Lithological and faunal stratigraphy of the Aptian and Albian (Lower Cretaceous) of the type Speeton Clay, Speeton, N.E England.

C.J. UNDERWOOD and S.F. MITCHELL

SUMMARY: Study of the Aptian and Albian part of the Speeton Clay Formation at Speeton, North Yorkshire, has produced a detailed stratigraphy and a large collection of stratigraphically constrained fossils, despite the general poor state of exposure. This has allowed the development of a readily applicable bed numbering scheme and detailed faunal range charts. The Barremian-Aptian boundary is marked by the appearance of abundant examples of the ammonite *Prodeshayesites* and a marked lithological change from black shale to sandy mudstone. Higher parts of the Aptian have yielded abundant faunas, including ammonites of the *fissicostatus*, *forbesi* and *deshayesi* Zones; the base of the *forbesi* Zone marked by the incoming of Ewaldi Marl facies. Poorly fossiliferous silty shales of the Albian *tardefurcata* Zone are succeeded by a bed with glauconite and phosphate pebbles, interpreted as marking the base of the *mammillatum* Superzone. This is overlain by fossiliferous clays of the Lower and part of the Middle Albian. Aptian and Lower Albian successions inland are highly variable, probably due to intra mid-Cretaceous fault movements. The same general stratigraphy as at Speeton, however, may be seen across much of the southern North Sea.

The stratotype section of the Speeton Clay Formation at Speeton, North Yorkshire (Fig. 1), exposes an almost complete marine Lower Cretaceous succession from the Upper Berriasian to the Middle Albian in a variable mudstone facies. This represents the only exposed example of the marine Lower Cretaceous of the North Sea Basin, and as such has proved critical in the study of Lower Cretaceous stratigraphy (see Rawson *et al.* 1978). Although frequently rather indifferently exposed, careful documentation of exposures has allowed the development of a detailed lithostratigraphy and biostratigraphy for the Speeton Clay, at least in sediments of Lower Barremian or older (e.g. Lamplugh 1889, 1924; Neale 1960, 1962; Fletcher 1969; Rawson and Mutterlose 1983; Doyle 1989; Mitchell 1992).

Despite extensive studies on the Speeton section, the upper part of the succession has remained poorly understood. Exposures of the upper Barremian part of the Speeton Clay to the lower part of the overlying Hunstanton Formation have always proved difficult to interpret, as they are only occasionally seen below shifting beach deposits or within eroding landslips, and typically occur as small coherent blocks separated by faults and slip planes. This type of exposure necessitates the gradual development of a composite stratigraphy. Despite early records of numerous fossils of Upper Barremian and Aptian age (e.g. Phillips 1829; Judd 1868; Spath 1924), attempts to develop a stratigraphy for these beds have been confused and have taken little account of faults and slips (e.g. Meÿer 1869; Lamplugh 1924; Ennis 1937; Wright & Wright *in* Swinnerton 1955), with beds missing or duplicated and, on occasion, including horizons from high in the Hunstanton Formation (Mitchell 1995). Much of the information on the succession described here was obtained from good exposures opposite Queen Rocks (see Fig. 2.) in Winter 1989-1990 and Autumn 1996, with additional information gained from other exposures at other times during this study. All exposures of the top B Beds and A beds were very badly deteriorated or obscured in Spring-Summer 1997 preventing further work.

1. PREVIOUS WORK.

Aptian and Albian fossils were first recorded form the Speeton Clay by Phillips (1829) and Judd (1868). It is unclear, however, whether these fossils were collected *in* *situ*, as Judd (1868) recorded the Aptian *Ammonites deshayesii* (probably *Prodeshayesites fissicostatus*) from the Cement Beds. The Cement Beds *sensu* Lamplugh (1889) and subsequent workers are now know to be Middle Barremian, but it is possible that Judd included within his concept of the Cement Beds all rocks exposed in the (now degraded) cement quarries along the Speeton clifftop.

In the first formal stratigraphic scheme for the Speeton Clay, Lamplugh (1889) divided the sequence into units lettered A to F from the top down, unit F being the Kimmeridge Clay, each defined on the occurrence of a different belemnite. In this scheme, the A beds were defined on *Belemnites minimus* (*Neohibolites* spp.) and B Beds on *Belemnites? semicanaliculatus* (later recognised as including belemnites of several genera within the Oxyteuthididae). The upper part of the B Beds and A Beds are not subdivided further. Better exposures later allowed a subdivision of these beds (Lamplugh 1896, 1924) in which the Aptian *Belemnites ewaldi* von Strombeck and Albian fossils were recorded from the A Beds, allowing them to be divided into two units; the Ewaldi Marl overlain by the Minimus Marl, whilst basal Aptian ammonites were recorded from the top of the B Beds. Further studies by Ennis (1937) also recognised the Ewaldi Marl and Minimus Marl, with the top of the former defined by the Greensand Streak, a thin bed rich in glauconite and phosphate nodules. The composite nature of this scheme, developed from observations made by several people (Lamplugh, Stather and Ennis) over many years, makes it difficult to interpret; the Minimus Marls succession, in particular, being difficult to relate to recent exposures.

A roughly similar scheme by Wright & Wright (*In* Swinnerton 1955) has formed the basis of subsequent published descriptions (e.g. Kaye 1964a; Wright 1968; Neale 1974; Rawson *et al*. 1978). The recognition of only one unit (A5) between the Greensand Streak and black clays of the B Beds has caused confusion. Subsequent authors have recorded seeing either pale marls with *Neohibolites ewaldi* or dark, almost unfossiliferous shales in this position, and so both these highly dissimilar units have become referred to as the 'Ewaldi Marl' in the literature. Further confusion, especially as regard the age of the top Speeton Clay, has been caused as the beds above the 'Greensand Bed' (bed A4 within the Wright and Wright scheme) contain ammonite-bearing units belonging to the Speeton Beck Member of the Hunstanton Formation (Mitchell 1995), suggesting, incorrectly, that the Speeton Clay ranges up to the Upper Albian. Controversy has also surrounded the dating of the Greensand Streak and immediately overlying clays (see Rawson *et al.* 1978 for details), which have been attributed to either the Lower or Middle Albian depending on what faunal groups were studied. This is largely due to the inclusion by Kaye (1964a) of the *mammillatum* Zone into the Middle Albian.

2. LITHOSTRATIGRAPHY

2.1. Bed numbering

To retain consistency with previous work, the bed numbering scheme used here follows that of previous workers as far as possible, although some alterations have had to be made. Lamplugh (1924) provided the first stratigraphic scheme for the A beds at Speeton, but gave no bed numbers. Ennis (1937) gave a numbering scheme of the A beds with the Greensand Streak as bed A7. This numbering system has not been used subsequently. The stratigraphic scheme of Wright & Wright (*in* Swinnerton 1955) and subsequent workers numbered the Greensand Streak as bed A4. The stratigraphy of the overlying beds of Wright and Wright (*in* Swinnerton 1955) is hard to relate to that seen here, and consists of a mixture of slipped A beds and Hunstanton Formation.

The beds between the top B Beds and the Greensand Streak have been assigned to A5 (Wright and Wright *In* Swinnerton 1955) or the Ewaldi Beds or Ewaldi Marl (following Ennis 1937), as it appears that none of these workers recognised both of the extremely dissimilar units below the Greensand Streak (LA1 to LA3 and LA5 to LA6 of present usage), or allowed for a slipped or faulted bed contact at this level. The twofold division of this level was, however, clearly noted by Lamplugh (1896, p181) who noted a 'dull black clay without fossils' below the marls with '*B. minimus*' and above the pale marls with belemnites (Ewaldi Marl).

The numbering of the Upper B Beds used here follows that of Ennis (1937), with his beds B1a to B1c being the same as UB1A to UB1C as used here, even though they have yielded none of the belemnites which define the B beds. The A Beds were considered best divided into an upper and lower unit, with the base of the Greensand Streak as the base of the Upper A Beds, with bed numbers prefixed with "U" or "L". Both the Upper and Lower A Beds have erosion surfaces with a bed of reworked phosphate pebbles at the base, making them important levels within the succession. In line with previous schemes, the Greensand Streak (previously A4) is now called bed UA4. This unit marks both a major erosion surface, and is often the best exposed and recognisable unit within the A beds. For similar reasons, the Ewaldi Marl is retained as LA5. Retaining this bed number leaves bed number LA4 vacant. This is intentional, as the state of present exposures gives no indication of what (if any) lithology is represented by the upper part of the Aptian, Upper Aptian sediments being well known from neighbouring areas of the North Sea (e.g. Lott *et al*. 1985). The extremely variable nature of the exposure at Speeton suggests that, if present, this interval will at some point be seen, and may be incorporated into the present bed-numbering scheme.

2.2. Lithostratigraphic descriptions (See Fig. 3.)

2.2.1. ***The Upper B Beds***

Undifferentiated Upper B Beds (at least 4 m, base and top not seen). Dominantly soft, black laminated shales. Highly pyritic, with large numbers of irregular pyrite nodules. Abundant belemnites (*Hibolithes minutus* Swinnerton and *Oxyteuthis depressus* Stolley) are present, often with partial pyrite overgrowths. Small ammonites (largely nuclei) are not uncommon and are invariably pyritised. There are at least two thin beds of paler grey-brown clay. These contain calcareous concretions of various sizes, including large septaria.

Bed UB3 (at least 0.4 m, base not seen). Lithologically identical to above. Soft, black, shale with numerous pyrite nodules.

Bed UB2C (0.15 m). Pale brown-grey shale. Common ammonites largely phosphatised. Base gradational over several centimetres.

Bed UB2B (<0.15 m). Brown sandy clay with some large sandy septaria. Sand-filled *Planolites* burrows common. Very common ammonites largely phosphatised, some smaller specimens pyritised. This is the only recorded level in the Type Speeton Clay with a high content of fine quartz sand. Base sharp.

Bed UB2A (At least 0.13 m, top not seen). Dark grey shale with common flattened aragonitic ammonites and some sand-filled *Planolites* burrows (UB2A i) overlain by 0.03 m of hard nodular siltstone with dark Chondrites burrows (UB2A ii).

Sediments of Beds UB1 and UB2 were not seen in contact, and there is a gap of unknown size in the succession.

Bed UB1C (At least 0.2 m, base not seen). 0.05 m of hard black mudstone (UB1Cii) overlain by 0.15 m of black shale (UB1Ci).

Bed UB1B (0.25 m). Hard black or dark grey marl with scattered pyrite nodules and partly pyritised ammonites and gastropods. Planktic forams appear in vast quantities in the upper part of this bed. Base gradational over several centimetres.

Bed UB1A (0.4 m). Dark grey or black shaly marl. Flattened pinkish-grey phosphate nodules common near the top and less commonly at the base. The top 5 cm (B1Ai) is a black shale, poorly seen as it is heavily bioturbated by burrows from the overlying bed. Planktic forams present in vast quantities. Base sharp.

2.2.2. ***The Lower A Beds***

Beds LA6 to LA5 constitute the Ewaldi Marl of earlier authors, characterised by abundant examples of *Neohibolites ewaldi*.

Bed LA 6 (0-0.1 m). A lenticular conglomerate of belemnites and reworked pinkish phosphate nodules in a rubbly pale grey marl matrix. The base is intensely burrowed, with the conglomerate piped down large *Thalassinoides* networks into the underlying sediment. Where Bed LA6 is absent, the *Thalassinoides* networks are still seen penetrating the top of the B Beds.

Bed LA5iii (0.6 m). Fairly hard grey marl with obvious burrows of various types. The lower half is somewhat greenish in places. Belemnites and inoceramid bivalves are common. Base sharp but burrowed.

Bed LA5ii (0.2 m). Softer yellowish-grey marl with some green weathering patches and burrow linings. Base sharp but burrowed.

Bed LA5i (At least 0.5 m, top not seen). Massive hard pale grey or yellowish marl. Belemnites and inoceramid bivalves less common than below. Base sharp but burrowed. This is the most commonly seen unit of the Lower A Beds.

There is a gap of unknown thickness above Bed LA5. It is possible that sediments similar to those seen elsewhere in the North Sea Basin (e.g. Lott *et al.* 1985) are present at Speeton but have not yet been observed.

Bed LA3 (At least 1.95 m, base not seen). Dark brown to black shaly mudstones with scattered small rounded phosphate nodules. The sediments are somewhat silty and micaceous. Both micro- and macrofossils are very rare. When well exposed this may be divided into six units: LA3vi, 0.1 m+, hard brown clay, rare nodules; LA3v, 0.4 m, medium brown shale; LA3iv, 0.25 m, soft dark brown shale; LA3iii, 0.2 m, harder brown burrowed clay, nodules sometimes common; LA3ii, 0.6 m, dark brown burrowed shale with scattered nodules; and LA3i, 0.4 m, soft black shale with occasional nodules.

Bed LA2 (0.2 m). Harder black shale with many flattened burrow fills and lenses of highly glauconitic and micaceous clay. Base sharp but burrowed.

Bed LA1 (0.7 m). Brown to black shaly mudstones with rare phosphate nodules. Silty and micaceous in places. Both micro- and macrofossils are very rare. Upper part full of burrows from overlying bed. When well exposed this may be divided into three units: LA1iii, 0.3 m, soft black shale; LA1ii, 0.25 m, dark brown shaly clay with rare ?reworked phosphates; and LA1i, 0.15m, Brown clay with phosphates common in places. Base sharp but burrowed.

2.2.3. ***The Upper A Beds***

The beds above Bed UA4 have frequently been referred to as the Minimus Marls by authors (Following Lamplugh 1924). We abandon this term as, although there are three species of *Neohibolites* present in these beds, *Neohibolites minimus* (Miller) is absent in the Speeton Clay, first appearing in the Upper Albian of the Hunstanton Formation (Mitchell 1995).

Bed UA4 (0.05-0.2 m). Green highly glauconitic clay with numerous black reworked phosphates. This is commonly piped down burrows into underlying bed. Slip planes commonly run parallel to this bed, and it is often seen repeated several times by slips.

Bed UA3C (0.1-0.3 m). Red clay rich in dark green glauconite. Calcareous and phosphate nodules, the latter occasionally coated in crystalline baryte, are seen in places. In some exposures, the upper 0.12 m (UA3Ci) is a smooth red clay lacking glauconite.

Bed UA3B (0.9 m). Soft brown bioturbated clay, phosphate nodules sometimes seen near base. In some exposure, a 15 cm micritic limestone (UA3Bii) is present 12 cm above the base of the bed. This is brown, reddish at the base, and is seen to overgrow baryte-covered phosphates. It is sometimes also contains septarian cracks filled with baryte.

Bed UA3A (0.7 m). Brown bioturbated clay with small phosphates near the top. Three thin (<0.05 m) seams of black clay are seen at the base (UA3Avi) and near the middle (UA3Aiv and UA3Aii). Belemnites become common in UA3Aiii and remain common throughout the overlying A Beds and much of the Hunstanton Formation.

Bed UA2C (0.45 m). Red or pink calcareous clay with scattered phosphates, some with a baryte coating. Two thin (<5 cm) seams of black clay are seen at the base (UA2Civ) and near the middle (UA2Cii).

Bed UA2B (0.12 m). Grey-green clay with abundant red *Chondrites* burrows.

Bed UA2A (0.2 m). Red calcareous clay.

Bed UA1C (1.75 m). Soft brown bioturbated clay with phosphate nodules, some with a baryte coating fairly common near the base. Two marker beds allow subdivision when well exposed. A 0.1 m black clay with burrows and small phosphates, probably reworked (UA1Civ) is present 0.5 m above the base, and a 0.1 m burrowed red clay (UA1Cii), 0.2 m above that.

Bed UA1B (at least 1.0 m, top not seen). Alternations of brown clay and at least three beds of red marly clay. This unit has only been seen in a deformed state and so subdivision has not been attempted.

Bed UA1A (probably at least 1.0 m, base not seen). Greyish or brown marly clay, usually with well defined burrows. Inoceramid bivalves are common and may form continuous plasters on bedding surfaces. This bed can appear superficially similar to LA5, but may be readily separated by the different belemnite species. This bed is usually seen as small isolated exposures, however, the top 0.3 m has been seen in contact with the overlying Hunstanton Formation (see Mitchell 1995).

3. FAUNAS AND BIOSTRATIGRAPHY

3.1. Macrofaunal Biostratigraphy (See Fig. 4.)

Although most of the Upper B Beds and A Beds are fossiliferous, there is a general rarity of ammonites throughout much of the succession. This has necessitated the use of other fossils, especially belemnites, in constructing a biostratigraphic correlation with other sites (See Fig. 6 for summary of zonal schemes).

The black shales of the undifferentiated Upper B Beds contain relatively abundant ammonites. During this study, *Aconiceras nissoides* (Nikitin), *Toxiceratoides* ex. gr.

royeri (d'Orbigny) and ?*Hamiticeras* sp. were recorded. Previous collections have yielded similar faunas including *Parancyloceras bidentatum* (von Koenen) (e.g. Spath 1924). These are associated with abundant examples of the belemnites *Oxyteuthis depressus* and *Hibolithes minutus*. This ammonite assemblage is indicative of the *bidentatum* Zone of the Upper Barremian.

The small exposure of Bed UB3 yielded specimens of both *A. nissoides* and *H. minutus*. Both of these species continue upwards into UB2, where they are associated with very numerous specimens of the basal Aptian index species *Prodeshayesites* ex gr. *fissicostatus* (Phillips). Although Bed UB3 contains no diagnostic Barremian taxa, we take the sudden appearance of *P.* ex gr. *fissicostatus* within UB2 to mark the base of the Aptian. *P. fissicostatus* (Phillips) is not here considered readily separable from *P. bodei* (von Koenen) as there appears to be a morphological gradation between these two 'species'. A single specimen belonging to a genus very close to, if not synonymous with, *Toxiceratoides* was recovered from Bed UB2B. This appears to be the same species as a specimen from the North Fordon borehole (Geological Survey Museum; GSM Zn 3236), also associated with a basal Aptian fauna. The posterior half of *N.* cf. *ewaldi* was collected from Beds UB2Aii. The rare occurrence of *N.* cf. *ewaldi* with *fissicostatus* (i.e. *bodei*) Zone ammonites in N.W. Germany was recognised by Stolley (1911). It has been suggested that belemnites of 'Barremian' aspect disappear within the *fissicostatus* Zone, before the appearance of *Neohibolites* (Mutterlose 1990). The specimen of *N.* cf. *ewaldi* recorded here associated with *H. minutus* and *P.*ex gr. *fissicostatus* demonstrates this to be untrue.

The dark marls of Bed UB1 contain poorly preserved specimens of *P.*ex gr. *fissicostatus*, but no other ammonites or any belemnites were seen. Bed UB1 is therefore within the '*bodei*' Subzone of the *fissicostatus* Zone.

Although recorded as lacking ammonites by Spath (1924), the Ewaldi Marl (LA5 and LA6) has yielded a reasonable diversity of ammonites, although these are generally poorly preserved. The basal pebble bed, Bed LA6, contains both derived and indigenous ammonites. Occasional examples of *P*. ex gr. *fissicostatus* are present as reworked and worn phosphate moulds. These are associated with part-pyritised specimens of *A*. *nissoides* and a pyritised body chamber of a juvenile *Cheloniceras (Cheloniceras)* sp.. A specimen identified as the lytoceratid *Hemitetragonites* sp. (Casey 1960) is recorded in the Geological Survey Museum (GSM 17042) as originating from the Ewaldi Marl. This had been previously cited as derived from the Greensand Streak (Spath 1924, who identified it as *Gaudryceras* cf. *aeolum*: Ennis 1937). The preservation in pyrite with no preserved aragonite is consistent with it originating from Bed LA6. Pyritised specimens of *forbesi* Zone *Deshayesites* (Rawson *et al*. 1978) probably also originated from Bed LA6. Bed LA6 also contains very common specimens of *Neohibolites ewaldi*. These belemnites are often broken and strongly bored suggesting a hiatal concentration. There is no ammonite evidence for the *obsoletus* Subzone of the *fissicostatus* Zone or the lower part of the *forbesi* Zone, suggesting that the erosion surface at the base of Bed LA6 represents a major time gap.

The marls of Beds LA5iii and LA5ii have also yielded ammonites. Several specimens of a small species of *Tonohamites* sp. are associated with flattened specimens of *Deshayesites* cf. *normani* Spath and *D*. cf. *forbesi* Casey. We therefore place Beds LA6 to LA5ii within the *forbesi* Zone, the specimen of *Cheloniceras (Ch.)* sp. suggesting that only a level high in this zone is represented. Ammonites from Bed LA5i include *Tonohamites* sp. as before, and single, partly flattened, specimens of *Tropeum* aff. *hillsii* (J de C Sowerby) and *Deshayesites* cf. *grandis* Spath. In southern England, both *T. hillsii* and *D*. *grandis* have their acme occurrences within the *grandis* Subzone of the *deshayesi* Zone (Casey 1960, 1964), although *T*. *hillsii* does extend up to the upper *bowerbanki* Zone (Casey 1980). Bed LA5i is therefore considered to represent the *deshayesi* Zone. *N. ewaldi* remains common throughout Bed LA5. There is no evidence that any Upper Aptian has been seen at Speeton (contrary to Rawson *et al*. 1978).

The remainder of the Lower A Beds contain very few age diagnostic fossils. A single specimen of the belemnite *Neohibolites strombecki* (Müller) amend Stolley was found in situ in Bed LA1ii, with a second specimen from a level in a degraded section somewhere between the lower part of Bed LA1 and the upper part of Bed LA3. This species is present in the *schrammeni* and *acuticostata* Subzones of the basal Albian *tardefurcata* Zone in N.W. Germany (Mutterlose 1990). Two fragments of *Epileymeriella (Epileymeriella)* cf. *hitzeli* (Jacob) were seen in Bed LA1i. Casey (1957) considered *E. (E.). hitzeli* to be indicative of the *regularis* Subzone of the *tardefurcata* Zone. We therefore consider Bed LA1i to be within the *regularis* Subzone. The lower parts of Bed LA3 yielded no identifiable macrofossils, and as such their age is poorly constrained. It is possible that they could extend down into the uppermost Aptian.

The glauconitic Bed UA4 (the Greensand Streak) has yielded a specimen of *E.(E.)* cf. *hitzeli* (see Lamplugh 1924, Spath 1924, Casey 1957). this specimen is preserved as a phosphate mould (Lamplugh 1924) and is probably reworked from the underlying beds. The only stratigraphically useful indigenous macrofossils are the rare specimens of the belemnite *Neohibolites minor* Stolley, which extends upwards to Bed UA3Av. Above this, *N. minor* is replaced by common examples of two undescribed species of *Neohibolites* belonging to the *minimus* group. *Neohibolites* sp. nov. A occurs in the remainder of Bed UA3A, above which it is replaced by *Neohibolites* sp. nov. B (*Neohibolites* sp. nov. cf. *N. pinguis* of Mitchell 1995) which extends upwards into the Hunstanton Formation. The only *mammillatum* Superzone ammonite known from the A Beds is a partial three dimensional specimen of *Otohoplites raulinianus* (d'Orbigny) from the base of Bed UA1C. This species is indicative of the *raulinianus* Subzone of the *auritiformis* Zone (Owen 1988). The lower part of the Upper A Beds, from Bed UA4 to Bed UA2 are thus tentatively assigned to the *chalensis* Zone of the *mammillatum* Superzone.

It has not yet proved possible to directly correlate the belemnite succession against the standard Lower Albian ammonite zones. Ammonite rich exposures of the *mammillatum* Superzone of southern England generally lack belemnites (e.g. Casey 1961), whereas the *mammillatum* Superzone is generally missing in the belemnite rich successions of northern Germany (e.g. Kemper 1973).

Isolated exposures of Bed UA1A have yielded bedding surfaces rich in poorly preserved *Hoplites* cf. *dentatus* Spath, a species also known from the basal Hunstanton Formation (Mitchell 1995), whilst *Hamites* sp. has also been recorded (Jeremiah 1996; unlocalised material in Geological Survey Museum). The associated shelly fauna includes bivalves and brachiopods otherwise known from the top of the Carstone on the East Midlands Shelf (Mitchell 1995). The top of the Speeton Clay is therefore within the Middle Albian *dentatus* Zone.

3.2. Associated Macrofauna (See Fig. 4.)

Although in the field much of the Upper B and A Beds appears to be devoid of fossils other than belemnites and ammonites, bulk sieving often yields a rich fauna of small macrofossils. About 100 kg of clays and marls were bulk sampled and sieved, allowing recovery of much of the fauna noted below.

The Upper B Beds contain a very impoverished benthos. The Barremian part (Bed UB3 and below) contains only occasional small bivalves *Grammatodon sp.* and *Corbula angulatum* (Phillips), as well as indeterminate small gastropods and a tooth of the shark *Protosqualus* sp. The benthos of Bed UB2 consists of only small nuculid bivalves and the gastropod ?*Procerithum* sp. Bed UB1 contained no bivalves, but gastropods were represented by at least three species, all poorly preserved, but including ?*Aporrhais* sp. Rare asteroid ossicles are present in bulk samples. Vertebrate material is more diverse, with teeth of the bony fish ?*Caturus* and an indet. seminotid together with teeth of the sharks *Pteroscillium* sp. nov. and ?*Pseudocorax* sp. nov.

The faunas of the Ewaldi Marl (Beds LA5 and LA6) are more diverse. Bivalves are represented by abundant *Inoceramus ewaldi* (Schüter)with occasional specimens of *Aucellina aptiensis* (d'Orbigny), whilst phosphate pebbles and larger ammonites are encrusted by *Dimyodon* sp. Brachiopods are represented by occasional specimens of *Terebratulina martiniana* (d'Orbigny), *Cyrtothyris cyrta* (Walker) and a thin shelled rhynchonellid (all specimens of which are crushed and none have been well enough preserved to be determinable). Rare specimens of the unusual brachiopod *Agyrotheca* sp. have also been collected. Echinoderms are also diverse. Echinoids are represented by the large spines of *Polycidaris phillipsi* (Desors) as well as smaller spines of diademids and holastids. Asteroid material is particularly abundant in bulk samples of the Ewaldi Marl, with several species being represented, suggesting a diverse and abundant fauna. Rare ossicles of the isocrinid *Ornareocrinus dentatogranulatus* (Wollemann) are also present. Barnacle plates are uncommon, but demonstrate the presence of at least two species. Fish teeth are also diverse, with bony fish represented by ?*Caturus* sp. and a seminotid, as well as a selachian fauna containing the sharks *Synechodus dubrisiensis* (Mackie), *Notorhynchus aptiensis* (Pictet), *Pteroscillium* sp. nov., ?*Pseudocorax* sp. nov. and ?*Chiloscillium* sp. and the ray *Spathobatis picteti* (Cappetta). Beds LA1 to LA3 have yielded no additional macrofauna except for rare fish fragments.

With the exception of Bed UA1A, the bulk of the Upper A Beds contain a poor shelly macrofauna. The only diverse macrofossils are selachian remains that have been described elsewhere (Underwood and Mitchell *Submitted*), which are dominated by teeth of the small shark *Protosqualus sigei* Cappetta. Small bryozoa and holastid spines are present throughout the Upper A Beds, but are never common. Indeterminate terebratulids are present in Bed UA4, whilst a specimen of *Aucellina aptiensis* was recovered from Bed UA2. Throughout Bed UA1, inoceramid debris is present in microfossil residues, but at only one level in Bed UA1B were crushed specimens assignable to ?*Birostrina* cf. *salomoni* (d'Orbigny) collected. The isolated exposures of UA1A yield a far richer fauna.

Inoceramus cf. *anglicus* Woods is extremely abundant, creating at least one shell plaster over a bedding surface. Other bivalves include *Neithea* aff. *quinquecostata* (J. Sowerby) and indeterminate pectenids. Brachiopods are also diverse, with specimens of *Burrirhynchia leightonensis* (Walker), *Capillarina diversa rubicunda* Cox and Middlemiss and "*Biplicatoria*" *anglica* (Owen). Other fossils include bryozoan fragments, coleoid arm hooks, holastid echinoid spines and plates of the barnacle *Zeugmatolepas mockeri* Withers.

3.3. Microfauna (See Fig. 5.)

Samples for microfossil examination were collected concurrently with the logging of sections and the collection of samples for bulk analysis. Most samples (between 100 g and 1 kg) were oven dried, soaked and sieved through a 63 μm sieve. Samples from harder lithologies were disaggregated by repeated freeze-thaw treatment with a supersaturated solution of sodium sulphate. The >250 μm fraction was picked in entirety, with smaller size fractions examined for critical species.

3.3.1. ***Foraminifera***

Little has been published on the foraminifera from the upper part of the Speeton Clay Formation, although both Aptian (Banner and Damini Desai 1988) and Albian (Dilley 1969) forms have been described. Aptian and Lower Albian foraminifera have been more extensively studied mainland Europe (Hecht 1938; Bartenstein 1962, 1965, 1974, 1976, 1978; Bartenstein and Kovatcheva 1982; Meyn & Vespermann 1994); (Bartenstein and Kaever 1973); and Trinidad (e.g. Bartenstein and Bolli 1986; Bartenstein 1987). Workable zonal schemes have been developed by: King *et al*. (1989) for the Cretaceous of the southern North Sea; Price (1977) for the Albian of NW Europe; and Bartenstein (1987) for benthic foraminifera.

The Upper B Beds yield relatively impoverished benthic foraminiferal faunas characterised by *Lenticulina (Lenticulina)* spp. and members of the Robertinacea [*Epistomina spinulifera* (Reuss) and *Hoeglundina carpenteri* (Reuss)] which have relatively low biostratigraphic value. The undifferentiated B Beds contain *Lenticulina (L.) ouachensis ouachensis* (Sigal),*Citharina acuminata* (Reuss) and *Marginulinopsis gracilissima* (Reuss) and *Marginulinopsis foeda* (Reuss). More species are present in bed UB2A, where various calcareous benthics [e.g., *Lenticulina (Lenticulina)* spp., *Gavelinella barremiana* Bettenstaedt, *Notoplanulina*? *schloenbachi* (Reuss), *Nodosaria* sp., *Marginulinopsis jonesi* (Reuss), *Psilocitharella recta* (Reuss), *Frondicularia* cf. *gaultina* Reuss] are present in moderate numbers. *Lenticulina (L.) nodosa* (Reuss) is abundant in bed UB1A.

The benthic foraminifera from the Upper B Beds are of low biostratigraphic value, as they are in late Barremian to early Aptian sediments in the North Sea (Lott *et al.* 1985). *C. acuminata* is a typical Barremian form (Bartenstein 1978, 1987), although in Germany, rare specimens occur as high as the *tardefurcatum* Zone. *L. (L.) nodosa* appears to range from the high Berriasian to the early Albian, being most abundant in the Valanginian to Lower Aptian (Bartenstein 1974, 1976, 1978, 1987; Bartenstein and Kaever 1973). *M. gracilissima* and *M. foeda* also range up into the Aptian, but are generally rare (Bartenstein 1978). The presence of very rare *Notoplan.? schloenbachi* has extended the range of this otherwise biostratigraphically useful species downwards from the mid Aptian (Crittenden 1983, 1987).

Three intervals characterised by the appearance of small planktic foraminifera are recognised in the Upper B Beds. Beds UB3 and UB2Aii yield moderately common examples, while Bed UB1A and the upper part of Bed UB1B (the latter not sampled in detail) are characterized by extremely abundant examples. Between these pulses, planktic foraminifera are absent. These forms belong to either *Blefuscuiana* or *Praehedbergella* (Banner and Damini Desai, 1988), and are not identified to species level here. In bed

UB1A, many of these planktic tests have been incorporated into the construction of a large agglutinated foraminiferan ("Klümpchen" of Bartenstein and Kaever (1973)), probably assignable to *Reophax* sp. (Bertram and Kemper 1982). Planktic foraminifera are present in the North Sea from the Barremian (Banner *et al.* 1993), with 'flood' abundances recognised in the Lower Aptian (Banner *et al.* 1993), and more commonly in levels assigned to the mid or late Aptian (Crittenden 1983, 1987; Lott *et al.* 1985; Hart *et al.* 1989). The distribution of planktic forams at Speeton is therefore similar to that recognised in the North Sea by Banner *et al.* (1993)

The Upper B Beds can, therefore, be divided faunally into two portions. the undifferentiated Upper B which yield only low abundance low diversity assemblages of benthic foraminifera, whilst Beds UB1 to UB3 (upper) which is characterised by floods of small planktics, and variable benthic assemblages (barren through to relatively diverse).

Beds LA6 and LA5 contain very rich assemblages of benthic foraminifera, the most abundant forms ranging throughout this interval being: *Lenticulina* (*Lenticulina*) spp., *Ammodiscus cretaceus* (Reuss), *Marssonella subtrochus* Bartenstein, *Gavelinella barremiana*, and *Laevidentalina* spp. In addition, the more biostratigraphically useful taxa *Frondicularia hastata* Roemer, *Psilocitharella kochi* (Roemer) and *Planularia crepidularis* Roemer all range through Beds LA6 and LA5i. These taxa range up to the *nutfieldensis* Zone in Germany (Bartenstein and Kovatcheva 1982; Meyn and Vespermann, 1994). *Textularia bettenstaedti* Bartenstein & Oertli, *Verneulinoides subfiliformis* Bartenstein and *Reophax minutus* Tappan all first appear in bed LA5i. *R. minutus* appears in the upper Lower Aptian (*deshayesi* Zone of German usage = *forbesi* and *deshayesi* Zones of Casey, 1961) in Germany (Bartenstein 1978). *Gaudryina dividens* Grabert also first appears at this level. This species has a restricted range world-wide (Bartenstein 1976, 1978, 1987), first appearing in the upper Lower Aptian (upper *deshayesi* Zone of German usage). A single specimen of *Conorotalites* *aptiensis* (Bettenstaedt) was collected from bed LA6. This species is characteristic of the Aptian (Bartenstein 1978, 1987).

Planktic foraminifera are abundant in Beds LA6 and LA5, with an assemblage identical to that described by Banner and Damini Desai (1988). *Leupoldina* gr. *cabri* (Sigal) is present in Bed LA5i. The *L.* ex gr. *cabri* Total Range Zone has been considered to be early late Aptian (Longoria, 1974). We therefore extend the base of the *L.* ex gr. *cabri* TRZ down to a level in the *deshayesi* Zone (mid Lower Aptian).

Impoverished foraminiferal assemblages are present in the upper part of the Lower A Beds (LA1 to LA3). Assemblages lack planktics and contain low-diversity assemblages of textularines (dominated by non-calcareous agglutinates: NCAs) with relatively few rotalines. The NCA taxa include the long-ranging *Ammodiscus cretaceus* (Reuss), *Glomospirella gaultina* (Berthelin), *Hyperammina/Bathysiphon* spp., *Haplophragmoides* spp., and *Text. bettenstaedti*. There are also a number of rarer forms such as *Falsogaudryinella moesiana* (Neagu). This its peak abundance in the late Hauterivian and early Barremian of the central and northern North Sea, but also occurs in small numbers in the Aptian and Albian of the southern North Sea (King *et al.*, 1989). The calcareous benthics present include *Lenticulina (Lenticulina)* spp., *Epistomina spinulifera* and *Frondicularia* cf. *concinna* Koch, as well as a number of other nodosariaceans. *F.* cf. *concinna*, which is probably distinct from *F. concinna* Koch from the Upper Hauterivian to Middle Barremian (Bartenstein and Kaever, 1973; Meyn and Vespermann 1994), is only common in bed LA1A.

The Upper A Beds yield a rich benthic foraminiferal fauna, with forms such as *Lenticulina (Lenticulina)* spp. and *Gavelinella* ex gr. *intermedia* (Berthelin) abundant throughout. Several benthic species, however, have more restricted ranges. *Notoplan.? schloenbachi* generally occurs within a restricted horizon in the Lower Albian (Hecht 1938; Crittenden 1983), although it may extend upwards to the top Albian (King *et al.* 1989). Although recorded in Bed UA4 (Dilley 1969), this study recorded this species at spaced intervals in beds UA2 to UA3B. The two main occurrences of this species (beds UA2B and lower UA3B) are also the levels at which small planktic foraminifera appear. Its distribution is, therefore, probably ecologically controlled.

Gaud. dividens has its last occurrence in the middle of Bed UA3A, while the first examples of *Spiroplectinata* appear in lower Bed UA3B. Upper Aptian '*Spiroplectinata*' (Betram and Kemper 1982), do not appear to be related to these Albian forms. The range overlap of *Spiroplectinata* and its possible ancestor *Gaud. dividens* (Bartenstein and Bettenstaedt 1962) is widely recognisable and forms a valuable biostratigraphic level (Bartenstein 1976, 1978).

Although the earliest examples of *Dorothia gradata* Berthelin appear in bed UA1B, poorly preserved, crushed specimens attributable to *Dorothia* cf. *gradata* are present in Beds UA1B and UA1C. Examples of *Arenobulimina macfadyeni* (Cushman) appear in bed UA3C. In a study of this genus, Price (1977b) recorded the earliest *Areno. macfadyeni* in the *Otohoplites raulinianus* Subzone, although he was unable to study older parts of the *mammillatum* Superzone. Unlike the Speeton specimens, however, these specimens were stunted, probably due to unfavourable conditions in the early Albian clays he sampled. Several species of *Lingulogavelinella* are present in the Upper A Beds. This genus was therefore clearly not endemic to the Paris Basin during the Lower Albian as suggested by Price (1977a). *Psilocitharina robusta* (Chapman) is a very characteristic species that appears in bed UA3A and occurs sporadically in beds UA1 and UA2 at Speeton, ranging up into the Upper Albian. *Psil. paucicostata* (Reuss) [=*Vaginulina strigillata* Chapman] occurs consistently in all the samples collected from bed UA1C to bed UA3C. Although rare above the Lower Albian, it is present in the Upper Albian of Folkestone (Chapman 1894) and sporadically in the Middle and Upper Albian at Speeton (Mitchell, unpublished), as well as at an unspecified horizon in the Lower Cenomanian (Chapman 1894). Members of the Robertinacea only occur in the lower part of the Upper A Beds up to Bed UA3A. This disappearance coincides with that other aragonitic fossils, and is considered to be taphonomic.

Planktic foraminifera have been found at two levels in the Upper A Beds. *Hedbergella infracretacea* (Glaessner) (together with other species of *Hedbergella*) appears as a small flood in lower bed UA3B and as a moderate flood in bed UA2B. As noted above, these are the levels at which *Notoplan.? schloenbachi* occurs.

3.3.2. ***Foraminiferal zonal schemes*** (See Fig. 6)

The foram zonal scheme for the Albian of NW Europe devised by Price (1977a) contains two Lower Albian zones. The lower of these (Zone 1), from the *schrammeni* Subzone of the *tardefurcata* Zone, is characterised by a low diversity assemblage of agglutinates. The upper zone (Zone 2), from the upper *mammillatum* Zone, contains diverse calcareous benthics. Sediments from the upper part of the *tardefurcata* Zone (*regularis* Subzone) and the lower part of the *mammillatum* Zone age were not sampled. The data presented here demonstrates that Price's Zone 1 extends up to the *regularis* Subzone of the *tardefurcata* Zone, and that Price's Zone 2 begins within the lower part of the *mammillatum* Superzone (although detailed correlation with the ammonite subzones of the *mammillatum* Superzone is not possible).

King *et al*. (1989) introduced a zonal scheme for the Cretaceous of the southern North Sea. As it is defined on downhole appearances, we treat it here from the top down. FCS 10 is characterised by abundant inoceramid debris. Inoceramid prisms occur abundantly in microfossil residues in Beds UA1A and UA1B, whilst the forams considered characteristic of this zone are common throughout Bed UA1. FCS 9 was characterised by *Osangularia* (=*Notoplan*?) *schloenbachi*. In our samples *Notoplan? osangularia* occurs consistently only in the lower part of the Upper A Beds. This suggests that FCS 10 ranges from the lower Upper Albian (within the Hunstanton Formation) to the mid *mammillatum* Superzone, with FCS 9 representing the lower *mammillatum* Superzone. FCS 8b was characterised by the downhole appearance of abundant agglutinates. This is equivalent to the upper part of the Lower A Beds (beds LA1 to LA3) and is equivalent to Price's Zone 1. It is, therefore, of *tardefurcata* Zone age, but may well extend down into the Upper Aptian. FCS 8a was characterised by the consistent occurrence of *Gaud. dividens*. This species occurs consistently in the upper part of the Ewaldi Marl (Bed LA5i). The base of zone FCS 8a is therefore in the *deshayesi* Zone. FCS 7 was characterised by the presence of small planktics, which are present at 'flood' abundances in FCS 7b. FCS 7b therefore correlates with Beds UB1A and UB1B; FCS 7b correlates with Beds UB1C to UB3. The rarity of *Conorotalites* in the Speeton succession prevents the recognition of FCS6.

Herein, we recognise five major foraminiferal assemblages at Speeton, these are:

A. Restricted benthic assemblage. Distinctive species include *Marg. gracilissima* and *Marg. foeda*. Upper Barremian.
B. Restricted benthic assemblage (more diverse than below) with levels containing abundant small planktics. Uppermost Upper Barremian to lower Lower Aptian (*fissicostatus* Zone). Equivalent to FCS 7 pars.
C. Diverse benthic assemblage, abundant small planktics. This is divisible into an upper subzone (C2) with *L. cabri* and *Gaud. dividens*, and a lower subzone (C1) lacking *L. cabri*. Upper Lower Aptian (*forbesi* and *deshayesi* Zones), probably up to *nutfieldensis* Zone. C2 = FCS 8a; C1 = FCS 7 pars.
D. Impoverished benthic assemblage, with abundant NCAs. Distinctive species include *Text. bettenstaedi* and *Reophax minuta*. Lower Lower Albian (*tardefurcata* Zone) and probably upper Upper Aptian. Equivalent to FCS 8b (=Price's Zone 1).
E. Diverse benthic assemblage with scattered small planktics. Distinctive species include *Areno. macfadyeni*, *Lingulogavelinella* spp. Divisible into three subzones: a lower

subzone (E1) with *Gaud. dividens*, *Notoplan? schloenbachi* and *Lingulogavelinella* spp.; a middle subzone lacking *Gaud. dividens* but with pulses of *Notoplan? schloenbachi* and *Lingulogavelinella* spp.; and an upper subzone lacking *Gaud. dividens*, *Notoplan? osangularia* and *Lingulogavelinella* spp. Upper Lower Albian (*mammillatum* Superzone): E1 and E2 of ?*chalensis* Zone age; E3 of *auritiformis* Zone age. Abundant, red-stained inoceramid prisms appear in the upper part of the *auritiformis* Zone. Equivalent to FCS 9 - 10 (=Price's Zone 2).

3.3.3. ***Ostracods***

Ostracods from the upper Speeton Clay, especially from the Albian, have been extensively studied by Kaye (1962, 1963a, 1963b, 1964c, 1964d) and the distribution of the most important forms summarized by Neale (1978).

The Upper B Beds contain a restricted ostracod fauna. The undifferentiated Upper B Beds contain *Schuleridea hammi* (Triebel), *Acrocythere hauteriviana* (Bartenstein) and *Apatocythere simulans* Triebel. Examples of *Schuleridea derooi* Damotte and Grosdidier occur in bed UB1A just below the Ewaldi Marl. According to Lott *et al.* (1985), *A. simulans* is restricted to the Barremian while *S. derooi* appears in the latest *Protocythere triplicata* Zone (upper Upper Barremian).

Ostracods are relatively rare in the Ewaldi Marl (beds LA6 and LA5), but large samples have produced relatively diverse faunas. *Pontocyprella rara* Kaye is the most common species throughout and *Cytherella ovata* (Roemer) is abundant in the samples from beds LA6 and LA5iii. Bed LA6 is additionally characterized by *Schuleridea derooi*, *Protocythere derooi* Oertli and *Rehacythereis bekumensis* (Triebel). Bed LA5iii is characterized by *Cytheropteron nova nova* Kaye, *R. bekumensis* and *Paranotacythere luettigi luettigi* Bassiouni. Bed LA5i is characterized by *Neocythere* cf. *bordeti* Damotte & Grosdidier, *Protocythere derooi* Damotte & Grosdidier, *P. mertensi langtonensis* Kaye & Barker and *Saxocythere tricostata subglabra* Kemper. These assemblages are very similar to those reported from the Sutterby Marl in Lincolnshire (Kaye and Barker 1965), in which *P. luettigi luettigi* was recorded as *P. inversa tuberculata* Kaye (Lott *et al.* 1985). *C. nova nova* is present in the upper part of Bed LA5iii at Speeton, while *C. nova reticulata* Kaye & Barker, its probable direct descendant (Kaye and Barker 1965), was recorded from from the Sutterby Marl. *R. bekumensis* was recorded from the lower sample from the Sutterby Marl and *R. sutterbyensis* from the upper sample (Kaye and Barker 1965). The former occurs in bed LA5 at Speeton, while the latter is absent. *S. tricostata subglabra* is not recorded from the Sutterby Marl.

A very similar assemblage of ostracods to those from Speeton and Sutterby was recorded from borehole B1/40 in the mid North Sea by Lott *et al.* (1985). The fauna recorded in the lower part of their Red Mudstone unit is almost identical to that from bed LA5 at Speeton. *Rehacythereis sutterbyensis* first appears in the middle part of their Red Mudstone, but before *Saxocythere tricostata tricostata* (Lott *et al.* 1985). This suggests that the upper Sutterby Marl sample is equivalent to the middle part of the Red Mudstone unit in the mid North Sea borehole of Lott *et al.* (1985).

Studies of German Aptian ostracods suggest that *Saxocythere* appeared in the upper Lower Aptian (*bowerbanki* Zone of Casey 1961) (Bartenstein 1978). Kemper (1971) indicated that the evolutionary lineage of *Saxocythere* began in the upper Lower Aptian with the subspecies *S. tricostata subglabra*, which gave rise to *S. tricostatus tricostatus* in the lower Upper Aptian. We record the earliest examples of *S. tricostata subglabra* in the *deshayesi* Zone at Speeton. Neale (1978) recognised two ostracod zones in the B Beds of the Speeton Clay, and considered that the fauna of the upper zone, that of *P. intermedia,* ranged throughout the whole of the Lower Aptian (*fissicostatus* to *bowerbanki* zones), only being replaced by a new fauna in the Upper Aptian (*nutfieldensis* Zone). The *P. intermedia* fauna is here seen to be restricted to the *fissicostatus* Zone, being replaced by a new assemblage in the *forbesi* Zone. At Speeton, beds LA5iii to LA5i (lower) are attributed to the *bekumensis* Zone, bed LA5i (upper) to the lower *subglabra* Zone, and the Sutterby Marl, of East Midlands Shelf, to the mid *subglabra* Subzone. This is consistent with the ammonite evidence which suggests that bed LA5 (*forbesi* and *deshayesi* Zones) is older than the Sutterby Marl (uppermost Lower to lowermost Upper Albian).

We recognise four zones in the Lower and lower Upper Aptian, each defined by the first appearance of their nominate index species. This scheme is a revision of the schemes suggested by Neale (1978) and Kemper (1982)(See Fig. 6).

Protocythere intermedia Zone. Lower Lower Aptian, *fissicostatus* Zone. This zone can only be recognized by the presence of the nominate index, all the other species are long ranging.

Rehacythereis bekumensis Zone. Mid Lower Aptian, *forbesi* Zone to lower *deshayesi* Zone. The base of this zone represents a major change in the ostracod fauna with the appearance of *R. bekumensis* and *P. luettigi luettigi*. Its base is defined by the appearance of the nominate species.

Saxocythere tricostatus subglabra Zone. Upper Lower Aptian to lower Upper Aptian (upper *deshayesi* Zone to *martinoides* Zone). The base of the zone is defined by the appearance of the genus *Saxocythere*.

Saxocythere tricostatus tricostatus Zone. Mid Upper Aptian, *nutfieldensis* Zone. The base of the zone is defined by the first appearance of *S. tricostata tricostata*. Sediments of this zone have not been recognised at Speeton.

Ostracods are rare in samples from bed LA1, and absent in beds LA2 to LA3. The most important species present in bed LA1 include *Protocythere nodigera* (Triebel), *P. mertensi mertensi* Kaye, *Pseudobythocythere goerlichi* Mertens and *Saxocythere dividera* (Gründel). Kaye (1965b) suggested that this assemblage indicated a Lower Albian age, while Neale (1978) used *P. nodigera* as an index species for his sole Lower Albian ostracod zone (presumably including the *mammillatum* Superzone into the Middle Albian *sensu* Kaye 1964a). Kemper (1982) indicated that this assemblage also occurred in the lower (but not the basal) Lower Albian of Germany. It seems most likely that the *nodigera* Zone is more or less equivalent to the *regularis* ammonite Subzone.

The Upper A Beds yield abundant and diverse ostracod assemblages, with many species recorded by Kaye (1962, 1963a, 1963b, 1964a, 1964c, 1964d). Only a small number of these taxa are, however, of stratigraphic significance.

Clithrocytheridea heslertonensis Kaye ranges from lower Bed UA3B to the top of Bed UA1B. It has previously been recorded from the Lower Albian of the Speeton Clay (Speeton and West Heslerton) (Kaye 1962, 1963a) and the *mammillatum* Superzone of the Paris Basin (Babinot *et al*. 1985) as well as from the Middle Albian of the Gault Clay (Kaye 1965a). The three Gault occurrences were stated to be restricted to the *H. spathi* Subzone (Kaye 1965a), probably equating with the lower *lyelli* Subzone of Owen 1984. This species is absent in the *spathi* Subzone in Norfolk and the Leighton Buzzard region (Mitchell, unpublished data). *C. heslertonensis* is therefore an important upper Lower Albian and lowermost Middle Albian (lower *lyelli* Subzone) index species. The only other ostracods characteristic of the Lower Albian at Speeton are *Saxocythere dividera* Kemper and *Dolocytheridea intermedia* Oertli. *S. dividera* appears in Bed LA1 and ranges up to Bed UA1Cv. *D. intermedia* occurs in the highest sample collected from Bed UA1B. It is particularly significant, since it is restricted to the Aptian and Lower Albian in France. Its direct successor, *Dolocytheridea vinculum* Wilkinson, is present in the basal Gault (supposed *lyelli* Subzone) in East Anglia (Wilkinson and Morter 1981). The presence of *S. dividera, C. heslertonensis* and *D. intermedia* clearly demonstrates that beds UA1B to UA3 are of Lower Albian age.

A single zone of *Clithrocytheridea heslertonensis* is erected here, and is divided into two subzones based on the appearance of *Cornicythereis bonnemai* in the upper part of the zone.:-

Clithrocytheridea heslertonensis Subzone. This assemblage is defined by the appearance of *C. heslertonensis* Kaye, which also defines the base of the zone. Other species that also occur at this level are *Protocythere speetonensis* Kaye and *Isocythere fortinodis* Triebel.

Cornicythereis bonnemai Subzone. This assemblage is characterised by the appearance of *C. bonnemai* (Triebel). The last representatives of *Dolocytheridea intermedia* occur in the upper part of the zone.

3.3.4. ***Calcareous Nannofossils***

Although calcareous nannofossils were not studied during the course of this work, recent work (Jeremiah 1996) has identified three nannofossil assemblage zones within the Albian part of the Speeton Clay. Re-interpretation of the stratigraphic context of the samples analysed (Mitchell and Underwood *In Press*) allowed nannofossil Zones NAL2, NAL3 and NAL4 to be assigned to Beds LA1, UA3B and UA1A respectively.

4. CORRELATION WITH OTHER SITES

4.1. Inland exposures of the Speeton Clay in the Cleveland Basin

The Speeton Clay Formation has a limited distribution on land, being present only within, and to the north of, the Howardian-Flamborough Fault Zone (e.g. Kirby and Swallow 1987) (See Fig. 1.). It has been penetrated by a number of boreholes, which record a large variation in thickness (e.g. Jeans 1973). None of these borehole records, however, is of sufficient detail to be of use as a comparative section. The outcrop of the Speeton Clay can be traced inland at the base of the Chalk scarp for about 25 km to the West of Speeton, although for much of its length it is obscured beneath Quaternary deposits. It is only around the village of West Heslerton that sections in the upper part of the Speeton Clay have been recorded (Ennis 1932, Kaye 1964a, b) (See Fig. 7). These sections have yielded fossils from the Aptian and Albian (Lamplugh 1898). Upper Barremian ammonites have also been obtained shallow boreholes (material in Geological Survey Museum from Heslerton No. 2 borehole).

The successions described from West Heslerton by Ennis (1932) and Kaye (1964b) are strikingly different, despite claims by Kaye (1964a) that they were from the same site. There are currently no exposed sections in the area, although the probable locations of two pits were found. The more easterly pit (SE 914 756) has some chalk exposed around the top, and is therefore probably the site described by Kaye (1964 a, b), where chalk was noted at the top of the section. A second pit slightly further down the scarp (SE 913 757) is presumably that described by Ennis (1932).

The section described by Ennis (1932) shows hard dark shales with a *fissicostatus* Zone ammonite fauna, overlain by brown clays 'similar to the Ewaldi Marl'. It is unclear whether Ennis (1932) encountered *N. ewaldi* in these beds, but 'belemnites of *ewaldi t*ype' were recorded from the same site by Sheppard (1927). These units were unexposed in the section recorded by Kaye (1964b), and lithologically and probably faunally correlate well with Beds LA5 and UB1 at Speeton. These are separated from clays of Upper A Bed type by a bed of phosphate nodules, with equivalents of beds Beds LA1 to LA3 at Speeton absent. The lowest beds recorded by Kaye (1964b) are glauconitic and sandy clays. These are overlain by a bed of phosphate nodules and glauconite. In both of these sections it is probable that the phosphate bed is equivalent to the erosively based UA4 (the Greensand Streak) at Speeton. The glauconitic clays in Kaye's (1964b) section are, therefore, missing in Ennis's section, presumably due to downcutting at the base of the UA4 equivalent phosphate bed and probably represent a more proximal equivalent of the silty and partly glauconitic Beds LA1 to LA3 at Speeton. Although not seen by Ennis (1932), these beds were seen by other early workers, as some fossils in collections from West Heslerton are preserved in a glauconitic matrix (Middlemiss 1976). Clays above the phosphate bed, which are equivalent to the bulk of the Upper A Beds at Speeton, are considerably thinner than at Speeton, but also vary in thickness between the two sections. In Ennis's (1932) section, the point at which abundant specimens of *Neohibolites* first appear may allow correlation with the middle of Bed UA3A at Speeton, where *Neohibolites* similarly becomes common. Ennis (1932) also records a specimen of *Hoplites* cf. *dentatus* from these upper clays. This is not figured, and it is unclear whether it is *Hoplites* or a misidentified Lower Albian hoplitid.

The considerable differences in the stratigraphic successions between the two sites at West Heslerton may be explained by the presence of a syndepositional fault. Many of the faults within the Howardian-Flamborough Fault Belt are known to have been active during the upper part of the Lower Cretaceous (Kirby and Swallow 1987). Slight relative uplift of Ennis's (1932) section prior to the deposition of bed UA4 and its equivalents would allow for sediments of the *mammillatum* Superzone to rest on Lower Aptian at one site, but on basal Albian a short distance away.

4.2. Sections on the East Midlands Shelf

A short distance from West Heslerton, the major faults of the Howardian-Flamborough Fault Zone mark the northern limit of the Market Weighton High. Exposures at Grimston Hill (See Fig. 7.), about 15 km to the South West of West Heslerton, show Albian sediments resting unconformably on Jurassic sediments (Jeans 1973). Here a very thin representative of the Hunstanton Formation rests on a 0.3 m ferruginous sandstone of the Carstone Formation. The age of the Carstone and base of the Hunstanton Formation is not known directly at this site. Faunas from other sites to the South suggest the top of the Carstone is around the Lower to Middle Albian boundary (Mitchell 1995). It is likely, however, that the Carstone is diachronous, and it is unclear whether the Carstone at Grimston Hill is equivalent to part or all of the Upper A Beds.

The Carstone is absent over the axis of the Market Weighton High, where Upper Albian Hunstanton Formation limestones rest on Lower Jurassic sediments (Mitchell

1996). Lower Cretaceous sediments gradually reappear to the South on the East Midlands Shelf, with Aptian rocks appearing between the Humber and the Wash. A borehole at Skegness (Gallois 1975) (Fig. 7.) showed rocks of Barremian, Aptian and Lower Albian age. The Upper Barremian Roach Formation is overlain by the Skegness Clay. The latter contains a fauna similar to the top B beds at Speeton, including *Prodeshayesites* ex gr. *fissicostatus* and *Hibolithes minutus*, as well as *Oxyteuthis depressus* Stolley (BGS BDF 3332, incorrectly labelled as *Hibolithes obtusirostris*). This is erosively overlain by the Sutterby Marl. The age of this unit is rather problematic, for although the lithology and belemnites are similar to the Ewaldi Marl, the ammonites suggest a top Lower to basal Upper Aptian age for this formation at other sites (Gallois & Morter 1979). It therefore seems likely that deposition of the Ewaldi Marl- Sutterby Marl facies in North East England extended from the *forbesi* Zone to at least the *martinoides* Zone. A major erosion surface is overlain by sandstones of the Carstone Formation. A specimen of *N. ewaldi* (incorrectly recorded as *N. strombecki*) at the base of the formation is reworked, but a specimen of *N*. sp. nov. B (BGS BDF 3235) near the base suggests that only the upper part of the *mammillatum* Superzone is represented by the Carstone Formation. The top of the Carstone Formation grades sharply upwards into the Middle Albian Hunstanton Formation.

4.2. Other Sections

Generally similar, if highly expanded, sequences to those at Speeton are present across much of the southern North Sea. Both in the central southern North Sea (Crittenden 1982; 1987) and in the Moray Firth approaches (Lott *et al*. 1985), calcareous mudstones, sometimes reddened, are present in the lower Aptian, and represent more expanded equivalents of the Ewaldi Marl and Sutterby Marl. These are overlain by less calcareous mudstones of Upper Aptian and Lower Albian age. In the central-southern North Sea (Crittenden 1987), the calcareous Lower Holland Marl Member is overlain by the Middle Holland Shale Member which yields an essentially Albian microfauna. In some sections, the lower part of this is silty and glauconitic with a microfauna dominated by agglutinated forams, considered (Crittenden 1987) to be a lateral equivalent of the Holland Greensand Member of the southernmost North Sea. This probably equates with Beds LA1 to LA3 at Speeton. The more calcareous upper part of the Middle Holland Shale Member often has a thin bed of glauconite and phosphates at the base (Crittenden 1987), possibly marking the same erosion surface as Bed UA4 at Speeton. In the Moray Firth approaches (Lott *et al.* 1985), the Lower Aptian marls are overlain by bioturbated mudstones with numerous bentonites. There does not appear to be any lithological or faunal equivalent of this unit at Speeton, as it presumably lies at a level between that of Bed LA3 and Bed LA5. This unit is overlain by a unit of variegated mudstones with an impoverished microfauna below the 'Red Chalk'. This may be an equivalent to beds LA1 to LA3 at Speeton. There is no evidence for beds of the *mammillatum* Superzone, and these may either be cut out by a Middle Albian erosion surface or incorporated into a diachronous based 'Red Chalk'.

The Lower Cretaceous of northern Germany was also deposited within part of the North Sea Basin, but is generally poorly exposed. The Lower Aptian of the more basinal regions shows a general three fold division (Kemper 1973). The bioturbated 'Bodei clays' of the *fissicostatus* Zone are overlain by laminated black 'Fish Shales'. Although the latter lack *N. ewaldi*, they are assigned to the forbesi Zone and may represent a level low in the *forbesi* Zone absent at Speeton. These are overlain by pale, belemnite rich 'Ewaldi Marl ' or 'Gargas Marl' within the *deshayesi* Zone. This succession shows general lithological similarities to the sequence of UB2, UB1 and LA5 of Speeton, but, if dating of the German material is reliable, a diachroneity of these facies changes is suggested by the stratigraphically earlier appearances of the laminated dark mudstones and Ewaldi Marl facies at Speeton. The Lower Albian sequences in Germany (Kemper 1973) are less readily related to those at Speeton. Facies within the *tardefurcata* Zone are generally of strongly transgressive mudstones with rich faunas. The *mammillatum* Zone is for the most part absent due to erosion prior to the Middle Albian.

Aptian and Lower Albian sediments in southern England and northern France are in Lower Greensand facies (Casey 1961) deposited within the Anglo-Paris Basin. These bear little lithological or faunal relationship to the successions at Speeton.

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FIGURE CAPTIONS

Figure 1. Locations of Speeton and other sites mentioned in this study. The distribution of Aptian and Lower Albian facies and the position of the Howardian-Flamborough Fault Zone are shown.

Figure 2. Location of Aptian and Lower Albian exposures at Speeton studied during this work. Note that all of these exposures are ephemeral.

Figure 3. Stratigraphic log with weathering profile of the upper part of the Speeton Clay Formation from the Upper Barremian to the base of the Hunstanton Formation.

Figure 4. Ranges of selected macrofossil taxa within the Aptian and Albian part of the Speeton Clay. Scale bar is in metres. For key to lithological log see Fig. 3.

Figure 5. Ranges of selected microfossil taxa within the Aptian and Albian part of the Speeton Clay. Scale bar is in metres. For key to lithological log see Fig. 3.

Figure 6. Correllation of microfossil and belemnite zonal schemes with the inferred standard ammonite zones within the Aptian and Albian part of the Speeton Clay. Scale bar is in metres. For key to lithological log see Fig. 3.

Figure 7. Lithostratigraphic correlation of the Aptian and Albian part of the Speeton Clay at Speeton with other sections in the Cleveland Basin and the East Midlands Shelf. Scale bar is in metres. For key to lithological log see Fig. 3.

C.J. UNDERWOOD

Department of Earth Sciences,

University of Liverpool,

Liverpool L69 3BX

U.K.

cju@liv.ac.uk

S.F. MITCHELL

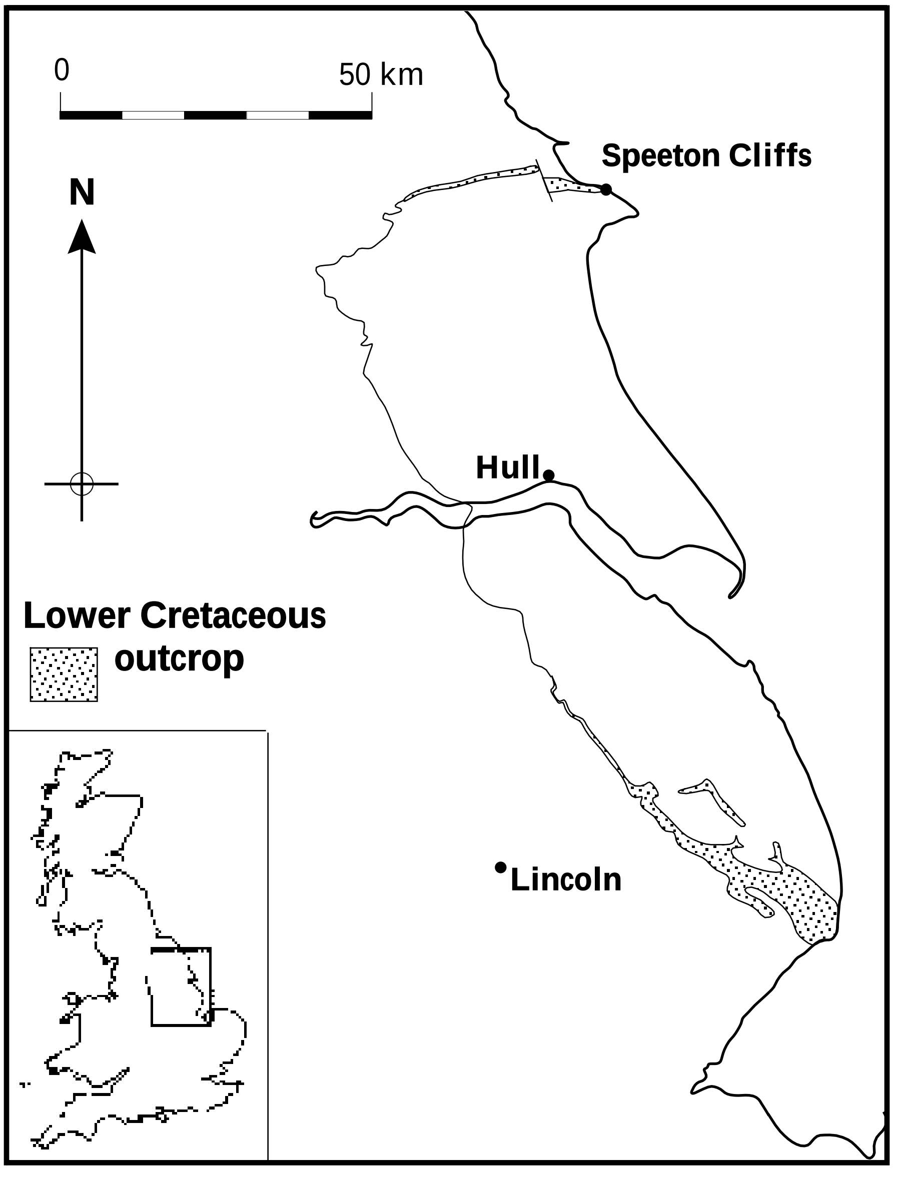
Department of Geography and Geology,

Mona Campus,

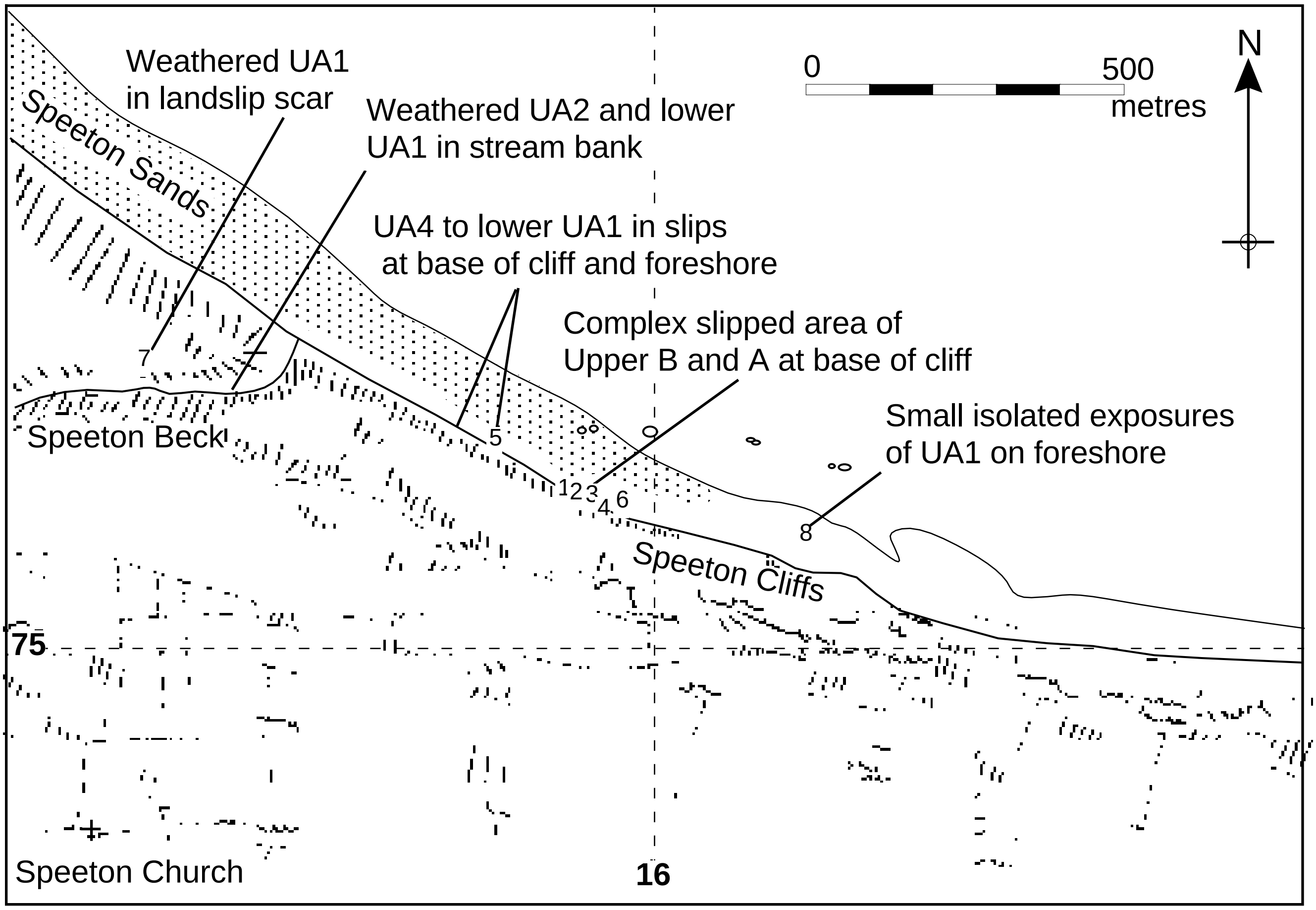
University of the West Indies,

Kingston 7,

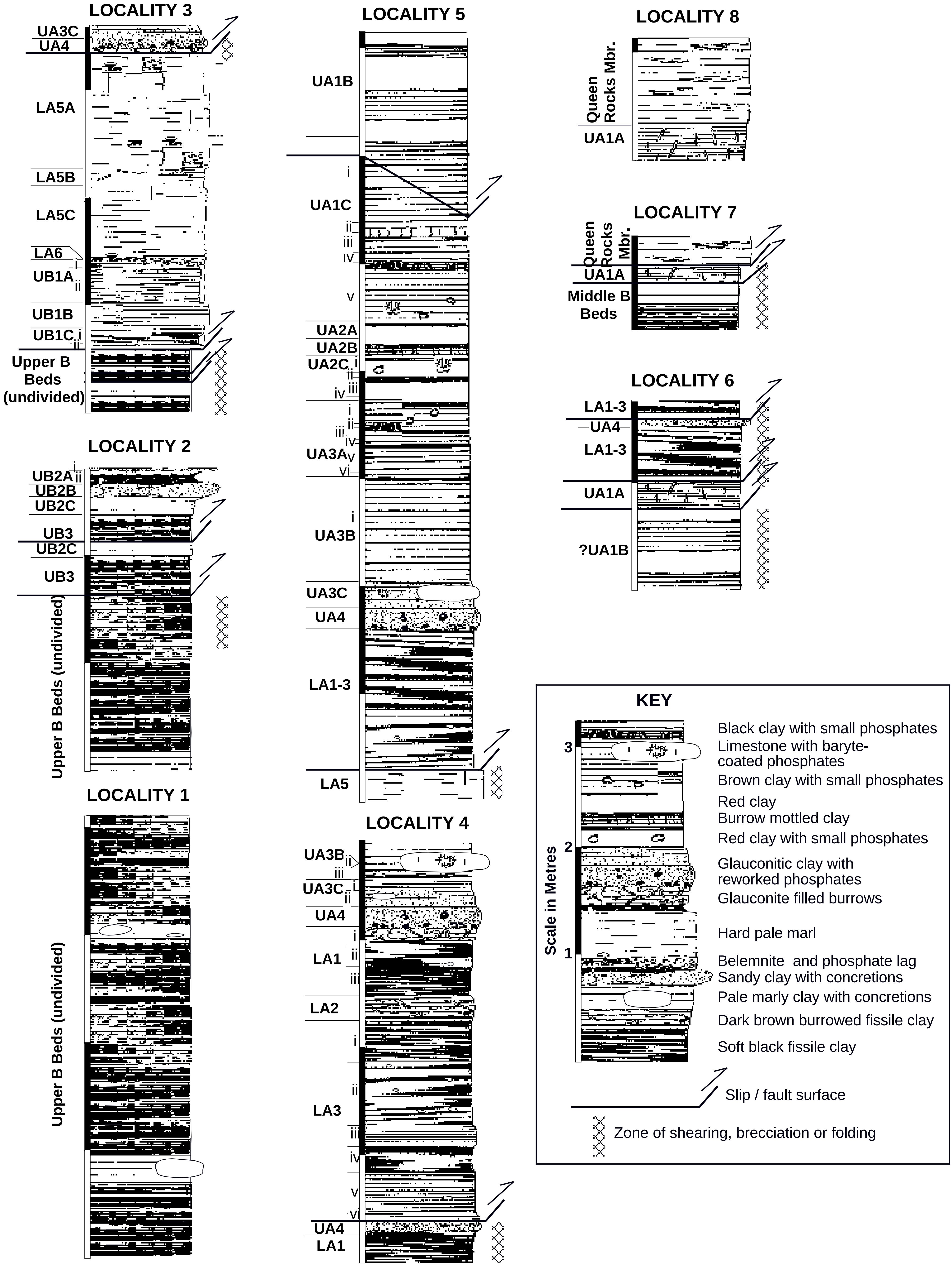
Jamaica

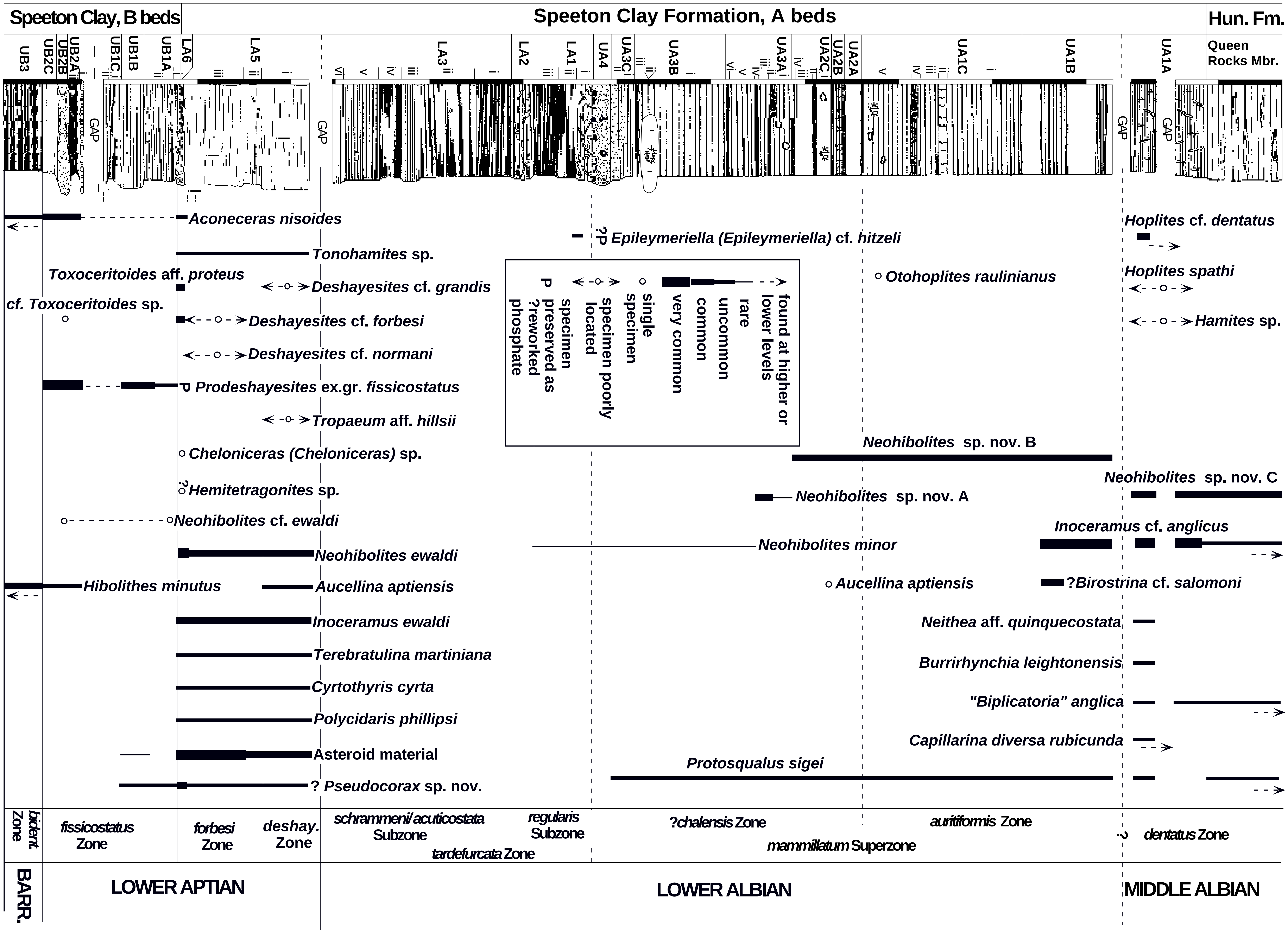


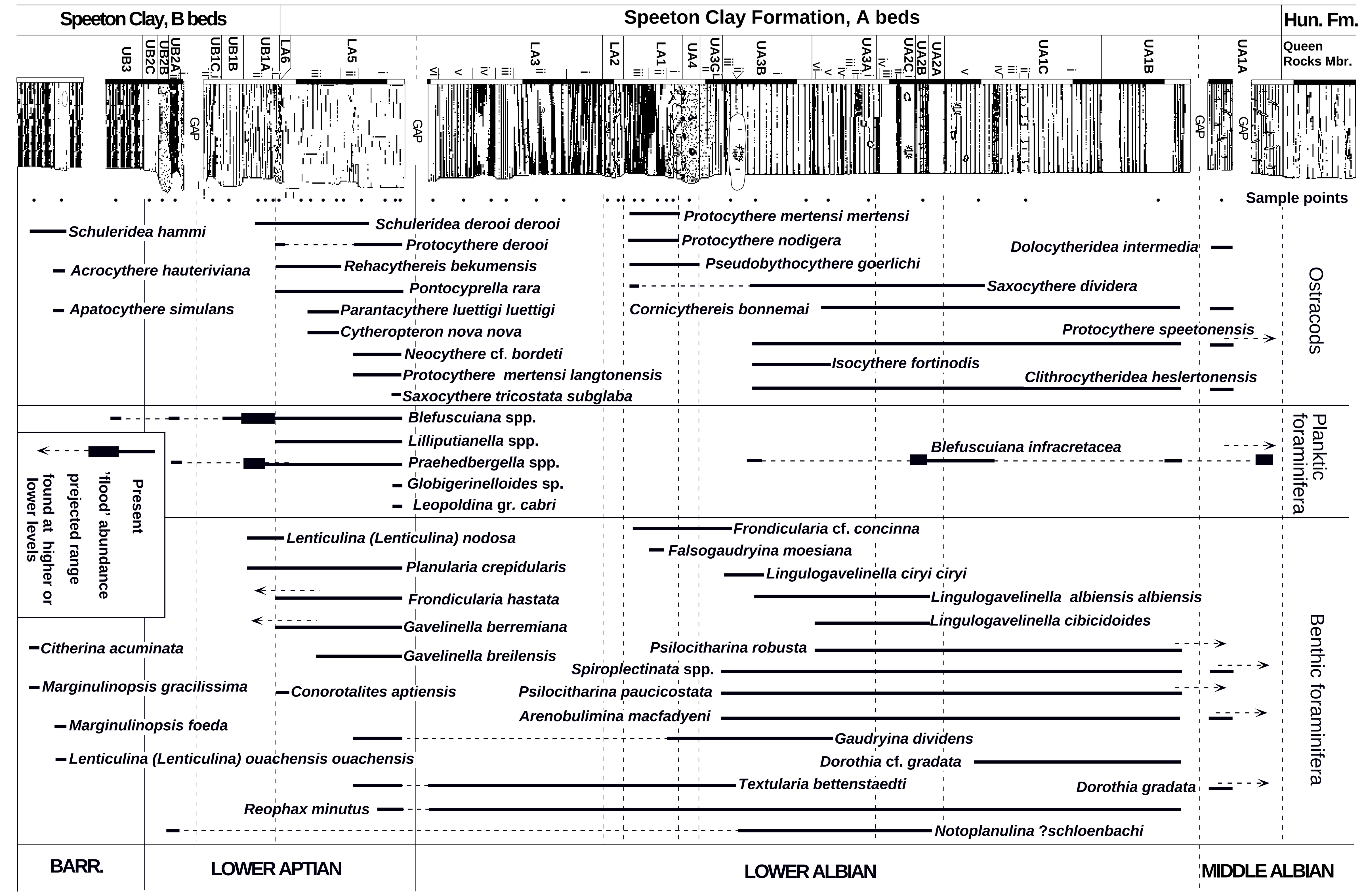
0
50 km
N
Speeton Cliffs
Hull
Lincoln
Lower Cretaceous outcrop



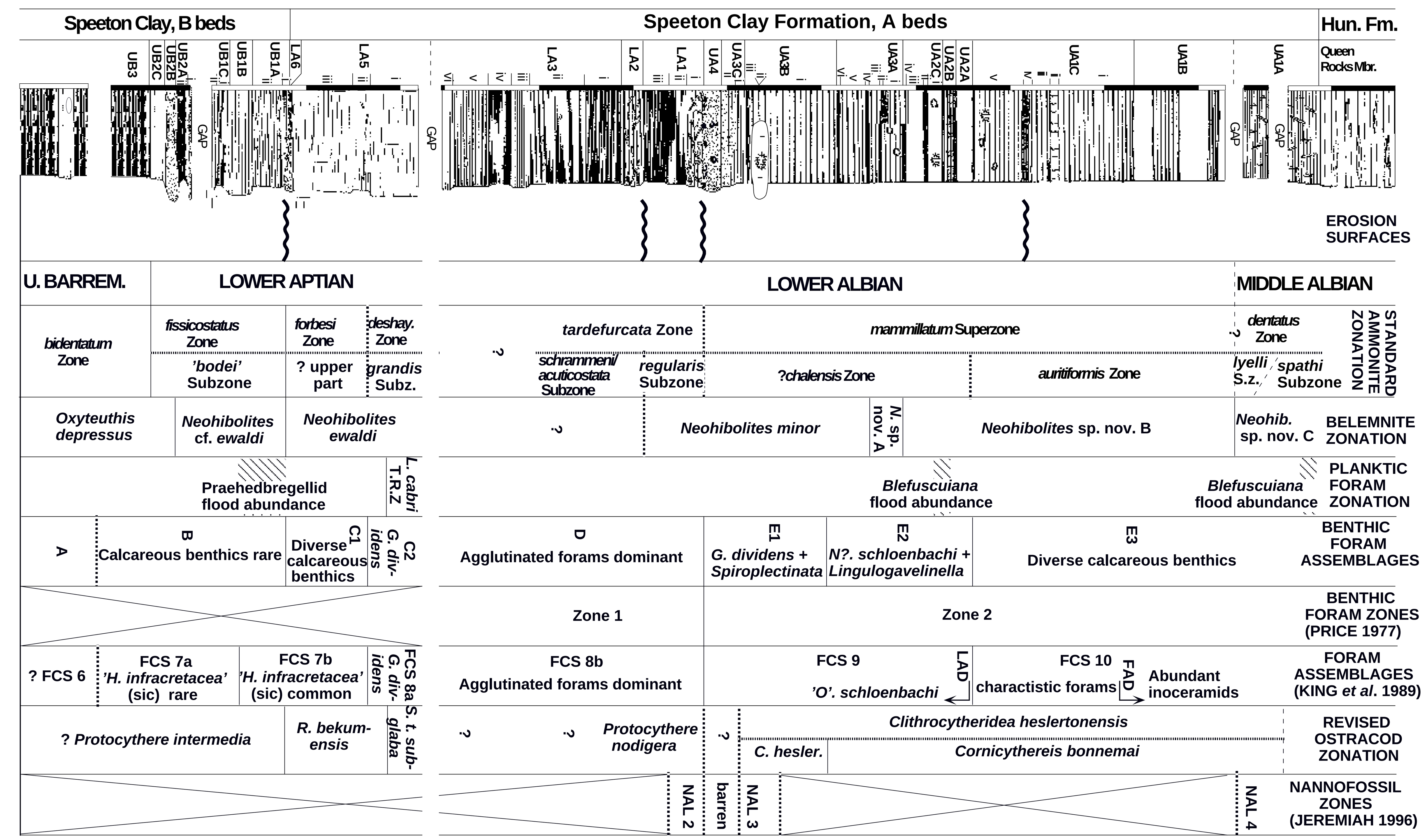
Weathered UA1
in landslip scar
Weathered UA2 and lower
UA1 in stream bank
0
500
metres
N
Speeton Sands
UA4 to lower UA1 in slips
at base of cliff and foreshore
Complex slipped area of
Upper B and A at base of cliff
Small isolated exposures
of UA1 on foreshore
7
5
1 2 3 4 6
8
Speeton Beck
Speeton Cliffs
75
Speeton Church
16

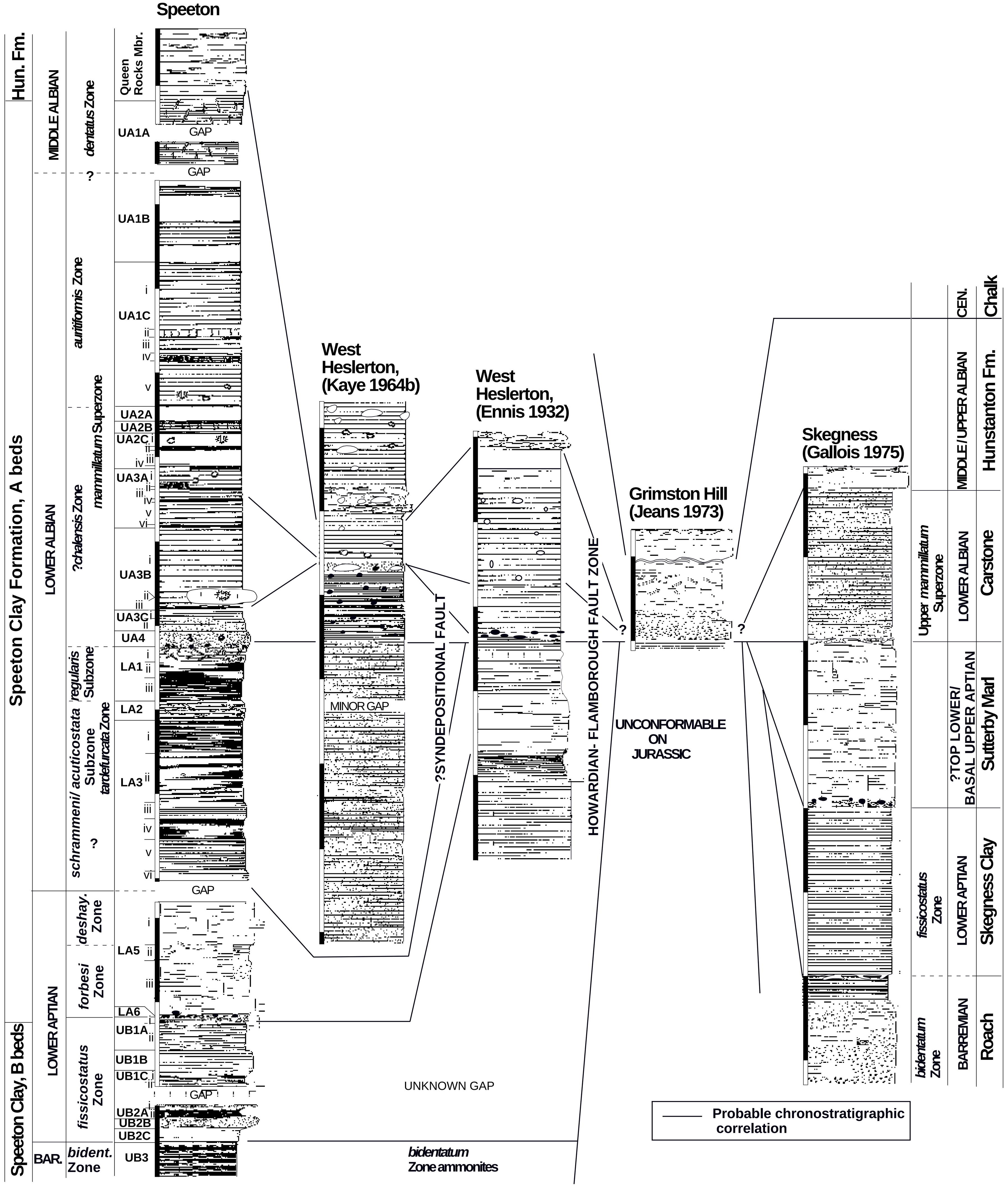

LOCALITY 3
UA3C
UA4
LA5A
LA5B
LA5C
LA6
UB1A
UB1B
UB1C
Upper B Beds (undivided)
LOCALITY 2
UB2A
UB2B
UB2C
UB3
UB2C
UB3
Upper B Beds (undivided)
LOCALITY 1
Upper B Beds (undivided)
LOCALITY 5
UA1B
UA1C
UA2A
UA2B
UA2C
UA3A
UA3B
UA3C
UA4
LA1-3
LA5
LOCALITY 4
UA3B
UA3C
UA4
LA1
LA2
LA3
UA4
LA1
LOCALITY 8
Queen Rocks Mbr.
UA1A
LOCALITY 7
Queen Rocks Mbr.
UA1A
Middle B Beds
LOCALITY 6
LA1-3
UA4
LA1-3
UA1A
?UA1B
KEY
Scale in Metres
1
2
3
Black clay with small phosphates
Limestone with baryte-coated phosphates
Brown clay with small phosphates
Red clay
Burrow mottled clay
Red clay with small phosphates
Glauconitic clay with reworked phosphates
Glauconite filled burrows
Hard pale marl
Belemnite and phosphate lag
Sandy clay with concretions
Pale marly clay with concretions
Dark brown burrowed fissile clay
Soft black fissile clay
Slip / fault surface
Zone of shearing, brecciation or folding


Speeton Clay, B beds
Speeton Clay Formation, A beds
Hun. Fm.
Queen Rocks Mbr.
UB3
UB2C
UB2B
UB2A
UB1C
UB1B
UB1A
LA6
LA5
LA3
LA2
LA1
UA4
UA3C
UA3B
UA3A
UA2C
UA2B
UA2A
UA1C
UA1B
UA1A
GAP
Aconeceras nisoides
?P Epileymeriella (Epileymeriella) cf. hitzeli
Hoplites cf. dentatus
Tonohamites sp.
Toxoceritoides aff. proteus
Deshayesites cf. grandis
Otohoplites raulinianus
Hoplites spathi
cf. Toxoceritoides sp.
Deshayesites cf. forbesi
Hamites sp.
Deshayesites cf. normani
Prodeshayesites ex.gr. fissicostatus
Tropaeum aff. hillsii
found at higher or lower levels
rare
uncommon
common
very common
single specimen
specimen poorly located
specimen preserved as ?reworked phosphate
Neohibolites sp. nov. B
Cheloniceras (Cheloniceras) sp.
?Hemitetragonites sp.
Neohibolites sp. nov. C
Neohibolites sp. nov. A
Neohibolites cf. ewaldi
Inoceramus cf. anglicus
Neohibolites ewaldi
Neohibolites minor
Hibolithes minutus
Aucellina aptiensis
Aucellina aptiensis
?Birostrina cf. salomoni
Inoceramus ewaldi
Neithea aff. quinquecostata
Terebratulina martiniana
Burrirhynchia leightonensis
Cyrtothyris cyrta
"Biplicatoria" anglica
Polycidaris phillipsi
Capillarina diversa rubicunda
Asteroid material
Protosqualus sigei
? Pseudocorax sp. nov.
bident. Zone
fissicostatus Zone
forbesi Zone
deshay. Zone
schrammeni/acuticostata Subzone
regularis Subzone
tardefurcata Zone
?chalensis Zone
auritiformis Zone
mammillatum Superzone
? dentatus Zone
BARR.
LOWER APTIAN
LOWER ALBIAN
MIDDLE ALBIAN

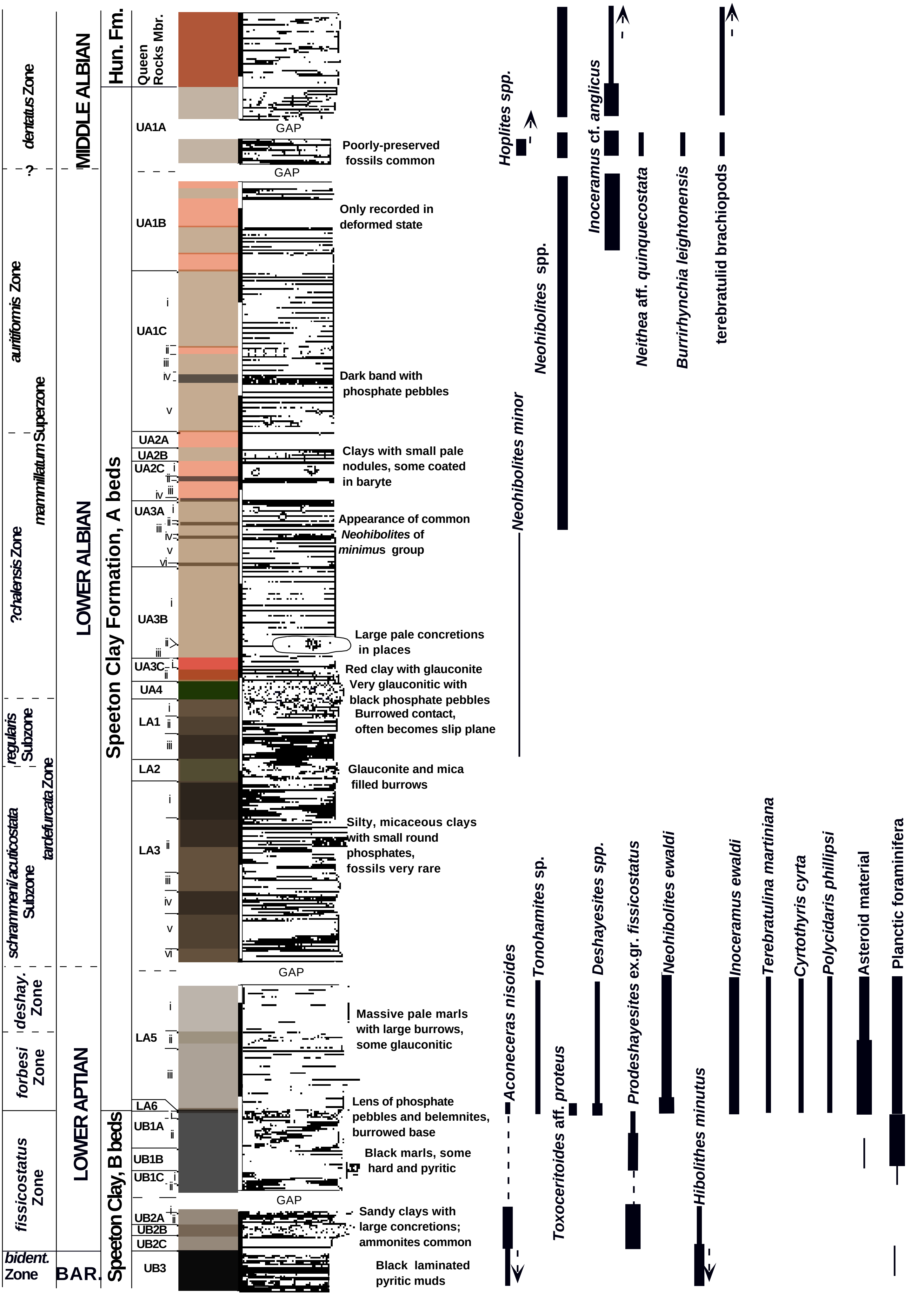


Speeton Clay, B beds
Speeton Clay Formation, A beds
Hun. Fm.
Queen Rocks Mbr.
UB3
UB2C
UB2B
UB2A
UB1C
UB1B
UB1A
LA6
LA5
LA3
LA2
LA1
UA4
UA3C
UA3B
UA3A
UA2C
UA2B
UA2A
UA1C
UA1B
UA1A
GAP
Sample points
Ostracods
Schuleridea hammi
Acrocythere hauteriviana
Apatocythere simulans
Schuleridea derooi derooi
Protocythere derooi
Rehacythereis bekumensis
Pontocyprella rara
Parantacythere luettigi luettigi
Cytheropteron nova nova
Neocythere cf. bordeti
Protocythere mertensi langtonensis
Saxocythere tricostata subglaba
Protocythere mertensi mertensi
Protocythere nodigera
Pseudobythocythere goerlichi
Cornicythereis bonnemai
Saxocythere dividera
Isocythere fortinodis
Dolocytheridea intermedia
Protocythere speetonensis
Clithrocytheridea heslertonensis
Planktic foraminifera
Blefuscuiana spp.
Lilliputianella spp.
Praehedbergella spp.
Globigerinelloides sp.
Leopoldina gr. cabri
Blefuscuiana infracretacea
Benthic foraminifera
Citherina acuminata
Marginulinopsis gracilissima
Marginulinopsis foeda
Lenticulina (Lenticulina) ouachensis ouachensis
Lenticulina (Lenticulina) nodosa
Planularia crepidularis
Frondicularia hastata
Gavelinella berremiana
Gavelinella breilensis
Conorotalites aptiensis
Reophax minutus
Frondicularia cf. concinna
Falsogaudryina moesiana
Lingulogavelinella ciryi ciryi
Lingulogavelinella albiensis albiensis
Lingulogavelinella cibicidoides
Psilocitharina robusta
Spiroplectinata spp.
Psilocitharina paucicostata
Arenobulimina macfadyeni
Gaudryina dividens
Dorothia cf. gradata
Textularia bettenstaedti
Dorothia gradata
Notoplanulina ?schloenbachi
Present
'flood' abundance
prejected range
found at higher or lower levels
BARR.
LOWER APTIAN
LOWER ALBIAN
MIDDLE ALBIAN


Speeton Clay, B beds
Speeton Clay Formation, A beds
Hun. Fm.
Queen Rocks Mbr.
UB3
UB2C
UB2B
UB2A
UB1C
UB1B
UB1A
LA6
LA5
LA3
LA2
LA1
UA4
UA3C
UA3B
UA3A
UA2C
UA2B
UA2A
UA1C
UA1B
UA1A
GAP
EROSION SURFACES
U. BARREM.
LOWER APTIAN
LOWER ALBIAN
MIDDLE ALBIAN
STANDARD AMMONITE ZONATION
bidentatum Zone
fissicostatus Zone
'bodei' Subzone
forbesi Zone
? upper part
deshay. Zone
grandis Subz.
tardefurcata Zone
schrammeni/ acuticostata Subzone
regularis Subzone
mammillatum Superzone
?chalensis Zone
auritiformis Zone
dentatus Zone
lyelli S.z.
spathi Subzone
BELEMNITE ZONATION
Oxyteuthis depressus
Neohibolites cf. ewaldi
Neohibolites ewaldi
Neohibolites minor
N. sp. nov. A
Neohibolites sp. nov. B
Neohib. sp. nov. C
PLANKTIC FORAM ZONATION
Praehedbregellid flood abundance
L. cabri T.R.Z
Blefuscuiana flood abundance
Blefuscuiana flood abundance
BENTHIC FORAM ASSEMBLAGES
A
B
Calcareous benthics rare
C1
Diverse calcareous benthics
C2
G. dividens
D
Agglutinated forams dominant
E1
G. dividens + Spiroplectinata
E2
N?. schloenbachi + Lingulogavelinella
E3
Diverse calcareous benthics
BENTHIC FORAM ZONES (PRICE 1977)
Zone 1
Zone 2
FORAM ASSEMBLAGES (KING et al. 1989)
? FCS 6
FCS 7a
'H. infracretacea' (sic) rare
FCS 7b
'H. infracretacea' (sic) common
FCS 8a
G. dividens
FCS 8b
Agglutinated forams dominant
FCS 9
'O'. schloenbachi
LAD
FCS 10
charactistic forams
FAD
Abundant inoceramids
REVISED OSTRACOD ZONATION
? Protocythere intermedia
R. bekumensis
S. t. subglaba
Protocythere nodigera
Clithrocytheridea heslertonensis
C. hesler.
Cornicythereis bonnemai
NANNOFOSSIL ZONES (JEREMIAH 1996)
NAL 2
barren
NAL 3
NAL 4



Speeton
West Heslerton, (Kaye 1964b)
West Heslerton, (Ennis 1932)
Grimston Hill (Jeans 1973)
Skegness (Gallois 1975)
Hun. Fm.
Speeton Clay Formation, A beds
Speeton Clay, B beds
MIDDLE ALBIAN
LOWER ALBIAN
LOWER APTIAN
BAR.
dentatus Zone
auritiformis Zone
mammillatum Superzone
?chalensis Zone
regularis Subzone
schrammeni/ acuticostata Subzone
tardefurcata Zone
deshay. Zone
forbesi Zone
fissicostatus Zone
bident. Zone
Queen Rocks Mbr.
UA1A
UA1B
UA1C
UA2A
UA2B
UA2C
UA3A
UA3B
UA3C
UA4
LA1
LA2
LA3
LA5
LA6
UB1A
UB1B
UB1C
UB2A
UB2B
UB2C
UB3
GAP
MINOR GAP
?SYNDEPOSITIONAL FAULT
HOWARDIAN- FLAMBOROUGH FAULT ZONE
UNCONFORMABLE ON JURASSIC
UNKNOWN GAP
bidentatum Zone ammonites
CEN.
MIDDLE / UPPER ALBIAN
Upper mammillatum Superzone
LOWER ALBIAN
?TOP LOWER/ BASAL UPPER APTIAN
fissicostatus Zone
LOWER APTIAN
bidentatum Zone
BARREMIAN
Chalk
Hunstanton Fm.
Carstone
Sutterby Marl
Skegness Clay
Roach
Probable chronostratigraphic correlation



dentatus Zone
?
auritiformis Zone
mammillatum Superzone
?chalensis Zone
regularis Subzone
tardefurcata Zone
schrammeni/acuticostata Subzone
deshay. Zone
forbesi Zone
fissicostatus Zone
bident. Zone
MIDDLE ALBIAN
LOWER ALBIAN
LOWER APTIAN
BAR.
Hun. Fm.
Speeton Clay Formation, A beds
Speeton Clay, B beds
Queen Rocks Mbr.
UA1A
UA1B
UA1C
i
ii
iii
iv
v
UA2A
UA2B
UA2C
UA3A
vi
UA3B
UA3C
UA4
LA1
LA2
LA3
LA5
LA6
UB1A
UB1B
UB1C
UB2A
UB2B
UB2C
UB3
GAP
Poorly-preserved fossils common
Only recorded in deformed state
Dark band with phosphate pebbles
Clays with small pale nodules, some coated in baryte
Appearance of common Neohibolites of minimus group
Large pale concretions in places
Red clay with glauconite
Very glauconitic with black phosphate pebbles
Burrowed contact, often becomes slip plane
Glauconite and mica filled burrows
Silty, micaceous clays with small round phosphates, fossils very rare
Massive pale marls with large burrows, some glauconitic
Lens of phosphate pebbles and belemnites, burrowed base
Black marls, some hard and pyritic
Sandy clays with large concretions; ammonites common
Black laminated pyritic muds
Hoplites spp.
Neohibolites minor
Neohibolites spp.
Inoceramus cf. anglicus
Neithea aff. quinquecostata
Burrirhynchia leightonensis
terebratulid brachiopods
Aconeceras nisoides
Tonohamites sp.
Toxoceritoides aff. proteus
Deshayesites spp.
Prodeshayesites ex.gr. fissicostatus
Neohibolites ewaldi
Hibolithes minutus
Inoceramus ewaldi
Terebratulina martiniana
Cyrtothyris cyrta
Polycidaris phillipsi
Asteroid material
Planctic foraminifera

Appendix;
Ammonites in Liverpool City Museum and Art Gallery

1 Aconiceras nisoides (Nikitin), Uppermost Barremian, Bed UB3
2 Aconiceras nisoides (Nikitin), Uppermost Barremian, Bed UB3
3 Aconiceras nisoides (Nikitin), Uppermost Barremian, Bed UB3
4 Aconiceras nisoides (Nikitin), Uppermost Barremian, Bed UB3
5 Aconiceras nisoides (Nikitin), Uppermost Barremian, Bed UB3
6 Aconiceras nisoides (Nikitin), Basal Aptian, Bed UB2C
7 Aconiceras nisoides (Nikitin), Basal Aptian, Bed UB2C
8 Aconiceras nisoides (Nikitin), Basal Aptian, Bed UB2C
9 Aconiceras nisoides (Nikitin), Basal Aptian, Bed UB2B
10 Aconiceras nisoides (Nikitin), Basal Aptian, Bed UB2B
11 Aconiceras nisoides (Nikitin), Basal Aptian, Bed UB2B
12 Aconiceras nisoides (Nikitin), Basal Aptian, Bed UB2B
13 Aconiceras nisoides (Nikitin), Basal Aptian, Bed UB2B
14 Aconiceras nisoides (Nikitin), Basal Aptian, Bed UB2B
15 Aconiceras nisoides (Nikitin), Lower Aptian, Bed LA6
16 Aconiceras nisoides (Nikitin), Lower Aptian, Bed LA6 (2 on slab)
17 *Cheloniceras (Cheloniceras)* sp., Lower Aptian, Bed LA6
18 *Deshayesites* cf.*grandis* Spath, Lower Aptian, Bed LA5i
19 *Deshayesites* cf.*forbesi* Casey, Lower Aptian, Bed LA6
20 *Deshayesites* cf.*forbesi* Casey, Lower Aptian, Bed LA6
21 *Deshayesites* cf.*forbesi* Casey, Lower Aptian, Bed LA5iii
22 *Deshayesites* cf.*forbesi* Casey, Lower Aptian, Bed LA5iii
23 *Deshayesites* cf.*normani* Spath, Lower Aptian, Bed LA5iii
24 *Deshayesites* sp. indet, Lower Aptian, Bed LA6
25 *Deshayesites* sp. indet, Lower Aptian, Bed LA6
26 *Epileymeriella* (*E.*) cf. *hitzeli* (Jacob), Basal Albian, Bed LA1
27 ?*Hamiticeras* Sp. Upper Barremian, UB (undifferentiated)
28 *Hoplites* cf. *dentatus* Spath, Middle Albian, Bed UA1A
29 *Hoplites* cf. *dentatus* Spath, Middle Albian, Bed UA1A, 3 on slab
30 *Otohoplites raulinianus* (d'Orbigny), Lower Albian, Bed UA1C
31*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2C
32*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2C
33*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2C
34*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2C
35*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2C
36*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2B
37*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2B

38*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2B, 2 on slab
39*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2B
40*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2B
41*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2B
42*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2B
43*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2B
44*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2A
45*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2A
46*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2A
47*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB1B
48*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB1B
49*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB1B
50*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB1B
51*Prodeshayesites fissicostatus* (Phillips), Basal Aptian, Bed UB2A
52*Prodeshayesites fissicostatus* (Phillips), Aptian, Bed LA6 (reworked)
53*Prodeshayesites fissicostatus* (Phillips), Aptian, Bed LA6 (reworked)
54 ?*Prodeshayesites Sp*., Aptian, Bed LA6 (reworked)
55 *Tonohamites* Sp., Lower Aptian, Bed LA6
56 *Tonohamites* Sp., Lower Aptian, Bed LA6
57 *Tonohamites* Sp., Lower Aptian, Bed LA6
58 *Tonohamites* Sp., Lower Aptian, Bed LA6
59 *Tonohamites* Sp., Lower Aptian, Bed LA5iii
60 *Tonohamites* Sp., Lower Aptian, Bed LA5iii
61 *Tonohamites* Sp., Lower Aptian, Bed LA5i
62 *Tonohamites* Sp., Lower Aptian, Bed LA5i
63 *Tonohamites* Sp., Lower Aptian, Bed LA5i
64 *Toxoceratoides* aff. *proteus* (Spath), Lower Aptian, Bed LA6
65 *Toxoceratoides* aff. *proteus* (Spath), Lower Aptian, Bed LA6
66 *Toxoceratoides* aff. *proteus* (Spath), Lower Aptian, Bed LA6
67 cf.*Toxoceratoides* Sp. Basal Aptian, Bed UB2B
68 ' hamitiform' indet. Basal Aptian, Bed UB2A
69 *Tropeum* aff. *hillsi* (J de C Sowerby) Lower Aptian, Bed LA5i