Speeton

[TA 146 759]

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Introduction

Located in Filey Bay, immediately south-east of Reighton Sands (Figure 4.22), North Yorkshire, Speeton is an important Quaternary site because of two separate exposures through a fossiliferous stratified sedimentary unit called the 'Speeton Shell Bed'. Since early descriptions of the Speeton Shell Bed by Phillips (1875), Lamplugh (1881c, 1891a), Stather (1905), Melmore (1935) and Versey (1938b), it has

The temperate marine molluscs contained within the Speeton Shell Bed indicate that it was deposited in an estuarine setting during a previous interglacial. Although this traditionally has been regarded as Hoxnian in age (e.g. Can and Penny, 1966; Edwards, 1978, 1981, 1987), the pollen grains enclosed within the shell bed possess affinities with Ipswichian interglacial floral assemblages from southern England (West, 1969). However, incomplete records of vegetation succession in the stratigraphical record hinder direct correlation between interglacial sites based upon pollen evidence alone (Jones and Keen, 1993). The different attitudinal and stratigraphical positions of the two exposures of the shell bed prompted Catt and Penny (1966) to suggest a dual age, specifically an Ipswichian age for the lower exposure underlying the Skipsea Till and a Hoxnian age for the upper exposure underlying Basement Till. Considerable evidence for glaciotectonic disturbance indicates that the upper exposure probably has been transported by glacial thrusting since its deposition (Edwards, 1978, 1981, 1987; Thistlewood and Whyte, 1993). Although Edwards (1981, 1987) suggests that this took place during the Wolstonian glaciation, he reports that Devensian not Wolstonian (Basement) till overlies the shell bed. More recently, amino acid ratios from the high elevation outcrop of the Speeton Shell Bed indicated that it is probably of Ilfordian interglacial age (Oxygen Isotope Stage 7; Wilson, 1991).

Despite the clear evidence for glaciotectonic disturbance and displacement of the upper exposure, the Speeton Shell Bed contains valuable information on the Quaternary palaeoenvironments of Filey Bay and eastern Yorkshire. Temperate deposits, dating to a former interglacial episode, record estuarine sedimentation at a time when the Vale of Pickering was still open to the sea, a .geography that was changed radically some time after the deposition of the Speeton Shell Bed when the emplacement of the Flamborough and Wykeham moraines (referred to locally as the 'Speeton Moraine') blocked the easterly drainage of the proto-Derwent and its tributaries (Valentin, 1957; Penny and Rawson, 1969). The prominent hummocky topography to the south and west of Reighton Sands constitutes part of the Flamborough moraine and documents the ice-marginal stacking of material in response to the intense compressive flow imparted on the North Sea glacier lobe as it flowed onshore during glacial conditions (Valentin, 1957; Straw, 1979b).

Description

The Speeton Shell Bed attains a maximum thickness of a little over 3 m and crops out at two localities. First, between Middle Cliff and New Closes Cliff [TA 147 758], it lies at 27–32 m OD and is sandwiched between Lower Cretaceous Speeton Clay and till, the latter regarded as Basement Till by Lamplugh (1891a), Catt and Penny (1966) and Catt (1977c), but as Skipsea Till or 'Lower Till Series' by Edwards (1981, 1987; (Figure 4.23)). Second, near Reighton Gap [TA 142 763], it lies at beach level between Kimmeridge Clay and Skipsea Till. Basement Till was originally reported as overlying the Speeton Shell Bed by Lamplugh (1879, 1891a). Because both the sediments and the enclosed fauna show a great similarity, the two exposures traditionally have been regarded as the same deposit, even though the intervening 450 m of cliff has never yielded any further outcrops of the Speeton Shell Bed. Owing to the infrequent exposure of the lower outcrop of the Speeton Shell Bed, the higher outcrop has been used almost exclusively for intensive investigations.

The sedimentology of the higher outcrop was described by Edwards (1987) as comprising 1 m of blue-black silty clay, overlain by 1 m of blue-brown silty clay and then 1 m of brownish silt and fine-grained sand. Slightly coarser grain sizes were recorded by Thistlewood and Whyte (1993; (Figure 4.24)). The colour changes in the Speeton Shell Bed have been interpreted by Catt (1977c) and Edwards (1981, 1987) as the products of weathering. There is some evidence, although not unequivocal as pointed out by Thistlewood and Whyte (1993), that the weathering patterns have been modified by glaciotec-tonic disturbance in the lower beds. Recognizable sedimentary structures within the shell bed comprise rhythmically bedded flat lamination, ripple cross-lamination and trough bedding with evidence of bioturbation. Overall the bedding dips southwards at approximately 15°. Some large chalk clasts occur in isolation in some beds. Downward-tapering cracks in the central unit of the shell bed are interpreted by Thistlewood and Whyte (1993) as either relict frost cracks or desiccation cracks. Iron-rich layers, probably representing iron pans, also exist in the lower half of the exposure (Figure 4.24). The shell bed is separated from the underlying Speeton Clay by 0.6 m of angular chalk gravel with quartzite erratics, named the 'Lower Gravel' by Thistlewood and Whyte (1993). A similar thickness of angular chalk gravel separates the shell bed from the overlying till, named the 'Upper Gravel' by Thistlewood and Whyte (1993).

Glaciotectonic disturbance of the Speeton Clay and chalk gravel was reported by Edwards (1978, 1981, 1987), who identified from the glaciotectonic structures a former north–south direction of glacier ice flow . This is in contrast to the predominant NE-SW flow directions of the late Devensian glacier ice in this area. The degree of glaciotectonic disturbance in the high-altitude Speeton Shell Bed itself diminishes up section. Specifically, monoclinal folding and thrust planes occur in the lower part of the shell bed and this gives way up-section to minor flexuring. In addition, valves of *Cardium edule* have been dislocated in the lower part of the shell bed but are intact and in life position towards the top. Edwards suggests that the Speeton Shell Bed was compressed and elevated over a vertical distance of 28 m during the glaciotectonic disturbance. The Upper Gravel lying on top of the shell bed is predominantly horizontally bedded, indicating to Edwards (1981, 1987) that it was deposited after glaciotectonic disturbance. Although Wolstonian till had been reported from Speeton by early research (e.g. Lamplugh, 1891a; Catt and Penny, 1966; Catt, 1977c), Edwards (1987) declares that no Wolstonian till directly overlies the shell bed except for a thin streak contained within the Lower Till Series.

Most of the higher exposure of the Speeton Shell Bed contains shells or shell fragments, although Thistlewood and Whyte (1993) point out that the density of shell is low in the beds immediately above and below the frost-desiccation crack horizon. The faunal list as compiled by Lamplugh (1881c) and expanded by Thistlewood and Whyte (1993) is reproduced in (Table 4.5) and represents an estuarine assemblage similar to the present-day Humber (Penny and Rawson, 1969; Penny, 1974). The microfauna collected and reported by Edwards (1978, 1987) indicates a slightly colder estuarine environment. Amino acid ratios were obtained on *Macoma balthica* shells by Wilson (1991) and are presented in (Table 4.6). Four shells originally collected by L.F. Penny had been coated with resin and, although this was removed, some contamination may have taken place, explaining the lower average ratio of 0.178. A higher average ratio of 0.203 was obtained on freshly collected shells, indicating an appreciably older age.

(Table 4.6) Amino acid (D/L) ratios of *Macoma balthica* from the Speeton Shell Bed (from Wilson, 1991).

Collection date	Laboratory identification	D/L ratio	Mean
1966	A	0.172	0.178 ± 0.005
(L.F. Penny)	B	0.173	
	C	0.182	
	D	0.184	
1988	50 cm*	0.154	0.203 ± 0.035
	1.20 cm*	0.224	
	1.60 cm*	0.230	

*Depth collected from top of shell bed

Additionally, a sequential reduction in amino acid ratios up-section is apparent in the samples collected recently.

The pollen enclosed within the higher exposure of the Speeton Shell Bed was originally investigated by West (1969), who identified an oak forest assemblage typical of Zone II(f) of the Ipswichian interglacial (Oxygen Isotope Stage 5e) of southern England (Table 4.7). Later investigations by Wilson (1991) identified three general characteristics: a) a rise in *Quercus,* peaking in the middle of the sedimentary succession; b) similar frequencies of *Ulmus* throughout the succession; and c) low frequencies of *Picea.* These characteristics resemble the interglacial assemblage at the Ipswichian type site at Bobbitshole (West, 1957, 1980), although the incomplete nature of the vegetational succession at both Speeton and Bobbitshole make any correlation tentative.

(Table 4.5) Faunal list for the Speeton Shell Bed (after Lamplugh, 1881c; Thistlewood and Whyte, 1993).

Psammobia sp.
Mactra sp.
Cerastoderma edule (L.)
Tellina balthica
Cardium edule
Macoma balthica (L.)
Scrobicularia plan (da Costa)
Scrobicularia piperata
Littorina littorea (L.)
L. rudis
Hydrobia (Peringia or *Sabanaea) ulnae*
(Pennant)
Retusa obtusa (Montagu) var. *pretenuis*
Mytilus edulis (L.)
Utriculus obtusus
Littorina saxatilis (Olivi)
Littorina littoralis (L.)
Balanus crenatus echinoid spines

Work on the palaeomagnetic and mineral magnetic properties of the high-elevation exposure of Speeton Shell Bed by Thistlewood and Whyte (1993) has provided important information on the depositional history of the deposit. Two sedimentary units were differentiated, the uppermost of which was subdivided into weathered and unweathered parts. Dips in mean magnetic foliation planes in the upper unit were interpreted as the product of rotation of the Speeton Shell Bed, probably by glacier ice pushing. In contrast to the (Wolstonian?) north-south ice-flow vectors reported by Edwards (1978, 1981, 1987), Thistlewood and Whyte interpret the structural evidence as a product of ice flow from the north-east, which is consistent with Devensian till fabrics. Most importantly, Thistlewood and Whyte conclude that the high-elevation Speeton Shell Bed is not *in situ* and it contains a weathering profile as suggested by Catt (1977c) and Edwards (1981, 1987).

(Table 4.7) Pollen of the Speeton Shell Bed (from West, 1969).

Arboreal pollen	Non-arboreal pollen
Betula	*Corylus*
Pinus	Gramineae
Ulm us	Cyperaceae
Quercus	Compositae (Ligulatae)
Carpinus	*Filipendula*
Picea	*Plantago maritima*
	Umbelliferae
	Sparganium-type
	Filicales

Interpretation

The marine fossils of the Speeton Shell Bed indicate temperate climatic conditions during which sedimentation was taking place in an estuarine environment probably during an interglacial phase. The exact age of this interglacial is a matter of debate, which is centred on the palynology and amino acid ratios of shells in the sediments in addition to the stratigraphical position of the shell bed in the Quaternary succession of Filey Bay.

Three groups of explanations for the altitude differences between the two outcrops of the Speeton Shell Bed have been proposed and are summarized by Catt and Penny (1966). First, the shell bed could represent the original topography of the floor of the estuary upon which it was deposited. Second, the higher exposure could have been thrust from sea level to its present position by glacier ice moving onshore. Third, the lower exposure could have been emplaced at sea level by landsliding. Catt and Penny (1966) rejected the glacier thrusting interpretation because the Speeton Clay and the Kimmeridge Clay underlying the two exposures appeared to be *in situ.* They therefore speculated that either the Speeton Shell Bed represents the former estuary floor, or there are two separate fossiliferous beds. The lack of further exposures between the two sites suggested to Catt and Penny that the former explanation was unlikely. Two separate ages, therefore, were proposed by Catt and Penny based upon stratigraphical associations with tills of apparently different ages. Specifically, the upper Speeton Shell Bed exposure appeared to lie stratigraphically below Basement Till, indicating a Hoxnian or earlier interglacial age. Based upon the similarity of the molluscs at Speeton with those in Hoxnian deposits at Kirmington (Reid, 1885), Catt and Penny confirmed Melmore's (1935) assignment of a Hoxnian age for the higher Speeton Shell Bed. The altitudinal similarity of the lower Speeton Shell Bed and the Sewerby interglacial beach, in addition to its capping by Skipsea Till, led Catt and Penny (1966) to suggest an Ipswichian interglacial age for the lower outcrop.

A Hoxnian age for the upper exposure of the shell bed was supported by Edwards (1978), who ascribed the glaciotectonic disturbance in the sediments to Wolstonian glacier ice, even though he did not support the classification of the overlying till as Basement Till. His interpretation was prompted by the fact that the glacio-tectonic disturbance did not continue into the Upper Gravel and therefore related to a pre-Devensian (pre-Dimlington) glacial advance. The absence of Basement Till at Speeton prompts a further reassessment of the diachronous nature of the two Speeton Shell Bed exposures as suggested by Catt and Penny (1966); in essence, the Devensian age of the till overlying both exposures indicates a similar age for the low and high elevation shell beds, although the lack of research on the flora and fauna of the low elevation exposure hinders further critique.

The pollen evidence presented by West (1969) and Wilson (1991) possesses affinities with the Ipswichian interglacial assemblage at Bobbitshole, questioning the Hoxnian age classifications proposed through stratigraphical analysis. As Wilson points out, however, the palaeoenvironmental records for the Ipswichian and other interglacials are assembled from fragmentary evidence derived from various sites. The corollary is that evidence of different inter-glacials could have been grouped incorrectly grouped into single stages. Important sites in this respect are Ilford and Aveley in the Thames estuary, with interglacial deposits that have been equated with the Ipswichian by West (1980) based upon pollen assemblages despite the fact that the evidence of vegetation succession is incomplete. Faunal evidence from these sites does not confirm the correlation with typical Ipswichian assemblages (Stuart, 1976; Sutcliffe, 1976), but, because this evidence is similarly incomplete, Quaternary scientists have begun to construct a chronostratigraphy based upon amino acid ratios (Bowen and Sykes, 1988). These data have highlighted the greater antiquity of the Hoxnian interglacial, now dated to Oxygen Isotope Stage 9 rather than stage 7, and identified the Ilfordian interglacial at Oxygen Isotope Stage 7 (Table 4.8).

(Table 4.8) Correlation of post-Hoxnian events, amino acid ratios and oxygen isotope stages (after Wymer, 1985; Bowen and Sykes, 1988).

Age (ka BP)	Oxygen isotope stage	D/L ratio (Macoma)	Stage
	2		Dimlington
24	3	0.085	
59	4		
71	5a–d		
122	5e	0.16	Ipswichian
128	6		Wolstonian 3
186	7	0.2	Ilfordian
245	8		
303	9	0.29	Hoxnian

An attempt to date the higher Speeton Shell Bed by Wilson (1991) using amino acid ratios on *Macoma balthica* resulted in the identification of pre-Ipswichian and post-Hoxnian values, prompting the attachment of an Ilfordian interglacial age. Stratigraphically, if Basement Till does overlie the Speeton Shell Bed (Lamplugh, 1879, 1891a; Catt and Penny, 1966) and/or the glaciotectonic disturbance of the shell bed is pre-Devensian (Edwards, 1978, 1981, 1987), the Basement Till and glaciotectonic features equate to Isotope Stage 6 or the Wolstonian' glaciation. However, amino acid D/L ratios of 0.057 on *Macoma balthica* shells from the Basement Till at Dimlington indicate a late Devensian age (Eyles *et al.,* 1994; see Dimlington site report, Chapter 5). Clearly some problems may have arisen from the misidentification of the Basement Till along the east Yorkshire coast, but the age of the Speeton Shell Bed has been placed by Wilson (1991) firmly at an earlier date than the maximum (Wolstonian) age of the till and g!acio-tectonic structures associated with the displacement of the shell bed. A Wolstonian age for the glacial thrusting implies that the construction of the Flamborough and Wykeham moraine belts and the blocking of the lower Vale of Pickering by ice-marginal stacking of thrust blocks could have been initiated as early as Oxygen Isotope Stage 6.

The frost or shrinkage crack horizon, with its associated reduction in shell material, identified by Thistlewood and Whyte (1993), possibly records a period of sea-level lowering during the deposition of the Speeton Shell Bed, although the exact climatic implications are uncertain. The sequentially younger amino acid ratios reported by Wilson (1991) provide ages for samples from above the crack horizon ranging from Ilfordian to Ipswichian. Although some importance was attached to this by Thistlewood and Whyte (1993), who incorrectly assumed that the younger sample only was taken from above their shrinkage crack horizon, there is a strong possibility that the upper sample has been contaminated by the weathering profile within which it was located; amino acid racemization is strongly controlled by the temperature history of the enclosing sediments. The weathering profile at the top of the Speeton Shell Bed is thought to have been produced during the Ipswichian interglacial (Catt, 1977c; Edwards, 1981, 1987), an assumption based solely on its stratigraphical position beneath glaciotectonically undisturbed 'Upper Gravel' and Devensian (Lower Series) till.

Conclusions

More than 100 years since its discovery, the Speeton Shell Bed remains central to reconstructions of late Quaternary events on the Yorkshire coast, specifically the critical post-Hoxnian to pre-Ipswichian time period. Because of its small exposures, the stratigraphical context of the Speeton Shell Bed has been difficult to elucidate and this has led to its exclusion from the most recent correlation of Quaternary deposits in the British Isles (Bowen, 1999). The application of new techniques in Quaternary science, particularly amino acid geochronology, has confirmed the importance of the Speeton Shell Bed as a rare interglacial deposit probably dating back to approximately 200 000 years BP when sea levels may have been 15 m higher than present (Wymer, 1985). Based upon the discussion presented above, the following conclusions can be made about the high-elevation Speeton Shell Bed.

1. It is an estuarine deposit containing a rich molluscan fauna indicative of temperate (interglacial) conditions, although micro-faunal evidence suggests temperatures slightly cooler than present. As such it documents a palaeogeography characterized by a tidal Vale of Pickering, when the proto-Derwent flowed along the vale to the North Sea.

2. It has been disturbed glaciotectonically in its lower layers, documenting a glacial thrusting episode of pre-Devensian (Wolstonian) age. The outcrop is not *in situ* but rather has been transported as a raft by glacial thrusting.

3. It is capped by undeformed chalk gravel (Upper Gravel), which in turn is overlaid by till (Lower Till Series or Skipsea Till Formation), more recently regarded as Devensian in age.

4. It has been weathered, particularly in its upper layers, probably during the Ipswichian interglacial (stratigraphically constrained by conclusions 2 and 3).

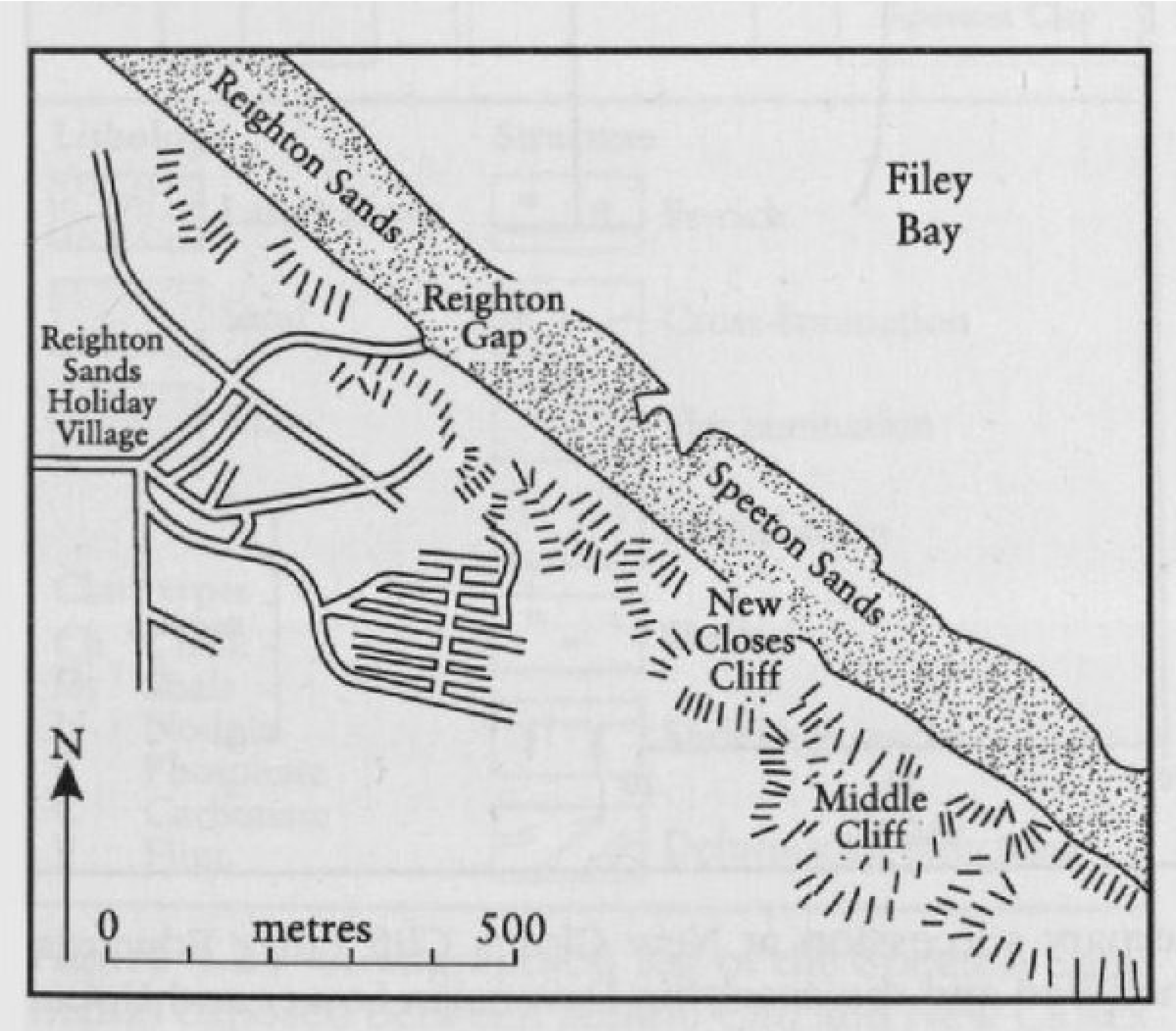
5. It contains evidence of a hiatus in the form of frost or shrinkage cracks associated with a horizon of sparse shell material. This indicates a complex depositional history but the palaeoclimatic implications are unknown.

6. Although previously it has been assigned to the Hoxnian interglacial on stratigraphical grounds and it contains a pollen assemblage similar to those of other Ipswichian sites, amino acid ratios indicate that it probably dates to Oxygen

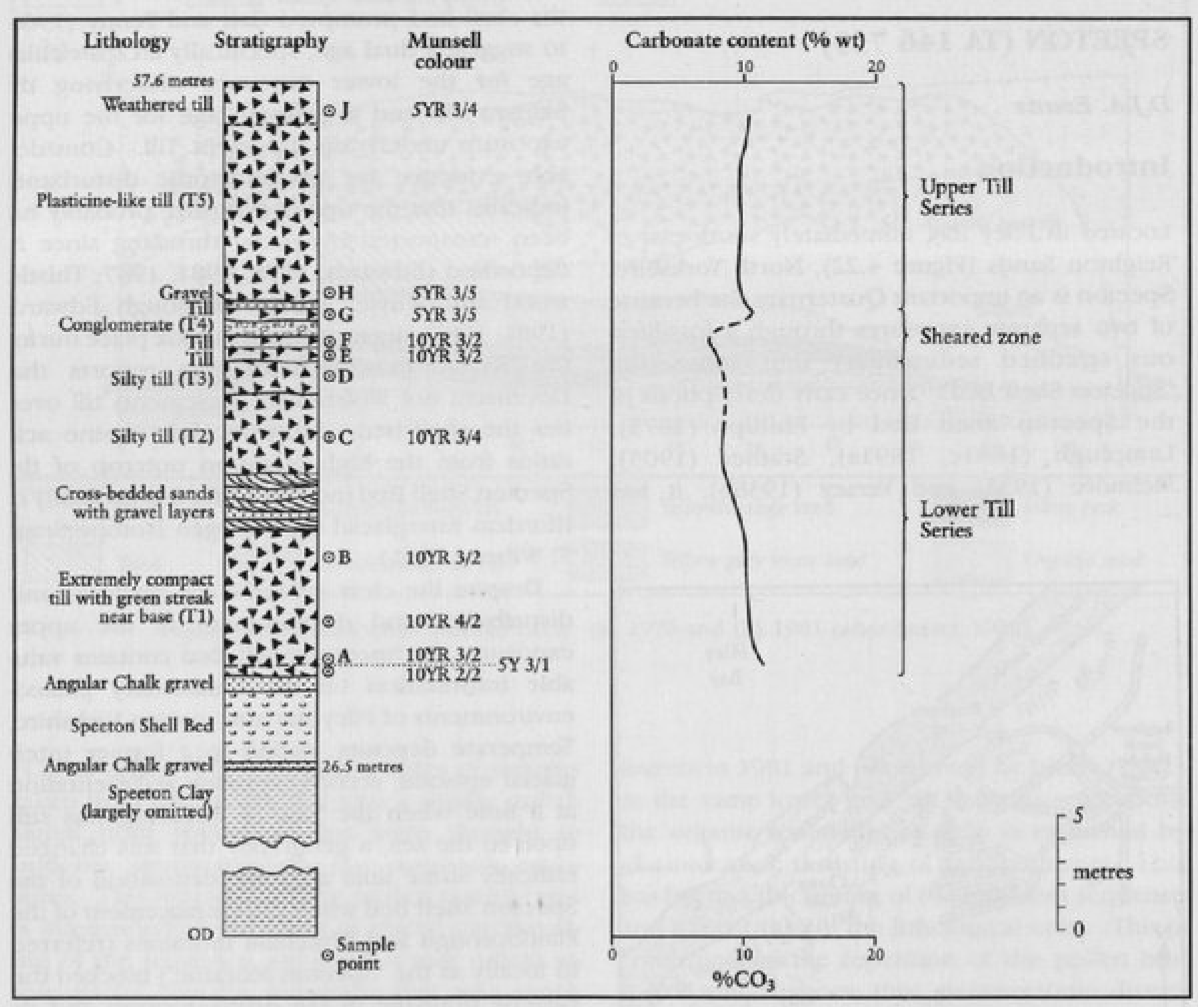
Isotope Stage 7 (Ilfordian interglacial).

Rather less is known about the lower exposure of the Speeton Shell Bed at Reighton Gap. An Ipswichian age was suggested by Catt and Penny (1966) based upon its attitudinal similarity with the Sewerby interglacial beach and the fact that it lay beneath Devensian till, but without further information on the stratigraphy and the amino acid geochronology any age differentiation is speculative. The possibility that it constitutes the undisturbed lateral equivalent of the glacially rafted, high-altitude outcrop of the Speeton Shell Bed is still viable.

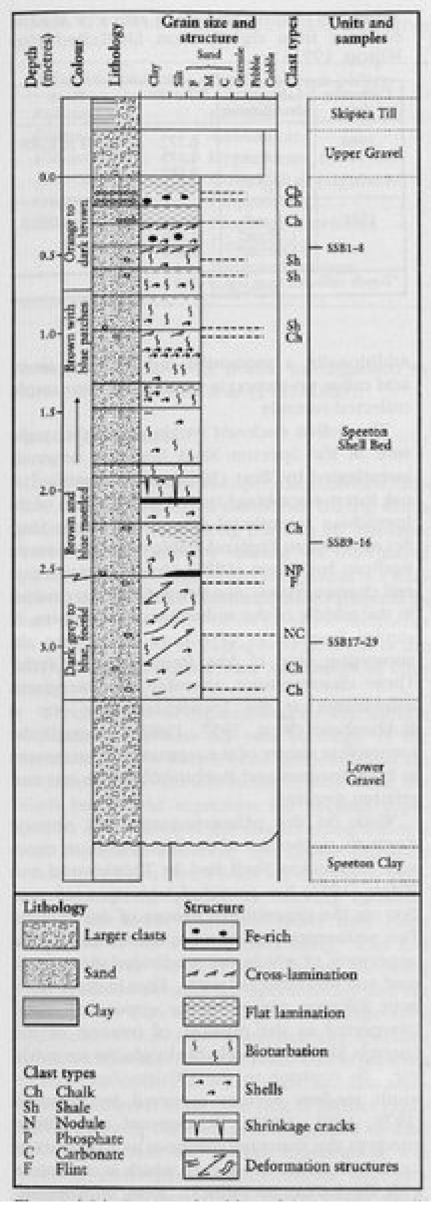
References



(Figure 4.22) Map of the Speeton Shell Bed localities. remained central to the reconstructions of late Quaternary palaeoenvironments of eastern Yorkshire, although its exact age and stratigraphical context have remained problematic.



(Figure 4.23) Stratigraphical log of the complete Quaternary succession at New Closes Cliff (after Edwards, 1981), showing the relationship between the Speeton Shell Bed and the overlying Devensian Lower and Upper Till Series (Skipsea Till Formation, Evans et al., 1995).



(Figure 4.24) Stratigraphical log of the Speeton Shell Bed as exposed between Middle Cliff and New Closes Cliff (after Thistlewood and Whyte, 1993).

Psammobia sp.
Mactra sp.
Cerastoderma edule (L.)
Tellina balthica
Cardium edule
Macoma balthica (L.)
Scrobicularia plana (da Costa)
Scrobicularia piperata
Littorina littorea (L.)
L. rudis
Hydrobia (*Peringia* or *Sabanaea*) *ulvae* (Pennant)
Retusa obtusa (Montagu) var. *pretenuis*
Mytilus edulis (L.)
Utriculus obtusus
Littorina saxatilis (Olivi)
Littorina littoralis (L.)
Balanus crenatus
echinoid spines

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*Depth collected from top of shell bed			

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