</i>	1	1	-	-	-	10	1	-	-	-	-	2
<i>Nitzschia punctata</i>	8	10	6	5	7	2	2	6	7	12	8	-
<i>Scolioptera tumida</i>	9	-	-	1	1	7	8	2	-	-	-	-
<i>Achnanthes brevipes v.int</i>	-	3	3	1	1	14	3	-	-	-	-	-
<i>Diploneis didyma</i>	76	31	25	80	99	1	75	29	13	10	7	-
<i>Navicula marina</i>	-	-	-	-	-	-	-	-	-	-	-	2
<i>Nitzschia acuminata</i>	-	-	2	-	-	-	-	-	-	-	-	-
<i>Achnanthes longipes</i>	-	-	-	-	-	-	1	-	-	-	-	-
<i>Caloneis subsalina</i>	-	-	-	-	-	-	-	-	-	-	-	1
<i>Cocconeis scutellum</i>	2	5	-	2	-	-	-	-	1	1	1	-
<i>C.scutellum v.stauroneiformis</i>	-	-	-	-	-	1	-	-	-	-	-	-
<i>Diploneis smithi</i>	2	3	-	11	6	4	-	1	5	4	5	1
<i>Rhaphoneis amphiceros</i>	1	2	-	2	-	-	1	2	1	3	1	-
<i>R.surirella</i>	1	-	-	-	-	-	-	-	-	-	-	-
<i>Actinoptychus undulatus</i>	5	2	6	1	1	2	3	1	2	3	5	1
<i>Thalassiosira decipiens</i>	1	-	1	-	-	-	-	-	-	-	-	-
<i>Dimerogramma minor v.nana</i>	-	-	-	-	-	-	1	1	-	-	-	-
<i>Navicula lyra</i>	-	1	-	-	-	-	-	-	-	-	-	-
<i>Nitzschia granulata</i>	-	5	4	-	-	3	2	1	-	-	1	-
<i>Surirella fastuosa</i>	1	1	-	-	1	-	-	1	1	1	-	-
<i>Trachyneis aspersa</i>	1	2	2	1	-	-	1	-	2	-	-	-
<i>Diploneis weissflogi</i>	-	-	-	-	-	-	-	-	-	-	1	-
<i>Grammatophora oceanica</i>	-	2	7	2	1	1	1	2	3	3	3	-
<i>G.serpentina</i>	-	-	1	-	-	-	1	1	1	-	-	-
<i>Plagiogramma staurophorum</i>	-	-	1	-	-	-	-	-	-	-	1	-
<i>Podosira stelliger</i>	1	7	1	3	4	-	-	1	-	1	-	-
<i>Rhabdonema adria ticum</i>	-	-	-	1	-	-	-	-	-	-	-	-
<i>R.minutum</i>	2	-	-	-	-	-	-	1	-	-	-	-
<i>Coccinodiscus nitidus</i>	-	1	-	-	-	-	1	1	-	-	12	-
<i>Diploneis bombus</i>	-	-	-	-	-	-	-	2	-	-	1	-
<i>Melosira sulcata</i>	22	25	20	23	27	3	18	19	11	10	22	2
<i>M.westi</i>	2	4	1	-	1	-	3	-	3	3	3	-
Total valves	199	200	203	192	198	200	202	199	200	189	200	204

YBS 13 Diatom Counts

XII

YBS 14; Diatom Counts

Co-ord. 50° 42' 03" N  
01° 30' 07" W

Grid ref. SZ 3515 8980  
Fieldwork 811210

Level	10	9	8	7	6	5	4	3	2	1
Height m.O.D.	-2.26	-2.30	-2.34	-2.38	-2.42	-2.48	-2.52	-2.56	-2.60	-2.64
Depth cm.	-316	-320	-324	-328	-332	-338	-342	-346	-350	-354
<i>Pinnularia gentilis</i>	4	3	-	4	5	-	2	4	2	-
<i>Stauroneis</i> spp.	-	-	-	3	-	-	-	-	-	-
<i>Eunotia exigua</i>	-	-	-	-	-	-	-	-	1	-
<i>E. gracilis</i>	-	-	-	-	1	-	-	-	-	-
<i>E. monodon</i> v. <i>bidens</i>	-	-	-	7	4	-	-	3	6	-
<i>Amphora ovalis</i> v. <i>libyca</i>	2	-	5	4	2	-	-	-	6	-
<i>Diploneis ovalis</i>	-	-	-	-	-	-	-	1	2	1
<i>Navicula dicephala</i>	-	1	-	2	1	-	-	-	-	-
<i>N. gracilis</i>	1	3	-	2	-	-	-	2	4	-
<i>N. pusilla</i>	-	-	-	1	1	-	-	-	2	-
<i>Pinnularia maior</i>	5	7	-	9	12	-	-	3	-	-
<i>Cymbella aspera</i>	1	1	2	-	-	-	-	1	-	-
<i>C. sinuatum</i>	-	-	-	-	-	-	-	1	2	-
<i>Eunotia tenella</i>	-	-	-	1	-	-	-	-	-	-
<i>Gomphonema angustatum</i>	-	1	-	1	3	-	-	-	-	-
<i>G. constrictum</i>	-	-	-	-	-	-	-	2	-	-
<i>G. intricatum</i>	-	-	-	6	-	-	-	3	-	-
<i>G. loncipes</i> v. <i>subclavata</i>	-	-	-	-	-	-	-	-	2	-
<i>Nitzschia sigma</i>	-	-	2	-	-	2	-	-	-	-
<i>Diploneis interrupta</i>	-	-	1	-	-	-	2	-	-	-
<i>Navicula digitoradiata</i>	-	-	1	-	1	-	-	2	2	-
<i>N. elegans</i>	-	1	-	-	-	-	-	1	3	-
<i>N. peregrina</i>	4	5	10	12	34	1	6	26	49	-
<i>Nitzschia circumscuta</i>	-	-	2	-	1	1	-	1	2	-
<i>N. navicularis</i>	-	-	10	4	14	-	4	5	5	-
<i>N. scalaris</i>	2	2	2	1	2	-	-	4	6	-
<i>Achnanthes delicuta</i>	-	-	-	-	-	-	-	-	1	-
<i>A. hauckiana</i>	-	-	1	-	-	-	-	-	-	-
<i>Caloneis formosa</i>	-	-	3	-	-	-	-	3	-	-
<i>Rhopalodia gibberula</i>	-	-	1	-	3	-	1	3	-	-
<i>Nitzschia punctata</i>	-	-	3	5	2	2	4	7	1	-
<i>N. punctata</i> v. <i>constricta</i>	-	-	-	-	-	-	-	1	-	-
<i>Scoliopleura tumida</i>	-	-	2	-	-	-	1	-	1	-
<i>Achnanthes brevipes</i>	-	-	1	-	-	-	-	-	-	-
<i>A. brevipes</i> v. <i>intermedia</i>	-	-	-	-	-	-	-	-	1	-
<i>Diploneis didyma</i>	-	1	41	7	10	6	11	10	2	-
<i>Cocconeis scutellum</i>	-	-	-	6	2	1	-	1	-	-
<i>C. speciosa</i>	-	-	1	-	-	-	-	-	-	-
<i>Diploneis smithi</i>	-	-	2	-	-	1	-	-	-	-
<i>Rhaphoneis surirella</i>	-	-	-	-	-	-	1	-	-	-
<i>Actinoptychus undulatus</i>	-	-	1	1	1	2	-	3	-	-
<i>Diploneis incurvita</i>	-	-	-	-	-	-	-	1	-	-
<i>Navicula cancellata</i>	-	-	-	-	-	-	-	1	1	-
<i>Nitzschia granulata</i>	-	-	-	-	1	-	-	-	-	-
<i>N. panduriformis</i>	-	-	-	-	-	-	-	1	-	-
<i>Pinnularia ambigua</i>	1	-	-	-	-	-	-	-	-	-
<i>Surirella fastuosa</i>	1	-	-	2	1	-	1	2	-	-
<i>Trachyneis aspersa</i>	-	-	-	1	1	-	1	2	-	-
<i>Grammatophora oceanica</i> v. <i>G. serpentina</i>	-	-	1	1	-	1	-	1	-	-
<i>Flagiogramma staurophorum</i>	-	-	-	1	-	-	-	-	-	-
<i>Podosira stelliger</i>	-	-	2	-	-	-	1	-	1	-
<i>Coccinodiscus apiculatus</i>	-	-	1	-	-	-	-	-	-	-
<i>C. nitidus</i>	-	1	1	-	-	-	-	-	1	-
<i>Diploneis bombus</i>	-	1	-	-	-	-	-	-	-	-
<i>Melosira sulcata</i>	-	-	12	9	9	2	3	5	1	-
<i>M. westi</i>	-	-	7	2	-	-	-	-	-	-
Total valves	21	27	115	92	111	19	39	100	105	10

## YBS 3; Diatom Counts

Co-ord 50° 42' 10" N  
01° 29' 56" WGrid ref. SZ 3538 8939  
Fieldwork 801115

Level	8	7	6	5	4	3	2	1
Height m.O.D.	-3.97	-3.99	-4.01	-4.03	-5.87	-5.89	-5.91	-5.93
Depth cm.	-477	-479	-481	-483	-667	-669	-671	-673
<i>Pinnularia baltica</i>	-	-	-	-	-	1	-	-
<i>P.gentilis</i>	1	-	-	4	-	-	-	-
<i>P.microstauron</i>	-	-	-	-	3	-	-	-
<i>P.minuta</i>	-	-	-	-	6	3	-	3
<i>Eunotia monodon v.bidens</i>	-	-	-	-	22	13	-	-
<i>E.praerupta</i>	-	-	-	-	24	15	-	2
<i>Amphora ovalis v.libyca</i>	-	-	-	2	-	-	-	-
<i>Diploneis ovalis</i>	4	-	7	5	10	3	1	-
<i>Navicula amphibola</i>	-	-	-	-	-	1	-	-
<i>N.pusilla</i>	-	-	-	2	4	4	3	2
<i>Achnanthes lanceolata v.vent.</i>	-	-	-	-	3	-	-	-
<i>Cymbella sinuata</i>	-	-	-	-	-	-	1	-
<i>Epithemia zebra v.porcellus</i>	-	-	-	3	-	-	-	-
<i>Eunotia tenella</i>	-	-	-	-	-	11	-	-
<i>Gomphonema intricatum</i>	-	-	-	-	-	1	2	-
<i>Meridion circulare</i>	-	-	-	-	-	1	-	-
<i>Stephanodiscus astrea</i>	1	-	-	-	-	-	-	-
<i>Nitzschia sigma</i>	-	-	-	-	2	2	1	-
<i>Diploneis interrupta</i>	2	3	13	1	110	121	22	126
<i>Navicula digitoradiata</i>	-	2	-	-	-	-	-	-
<i>N.elegans</i>	-	-	-	6	-	-	-	-
<i>N.peregrina</i>	13	2	23	90	2	-	-	-
<i>Nitzschia filiformis</i>	15	21	5	17	-	-	-	-
<i>N.navicularis</i>	5	7	4	-	10	12	20	19
<i>N.scalaris</i>	6	1	1	68	-	-	-	-
<i>Caloneis formosa</i>	22	28	42	-	-	-	-	-
<i>Rhopalodia gibberula</i>	2	-	21	-	-	-	-	-
<i>Nitzschia punctata</i>	8	7	3	-	-	3	-	1
<i>N.punctata v.constricta</i>	-	-	1	-	-	-	-	-
<i>Achnanthes brevipes</i>	-	-	9	-	-	1	-	-
<i>A.brevipes v.intremedia</i>	-	-	-	-	-	-	-	2
<i>Diploneis didyma</i>	11	5	1	-	-	1	-	2
<i>Navicula marina</i>	-	1	-	-	-	-	-	-
<i>Cocconeis scutellum</i>	2	-	1	-	-	-	-	-
<i>Rhaphoneis amphiros</i>	1	-	1	-	-	-	-	-
<i>Actinoptychus undulatus</i>	7	11	9	1	-	-	-	-
<i>Thalassiosira decipiens</i>	1	5	1	-	-	-	-	-
<i>Auliscus sculptus</i>	-	-	1	-	-	-	-	-
<i>Dimerogramma minor v.nana</i>	-	1	-	-	-	-	-	-
<i>Diploneis fusca</i>	-	-	1	1	-	-	-	-
<i>D.incurvita</i>	-	-	-	-	-	-	-	6
<i>Nitzschia granulata</i>	7	1	-	-	-	-	-	-
<i>Surirella recedens</i>	2	-	-	-	-	-	-	-
<i>Achnanthes septata</i>	-	1	6	-	1	1	-	-
<i>Cocconeis costata</i>	-	1	-	-	-	-	-	-
<i>Grammatophora oceanica v.mac.</i>	7	2	1	-	-	-	-	1
<i>G.marina</i>	-	1	-	-	-	-	-	-
<i>Grammatophora serpentina</i>	1	-	-	-	-	-	-	-
<i>Podosira stelliger</i>	4	1	1	-	-	-	-	1
<i>Coscinodiscus nitidus</i>	1	2	-	-	-	-	-	-
<i>Diploneis bombus</i>	-	-	2	-	-	-	-	-
<i>Melosira sulcata</i>	55	48	38	-	3	4	4	8
<i>M.westi</i>	4	10	6	-	1	1	1	4
Total valves	183	161	198	200	201	199	55	177

Co-ord. 50° 42' 05" N  
01° 30' 08" W

Grid ref. SZ 3515 8928  
Fieldwork 801116

Level	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height m.O.D.	-3.76	-3.80	-3.84	-3.88	-3.92	-3.96	-4.00	-4.04	-4.06	-4.10	-4.14	-4.18	-4.20	-4.24	-4.26
Depth cm.	-451	-455	-459	-463	-467	-471	-475	-479	-481	-485	-489	-493	-495	-499	-501
<i>Nitzschia subtilis</i>	11	3	5	1	8	10	6	-	4	-	-	-	-	-	-
<i>Pinnularia cardinalis</i>	-	-	-	-	-	-	-	-	-	1	-	12	10	16	40
<i>P.gentilis</i>	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
<i>P.interrupta</i>	-	-	-	-	-	-	-	-	-	-	-	-	8	7	3
<i>P.microstauron</i>	-	-	1	-	-	-	-	2	-	-	-	4	4	9	6
<i>Cymbella Bouleana</i>	-	-	-	-	-	-	-	-	-	-	-	4	2	41	24
<i>Eunotia diodon</i>	-	-	-	-	-	-	-	-	-	-	-	62	81	5	14
<i>E.monodon v.bidens</i>	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
<i>Fragilaria virescens v.ell</i>	-	-	-	-	-	-	-	3	-	-	-	19	15	82	63
<i>Amphora ovalis v.libyca</i>	1	-	-	-	-	-	1	9	1	-	-	-	-	-	1
<i>Anomooneis sculpta</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Diploneis ovalis</i>	-	3	2	1	17	-	15	-	2	-	2	3	2	12	17
<i>Navicula dicephala</i>	-	-	-	-	-	-	-	-	-	-	-	2	1	1	-
<i>N.gastrum</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
<i>N.gracilis</i>	-	-	-	-	-	-	1	-	-	-	-	2	4	-	-
<i>N.pusilla</i>	-	-	-	-	3	2	9	-	-	-	-	1	1	-	-
<i>Pinnularia maior</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Stauroneis phoenicentron</i>	-	-	-	-	-	-	-	-	-	-	-	3	2	4	4
<i>Surirella americana</i>	1	-	-	-	1	-	-	-	-	-	-	1	-	-	-
<i>Cocconeis placentula</i>	-	-	-	-	-	-	-	-	-	1	-	8	10	6	7
<i>Gomphonema intricatum</i>	-	-	-	-	-	-	-	-	-	-	-	4	3	-	-
<i>Meridion circulare</i>	-	-	-	-	-	-	-	-	-	-	2	1	1	-	-
<i>Cocconeis pediculus</i>	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Diploneis interrupta</i>	3	2	1	1	1	-	55	6	3	2	1	-	-	-	-
<i>Navicula digitoradiata</i>	1	2	1	1	1	1	11	-	2	1	3	-	-	-	-
<i>N.elegans</i>	-	-	-	-	-	1	-	2	3	-	8	3	2	-	-
<i>N.halophila</i>	-	-	-	1	1	7	-	-	-	1	1	-	-	-	-
<i>N.peregrina</i>	1	3	7	2	6	2	86	114	56	3	3	57	30	11	9
<i>Nitzschia bilobata</i>	-	-	-	-	1	-	3	-	-	1	-	-	-	-	-
<i>N.navicularis</i>	116	60	85	56	111	105	7	8	39	56	45	-	2	-	-
<i>N.scalaris</i>	-	2	2	-	-	-	3	43	20	8	1	3	2	-	1
<i>Surirella striatula</i>	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
<i>Galoneis formosa</i>	2	7	6	2	5	6	9	-	2	11	4	-	-	-	-
<i>Rhopalodia gibberula</i>	-	1	-	-	-	-	14	-	-	-	-	3	3	-	-
<i>Nitzschia punctata</i>	6	12	6	3	3	9	-	-	8	12	13	-	-	-	-
<i>N.punctata v.constricta</i>	-	-	1	1	1	1	-	-	-	2	1	-	-	-	-
<i>Scoliopleura tumida</i>	3	10	10	21	3	11	-	-	10	6	2	-	-	-	-
<i>Achnanthes brevipes v.int.</i>	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
<i>Diploneis didyma</i>	13	14	20	73	13	19	-	-	8	13	19	-	-	-	-
<i>Navicula abrupta</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
<i>N.Galikii</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>N.marina</i>	-	-	2	8	-	-	-	-	-	-	1	-	-	-	-
<i>Nitzschia acuminata</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
<i>Achnanthes longipes</i>	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cocconeis scutellum</i>	-	1	2	-	-	-	-	-	-	-	3	-	-	-	-
<i>C.speciosa</i>	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Diploneis smithi</i>	3	5	2	-	6	2	11	7	1	3	-	-	-	-	-
<i>Rhaphoneis amphiceros</i>	-	1	1	-	-	-	-	-	1	1	1	-	-	-	-
<i>Actinoptychus undulatus</i>	3	3	7	1	-	3	1	-	2	7	8	-	-	-	-
<i>Thalassiosira decipiens</i>	1	1	-	-	2	1	-	-	1	4	1	-	-	-	-
<i>Dimerogramma minor v.nana</i>	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-
<i>Diploneis fusca</i>	-	-	-	-	-	-	-	9	1	-	-	-	-	-	-
<i>Navicula hennedyi</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
<i>Nitzschia granulata</i>	5	6	4	2	2	-	-	-	5	3	1	-	-	-	-
<i>Surirella fastuosa</i>	-	-	-	-	-	-	1	-	1	-	1	-	-	-	-
<i>Trachyneis aspersa</i>	1	3	2	-	-	-	-	-	7	10	9	-	-	-	-
<i>Diploneis weissflogi</i>	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
<i>Grammatophora marina</i>	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
<i>G.oceanica v.macilentia</i>	2	2	2	-	-	-	-	-	-	4	5	-	-	-	-
<i>G.serpentina</i>	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Opephora pacifica</i>	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-
<i>Plagiogramma staurophorum</i>	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Podosira stelliger</i>	-	3	1	-	-	2	-	-	3	6	1	-	-	-	-
<i>Rhabdonema minutum</i>	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Coscinodiscus nitidus</i>	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-
<i>Diploneis bombus</i>	1	3	-	1	-	-	-	-	-	-	-	-	-	-	-
<i>Melosira sulcata</i>	24	38	25	17	11	19	14	-	29	42	57	8	14	-	-
<i>M.westi</i>	-	8	1	7	2	-	1	-	-	1	7	-	-	-	-
Total valves	201	199	199	199	200	202	209	203	210	202	203	206	200	201	205

YBS 9 Diatom Counts

LXXVII

Browdown 13/14 53; Diatom Counts

Grid ref. SZ 585 985

Level	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height m.OD.	-10.10	-10.18	-10.28	-10.38	-11.25	-11.35	-11.45	-11.85	-11.95	-12.05	-12.15	-18.90	-18.96	-19.03	-19.13
Depth cm	-460	-468	-478	-488	-575	-585	-595	-635	-645	-655	-665	-1340	-1346	-1353	-1363
<i>Pinnularia microstauron</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
<i>Diploneis ovalis</i>	-	13	28	4	-	-	-	2	-	-	-	-	-	-	-
<i>Fragilaria brevistriata</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
<i>Cocconeis pediculus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Diploneis interrupta</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2
<i>Navicula peregrina</i>	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
<i>Nitzschia navicularis</i>	12	33	51	31	40	50	110	104	26	17	32	64	136	84	120
<i>Caloneis formosa</i>	1	7	4	2	-	-	-	-	-	-	-	-	-	-	-
<i>Rhopalodia gibberula</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Nitzschia punctata</i>	14	6	10	1	4	9	11	7	4	3	6	10	6	7	22
<i>Diploneis didyma</i>	24	33	20	16	8	5	5	24	1	2	10	4	9	3	5
<i>Navicula marina</i>	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2
<i>Cocconeis scutellum</i>	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
<i>Diploneis smithi</i>	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-
<i>Rhaphoneis amphiceros</i>	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>R. surirella</i>	-	-	-	-	-	-	3	-	1	1	1	4	5	2	4
<i>Actinoptychus undulatus</i>	-	2	11	1	-	-	-	-	-	1	5	2	2	2	-
<i>Thalassiosira decipiens</i>	-	-	-	1	-	-	-	-	-	-	-	3	-	-	-
<i>Dimerogramma minor v.nana</i>	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-
<i>Navicula hennedyi</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Nitzschia granulata</i>	2	3	7	2	2	1	6	4	1	2	2	4	8	4	1
<i>Trachyneis aspersa</i>	-	9	4	10	-	-	-	-	-	-	-	-	-	-	-
<i>Diploneis weissflogi</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Grammatophora marina</i>	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-
<i>G.oceanica v.macilentia</i>	-	-	-	-	-	1	3	-	1	-	-	-	-	-	-
<i>G.serpentina</i>	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-
<i>Opephora marina</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
<i>O.pacifica</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
<i>Plagiogramma staurophorum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Podosira stelliger</i>	-	-	-	-	4	4	3	4	-	2	5	-	-	-	-
<i>Coccinodiscus nitidus</i>	-	-	1	-	1	-	-	-	-	-	-	2	4	1	11
<i>Diploneis bombus</i>	-	-	-	-	-	-	2	1	-	-	3	-	-	-	-
<i>Melosira sulcata</i>	23	81	53	25	8	18	28	18	15	17	42	50	25	27	19
<i>M.westi</i>	5	4	3	1	2	2	4	9	6	2	4	6	3	-	-
Total valves	86	192	199	95	69	91	179	173	57	50	111	150	200	130	187

Browdown 13/14 53 Diatom Counts

Xlil



Pett Level 4; Pollen Counts

Co-ord. 50° 53' 14" N  
00° 41' 15" E

Jrid ref. TQ 8903 1331  
Fieldwork 820924

Level	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Height m.O.D.	+0.02	-0.02	-0.05	-0.07	-0.10	-0.14	-0.22	-0.28	0.33	-0.35	-0.37	-0.38	-0.43	-0.49	-0.53	-0.57	-0.63	-0.67	-0.71	-0.77	-0.79	-0.81
Depth cm.	-1	-5	-8	-10	-13	-17	-25	-31	-36	-38	-40	-41	-46	-52	-56	-60	-66	-70	-74	-80	-82	-84
Betula	17	16	18	20	17	18	5	23	8	26	14	17	8	7	12	7	10	7	6	12	9	10
Pinus	-	-	-	-	3	1	-	-	-	-	1	-	-	-	1	-	3	-	1	-	2	1
Ulmus	-	1	1	1	1	1	-	1	-	-	1	-	1	-	1	1	2	-	3	-	1	-
Quercus	15	10	7	10	11	8	12	14	16	11	11	14	18	10	14	20	22	31	15	7	18	23
Tilia	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2	-	-	5	1	2	7	4
Fraxinus	1	6	1	3	1	-	2	-	2	2	1	2	1	2	-	-	2	3	1	1	1	1
Fagus	1	1	2	1	2	1	2	2	3	2	-	-	2	-	2	3	-	-	-	-	-	-
Carpinus	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus	206	107	243	228	94	214	147	303	412	414	421	396	220	306	248	95	209	278	366	401	324	351
Corylus	16	11	18	25	17	23	24	43	22	12	19	25	27	33	37	71	40	45	28	34	40	34
Lonicera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhamnus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	2
Ilex	-	1	1	-	-	-	-	5	-	-	1	-	-	1	-	-	-	1	-	-	-	1
Frangula	1	3	1	1	3	1	-	-	1	-	-	-	-	-	1	3	1	1	2	-	2	-
Hedera	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-
Calluna	-	-	2	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viburnum	-	-	1	2	3	-	1	1	-	-	-	2	2	2	-	4	6	6	4	13	3	-
Salix	136	244	101	105	161	126	64	3	1	4	4	8	21	38	97	77	23	10	3	3	37	9
Gramineae	25	28	38	40	75	60	54	34	11	4	7	7	48	40	32	70	34	26	10	9	4	3
Cyperaceae	69	56	45	31	55	22	128	38	6	12	8	10	88	29	20	101	67	11	21	9	39	48
Compositae tub.	1	-	3	2	9	1	4	-	-	-	-	-	3	1	-	10	9	-	-	-	-	-
Centaurea	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Compositae lig.	-	-	1	-	1	-	3	-	-	-	-	-	2	-	-	1	4	1	-	-	-	-
Artemisia	-	-	-	-	2	-	-	1	-	-	-	-	1	-	1	-	-	5	-	-	-	-
Ranunculus-type	4	1	2	4	8	4	6	5	5	7	4	5	6	3	10	2	5	18	9	2	4	7
Caltha-type	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-
Cruciferae	-	-	-	2	-	-	1	1	-	-	-	-	-	1	1	-	4	-	-	-	-	-
Caryophyllaceae	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Chenopodiaceae	-	-	-	-	1	-	-	1	1	-	1	-	3	1	3	3	3	2	-	1	1	-
Leguminosae	-	-	-	3	-	1	-	-	-	-	-	-	3	2	2	-	-	-	-	-	-	-
Rosaceae	-	1	-	1	1	1	1	-	-	-	-	2	1	-	-	-	1	1	1	-	-	-
Filipendula	2	5	1	6	20	3	14	16	8	3	4	8	25	15	7	21	30	32	15	2	-	3
Potentilla-type	-	3	-	-	1	-	1	-	-	-	-	-	-	-	1	1	7	1	-	-	1	-
Lythrum	-	-	-	1	4	1	-	-	-	-	-	1	1	-	-	-	1	1	-	-	1	2
Hydrocotyle vulgare	-	-	-	1	-	-	-	-	-	-	-	-	3	-	-	-	1	-	-	-	-	-
Umbelliferae	1	2	5	1	4	2	12	1	2	1	-	-	3	1	2	-	1	2	3	-	1	-
Rumex	3	-	2	4	1	2	7	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glaux	-	-	-	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Convolvulus	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calystegia	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Plantago lanc.	2	3	5	6	2	5	7	1	1	-	-	3	5	3	3	6	8	8	3	2	1	-
Plantago maj/med.	-	1	-	-	1	-	2	-	-	-	-	-	-	-	1	3	5	1	-	-	-	-
Wahlenbergia	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	2	1	-	-
Galium	-	-	1	-	-	1	2	1	-	-	1	-	4	2	1	1	-	-	-	-	-	1
Succisa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myriophyllum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Alisma	-	-	-	-	2	1	-	-	-	-	-	-	1	1	2	-	-	-	-	-	1	-
Potamogeton	-	-	-	-	2	-	-	-	-	-	-	-	1	1	-	-	5	-	1	-	-	2
Typha latifolia	1	-	-	1	1	-	-	-	-	1	-	-	20	-	1	-	3	1	-	-	-	-
Typha angustifolia	3	1	8	13	61	22	27	7	2	7	5	14	-	37	23	18	44	35	45	19	25	13
Osmunda	-	-	-	-	-	-	2	5	4	1	5	3	-	19	14	34	40	58	7	4	8	8
Pteridium	-	3	5	11	13	3	17	11	4	1	4	-	-	1	2	1	1	-	-	2	1	8
Polypodium	-	-	-	-	1	-	1	3	-	1	-	-	-	-	1	1	1	-	-	-	-	1
Sphagnum	-	-	-	-	-	-	-	-	19	27	20	24	-	11	4	16	11	4	9	5	10	11
Filicales	16	5	3	12	44	11	6	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Pilularia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium	33	22	24	15	36	15	30	16	9	11	13	15	35	52	41	39	59	67	55	27	34	24