QUATERNARY RESEARCH ASSOCIATION

FIELD GUIDE

EAST YORKSHIRE & NORTH LINCOLNSHIRE

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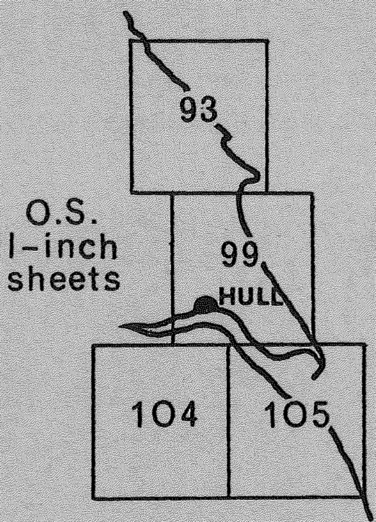

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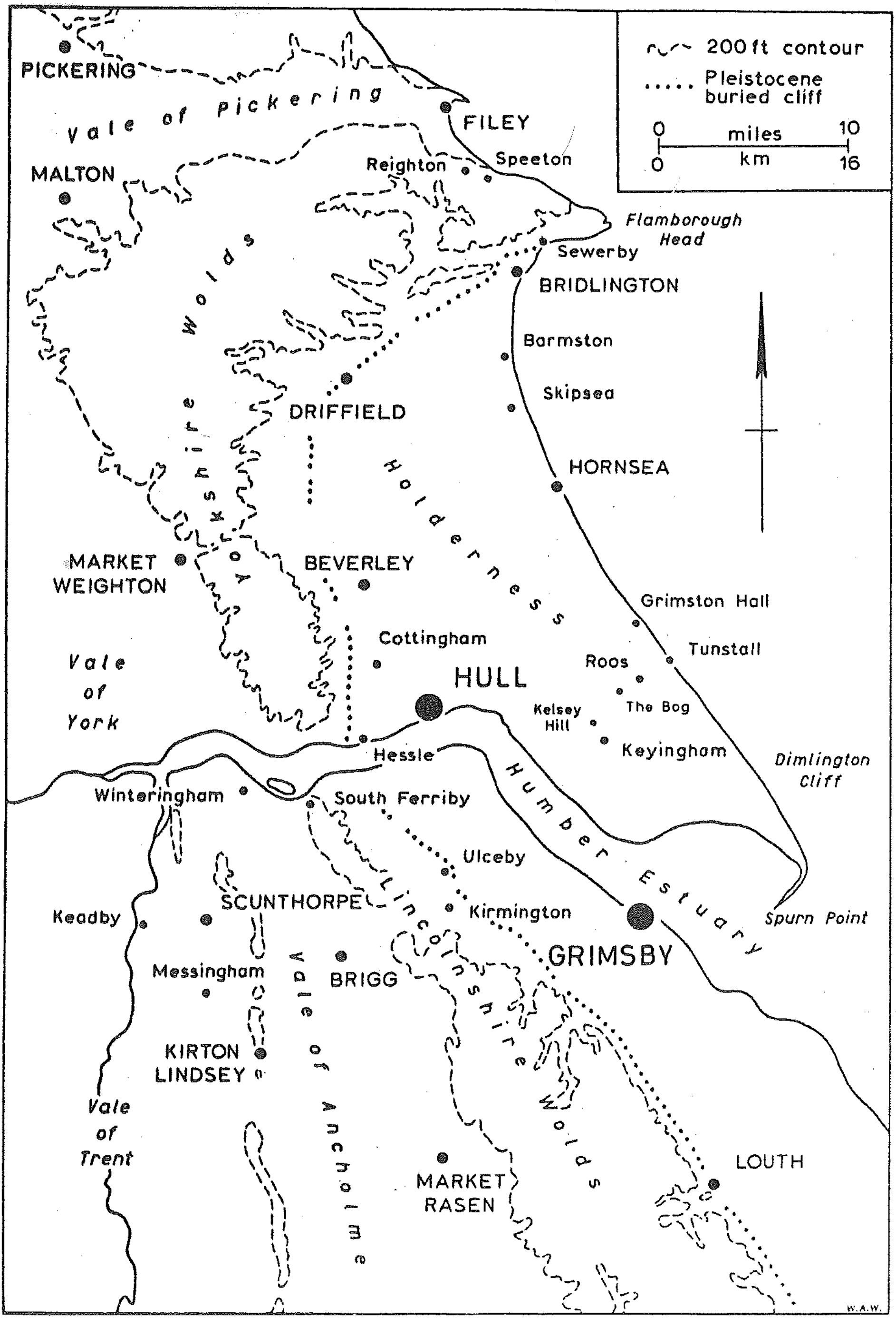

Fig. 1. Locality map.

INTRODUCTION

East Yorkshire and Lincolnshire form a natural region of Quaternary history, fortuitously divided by the Humber. This obstacle (social no less than physical) has often resulted in research in the two counties proceeding at different rates, and sometimes along different lines; one of the aims of this meeting will be to bring out the essential unity of the region, and perhaps to lay the foundations of a uniform terminology.

The best starting point in a summary of this sort is the Pleistocene Buried Cliff which runs along the eastern foot of the Wolds. This is exposed at Sewerby, was formerly seen at Hessle, and can be located at many places from borehole records in both Lincolnshire and Yorkshire; it is shown on the locality map (fig.1) by a dotted line. This is generally agreed to belong to the Last Interglacial by virtue of its low altitude and the mammalian fauna in the beach deposits associated with it. It is, in other words, the shoreline of the Eem Sea.

From this agreed datum we may now work upwards, and later downwards, in the succession. The deposits which conceal the buried cliff are a series of tills and associated sediments, which are responsible for the "Newer Drift" relief of Holderness and the Lincolnshire Marsh, and must by any criterion be Weichselian. In Yorkshire they are divided into three (in ascending order, the Drab, Purple and Hessle Tills), and in Lincolnshire into two (the Lower and Upper Marsh Tills).

The precise phase to which the Drab, Purple and Hessle Tills belong is indicated by the recent radiocarbon dates from the Dimlington Silts, which immediately underlie the Drab Till and are dated at around 18,000 B.P. (Penny, Coope and Catt, 1969). The entire Weichselian till sequence of Holderness therefore belongs to the now well documented ice advance which came toward the end of the Weichselian and is variously known as Upper Pleniglacial, Late Devensian, or Main Würm. In Lincolnshire, the same may be said of the Upper Marsh Till, but the position of the Lower Marsh Till is still unresolved.

During its advance down the east coast and into the Holderness embayment, this ice had apparently passed over a great deal of shelly (littoral) Eemian sediments. These were incorporated by the advancing ice and eventually reappear in many of the Weichselian outwash

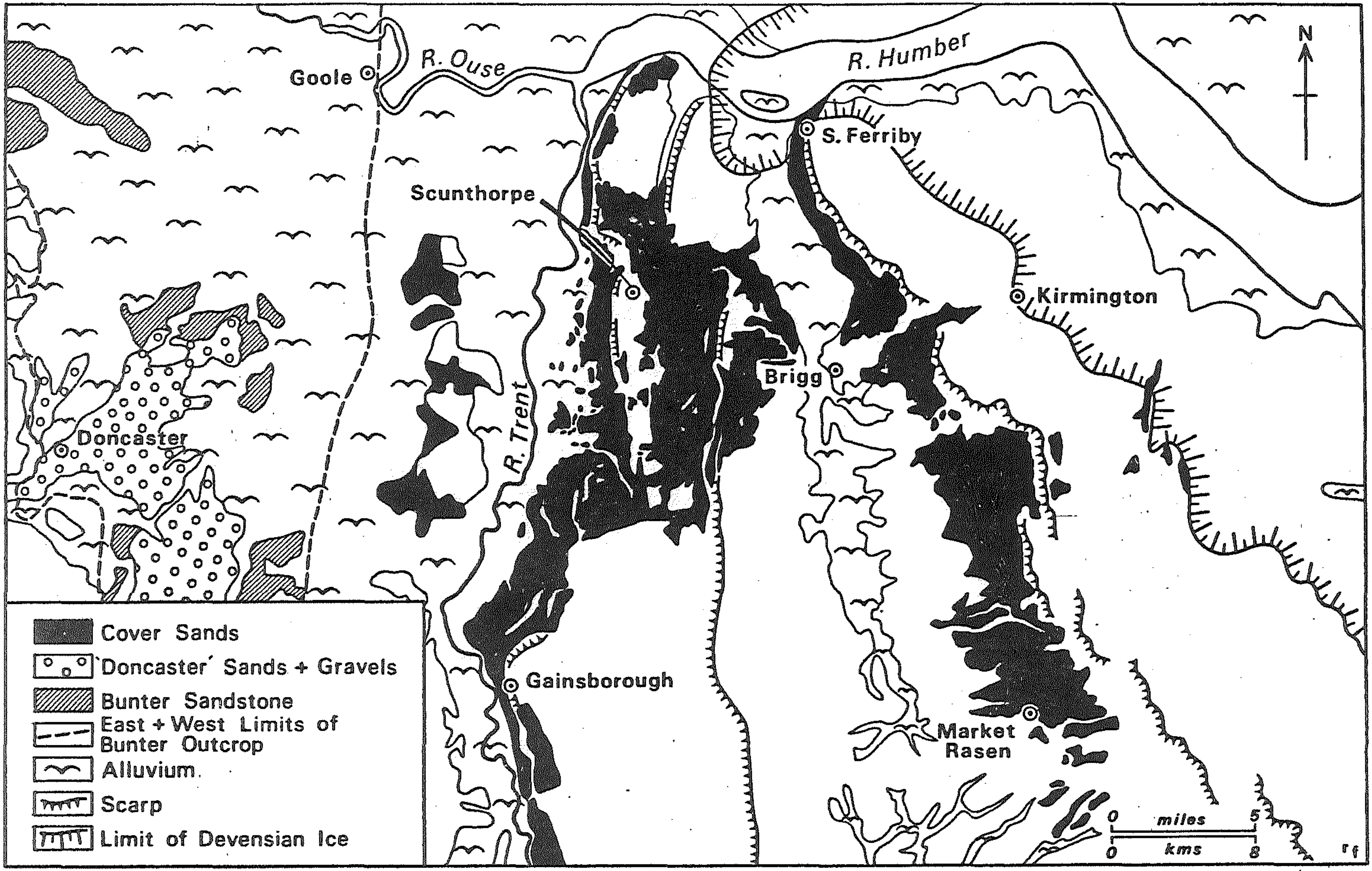

Fig. 2. Quaternary features of North Lincolnshire.

sands and gravels of Holderness and North Lincolnshire. Almost all of these contain a few shells, but for some reason they are most abundant in the Kelsey Hill Gravels, which form a low ridge (? esker) near Keyingham. As well as the predominantly shallow-water marine shells, they contain abundant Corbicula and occasional mammalian bones, all suggestive of the Last Interglacial.

Outside the limits of the Weichselian ice sheet, periglacial conditions produced a variety of features and sediments which still await detailed investigation. The most extensive deposits are the Cover Sands of north-west Lincolnshire (Straw, 1963). Fig.2 indicates their approximate extent, based on the Old Series sheets of the Geological Survey map of the late 19th Century. They comprise a broken sheet of grey and yellow sands, particularly expansive at and south of Scunthorpe, with extensions south along the lower slopes of the Jurassic escarpments. Similarly, the Cretaceous escarpment south from the Humber to Market Rasen rises above a zone of variable width of sands and fine gravels. Some of these are of glacifluvial origin, but aeolian sands predominate. The sediments clearly post-date not only deposition of, but also much dissection of the Saale [Wolstonian] tills of N.W. and central Lincolnshire, and pre-date the accumulation of Trent and Ancholme Alluvium, which began at least as early as Zone VIIa (Smith, 1958). The disposition of the Cover Sands against major relief features alone testifies to the influence of westerly winds, and although mineralogical analysis has not yet been attempted, the gravel areas and Trias outcrops around Doncaster may be suspected as a general source for the sand. In several localities the basal layers of the Sands are cryoturbated, and on the Wolds, pockets of sand occur in abandoned meltwater channels of Devensian age.

At South Ferriby, exposures of sand intercalated and intermixed with chalk rubble occur in the low cliffs fronting the Humber shore. The rubble is a soliflual slope deposit, producing a narrow shelving terrace, and it overlies Devensian till.

Elsewhere, and especially on the Wolds, the effects of cambering, cryoturbation and solifluction have been frequently observed, affecting 'solid' rocks and surficials alike. These periglacial manifestations are most common west of the maximum Devensian limit as indicated by the upper border of tills and by meltwater channels on the Wolds. Such geographical contiguity of regions characterized by either glacial or periglacial deposits and landforms strongly suggests the broad contemporaneity of these features.

This Latè Devensian glaciation in East Yorkshire and Lincolnshire lasted, in all probability, no more than four or five thousand years, for north Lancashire was ice-free by about 14,000B.P. and southern Scotland probably by 13,000 B.P. As the ice retreated, it left a series of morainic ridges (Killingholme-Hogsthorpe in Lincolnshire; Sutton, Sproatley, Roos etc. in Yorkshire), some of which may represent minor readvances; and on this undulating surface kettle holes and other enclosed hollows developed. One such hollow is The Bog, near Roos, where sedimentation has been continuous since pre-Allerød times; others are occasionally seen in the cliffs as marine erosion cuts into them.

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We may now return to our datum, the Eemian buried cliff, and work backwards from there. Below the Weichselian tills (and below the Dimlington Silts, where they are present) is another till, the dark grey Basement Till which has, in places, a leached upper surface. Except that it is older than the Silts, there is no field evidence at Dimlington as to the age of this till. But at Sewerby it must have been planed off by the sea which cut the Eemian buried cliff, because here the fossil beach shingle is occasionally seen lying on an eroded surface of the Basement Till. The till is therefore Saale [Wolstonian] or earlier. It encloses erratic lenses of marine sand and clay (Bridlington Crag of Bridlington, Sub-Basement Clay of Dimlington) which probably represents the marine sediment (? Hoxnian) over which the Basement ice advanced (Catt and Penny, 1966).

Apart from outliers of Basement Till on the Flamborough peninsula, no clear evidence of this glaciation has been seen inland in East Yorkshire; but in Lincolnshire much more is known of it (Straw, 1969a). There it deposited on and westward of the Wolds, in a typical "Older Drift" situation, four different tills. The ice advanced from the N or NNW, roughly along the strike of the Mesozoic rocks, so that the tills, though contemporary, each have their own characteristic lithology and erratic content - to the east the Calcethorpe Till (intensely chalky); west of this, the Belmont Till (Lower Cretaceous predominating); then the Wragby Till (mainly Upper Jurassic, with some Middle Jurassic to the west); and finally the Heath Till (Lower Jurassic). The last three pass into one another and are merely different facies of one lobe that deployed from the Vale of York. The

Calcethorpe Till, however, may have been laid down by a separate (though roughly contemporaneous) lobe that approached Lincolnshire from the north, and sometimes locally overlies the Belmont.

Of the Hoxnian Interglacial, which preceded the deposition of these tills, less is known. The Kirmington Interglacial Deposits belong either here (Catt & Penny, 1966; Boylan, 1966a) or in the Last Interglacial (Straw, 1969). There is similar doubt about the age of the Speeton Shell Bed, which is overlain by the Basement Till (Catt & Penny), but contains pollen that may be Ipswichian (West, 1969). A marine deposit, probably of Hoxnian age, has been found on the bed of the North Sea some 20 miles off the Lincolnshire coast (Fisher, Funnell and West, 1969), but it is too soon to speculate on its palaeogeographical relationship to other Hoxnian deposits.

The earlier history of the area is recorded more by erosional features than depositional. Straw (1961a) has described five dissected erosion surfaces in the Lincolnshire Wolds, of which one is almost certainly marine (the Kelstern Surface, running up to a bench at 420 ft.) and another may be partly marine (the Burnham, at about 220 ft.). In Yorkshire, Lewin (1969) has described eight, of which one, or possibly two, are marine (650 ft. and 375 ft.). But the dating of such planation surfaces remains speculative, and is complicated by problems of subsequent denudation and the possibility of tectonic movement along various late Tertiary (or early Quaternary ?) lines such as the Audleby Monocline and the Humber Fault. By comparison with south-east England, the "650-foot surface" of the Yorkshire Wolds may be a correlative of the bench in the Chilterns and the Downs on which rest deposits correlated with the Red Crag of East Anglia. The crest of the Lincolnshire Wolds is clearly planed at c.500 ft. O.D. in several places (parts of the High Street - Bluestone Surface) producing 'feather-edges' of Chalk, and it is considered that such planation was more likely the work of a transgressive late Pliocene sea than a regressive early Pleistocene one (Straw, 1970). The Kelstern Surface (420-380 ft.) in the central Lincolnshire Wolds and the Burnham Surface (220-180 ft.) in the north Lincolnshire Wolds suggest later marine transgressive phases (probably early Pleistocene). The only firm statements that can be made are that remnants of planation surfaces exist in both the Yorkshire and Lincolnshire Wolds, and that such surfaces, down to and including the Brocklesby Park Surface (130-80 ft.) in north-east Lincolnshire predate the Wolstonian Glaciation.

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It is not our purpose in this Guide to pretend that we have all the answers to the glacial history of Yorkshire and Lincolnshire. Instead, we finish our introduction by putting a number of questions which members may like to ponder during the meeting, and which suggest the directions in which further work will probably be aimed:-

1. Why are the Weichselian outwash gravels so much more shelly at Keyingham than anywhere else?

2. What is the correlation between the Drab-Purple-Hessle series of Yorkshire and the Marsh Tills of Lincolnshire?

3. What is the status of the break between the Lower and Upper Marsh Tills?

4. If the Basement Till (Yorkshire) and the Calcethorpe Till (Lincolnshire) are both Wolstonian, why are they so dissimilar?

5. What is the age of the Kirmington Interglacial?

6. What was the effect of closure of the Humber Gap, in terms of fluvial/lacustrine conditions to the west?

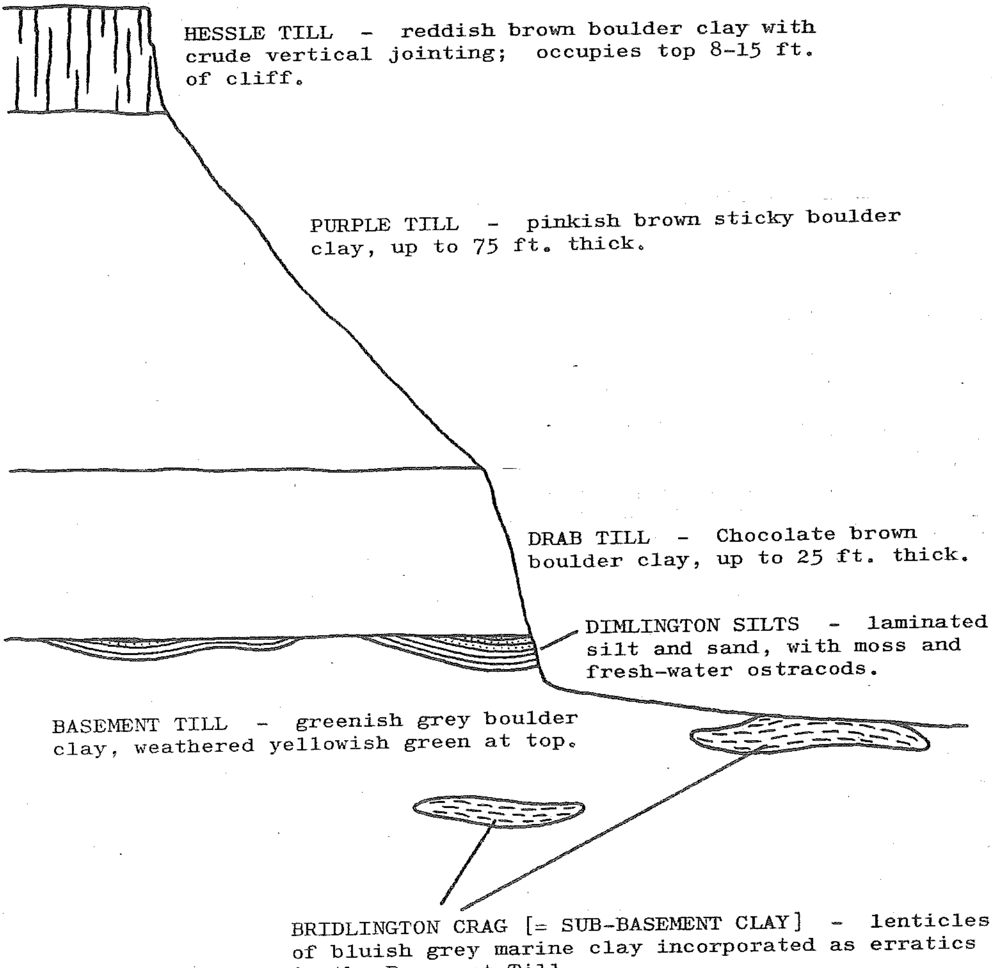


Fig. 3. Dimlington Cliff.

DIMLINGTON

The Dimlington - Out Newton cliff section is the best exposure of Pleistocene deposits in Yorkshire. The Basement Till (Saale) with its fossiliferous inclusions of Bridlington Crag [= Sub-Basement Clay] is almost always exposed, and the Drab, Purple and Hessle Tills (Weichsel) reach a maximum thickness of 100 ft. at Dimlington Cliff (Fig.3). We leave the coaches and descend the cliff about half a mile north of Easington (TA 399205).

Basement Till

The beach platform is here cut entirely in Basement Till and Bridlington Crag. The top of the till is at 5-20 ft. O.D. and is often visible in the base of the cliff and on the foreshore where beach deposits are thin or absent. Augering showed that the till is at least 40 ft. thick near Out Newton, and a borehole at Kilnsea (ca. 3 miles SSE of Dimlington) showed that it extends down to within 3 ft. of the Chalk at -105 ft. O.D. (Lamplugh, 1919).

The matrix of the till is dark greenish-grey; erratics include chalk, flint, magnesian limestone, Carboniferous limestones, Carboniferous and Middle Jurassic sandstones, and various igneous and metamorphic rocks from Scotland and Scandinavia. Stone orientation measurements between Dimlington and Out Newton show maxima ranging from NNE-SSW to WNW-ESE. The strongest WNW-ESE maxima occur in small folds near the top of the till, which were probably formed when the Weichsel glacier over-rode and contorted the Basement Till. This suggests that the original stone orientation and direction of ice movement were NNE-SSW, and that most of the Basement Till visible at Dimlington was reorganised by the Weichsel glacier (Penny & Catt, 1967). Contortions are sometimes seen in the till exposed on the beach platform, but they are difficult to detect in till of uniform colour and texture. At Sewerby, near Bridlington, the Basement Till is overlain by Eemian beach deposits indicating an interglacial sea level of 3-5 ft. O.D. If the till was planed by the Eemian sea, the height to which the till rises at Dimlington is anomalous, and again implies considerable modification of its eroded surface by the Weichsel glacier.

Near Out Newton the Basement Till contains large, undigested erratic masses of red-brown stoneless clay (possibly Keuper Marl) and stony, fossiliferous, blue-grey marine clay (Bridlington Crag).

Bridlington Crag [= Sub-Basement Clay]

The largest known mass of Bridlington Crag is over 350 ft. long and at least 15 ft. thick, and occurs about half a mile north of Dimlington Farm (TA 395224). Bisat

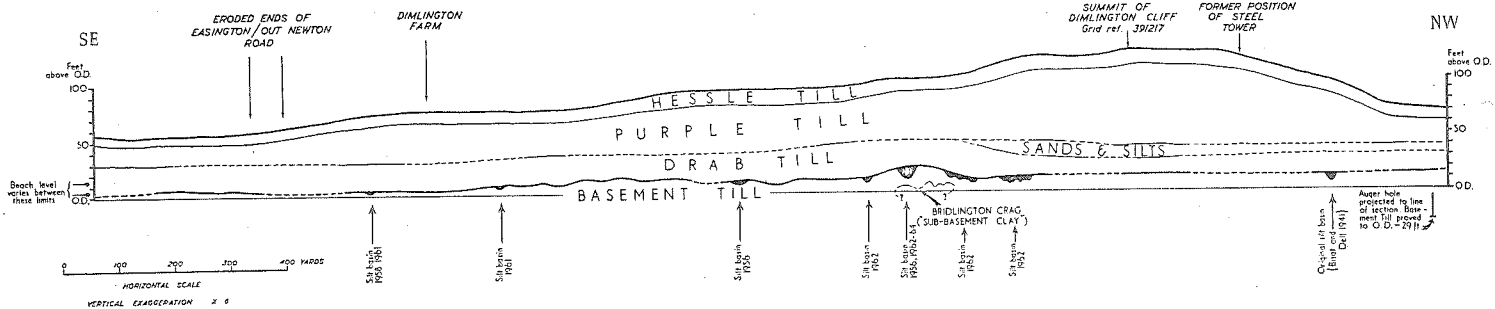


Fig. 4. Dimlington Cliff : longtitudinal section. Dimlington Silts shown in black.

(1939) called this deposit the "Sub-Basement Clay", but Reid (1885) had earlier noticed that its marine fauna is similar to that of erratic masses of glauconitic sand in the Basement Till at Bridlington. The blue clay at Dimlington and the glauconitic sand at Bridlington merely represent two facies of the sediment deposited on the floor of the North Sea before the Basement Glaciation, and both are now termed "Bridlington Crag".

The fauna at Dimlington is rich and indicative of fairly cold, shallow water. The commonest molluscs are Arctica islandica, Astarte semisulcata, Macoma balthica, Mya truncata, Dentalium entalis and Turritella tricarinata. However, many of the shells are broken, probably as a result of glacial transportation. The microfauna is well preserved, and comprises 30-40 species of foraminifera and 11 of ostracods; many are typical arctic forms.

The fauna includes very few extinct species, and is therefore not much older than the Basement Till. Together with the boreal nature of the fauna, this suggests that the Bridlington Crag was originally deposited during late Hoxnian times or an early Saale interstadial.

The erratics in the blue-grey clay differ from those of the Basement Till, as they are almost entirely Scandinavian (e.g. rhomb porphyries, larvikite) or Scottish, and many are partly rounded. This suggests they were mixed with the clay before it was removed from the sea floor by the Basement glacier. They were possibly dropped from floating ice, which had originated in the highlands of Scotland and Scandinavia, and had picked up river- or beach-worn cobbles.

Dimlington Silts

The surface of the Basement Till is irregular and locally discoloured by slight weathering. Many of the surface hollows are filled with fossiliferous silts (The Dimlington Silts); Fig.4 shows the location of the largest of these seen over the last thirty years. The macroflora of the silt consists mainly of moss remains, but there are also a few seeds of aquatic and near-aquatic plants (Eleocharis palustris, Menyanthes trifoliata, Potamogeton filiformis, P. alpinus, Daphnia ephippia, Batrachinus sp.). The fauna includes five species of freshwater ostracods and an impoverished mid-Weichselian coleopterid assemblage, which indicates that the silts were deposited under very cold conditions in ponds with little aquatic vegetation surrounded by open ground with mossy patches.

Samples of moss were radiocarbon dated by two different laboratories, which gave the following results: 18500 ± 400 years BP (Isotopes Inc.) and 18240 ± 250 years BP (Birmingham). The overlying Drab, Purple and Hessle

	HESSLE	PURPLE	DRAB	BASEMENT
1. Colour of till matrix (moist)	Reddish brown (5YR 4/3, 4/4, 3/3, 3/4)	Dark brown (7.5YR 3/2)	Very dark greyish brown (10YR 3/2)	Very dark grey (5Y 3/1)
2. Typical particle size distribution (Mean of:)	4 samples	4 samples	7 samples	7 samples
> 2000 μm (> - 1ϕ) Stones	4.8	3.5	5.2	2.3
250- 2000 μm (+2 to -1ϕ) Coarse Sand	6.2	4.4	8.4	6.4
63- 250 μm (+4 to +2ϕ) Fine Sand	19.5	13.9	22.1	22.0
16- 63 μm (+6 to +4ϕ) Coarse Silt	17.9	19.9	20.2	13.9
2- 16 μm (+9 to +6ϕ) Fine Silt	22.4	24.0	16.2	11.5
< 2 μm (< +9ϕ) Clay	29.2	34.3	27.9	43.9
3. Main types of erratic stones				
% Chalk and flint	10-30	10-20	20-30	10-20
% Red sediments and Magnesian Limestone	10-20	20-30	10-20	20-30
%Sandstones (not red)	30-40	10	30-50	10
% Shales (not red)	10	30-50	10-20	10
% Igneous and metamorphic rocks	20-30	10-20	10-20	40-50
4. Main differences in heavy minerals of fine sand (50-250 μm) fractions	More biotite, chlorite, zircon, chamosite and rutile than in Drab and Basement; siderite and pyrites rare.	More biotite, chlorite, zircon, chamosite and rutile than in Drab and Basement; siderite and pyrites common.	More limonite, haematite and sphene than in Basement; siderite and pyrites common.	More epidote, garnet and amphiboles than in Hessle, Purple and Drab; siderite pyrites fairly common.
5. Mineral composition of clay (< 2 μm) fractions				
% Expanding minerals (smectite and vermiculite)	35 (Ve > Sm)	50 (Sm > Ve)	50 (Sm > Ve)	55 (Sm > Ve)
% Mica	35	30	25	30
% Chlorite	5	5	5	5
% Kaolinite	25	15	20	10

Table 1. Lithological characteristics of the four tills exposed at Dimlington

Tills were therefore deposited between approximately 18000 and 13000 BP, because the Hessle Till is overlain at Roos, Star Carr (Walker and Godwin, 1954) and other localities by pre-Allerød deposits. They belong to the main glacial phase that occurred towards the end of the Weichsel (i.e. the Upper Pleniglacial of the Netherlands). The moss used for dating was Pohlia wahlenbergii cf. var. glacialis, which lives in cold water habitats such as glacial meltwater, and therefore suggests that the silts were deposited not long before the arrival of the Weichsel glacier.

In some of the hollows the silts pass up by alternation into yellow sand, which is probably windblown and indicative of dry, cold conditions in front of the advancing ice sheet. In places the deposits are contorted, with overfolds indicating a compressive force acting from NE to SW, the same as that responsible for contorting the Basement Till and re-orientating its stones. The fabric of the Drab and higher tills shows that the Weichsel glacier moved in this direction. The silt-filled hollows are not individual basins of deposition, but are probably remnants of what was originally a large shallow lake or marsh, the deposits of which were pushed in front of the Weichsel glacier, contorted and lifted on the disturbed Basement Till that formed the core of the push moraine, and eventually over-ridden.

Drab, Purple and Hessle Tills

These are distinguished ultimately by their erratic content, particle size distribution, heavy mineral content and clay mineral composition (Table 1). But in the field the best method is a careful comparison of their overall colour, which has proved to be reliable over long distances. The Drab (chocolate-brown) is 20-25 ft. thick along most of the Dimlington Cliff section, but thins northward beneath a bed of englacial sand which separates it from the overlying Purple. It is always distinguishable from the Basement Till by the fact that it is (a) browner, (b) more stony, and (c) contains many small pebbles of chalk.

The Purple and Hessle Tills are redder than the Drab, but contain fewer chalk erratics. The Purple (pinkish-brown) is ca. 70 ft. thick at Dimlington Cliff, but thins both north and south so that it forms a lenticular mass extending from Easington to Mappleton near Hornsea. As well as having a distinctive colour, it is much more sticky than the other tills and contains more visible fragments of red sandstone. It is separated from the Hessle in many places by thin sands or gravels, which are responsible for seepages near the top of the cliff. The Hessle Till forms the highest 8-15 ft. of the cliff. Apart from the highest 2-3 ft., it is vertically jointed throughout and has a coarse prismatic structure; the vertical cracks are lined with grey clay, but most of the till is a deep reddish-brown. These and other effects of post-glacial weathering in the Hessle Till are described in greater detail in the section on Soils.

Other Interesting Features

The coast erosion at Dimlington averages 5 ft. per year, and landslips are common. Along most of the Holderness coast the modern beach is in the form of NW-SE ridges oblique to the coastline. These are separated by troughs, known locally as "ords", which contain little or no beach deposit, and thus provide good exposures of the tills, etc. The ridges originate as off-shore bars, and are driven southwards approximately one mile per year by northerly storms. Where a ridge abuts on the coast the cliff is temporarily protected from wave action, but where an "ord" occurs the cliff-foot is subjected to vigorous erosion, resulting in over-steepening and instability. The cliff at any one point thus undergoes a cyclic process, in which, as the ridges move southward, periods of erosion and landslipping alternate with periods of relative stability.

The erratic stones in the tills and beach deposits are extremely varied, and are a ready source of numerous rocks from northern England, Scotland and Scandinavia, of fossil corals (Carboniferous), ammonites, belemnites, crinoids, etc. (Lias), and of semi-precious stones (jasper, agate, etc.). Armoured mud-balls composed of till eroded from the cliffs are also common on some parts of the shore.

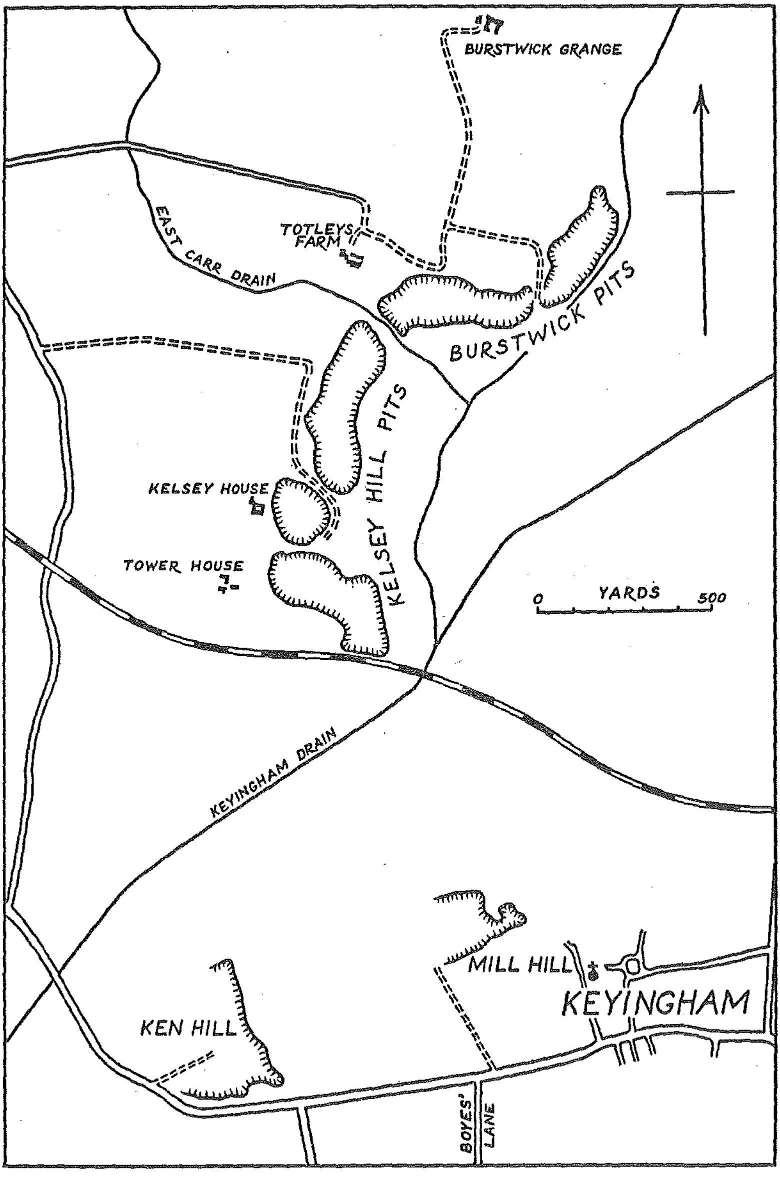


Fig. 5. Gravel pits in the Kelsey Hill area.

THE KELSEY HILL GRAVELS

The Kelsey Hill Gravels form a low sinuous ridge about 3 km. long, running NNE-SSW from Ridgmont (TA 245288) to Tower House (TA 236265). South of this they spread out to form a slightly lower and gently undulating area embracing the villages of Thorngumbald, Ryhill and Keyingham. They are a complex of light yellowish-brown water-lain gravels with subordinate sand and silt, often strongly current-bedded, and showing rapid changes of lithology both vertically and horizontally. The gravels take their name from the original workings at Kelsey Hill (TA 236267), but the best exposure at present is at Ken Hill (TA 236253) (Fig.5).

The form of the ridge suggests an esker, though one must admit that its morphological expression is weak compared with other eskers in the north of England. It is sinuous; transport of material was mainly along its axis (southward), but occasionally away from it on both sides; and it carries enclosed hollows on its surface. It lies on the Drab Till, but its relation to the Hessle Till is more complicated: in some places Hessle Till overlies the gravels, but in others, armoured mud-balls and larger lenticles of Hessle Till have been found in the gravels. Our conclusion is that the gravels were deposited during a late stage of the melting of the Weichselian ice sheet, when the ice had retreated to a line passing roughly through Ryhill and Keyingham. The Drab had already melted out; the Hessle was in the process of melting (hence sometimes on and sometimes in the gravels); the sinuous part represents the esker proper, and the "hammer-head" its sub-aerial continuation (Catt & Penny, 1966).

The particular interest of the gravels lies in the assemblage of derived fossils they contain. There are over 50 species of marine Mollusca of generally temperate type and littoral to sub-littoral habitat, i.e. very much what one could pick up around the coasts of Britain today - Cardium, Mytilus, Macoma, Ostrea, Buccinum, Littorina, Nassa etc. - though perhaps a shade more northerly than the present Yorkshire coast (Cambridge, in Penny & Rawson, 1969). Added to this, one fresh-water species, Corbicula fluminalis (fairly common), which nowadays has a restricted distribution in certain rivers of North Africa, Iraq, Persia, Kashmir etc. There is also a miscellaneous collection of vertebrate remains (Penny, 1963) which range climatically from mammoth, reindeer and bison to the much warmer straight-tusked elephant and dicerorhine rhinoceros (Table 2). Clearly it is a mixed assemblage but, as Lamplugh asked nearly 50 years ago, "Whence came they?".

Table 2. Consolidated list of mammalian species that have been unequivocally identified from the Kelsey Hill Gravels (up to 1971).

Proboscidea	Palaeoloxodon antiquus Mammuthus primigenius
Perissodactyla	"Dicerorhinus" hemitoechus
Artiodactyla	Sus scrofa Rangifer tarandus Cervus elaphus Megaceros giganteus Bison priscus Bos taurus Bos primigenius
Carnivora, Pinnipedia	Halychoerus grypus Odobenus rosmarus

This list does not include the many identifications which have been taken to the level of family or genus only, nor those about which any uncertainty exists, nor secondary determinations such as "hyaena gnawings".

The "warm" vertebrates are few in number, and could be Eemian or Hoxnian (but not earlier). The "cold" ones could be anyting from Saale to Mid-Weichsel. Corbicula, when found in abundance (as it is at Kelsey Hill), is strongly suggestive of Eemian, though it also occurs sparingly in earlier interglacials. The marine Mollusca could strictly be Hoxnian or Late Eemian, but not Eemian optimum, when the fauna was augmented by southern species which are not found in the Kelsey Hill Gravels. There is a similar molluscan fauna in Late Eemian deposits around the Ems estuary (Dechend, 1958), and the proportion of extinct species in the Kelsey Hill Gravels (1 out of 55) is nearer to the Eemian figure of 2% given by Van der Vlerk & Florschütz (1950) than the Needian [Hoxnian] figure of 8%. On balance, Eemian to Mid-Weichselian seems the most likely age for the assemblage as a whole.

Since the gravels are intimately associated with the Weichselian (Late Devensian) tills, it seems probable that the advancing ice incorporated the shells and vertebrate remains from Eemian and early Weichselian deposits over which it passed, and that they were subsequently washed out to form the Kelsey Hill esker. Unfortunately, though shells and vertebrate remains are occasionally found in the Weichselian tills, none sufficiently rich to be called a "shelly" till, nor containing anything like the number of species required to provide the Kelsey Hill fauna, has ever been seen in Holderness. (There is no question of deriving the Kelsey Hill Mollusca from the shelly inclusions in the Basement Till, which are much more arctic and do not contain Corbicula).

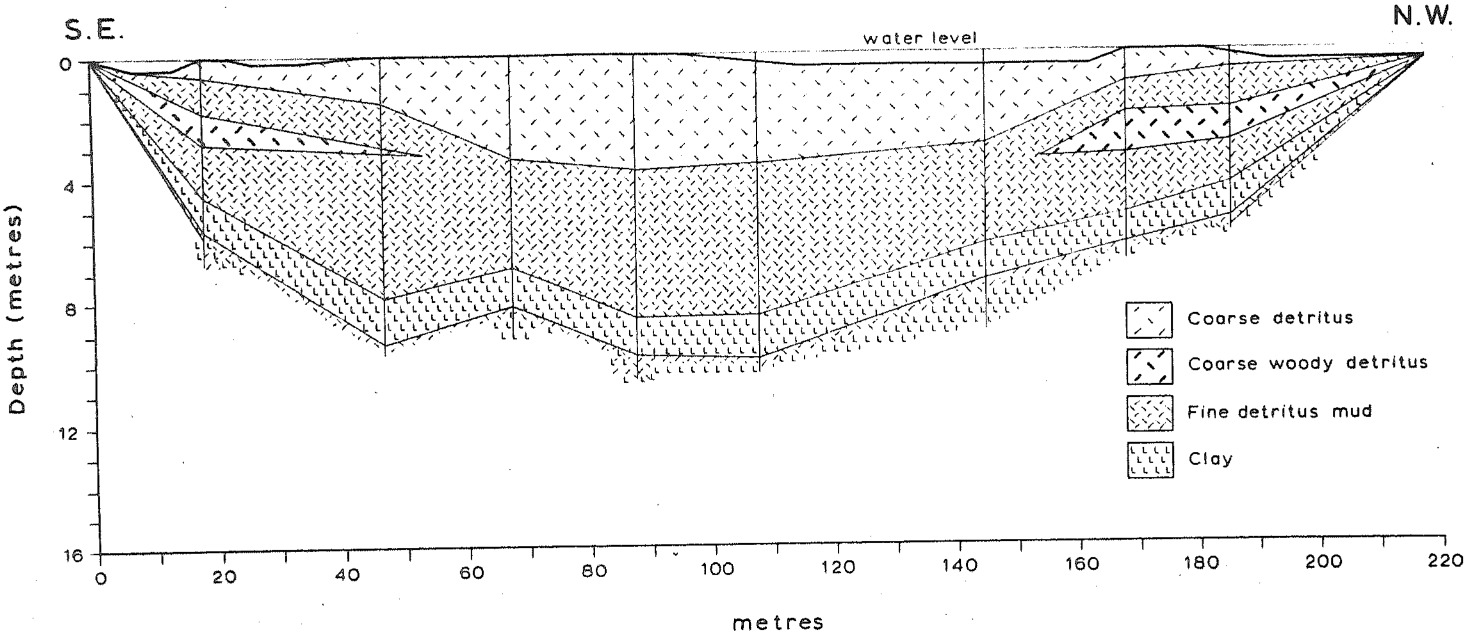


Fig. 6. The Bog, Roos.

THE BOG, ROOS

The Bog, Roos (TA 274288) lies in outwash deposits laid down in the Late Devensian. Roughly pear-shaped, with its long axis not more than 300 m. in length, it is almost entirely enclosed by the 25' contour. This rim isolates The Bog from the valley of Sand-le-Mere, a former mere of much larger size. Aerial photographs taken in 1946 show The Bog to be dry and well-wooded with Oak, Birch and Larch. There is an outflow from The Bog through a pipe, draining to the north-east, suggestive of earlier attempts at drainage. Excavations by the owner at one end of The Bog in recent years have resulted in the flooding of the site to an average depth of 20-30 cm., and the death of the former tree cover.

Valentin (1957) described The Bog as a basin excavated by ice. However, the depth of the deposits (up to 10½ metres) suggests that the site is a kettle hole. The lowest deposits probably lie on the Hessle Till, so that a likely maximum age for them would be about 13,000 B.P.

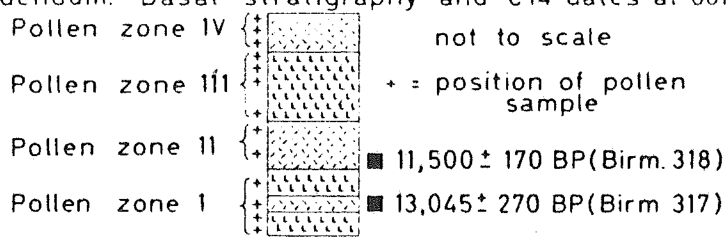
The lowest sediments consist of pinkish grey clays alternating with detritus muds (Fig.6). Three distinct clay bands and two organic bands are distinguishable. The upper clay band contains fragments of the moss Fontinalis antipyretion, which usually grows submerged in open water. The lower clay has fragments of the moss Leptodictyum sp., a moss favouring lowland habitats near water. Above the top clay is a thick layer of detritus mud, formed in open water conditions, containing some well-preserved fragments of leaves of Willow and Birch. Above this is a swamp deposit of fibrous detritus with plentiful plant fragments.

The clays appear to be formed by solifluction, and they and the detritus mud look like late-glacial deposits. Preliminary pollen analysis has confirmed the presence of zone II- and III- type pollen spectra in the upper detritus mud and upper clay layer, respectively. The presence of the lower organic layer which may be pre-zone II means that pollen analysis and radiocarbon dating of these lower levels in particular (about to commence at the time of going to print) is of particular interest.

Erratum

For Fontinalis antipyretion read F. antipyretica

Addendum. Basal stratigraphy and C14 dates at 88m



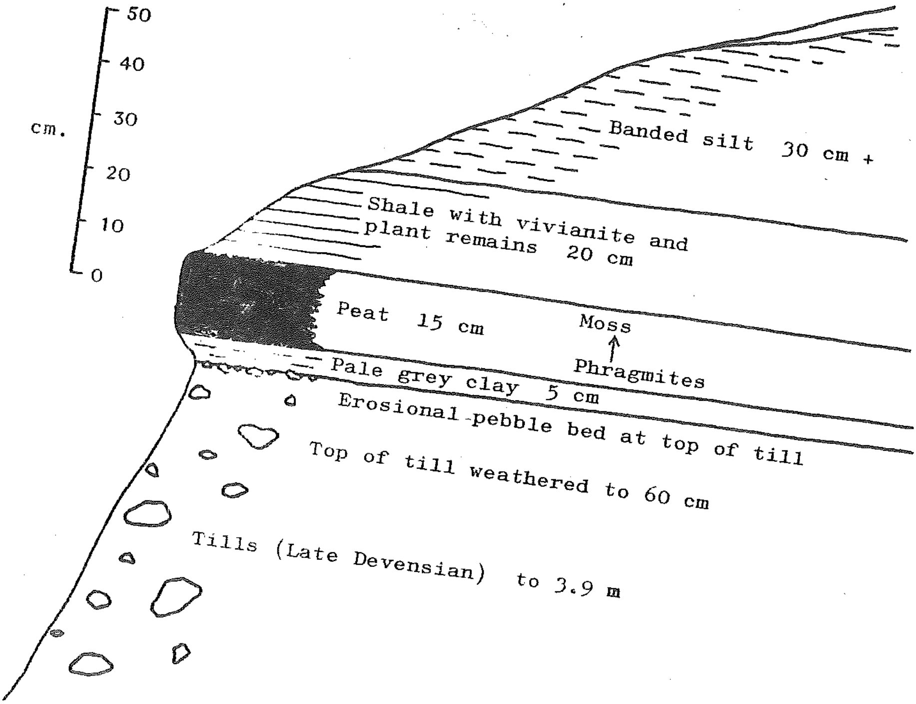


Fig. 7. Grimston Hall. Section in rotated block at foot of cliff.

GRIMSTON HALL

On the coast opposite Grimston Hall (at TA 289352) a channel in the surface of the Late Devensian tills is being exposed by modern marine erosion. The channel contains, among other things, a peat bed 15 cm. thick which is thought to be of Allerød age (unpublished pollen analysis by Miss R. Andrew). It is exposed in a rotated landslip block at beach level (Fig.7) and will also be seen _in situ_ in the cliff behind the slip.

The peat (lying on a thin rootlet bed of pale grey clay) is _Phragmites_- rich in its lower layers, passing up into solid mats of moss in which beetle remains are common. The mosses have been identified by Dr. J. Dickson as _Helodium blandowii_ (abundant), with subordinate _Aulacomnium palustre_ and _Acrocladium giganteum_.

The peat is overlain by 20 cm. of grey shale containing fragmentary plant remains and the iron phosphate Vivianite (bright blue spots). Laboratory experiments by Dr. Kuhn at Rothamsted have shown that the conditions necessary for vivianite formation are the availability of ferrous and phosphate ions in a neutral or slightly acid solution, and a temporarily anaerobic environment. White amorphous ferrous phosphate is precipitated initially, and slowly crystallises, providing that these conditions remain unchanged. The blue colour appears when a return to aerobic conditions oxidises part of the ferrous iron to ferric.

The shale is finally overlain by 30 cm. of banded silt (90 cm. formerly seen).

Addendum

We are indebted to Prof. F.W. Shotton for the following radiocarbon dates from the peat bed at Grimston Hall:-

Birm-301. Moss peat, 12-14 cm above base of peat bed.
11,250 ± 170 B.P.

Birm-298. Leaves, 6-7 cm above base of peat bed.
12,230 ± 120 B.P.

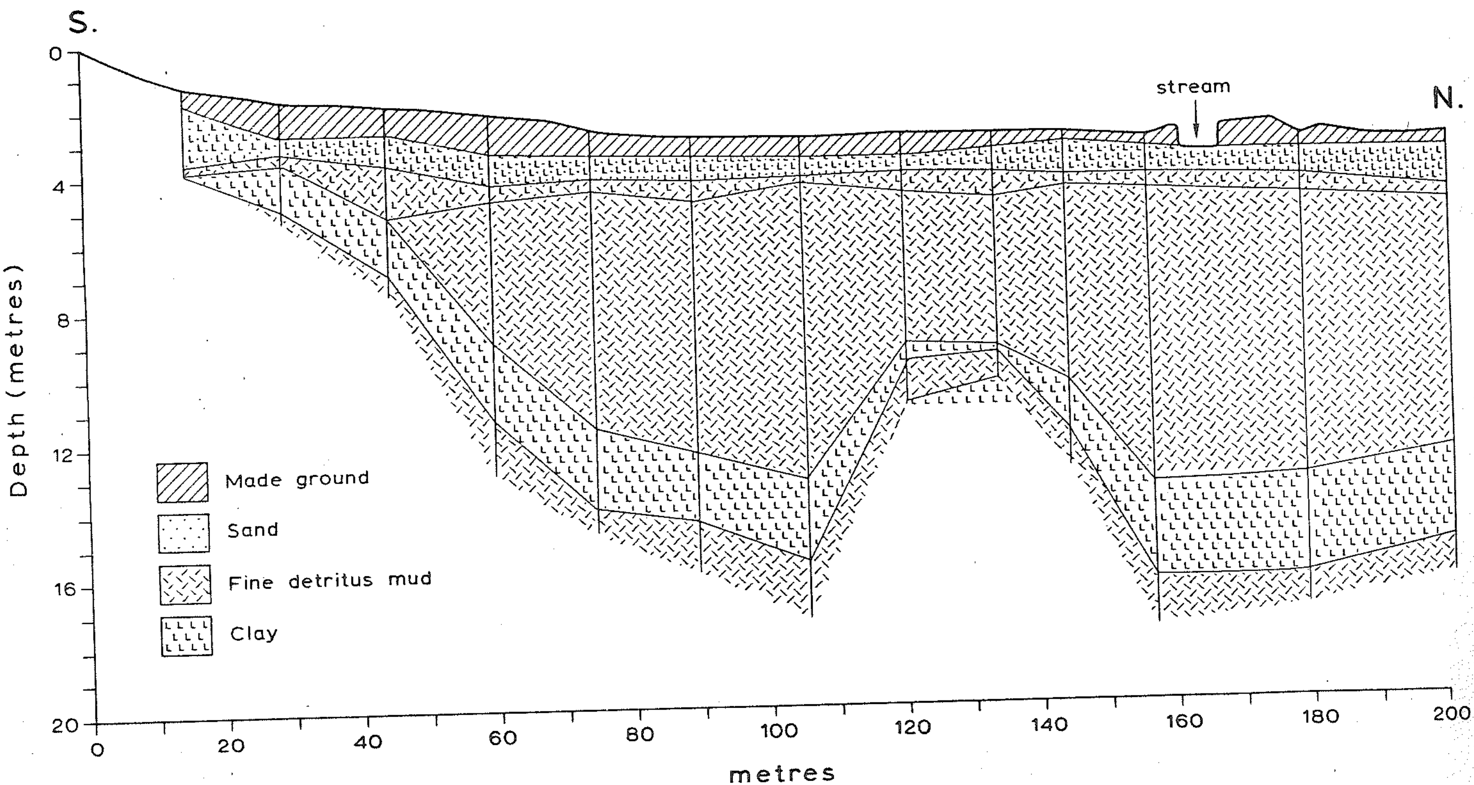


Fig. 8. The Old Mere, Hornsea.

THE OLD MERE, HORNSEA

The Old Mere site at Hornsea lies between the existing mere - the last of many post-glacial meres of Holderness - and the sea. It is up to 300 m. in width and more than 500 m. long, and has a distinct shoreline. Its centre is now crossed by the Stream Dyke, which drains the existing mere. The ground level has been raised by the addition of large amounts of topsoil, but below this are up to 14 metres of deposits. Much of the sediment is a dark brown, very homogeneous fine detritus mud, with scarcely any plant fragments visible. Beneath this is a pinkish clay up to two metres thick, and below this again lies a dark detritus mud. The stratigraphy suggests that late-glacial deposits are present, namely the clay and the lower detritus mud. It is hoped to penetrate this lower organic band so that a pollen analysis of the complete late-glacial deposits can be carried out, and the results compared with the late-glacial pollen analysis from Roos.

It seems likely that the mere was breached by the sea, as a result of the rapid coastal erosion in this area. The site may have been an inlet of the sea up to comparatively recent times (to be sure of this it would be useful to know if the clay just below the surface is of marine origin). This mere therefore probably extended well to the east, on land now eroded by the sea; it was also probably continuous with the existing mere. It must, therefore, have been a basin of some considerable size. The Bog, Roos, being a much smaller site, a comparison of the pollen spectra from these two sites may show some interesting features of pollen accumulation in relation to size of basin.

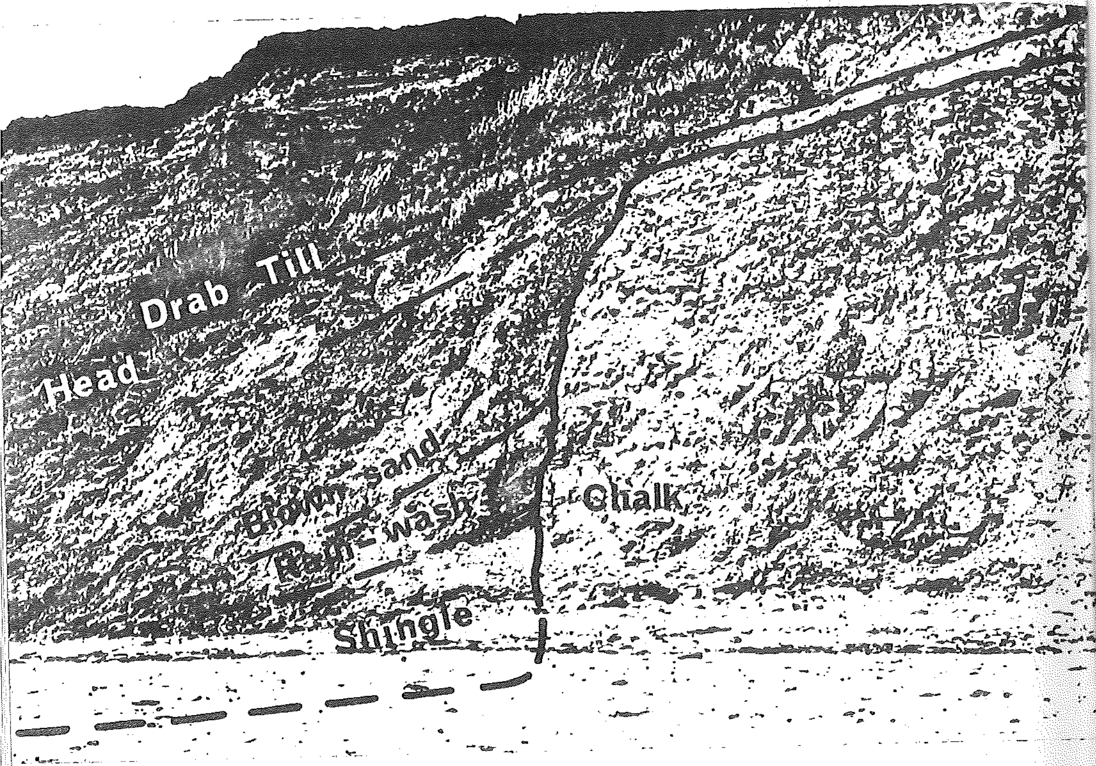


Fig. 9. Sewerby : the buried cliff.

SEWERBY

The cliffs at Sewerby (TA 198684) north-east of Bridlington provide an oblique section of the Eemian buried cliff and its associated deposits (Fig.9). We leave the coaches at the eastern end of Bridlington seafront (TA 193678), and walk half a mile eastwards along the shore to Sewerby steps (TA 202686).

The Eemian cliff is cut in the Upper Chalk (Inoceramus lingua zone at Sewerby). The deposits associated with it are now usually obscured by the talus at the foot of the modern cliff, but it is hoped that most of the deposits listed below will be identifiable. The site was dug out and thoroughly investigated in the 1880's by a British Association committee (Lamplugh, 1891), who found the following sequence of deposits, in ascending order, resting on the chalk platform and banked against the cliff:

a) At the base, a beach shingle composed of rounded chalk cobbles, erratic stones, and shells of marine molluscs (Littorina littorea, Ostrea edulis, Mytilus edulis and "Purpura" lapillus). The chalk platform beneath the shingle is about 2 metres above O.D., so that the mean sea level was probably no more than 1 metre higher than at present.

b) A chalky colluvial deposit (rainwash), 1.5 metres thick, which overlies and partly interdigitates with the marine shingle and contains terrestrial molluscs (Helix hispida, H. pulchella, Pupa marginata and Zua subcylindrica); this deposit indicates that the sea had receded and was failing to wash the beach clean.

c) Yellow aeolian sand, up to 8 metres thick near the cliff; this indicates a drier period, during which the cliff face was polished by sand-blasting.

d) A solifluction deposit (head) composed of angular flint and chalk fragments in a yellowish brown loamy matrix, which is thin above the cliff, but thickens south-westwards to over 6 metres; the rainwash and aeolian sand thin in the same direction, so that away from the cliff the solifluction deposit rests directly on the beach shingle.

The mammal remains found in the beach shingle, rainwash and aeolian sand were listed by Lamplugh (1891) and revised by Boylan (1967). They are listed in Table 3.

Some of the mammals are significant chronologically and indicate that the fauna dates from the Eemian climatic optimum or just after. Crocuta crocuta, Hippopotamus amphibius and Arvicola terrestris are all common in British

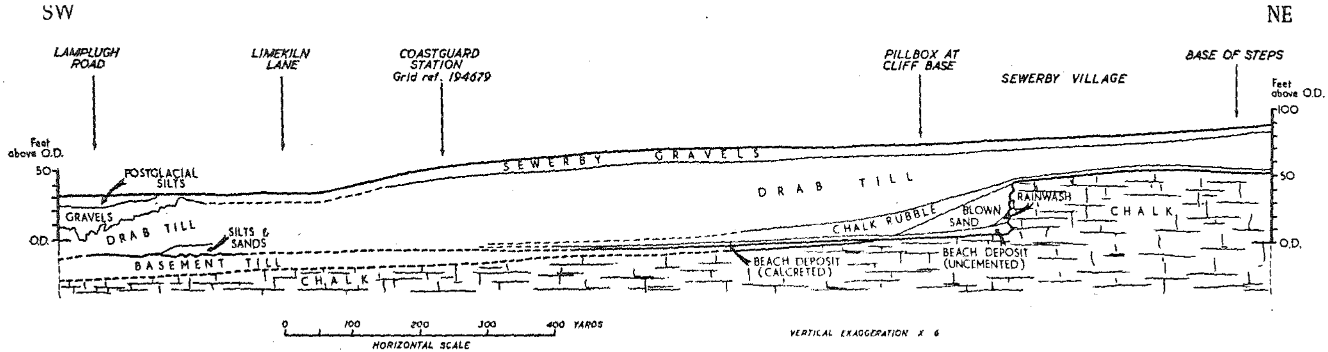


Fig. 10. Section from Bridlington to Sewerby, showing relationship of tills to buried cliff.

Table 3. Mammalian fauna of the Sewerby interglacial deposits, based on Boylan (1967)

	Beach Shingle	Rainwash	Aeolian Sand
HYAENA, Crocuta crocuta (an ulna and gnawings on other bones)	X	-	X
BEAR, Ursus sp. (a lower jaw)	-	X	-
STRAIGHT-TUSKED ELEPHANT, Palaeoloxodon antiquus (4 tusk fragments & many molars)	X	-	X
NARROW-NOSED RHINOCEROS, Didermocerus hemitoechus (sixteen cheek teeth)	X	-	X
HIPPOPOTAMUS, Hippopotamus amphibius (a fragmentary canine tooth and a molar)	X	-	-
? GIANT DEER, Megaceros giganteus (antler fragments)	-	X	-
BISON, Bison cf. priscus (left metatarsal, left metacarpal, calcaneum)	X	X	X
WATER VOLE, Arvicola terrestris (a cheek tooth and two incisors)	-	X	-

Eemian deposits, but are rare or absent in Hoxnian deposits. Didermocerus hemitoechus is accompanied by D. kirchbergensis (Jäger) at most Hoxnian and early Eemian sites, and the absence of D. kirchbergensis from Sewerby suggests a comparison with later Eemian deposits, such as the Lower Floodplain Terrace of the Thames. A similar age is indicated by the elephant remains, which consist only of Palaeoloxodon antiquus, and do not include earlier forms of mammoth.

Lamplugh described the till overlying the solifluction deposit as the Basement, and the cliff as "preglacial", but the till resembles the Drab in colour, erratic content and mineralogical composition. The sequence of deposits therefore spans the period from the later part of the Eemian Interglacial to the arrival of the Weichsel glacier soon after 18,000 years B.P. The rainwash and aeolian sand seem to be late Eemian, because they contain some of the interglacial mammal remains; the solifluction deposit is Weichselian and may represent an early Weichselian cold period, but strictly could be either older or younger than the Dimlington Silts.

Basement Till is occasionally exposed at low tide on the modern shore 100 metres or more from the buried cliff (Fig.10). These exposures are partly covered by large masses of calcreted conglomerate containing chalk pebbles, erratics, and shells of Littorina, Ostrea and Mytilus. The conglomerate is Eemian beach shingle, which has been cemented by carbonate derived from the solifluction deposit and redeposited above the impervious till. The Basement Till is therefore older than the Eemian beach, and must have been planed by the Eemian sea. However, the marine erosion surface was later modified, because at Dimlington the Basement Till rises to approximately 8 metres O.D., and at Bridlington Lamplugh reported (1881) that it rises into the cliffs between the Alexandra Hotel and Regent Terrace north-east of the harbour. We suggest that these irregularities result from pushing by the Weichsel glacier.

The cliffs along most of the Sewerby section are capped by gravels (the Sewerby Gravels), and the Purple and Hessle Tills are absent. It is not clear whether the gravels are englacial, proglacial outwash, or postglacial stream deposits. Similar gravels spread over large areas of northern Holderness, and have been worked at many places. Towards Driffield and Hornsea the outcrops are usually arcuate, suggesting deposition around ice lobes during retreat, but near Bridlington this pattern is less clear.

THE SPEETON SHELL BED

The Speeton Shell Bed consists of 12 ft. of estuarine silt and sand, exposed at about 90 ft. O.D. in the cliffs near Speeton (TA 147758). It lies on Speeton Clay (Lower Cretaceous) and is overlain by Basement Till which, from the evidence at Sewerby, is Wolstonian or earlier. The fauna of the shell bed includes Cardium, Scrobicularia and Macoma, often with their valves united, and the tiny gastropod Sabanaea ulvae. In other words it is a typical temperate estuarine assemblage (such as lives in the Humber at the present day) and must be climatically of interglacial status. The species themselves are long-ranging and give no clue as to age, but stratigraphically and altimetrically the bed would seem to be Hoxnian (Catt and Penny, 1966). The pollen, on the other hand, bears some resemblance to certain mixed oak forest spectra from zone II(f) of the Ipswichian (West, 1969). But it is difficult to reconcile an Ipswichian estuarine deposit at this height with the Eemian sea level of O.D. + 3-5 ft. at Sewerby; and the corollary that the Basement Till would be Devensian introduces even greater difficulties.

Note: There are two deposits which have been called The Speeton Shell Bed. The other is at beach level and may indeed be Ipswichian. It is not exposed at present and will not be visited. For further details see Catt & Penny, 1966, pp.399-400.

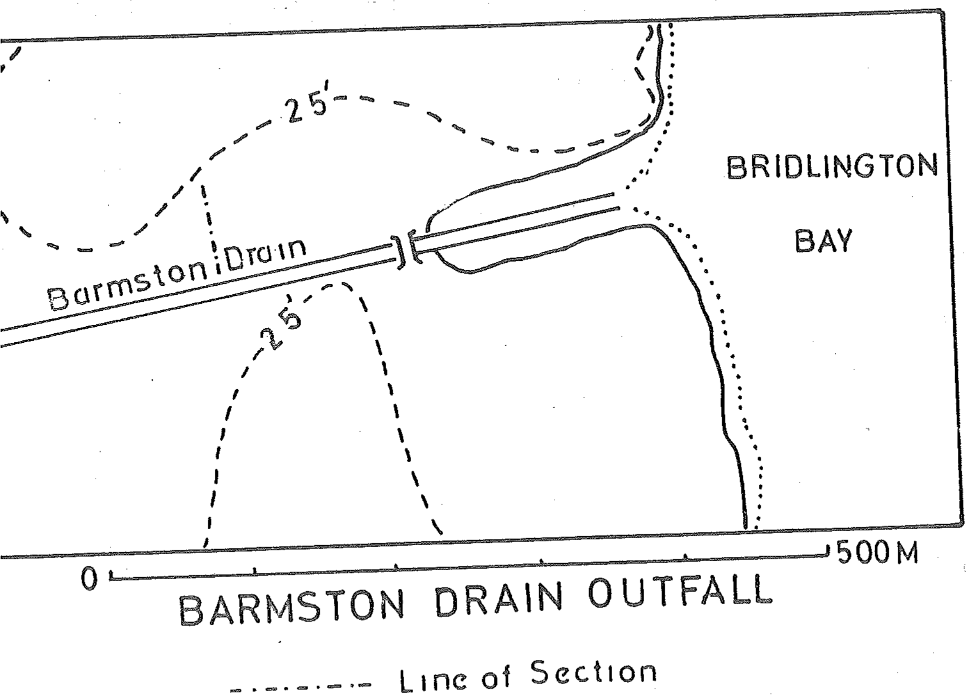


Fig. 11. Barmston : locality map.

BARMSTON

Exposures revealing an interesting complex of Late and Post-Glacial deposits at the outfall of Barmston Drain (TA 172587) have probably been open since the time of its construction about one hundred and seventy years ago. Surprisingly, they received little attention until 1945 when a study of the Holocene mollusca was initiated by members of the Hull Geological Society. Boylan (1966b) has summarised and discussed the environmental implications of their findings. Subsequently, a more comprehensive investigation, in connection with an archaeological excavation, has been carried out by Varley (1968).

The general sequence is given in the cross-section (Fig.12) which was compiled from excavations and borings within the shallow depression to the west of the small bridge at the outfall (Fig.11). Drab till is shown to be overlain by varved silts and a hollow in the latter is almost completely infilled with successive beds of gravel, peat, and hillwash. The excavations have been closed but parts of the succession may be examined in the sea cliff and at points in the northern bank of the Drain.

Although the varved silts clearly represent a depositional phase when an ice-dammed lake occupied the Barmston area, Varley was unable to date them precisely. He found that correlation with the Scandinavian series was impossible and their place within the Late Glacial remains uncertain.

The gravels include thin beds of sand and clay as well as a silty clay 'shell bed' which contains a rich fresh water fauna notably Valvata cristata, Lymnaea pereger, Ancylus fluviatilis and Pisidium casertanum with the addition of a few land molluscs (Boylan 1966b).

Gravels underlying the 'shell bed' are considered by Varley to be outwash deposits. He believes that, following the draining of the lake associated with the varves, melt-waters eroded a channel through the sediments down to the underlying till.

On the evidence of the mollusca Boylan concludes that the 'shell bed' is late Boreal in age, probably the product of a slow-flowing stream or of a lake in a wooded fenland, the latter being subject to periodic flooding. In the area of the excavations evidence of human settlement, including cobbled floors and hearths, rested directly upon the 'shell bed'.

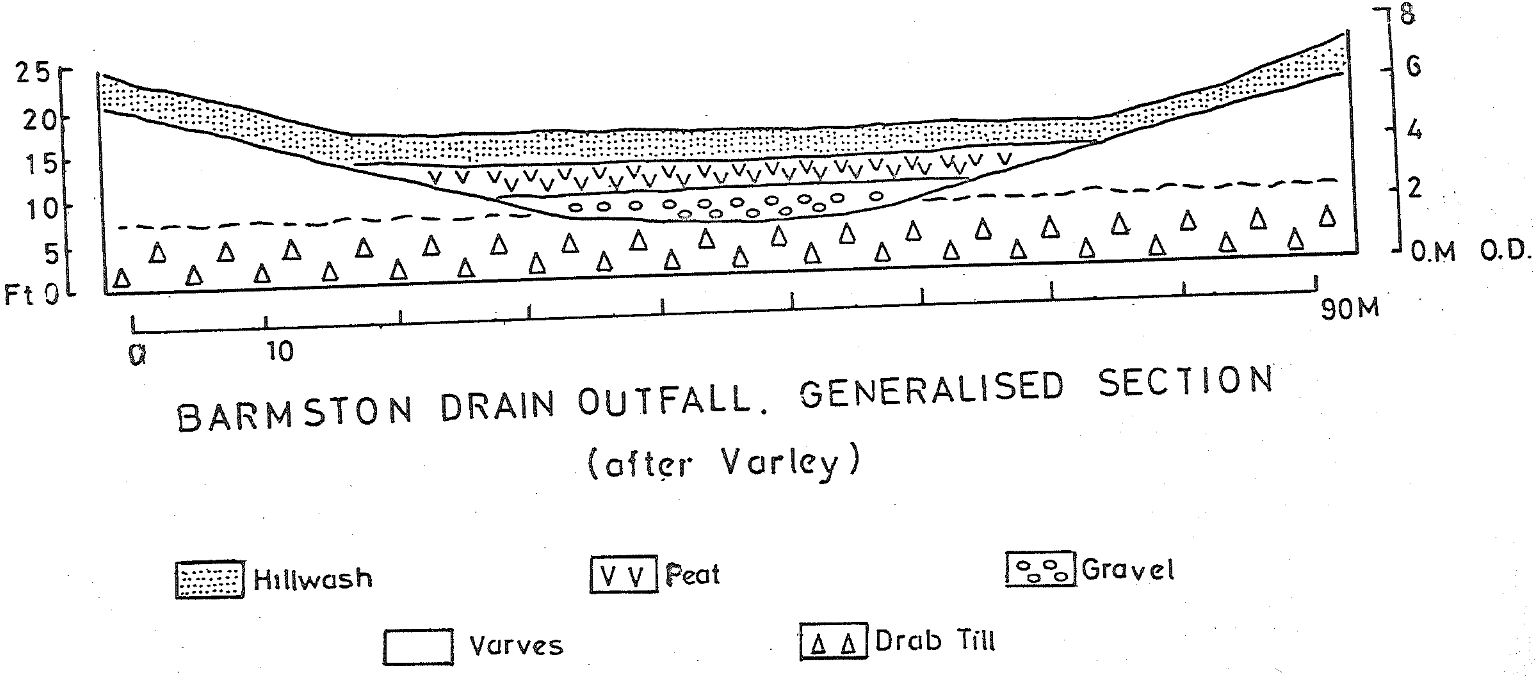


Fig. 12. Barmston : generalised section (after Varley).

The peat above contained axe-trimmed timbers thought to have been originally part of rectangular, hut-like buildings. Carbon 14 dating of this wood gave ages of 2960 ± 150 and 2890 ± 150 years (Barker and Mackey 1963). At the same level in the peat Varley's pollen diagram indicates the presence of birch, alder, beech and elm (Zone VIIb?).

Evidence of wooden structures (crannogs) occurs at other poorly drained sites in Holderness (Smith 1911). Following excavations in the early part of this century it was generally accepted that all local crannogs represented piled lake dwellings. On the results of his work at Barmston, Varley prefers an interpretation commencing with the late Bronze Age occupation of a marshy hollow. Flooding related to later environmental change is considered to have caused the abandonment of the site. The presence of worked timbers in the peat is thus attributed to the burial of a settlement by a developing bog and not to lake dwellings.

The upper surface of the peat, which has some evidence of Iron Age occupation, is covered with hillwash. In places there is a capping of upcast dating from the digging of the Drain.

SKIPSEA WITHOW

At Skipsea, 13 km south of Bridlington, coast erosion has sectioned one of the numerous meres (now mostly drained) of Holderness. The post-glacial (Flandrian) deposits consist chiefly of a peat bed, crescentic in section, about 100 m wide and almost 3 m. thick in the centre. Samples were pollen-analysed by H. and M.E. Godwin (1933) who recorded the following section (here metricated):

0-76 cm. Fine brown clay - now cracking into columnar form. A fresh water deposit.

76-289cm. Solid black or brown amorphous peat with large numbers of horizontal tree branches or trunks, including much oak (Quercus) especially in the upper 60 cm., which is almost solid with them. Hazel nuts found at 201 cm., 246 cm., 268 cm. and its very base.

289-304cm. Brown sand silt- with fragments of Pinus bark, fins of pike (Esox lucius) and flint artefacts. Stone fruit of ? Prunus.

304- ? Buttery blue clay.

The chief interest of the site lies in the discovery in 1903 of a barbed bone point of Maglemose (mesolithic) type in the brown sandy silt (Armstrong 1923), along with remains of reindeer. Giant deer (Megaceros giganteus) has also been found.

Pollen analysis showed the silt containing the bone point to belong to zone VIc (Late Boreal), while the peat belonged to zones VIIa (Atlantic) and later.

The silt also contains an interesting mollusc fauna (Boylan 1966b) of 20 species, chiefly 'catholic' or 'moving water' species. The complete absence of drifted land shells suggests, however, only slowly moving water.

The chief points worthy of further investigation are perhaps these:

1. The origin and early history of the mere. It is not often that one can see the margins of a mere in section, and they may give information on the earliest stages.

2. The possibility of finding further mesolithic artefacts.

3. The nature of the uppermost fine brown clay. Is this really a fresh water deposit (in which case, why did peat formation cease?), is it slope wash resulting from early ploughing, or could it have resulted from a marine incursion (perhaps a very temporary one like the 1953 floods)?

SOILS

The soils of Holderness, the Lincolnshire Marsh, and the Yorkshire and north Lincolnshire Wolds have never been mapped or studied in detail, except for the artificial warpland soils on the northern side of the Humber (Heathcote, 1951), but Crompton (1961) and Straw (1969b) have given general accounts of soil distribution in these areas.

The higher parts of the Wolds west of the Weichsel glacial limit have thin, loamy and flinty soils over chalk, which are mainly under arable cultivation. Brown earths occur on the gently sloping interfluve areas, but are replaced on steeper slopes (e.g. in dry valleys) by brown calcareous soils and rendzinas. Most of these soils are derived from a thin cover of loess, but the sporadic occurrence of erratic stones and coarse sand suggests that a remanié of Saalian or older glacial drift is locally included. Silt loams and silty clay loams more than 1m. thick occur on the highest parts of the Yorkshire Wolds, but most of the loamy soils are much thinner. Heavier soils contining clay-with-flints horizons occur near Staxton (TA 016763), but are unknown elsewhere. On the floors of the dry valleys deeper soils are developed on flinty colluvial deposits of variable texture.

Soils developed on the Hessle Till occupy most of eastern Holderness, and form a wide strip along the eastern margin of the Wolds; small areas also occur in the northern part of the Ancholme valley west of the Lincolnshire Wolds. Most of these are imperfectly drained clay loams, and have a coarse prismatic structure in subsoil horizons with deep-reaching fissures and grey structural faces, but where the till is thin and overlies chalk or gravel some of the soils are freely drained. The soil is decalcified to a depth of at least 0.7m., and below there is commonly a zone of carbonate accumulation containing impure pinkish concretions up to 10 mm. across. Chemical analyses of samples from successive horizons in a profile of this type near Tunstall (TA 314318) showed that only about 5% of the carbonate lost from higher horizons was redeposited in the accumulation zone, so that most of it is carried away in the groundwater. Disruption of erratic stones derived from clastic sedimentary rocks is another effect of weathering detectable in the field. In the ploughed layer all stones except the most resistant ones (flint, quartzite) have weathered and disaggregated, and their constituent particles have been separated and mixed with other soil material. Softening of stones also occurs in lower horizons down to 1.4 m. depth, but here the soil is less disturbed and the stones are still recognisable.

Detailed particle size and mineralogical analyses of samples from the Tunstall profile indicated that the soil parent material was originally homogeneous, but that weathering has considerably altered the layer silicate minerals, especially in the finer fractions, and that clay has been translocated from the highest 0.33 m. of the profile to lower levels. In the fine sand (50-250μm) and coarse silt (20-50μm) fractions, the amounts of muscovite, biotite, chlorite and apatite are much less in the higher soil horizons than in lower, which suggests that even these comparatively coarse particles have been partly removed by weathering. Comparison of the total amounts of each mineral in the fine silt (2-5 m), coarse clay (0.25-2μm) and fine clay (< 0.25μm) fractions of successive soil horizons with those of the almost unaltered Hessle Till at 2.2 m. depth showed that smectite and chlorite in the fine silt and coarse clay fractions, and kaolinite in the fine silt, are also less abundant in higher parts of the profile than in lower. These losses are partly balanced by gains of the same minerals in the fine clay fractions of the lower horizons; weathering therefore made the particles of these minerals smaller, and the fine clay thus produced near the surface was washed down to lower horizons. There have also been considerable losses of mica from the fine silt and clay fractions of higher horizons. This seems to have been weathered to fine clay vermiculite, because the amounts of fine clay vermiculite gained in horizons of clay accumulation greatly exceed the small quantities of vermiculite lost from higher horizons. Some alteration of mica to vermiculite probably occurs even to 1.4 m. depth, because of the losses of mica from coarse clay and fine silt fractions of these subsoil horizons are balanced by similar gains of vermiculite in the same size fractions of the same horizons. Removal of interlayer potassium from the soil mica was therefore an important weathering process.

All these pedological changes have occurred since deposition of the Hessle Till 14,000 - 18,000 years ago, and most of them presumably result from Post-glacial weathering in the last 10,000 years. Further, there has been little or no surface erosion of the till in most of the flat or gently sloping parts of eastern Holderness, so that the full effect of post-depositional alteration is preserved in profiles resembling that at Tunstall.

Heavy soils with imperfect or poor drainage occurs on the Holocene deposits, which occupy low-lying areas in the Hull valley, on the north and south banks of the Humber, and on the Lincolnshire coast. Strongly organic soils under pasture or arable cultivation occur in the upper parts of the Hull valley north of Beverley. This was a region of freshwater marsh and meres (carr) until the early nineteenth century, when channels were cut to drain water into the sea at Barmston, the River Hull near Beverley and the Humber at Marfleet (Sheppard, 1958).

In the Hull valley south of Beverley and in areas adjacent to the Humber, the soils are derived mainly from grey calcareous alluvium (warp). Much of this was deposited naturally before medieval times by tidal flooding of the low-lying areas. Primitive embankments to prevent flooding were first built in the late thirteenth century, and since then the area of reclaimed saltmarsh has steadily increased. For example, in the seventeenth century Sunk Island (TA 267183) was a small mudbank 200-300 m. across in the Humber estuary, but it was progressively enlarged by embankments built in 1744, 1770, 1800, 1811 and 1826, and since 1850 has been part of the Holderness mainland. Since 1750 the land surface in many low-lying areas near the Humber has been raised by artificial warping. At flood-tide, water carrying silt and clay in suspension was allowed through sluice gates into an area enclosed by banks, and was then slowly drained off at ebb-tide after the mud had been deposited. In suitable sites more than 0.5 m. of sediment could be accumulated each year by repeated warping. Many of the soils on eighteenth and nineteenth century warp are still naturally calcareous, but the surface horizons of older deposits are usually decalcified. Groundwater is permanently close to the surface in many of them, but the better drained soils are very fertile, and are farmed mainly for cash crops.

NORTH LINCOLNSHIRE

General Remarks

The excursion to North Lincolnshire is planned to demonstrate the main Quaternary features of the area, and to provide some contrast to those of Holderness. It is not possible to be comprehensive, but consideration of certain areas will highlight various problems and hopefully stimulate discussion.

Geomorphologically, the whole area has been fashioned during the Quaternary. Most of the superficial deposits are of Devensian or Flandrian age, and certainly none are older than Hoxnian. The position and form of the escarpments are the result of post-Hoxnian glacial and fluvial activity under changing climatic conditions, and only the back-slope of the Chalk cuesta is considered to retain any relics of pre-glacial morphology, in the form of dissected spur benches of limited extent. The dry valley systems on the Wolds display two elements - a subparallel group of trunk valleys opening toward the north-east, and a large number of lateral valleys of simple morphology and dendritic pattern. The latter are believed to have originated under a hydrological régime associated with periglacial conditions, whilst the trunk valleys, although deepened and remodelled under those conditions, reflect in their orientation a pattern inherited from valleys initiated on the Burnham Surface (220-180 feet) (Straw, 1961a). Valleys on the Jurassic cuestas are all of simple form and of post-Wolstonian development.

The major lines of drainage of north Lincolnshire are to the north. The Ancholme drains, not too effectively, the restricted tract of Upper Jurassic clays between the northerly-converging Cretaceous and Middle Jurassic cuestas. The banks and sluices at South Ferriby protect the levels for each 15 hours out of 24 that Humber water is higher than the river, and were last engineered, apart from maintenance, in 1845 by Sir John Rennie. The alluvium is about 100 feet thick beneath South Ferriby Sluice, and appears to consist entirely of Flandrian sediments, resting on Upper Jurassic clays.

Westward the small Winterton Beck follows a parallel strike course to the Humber between the subdued scarp of the Lincolnshire Limestone (Inferior Oolite) and the gentle backslope of the Lias cuesta. Westward again the Trent flows north to join the Ouse, its alluvial tract bounded on the west by low eminences of Keuper Marl that comprise the Isle of Axholme and a smaller swell at Crowle. The Trent alluvium is essentially fine sand, silt and clay, intercalated with thin peats, the highest of which expand into the vast peaty areas of Thorne Waste and Hatfield Chase west of the Keuper mounds. All these materials are most likely of Flandrian age (Smith, 1958).

These strike streams and the intervening cuestas are closely influenced by the 'solid' geology. The westernmost scarp rises abruptly from the Trent alluvium, and consists of Lower Lias clays capped by thin limestones. The Frodingham Ironstone and higher Lower Lias clays crop out on the backslope, and have been exposed extensively in the opencast workings around Scunthorpe. Normally these rocks are masked by the sheet of Cover Sands and small patches of chalk-bearing till. The central scarp, capped by the Lincolnshire Limestone, rises across attenuated Middle and Upper Lias sediments, and is the northern extension of Lincoln Edge. The narrow backslope carries Cover Sand deposits east and south-east of Scunthorpe and Devensian till and gravel in the north near Winteringham. The Cretaceous scarp stands clearly above the Ancholme alluvium, but is not as impressive a feature as further south. The Chalk lies directly on Kimmeridge Clay, and has been subjected to cambering and some slumping. Along the foot of the scarp a narrow strip of Cover Sand provides a fortunate location for numerous 'spring-point' villages. The rounded crest rises to about 300 ft. O.D. from which the land surface, largely under arable cultivation, descends gently east-north-east. Below about 200 ft. O.D., thin Devensian tills, generally weathered reddish-brown, overspread the spurs, and thicker accumulations, often with weak constructional topography, occupy the lower ends of the trunk valleys. East of the 100-foot contour, till and gravel completely obscure the Chalk, but themselves disappear eastward beneath alluvial marsh bordering the lower Humber estuary.

Only one tectonic feature influences the surface morphology. It may be noted that the Lias scarp is 'kinked' at Flixborough (SE 873151), the Oolite scarp at Dragonby (SE 903141) and the Chalk scarp between Somerby (TA 060067) and Clixby (TA 103043). This is controlled by a pronounced post-Cretaceous flexure which is monoclinal in the south-east (Audleby moncline with a throw of 300 ft. to the north) and faulted synclinal in the north-west.

The distribution of superficial materials is readily appreciated. Eastward of the Devensian limit shown on Figure 2, greyish-brown tills and associated sands and flint and erratic-bearing gravels underlie the ground other than marsh. Alluvium floors the Trent and Ancholme valleys and borders the Humber estuary. The Cover Sands blanket most of the Jurassic area around Scunthorpe and north of Market Rasen. The only other superficials consist of fragmentary patches of sand and gravel around the margins of the Ancholme alluvium, e.g. at Brigg (Low Level Deposits of the Ancholme - Ussher, 1890), and relict patches of till consisting essentially of regurgitated Jurassic material with erratic chalk. A few patches of this till have been observed beneath Cover Sands near Scunthorpe, and a patch occupies the ridge crest east of Brigg. Further south the till is more extensive on the Lias east of Gainsborough and on Kimmeridge Clay between Brigg and Market Rasen. In all these locations, the till occupies higher ground on ridge crests and has, therefore, been dissected and mostly removed by the Ancholme, its tributaries, and other streams. This till constitutes part of the Older Drift of Lincolnshire, and is believed to have been originally emplaced by ice deploying south-south-east from the Vale of York. A Wolstonian age is considered probable.

Elsewhere, along the lower slopes of scarps and certain valley-sides, soliflual rubble and loams up to a few metres in thickness are common.

THE SCUNTHORPE AREA

The excursion route from Goole to Keadby Bridge mostly crosses reclaimed alluvium. From Keadby Bridge (of 1927 vintage) the road along the foot of the Lias scarp will be followed to Messingham, affording some appreciation of the Cover Sands.where they emerge from beneath the Trent alluvium. The Sands are yellow or grey in colour, depending on oxidation conditions, and frequently give rise to low mounds which west of Messingham suggest a dune form. Increasingly, softwood plantations are encroaching on the former commons, and on areas of 19th Century enclosure. The Lias briefly appears on the brow of the scarp at Messingham, but the Cover Sand sheet then extends unbroken east to Scawby on the Inferior Oolite backslope. Exposures of the Sands occur at the workings of British Industrial Sands Ltd. (SE 912039) where undulating seams of yellow sand incorporate thin bands of organic material and rootlet horizons, and are strongly podsolized at the surface.

In the Manton Warren area (SE 940050) the Sands sweep over the Oolite scarp with dune-like mounds in places to the lee of the crest. Such forms however are likely to be of comparatively recent origin, for there are frequent records of sand movement over the past few centuries resulting from vegetation disturbance, encouragement of rabbit warrens and unwise cultivation. The most mobile area of sand at present is in Risby Warren to the north (SE 930135).

Specific problems relating to the Cover Sands are:-

1. Source and provenance of the sand

2. Period and manner of emplacement

3. Environmental conditions during deposition

4. Influence on ground-water conditions and soil evolution

5. Influence on vegetation development and circumstances for human settlement (the sands provided open stations for late Creswellian and Mesolithic communities - details and artefacts in Scunthorpe Museum).

BRIGG AND THE BARNETBY GAP

At Brigg the Ancholme levels are very narrow, a point fully appreciated by early Man in this area, for numerous late Bronze Age and Iron Age finds have been made in the locality, including a timber causeway (Smith, 1958). Brigg is sited on a low terrace of sand and fine gravel (probably indicative of a late Devensian lacustrine phase in the Ancholme valley) but north-east of the town the A.18 climbs a ridge of Upper Jurassic clays capped by a strip of Wolstonian till. At Wrawby, and again north-west of Barnetby, the till is overlain by well-bedded gravels (Wrawby Gravel) consisting almost entirely of chalk and flint in a sand matrix. These gravels appear to be relics of a fan of glacifluvial material prograded from the east onto the Wolstonian till during disappearance of the Wolstonian ice. This dating is suggested by their relict character on the ridge crest, by their topographic and constitutional differentiation from Devensian outwash materials in the Barnetby gap on the south side of the ridge, and by the presence of deep cryoturbation and some ice-wedge casts in the surface layers (uncommon in Devensian outwash).

The Barnetby gap carried Devensian meltwaters south-west when the ice front lay at Kirmington. Outwash sand and gravel, comparatively rich in far-travelled erratics, underlie the area south and south-west of Barnetby. The surface layers have however been disturbed and rearranged by wind action and therefore strictly contribute to the sheet of Cover Sands. The floor of the gap reaches only 80 feet O.D. and water appears to have drained into the Ancholme valley from a shallow lake impounded west of Kirmington. Clays and silts occupy the low ground here, and meltwater channel systems terminate at c. 90 feet O.D. presumably into the lake. One weakly integrated sub-marginal system commenced near Thornton Curtis and discharged south to Vale House (TA 107136) near Ulceby. A larger system worked from the central Wolds by Swallow and Limber and discharged into the lake through the Mere Hill channel (TA 118108) in Brocklesby Park (Straw, 1961b).

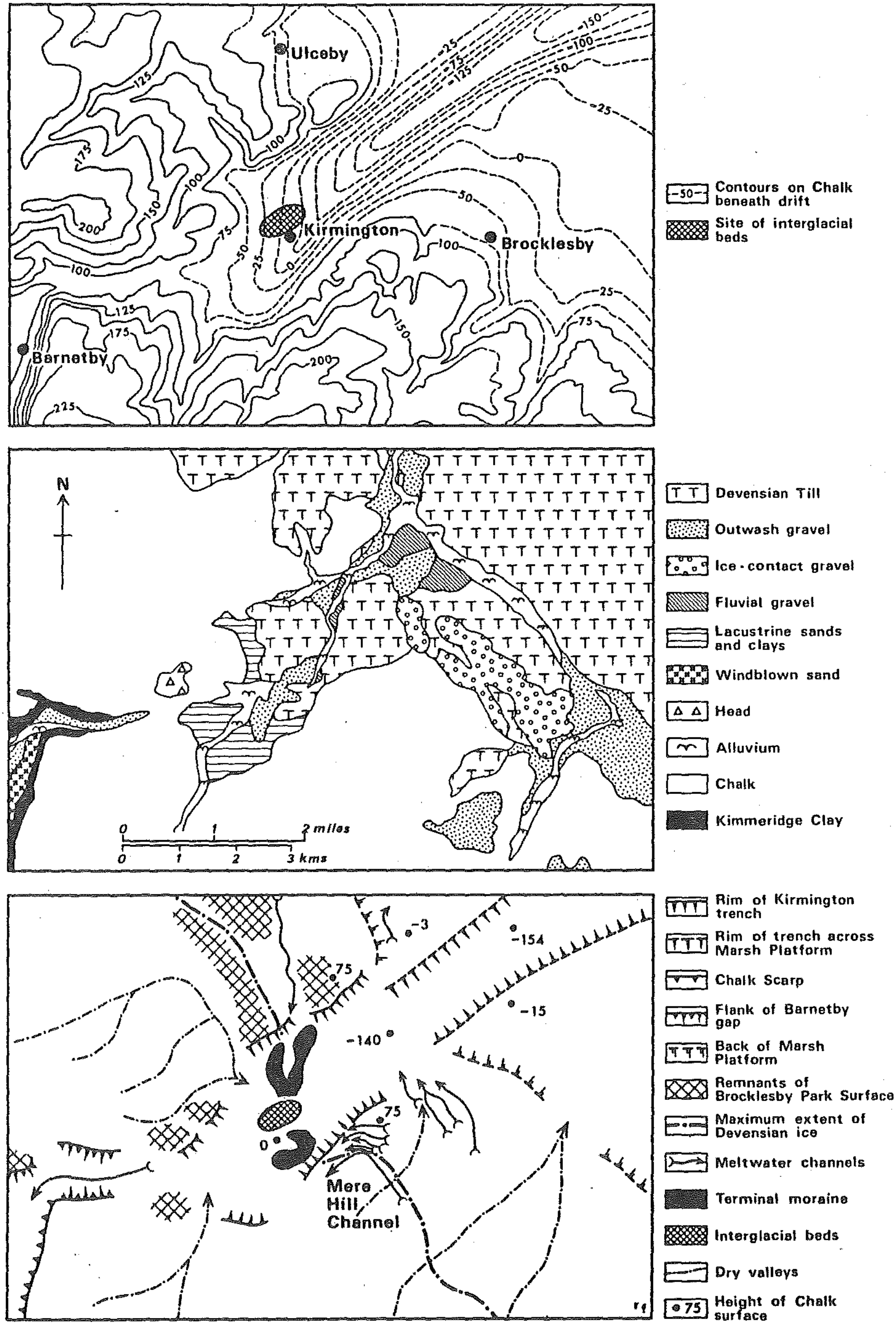


Fig. 13. The geological and geomorphological relationship of the interglacial deposits at Kirmington.

KIRMINGTON

Across the Kirmington valley, the Devensian limit is marked by weak morainic mounds south and north of the village (Fig.13). The village itself is sited on the flank of a low hill composed mainly of stratified fossiliferous sediments that constitute the controversial interglacial deposits.

The sediments are at present poorly exposed but some of the members can be observed in the old brick pit (TA 102116). The deposits attracted interest in the 19th Century and in 1903 a bore was put down by the British Association through 93 feet of sediment to touch Chalk at about present Ordnance Datum. Details of the bore are as follows:-

		Ft.	Ins.
15	Surface soil	1	0
14	Clay with foreign stones	4	0
13	Well-worn shingle principally of battered flints	8	0
12	Laminated warp with estuarine shells, and at its base a thin seam of peat associated with a sandy warp containing freshwater shells	18	6
11	Clean yellow sand with pebbles of chalk and flint	4	9
10	Red clay passing downwards into tough reddish-brown clay	7	6
9	Purple clay, streaked with silt and loam, passing downwards into tough purple clay with small stones including some erratics	10	6
8	Stoneless purple clay	5	0
7	Stoneless yellow clay	6	0
6	Flinty gravel	4	6
5	Yellow clay and loam with small drift pebbles	5	0
4	Yellow sand, full of well-rounded quartz grains and specks of chalk	8	0
3	Yellow sand and laminated clay	4	0
2	Tough compact lead-coloured clay with a few small foreign pebbles	5	3
1	Tough yellow clay streaked with chalk	1	0
	Solid chalk and flint	3	0
	TOTAL	96	0

At present, only the four highest members are to be seen, poorly exposed, and description and interpretation of lower beds remains somewhat speculative. Generally, the sequence might be summarized as:-

(14,15)	Till and soil	5	0
(13)	Marine shingle	8	0
(7-12)	Estuarine sands, silts and clays	52	3
(1-6)	Glacial and/or periglacial till, sands, gravels and loams	27	9
	Total	93	0

The marine shingle (13) consists of wave-battered flints and is best exposed in the eastern pit (TA 105117). It has the character of storm beach material thrown up by waves onto the estuarine sediments (12) as the shoreline receded gradually westward. The shingle is thus unreliable as an indicator of mean sea-level at that time. The shingle was subsequently (presumably before deposition of the till) thoroughly cryoturbated, and frost-cracked cobbles are common. It can also be argued that the estuarine silts were built up to the level of High Water Springs, so that allowing for a 20-foot tidal range, the maximum height that mean sea-level attained was around 72 feet O.D., not the 100 feet O.D. widely quoted by several authors. These silts (warp) appear to have aggraded in the shelter of a spit or bar throughout a period of net rise of sea-level, and were formerly much more extensive. The hill at Kirmington lies within a valley about a mile across at the 100-foot contour (Figure 15). The estuarine sediments must have occupied much of this depression, and the present eminence is clearly a residual mass, isolated by erosion and removal of much of the sediment. It is a point for discussion whether such erosion was by glacial or fluvial agencies.

The Kirmington interglacial sediments are overlain by a brown till (14), which spreads eastward onto lower ground with a constructional glacial topography and northward into a low morainic ridge. This till, on its erratic suite and topographic expression, is part of the Newer Drift of east Lincolnshire (i.e. Devensian) and has been designated elsewhere the Lower Marsh Till (Straw, 1969). This till should not be referred to as Hessle Till, for in spite of superficial similarities of colour, it is believed to be a stratigraphically lower deposit than the true Hessle Till of Holderness. It rests abruptly on the shingle in the eastern pit, but on a thin, less coarse gravel in the old brick pit west of the road. The Kirmington hill therefore lies precisely at the maximum limit of Devensian ice, and is incorporated into its weak terminal moraine. On the south side of the hill glacifluvial gravels, bedded to the west, underlie the Rectory and the south part of the village, and occupy what was a local meltwater breach in the moraine.

Beds beneath the estuarine silts (12) cannot now be seen, but Boylan (1966) gives reason to suppose that the sands and clays (7-11) are also part of the interglacial series. The red and purple clays (10,9) have been regarded as possible tills, but the chalk fragments and occasional erratics could well have been introduced into the clays by stream action or creep from glacial materials on the higher ground to north and south. The lowest deposits (1-6) may fairly be regarded as glacial and possibly periglacial materials, comprising a basal till, with superjacent outwash and soliflual sands and loams.

Determination of the age of the estuarine sediments has proved difficult to date. Considerations involve the organic content of the sediments (plant and animal), mineralogy, archaeological material, and relationship to the overlying and subjacent deposits. Most authors accept the sediments as genuinely interglacial and 'in situ' (Carruthers, 1948, suggested a 'raft'), but disagreement exists on whether they are Hoxnian or Ipswichian. The consensus of earlier opinion was that a Last Interglacial (Ipswichian) date was likely (Burchell, 1931, 1935) but more recent studies suggest a Hoxnian affinity. Watts (1959) examined the pollen content and preferred a Hoxnian date, though the comparatively meagre evidence was far from conclusive. Boylan (1966a) reviewed the available archaeological material (20 specimens only) and seemed prepared to accept the presence of a Lower or Middle Palaeolithic industry at Kirmington, suggestive again of the Hoxnian Interglacial. All the specimens are flakes, with varying degrees of rolling subsequent to manufacture. It seems pertinent to observe that with regard to natural flaking and rolling of flints, some fracturing and abrasion of cobbles may well have occurred during the construction of the storm beach, and some certainly took place at a considerably later date when the shingle was cryoturbated. Catt and Penny (1966) determined the mineralogical composition of beds 10, 11, 12 and pointed to similarities with the Bridlington Crag, believed to be of pre-Wolstonian age. These similarities are far from conclusive. The Kirmington silts would have been derived from materials on surrounding slopes as well as detritus carried in by the sea, and pure derivation from and therefore correlation with any single pre-existing deposit should not be expected. The only clear statement is that, because the Kirmington deposits in their mineral assemblage may be dissociated from the Drab/Purple/Hessle complex, they are older. It might be suggested however, that comparison with the mineral assemblages of other pre-Devensian sediments does not tell us precisely how much older.

In 1969, Harland and Downie examined, in particular, the dinoflagellates in the estuarine silts (12), but could make no comment on their relative age. The evidence therefore is imprecise and somewhat contradictory. Convergence of biological, archaeological, geological and geomorphological evidence is essential before any valid conclusion can be made. It is instructive, however, to follow one or two lines of argument further.

A Hoxnian age? - if the interglacial deposits are of Hoxnian age then they have survived the Wolstonian Glaciation when ice covered Lincolnshire, and not only laid down tills over the County, but also achieved much erosion of the Jurassic and Cretaceous rocks. Although it could be claimed that most of the Kirmington deposits had been scoured away by ice, leaving the residual hill as the only vestige, it is surprising that the estuarine sediments remain undisturbed, and the shingle has suffered only cryoturbation, when the general locality was under several hundred feet of flowing ice that can be shown to have eroded and scraped the surface of the Upper Chalk to the north and south-east. Again, however, erosion through the Ipswichian Interglacial could be held to have removed any Wolstonian glacial features before Devensian ice invaded the area. The real question here is whether the biological and archaeological evidence is strong enough to demand that survival of the deposits through the Wolstonian Glaciation occurred.

An Ipswichian age? - the stratigraphic evidence shows the deposits to be overlain only by Devensian till at its maximum extent, and geomorphological considerations render it difficult to reconcile survival of the deposits with indications of Wolstonian erosion in adjacent areas. A further consideration exists. The Kirmington deposits lie in the centre of a broad channel that descends to over -200 feet O.D. beneath Immingham at the present coast. There is no justification in assuming a fluvial origin as the only possibility (Shillito, 1937; Boylan, 1966a), and glacial or glacifluvial erosion of the depression would seem more feasible (Linton, 1963; Straw, 1970).

It is tempting also to identify the Wrawby Gravel deposits on Wolstonian till with material eroded from the Kirmington depression. If the depression did in fact originate beneath Wolstonian ice, then no Hoxnian deposits could ever have occupied it. The question here, therefore, is whether the stratigraphic and geomorphologic evidence, which suggests an Ipswichian date, is convincing enough to outweigh the indications of a Hoxnian age. Put another way, is the biological, archaeological and mineralogical evidence so inconclusive and ambiguous that it does not deny the stratigraphic and geomorphic indication of an Ipswichian date?

If an Ipswichian date is ever convincingly demonstrated, then the altitude of the deposits becomes a critical consideration. Recent authors are reluctant to accept a highest Ipswichian sea-level above 50 feet O.D., and the surface of the estuarine silt at Kirmington lies a little over 80 feet O.D. Even allowing for a large tidal range and suggesting a mean sea-level of 70 feet O.D., Kirmington is rather high. But altitude alone should not deny an Ipswichian age for the Kirmington deposits. One might for example suggest slight relative uplift of the site cf. East Anglia and the south coast as the result of long-delayed glacio-isostatic recovery, or movement associated with development of the North Sea geosynclinal basin.

The date of the interglacial sediments also bears indirectly on the age of the underlying deposits (1-6). Reasons can be given for regarding them as glacial, at least in part. Boylan (1966a) preferred an Anglian (Lowestoft) age, to be compatible with a Hoxnian age for the overlying beds. Early descriptions of the clays pointed, however, to similarities with the Basement Clay of Holderness, now firmly regarded as of Wolstonian age.

KILLINGHOLME, BARROW AND BARTON

North from Kirmington, the route crosses the backslope of the Chalk cuesta to the maximum Devensian limit. Some 5 miles away to the east lies a younger Devensian feature, the Killingholme moraine, which leaves the Wolds near Keelby (TA 164100) and strikes north to the Humber. In front of this moraine, along the Wold edge, is a long tract of outwash gravels from Brocklesby to Goxhill, still largely followed by East Halton beck.

Barton-on-Humber is underlain by up to 40 feet of Devensian till which is packed against steepish slopes of Chalk that constitute the southern flank of the Humber estuary. Borings show that beneath Barton and Barrow the Chalk surface flattens beneath the till to form a shelf which is part of a much more extensive platfomm (Straw, 1961a) that underlies the whole of east Lincolnshire east of the Wolds. This platform correlates with a similar feature beneath Holderness (Valentin, 1957) and its form and extent suggest that it is largely the product of marine erosion. The great width of the platform (up to 10 miles - overall gradient 1 in 500) indicates that it is the cumulative result of several periods of marine plantation, though there seems little doubt that the Eem Sea was important in its final shaping, and its backing bluff is generally accepted as an Eemian shoreline.

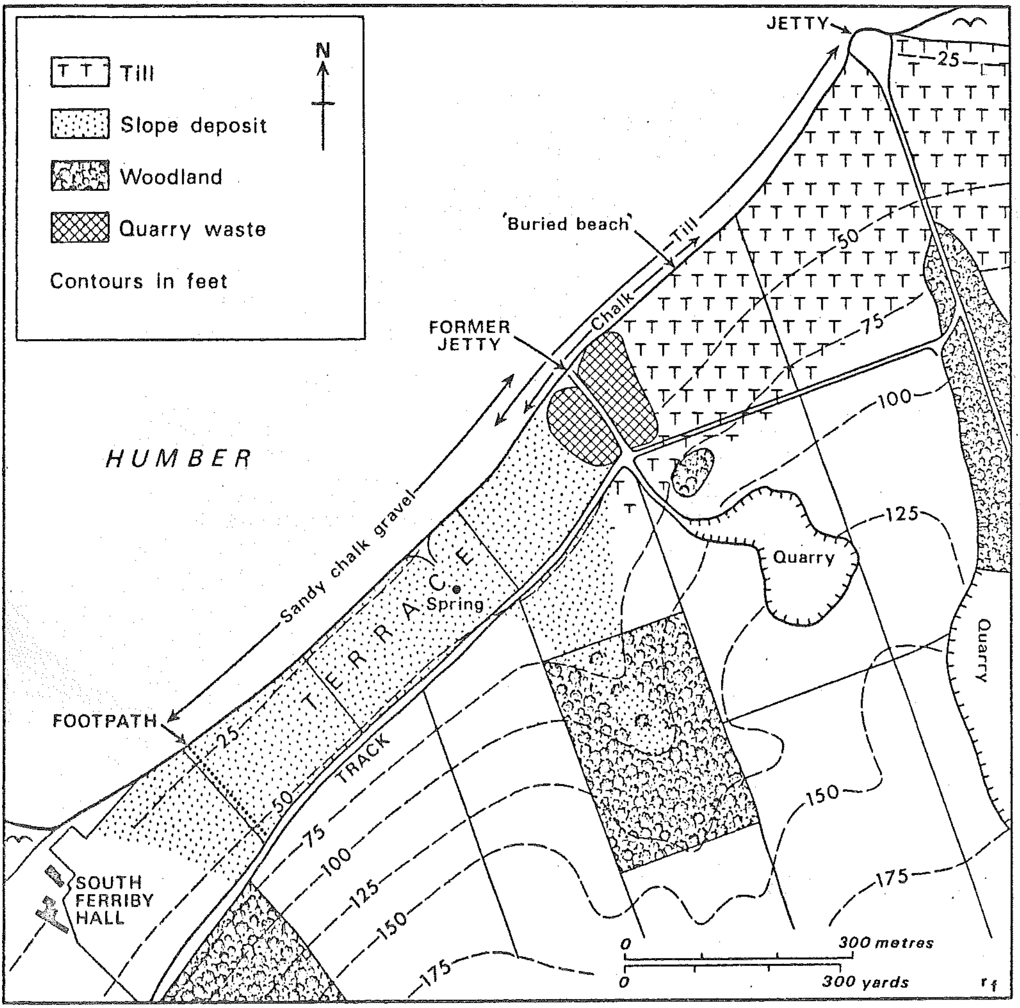


Fig. 14. The Humber cliff zone near South Ferriby.

SOUTH FERRIBY

At South Ferriby, the estuarine marshes are cut away at a point where the Humber impinges on the Chalk slopes. Here, though the foreshore is cut across Chalk, the low cliff displays an interesting series of glacial and periglacial deposits which reflect much of the late Quaternary history of the area. The wider significance lies in the fact that these deposits are preserved in the Humber gap which controls the drainage of a large part of eastern England.

The total length of the cliff is about 1,250 yards (Fig.14), between a jetty at the north-east end and a field-side path at the south-west. At this south-west end, the cliff, barely 6 feet high reveals poor sections in bedded sands containing thin seams and wisps of chalk fragments, alternating with layers of angular chalk gravel with a clayey sand matrix. Deposition in water is indicated, the chalk material moving a short distance from the rising ground to the south-east possibly under solifluction.

Northeastward, the cliff gradually gains height and the sandy chalk gravel becomes dominant. The uppermost 4 to 5 feet of this gravel displays no stratification and has been thoroughly cryoturbated. In places, where seams of sand and silt appear lower in the section, distinct involutions have been observed, to a depth of 10 feet beneath the surface.

Opposite the mouth of a small dry valley that indents the Chalk slopes, the cliff, now over 12 feet high, is cut entirely in the unstratified sandy chalk gravel. This suggests a greater supply of chalk rubble moving out of the dry valley than off the regular Chalk slopes. Northeastward again, the gravel begins to thin with the emergence in the foot of the cliff of a brown clayey till until it ceases at the site of a former jetty serving a small disused Chalk quarry.

Along the whole of the gravel section, solution pipes and soil tongues are pendant from the surface. Only one ice-wedge cast has been observed, and this was mainly developed in the till where the overlying gravel was only about one foot thick. These sands and gravels give rise to a narrow shelving terrace that has an overall cross-slope of 4°-5° rising to about 55 feet O.D. which then gives way to Chalk slopes of 8°-10°. It is impossible to state how far the terrace formerly extended beyond the present cliff-line.

At the former jetty site the brown till rests directly on a planed surface of Chalk, which is disturbed and steeply dipping in places. The till contains a range of igneous, metamorphic and sedimentary erratics typical of the Newer Drift of east Lincolnshire, and it is firmly regarded as Devensian. The till spreads east through Barton but also passes south-west into the Ancholme valley as far as Horkstow, where a weak moraine swings across the valley narrowing the levels to half a mile, and west to Winterton and Winteringham. East of the latter village, numerous low mounds with shallow intervening kettle-holes stand 10 or 20 feet about the Humber alluvium, and once provided a site for a sizeable Roman station at the north end of Ermine Street.

North-east of the former jetty, the cliff is cut almost wholly in till, but for some distance several feet of Chalk or chalk rubble appear at the base. At the former jetty, the till includes a narrow band of shear-clays, and nearer the north-east jetty where the cliff gets up to 25 feet high a dark purplish-brown or grey-brown variant of the till appears. It does not seem to be a separate till, and it may be that the colour variation is the result of differential weathering.

There is one further feature of considerable interest. About 400 yards south-west of the north-east jetty a thin narrow deposit of gravel intervenes between till and Chalk. Reid (1885) made mention of a thin ripple-marked flaggy sandstone, and Jukes-Browne (in Ussher, 1890) referred to the gravel as an old sea beach. Later authors blithely (e.g. Burchell, 1931) related the deposit to gravels at Barton and Horkstow (glacial outwash) and identified a spurious '50-foot raised beach' along the Humber shore. The gravel, less than 2 feet thick, has an indurated surface layer which retains ripple marks. It is composed of rounded pebbles of chalk including red chalk and erratic rocks, and may be described as shingle. It lies at 12 feet O.D., and is a small fragment of beach deposited on the Chalk before emplacement of the till.

<u>Several questions may be asked about the Ferriby deposits, followed by some discussion of each</u>.

1. What is the relation of the till to the Holderness tills and that at Kirmington?

2. Is the small beach indicative of marine or lacustrine conditions?

3. What is the relation of the beach to the planed Chalk surface on which it rests?

4. When did the sandy chalk gravel accumulate to form the terrace feature, and what is the source of the sand?

LINCOLNSHIRE : PROVISIONAL CHRONOLOGY

It may be appropriate, and provoke discussion, if a provisonal sequence of events be stated for the north Lincolnshire area.

FLANDRIAN		Humber and Ancholme Alluvium Cover Sands	Rising sea-level
LATE DEVENSIAN	3. Readvance	Cover Sands '25-foot drifts' of Vale of York. Low Level Deposits of Ancholme. South Ferriby solifluction terrace (sandy chalk gravel). Upper Marsh Till (Killingholme moraine).	late low stage of Lake Humber
	2. Interstadial	(?Dimlington silts and moss)	
	1. Maximum advance	Upper Kirmington Till. South Ferriby Till (Horkstow-Winteringham moraine)	maximum stage of Lake Humber (100ft)
		South Ferriby beach	early low stage of Lake Humber
MIDDLE & EARLY DEVENSIAN		Dissection & erosion of most of Kirmington I.G. sediments	Low sea-level
IPSWICHIAN		?Kirmington I.G. sediments	High sea-level
WOLSTONIAN		Wrawby Gravel Basal till at Kirmington Chalk-bearing Jurassic-rich tills of central and west Lincolnshire. Chalky till on Wolds.	Complete glaciation ?Sub-glacial erosion of Kirmington depression
HOXNIAN		Brocklesby Park surface (80-130 ft.O.D.- subaerial, glacially modified)	High sea-level
ANGLIAN		No trace	?Complete glaciation
'PRE-GLACIAL' PLEISTOCENE		Formation and dissection of planation surfaces in Wolds, down to and including the Burnham surface (180-220 ft O.D.-?marine, glacially modified).	Oscillating sea-level; net fall from c. 700 ft O.D.

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