University of Hull

LOWER CRETACEOUS FORAMINIFERA FROM THE SPEETON CLAY OF YORKSHIRE

being a thesis for the Degree of

Doctor of Philosophy

in

The University of Hull

by

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SUMMARY

One hundred and five species of foraminifera from the D, C and Lower B beds, representing the Berriasian, Valanginian, Hauterivian and lower Barremian stages of the Lower Cretaceous Speeton clays are described. The need for accurate localisation of samples resulted in a critical examination of the stratigraphy and lithology of these clays and the measurement of numerous temporary beach and cliff exposures. A detailed section of the C beds is given for the first time and Lamplugh's divisions of these beds are further subdivided. A new lithological section through the Cement beds is also described. The foraminifera from the D beds show that four faunal units can be recognised. The lowest beds are of Berriasian age, and the fauna is older than any Lower Cretaceous ones described from North-west Germany; the middle and upper D beds are Valanginian and correlate with the German succession Mittel Valendis 1 and 2 to Ober Valendis 3, whilst the uppermost few feet are of Hauterivian age. The C beds have a rich Hauterivian fauna comparable to beds of similar age elsewhere in Europe. On the basis of the foraminifera it is suggested that the basal 19 feet of the Lower B beds are of Hauterivian age whilst the remainder is Barremian. There is a marked similarity in the fauna of the Lower B beds with that in North-west Germany and Trinidad. The foraminifera from the Fordon G1 borehole has enabled a correlation to be made with the type section and confirms the suggestion by Neale (1960A) that the Hauterivian beds at Fordon are twice as thick as at the coast.

The first occurrence of holothurian sclerites in the Lower Cretaceous of Britain is recorded and two new form species are described. Of the 105 species of foraminifera described 5 are new and 10 are left with open nomenclature.

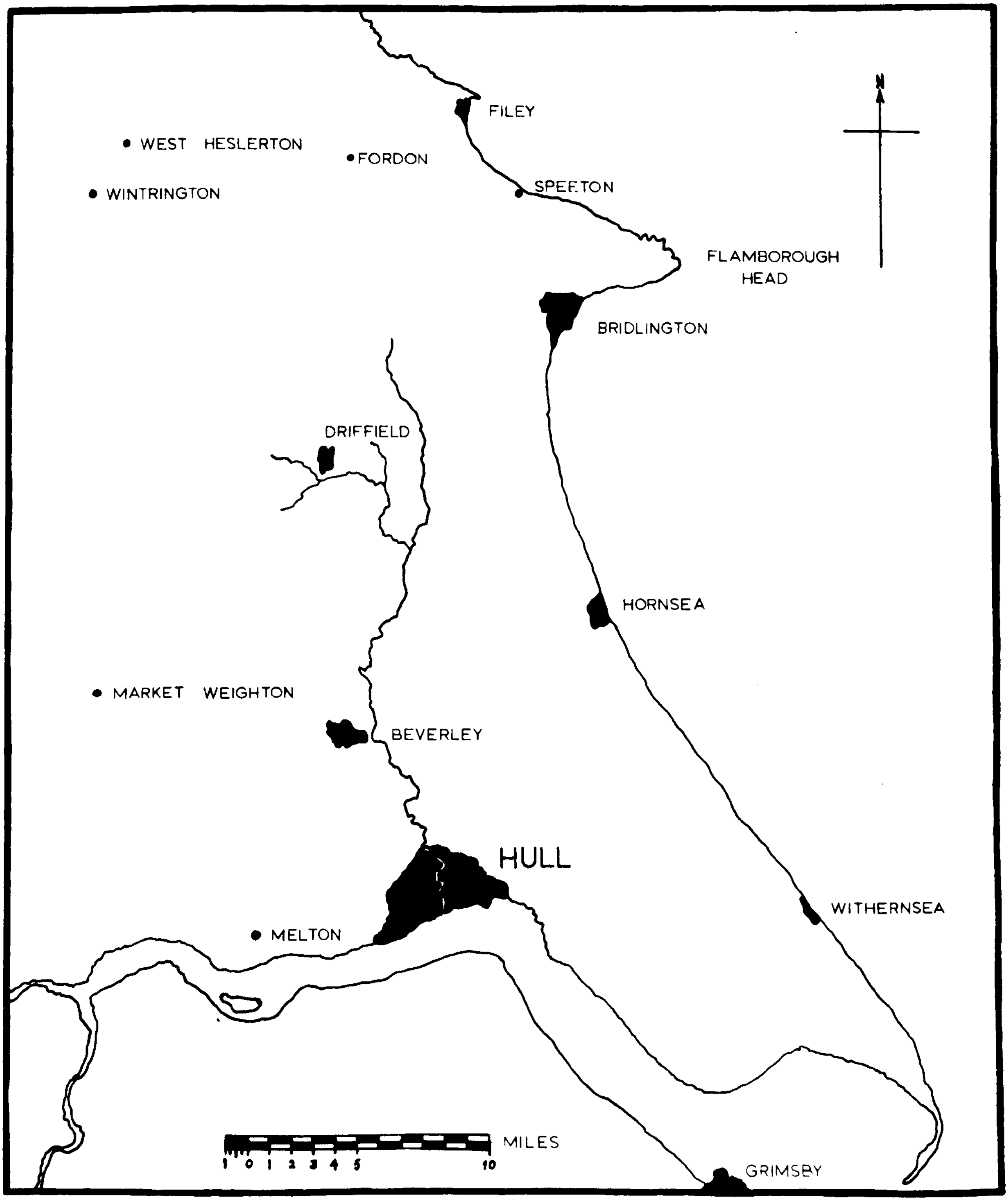
The stratigraphical distribution of the foraminifera is similar, but not identical, to that of Germany.

CHAPTER I

Introduction and Acknowledgments

The classic exposure of marine Lower Cretaceous in Britain occurs at Speeton (figs. 1 & 2) which is forty miles north-north-west of Hull. Here all the stages of the Neocomian are represented from the Berriasian, which lies unconformably upon the Kimmeridge clay, to the Albian which passes gradually into the Cenomanian White Chalk. The Lower Cretaceous succession is an argillaceous one which, by its very nature, easily slips, the cliff exposures being so badly affected by landslipping and weathering that interpretation is difficult and in some parts impossible. Fortunately rare beach exposures give almost ideal sections. Lamplugh (1889 p. 575) states "It needs a high and stormy tide, to reveal a fresh unweathered surface of clay at the foot of the slopes, or a heavy onshore gale, to sweep aside the sand and shingle off the beach, before the student of the section can make any really satisfactory progress either in collecting the fossils or in studying the sequence of the deposits; and many repetitions of such conditions are necessary before the many difficulties of the section can be grasped." This is very true; the writer found that it was only by visiting Speeton at weekly intervals, and observing chance exposures, that any progress could be made in understanding the detailed geology.

The clays at Speeton, which are covered by the maps of the Geological Survey, New Series, Sheet No. 54 (Scarborough) and 55 (Flamborough), have long attracted attention and speculation as to their age and their



LOCALITY MAP

Fig. 1.

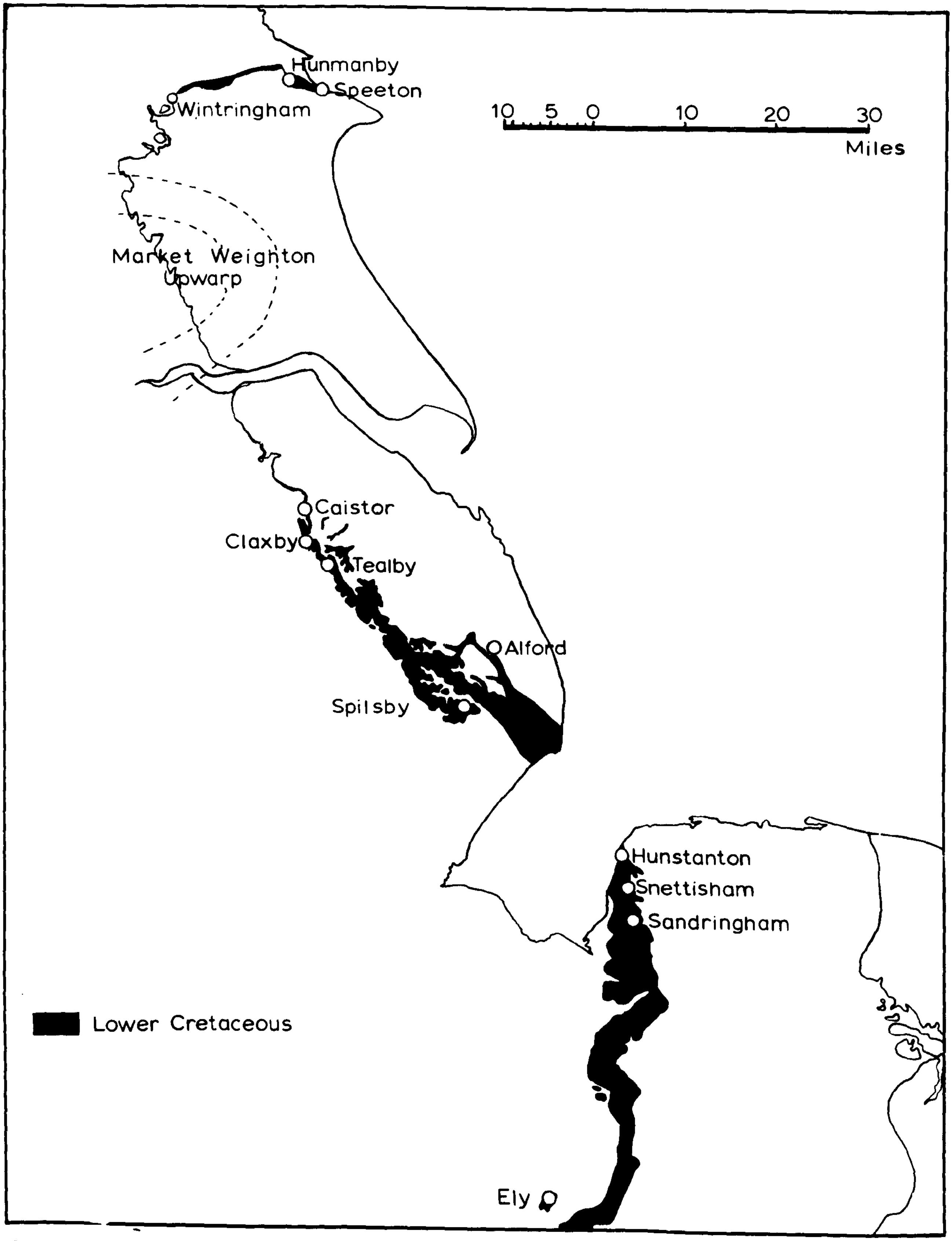


Fig. 2. Distribution of Lower Cretaceous deposits in Northern England.
(After Neale)

equivalents. It was Leckenby in 1859 who first attempted a subdivision of the clays and this was followed in 1868 by the more sophisticated study of Judd. The major work on the Speeton Clays still remains that by Lamplugh in 1889. A comparison of these early lithological divisions is shown in fig. 3.

Palaeontological knowledge of the section is still in its infancy, for in spite of the large number of ammonites and other macro-fossils which have been obtained no detailed sections have existed, until very recently, to record the horizon of these fossils with any precision. Consequently only Spath's rather broad zoning of the section on the ammonites exists.

The Chalk of the Yorkshire Wolds is folded into a very gentle syncline with a shallow plunge to the south-east. Inland the Speeton Clay crops out from beneath the northern limb of this fold along the southern edge of the Vale of Pickering. Downwash from the Chalk scarp and the glacial sands of 'Lake Pickering' everywhere mask the Speeton Clay. Recent boreholes show that a surprising variation in thickness of the Speeton Clay occurs inland from the coast section.

Samples for micropalaeontological purposes were collected from the whole of the Speeton Clay but only those up to and including the Lower Barremian are included in this thesis.

Acknowledgments:-

The work described in this thesis was carried out during the tenure of a N.A.T.O. research studentship of the Department of Scientific and Industrial Research and the author would like to express his thanks to this Department. He would also like to thank the Heads of the Department of Geology at Hull University (Mr. L. F. Penny until October 1962 and Professor D. T. Donovan since that time) for the use of the many facilities of the department.

Thanks are also due to my supervisor Dr. J. W. Neale for his continual guidance, even whilst in America, and for his generosity in allowing use to be made of the foraminifera from his research samples of the D beds. He has read the manuscript of this thesis and has given helpful criticism. The author is indebted to the following persons who have either sent him offprints of their work or discussed points with him or both:- H. Bartenstein; H. Beckmann; F. Bettenstaedt; A. Buch; G. L. Carini; R. Casey; G. Colom; W. G. Cordey; M. Deflandre-Rigaud; D. T. Donovan; A. J. Ehlmann; D. L. Frizzel; J. Haynes; R. H. Hedley; H. Hiltermann; D. W. Humphries; D. L. Jones; P. Kaye; E. Kemper; J. F. Kirkaldy; W. Koch; L. S. Kornicker; A. R. Loeblich; G. F. Lutze; F. A. Middlemiss; M. Moullade; J. W. Murray; J. W. Neale; G. L. Peterson; M. Rioult; J. Sztejn; Y. Takayanagi; H. Tappan; E. Triebel.

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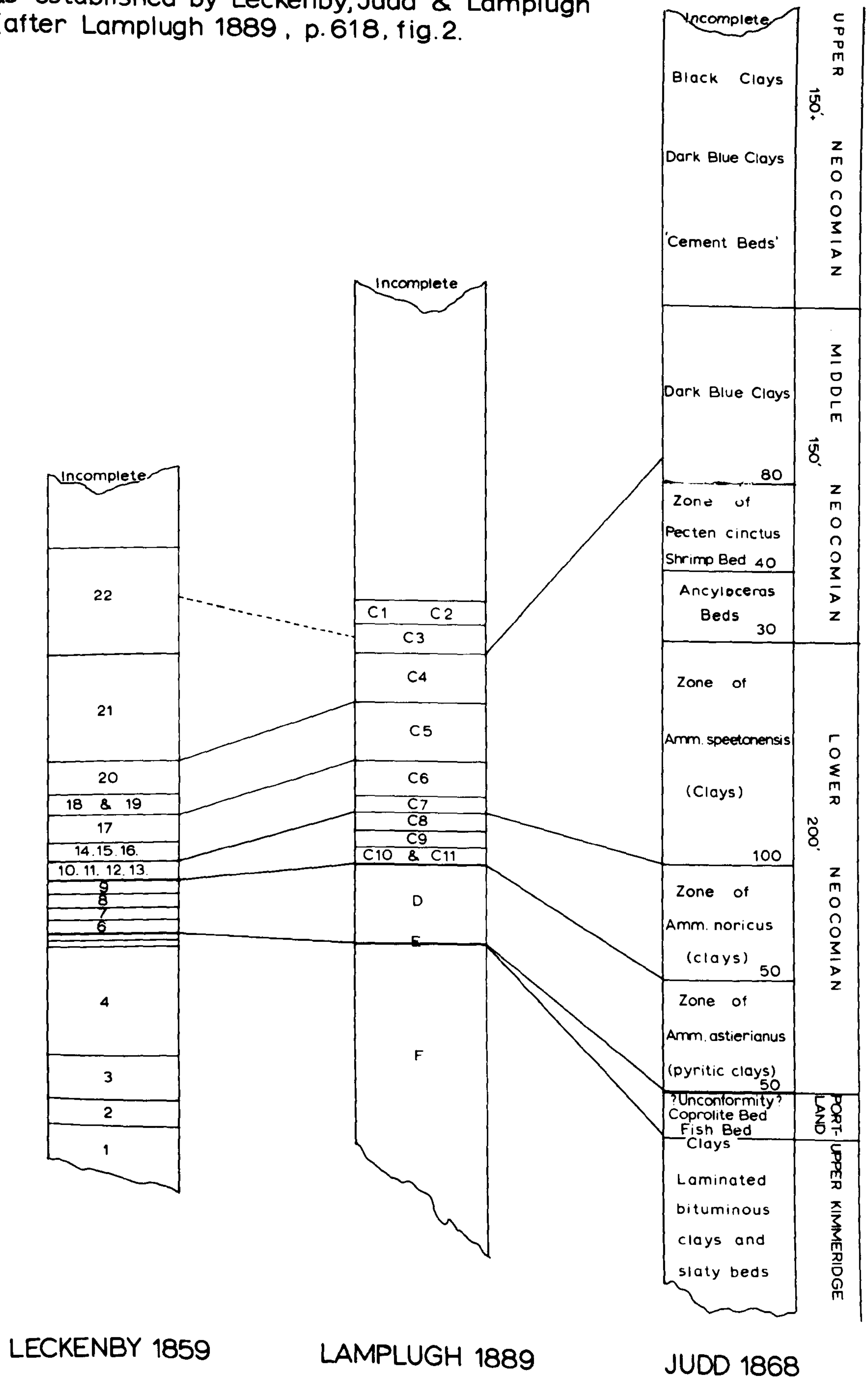
Figure.3. Comparison of the succession of rocks at Speeton as established by Leckenby, Judd & Lamplugh (after Lamplugh 1889, p.618, fig.2.



CHAPTER 2

HISTORY OF RESEARCH ON THE SPEETON CLAYS

The earliest mention of the Speeton clays is by Young and Bird (1822) who described these beds as the 'upper shale' but it was Phillips (1829) who first gave the name Speeton clay to the dark grey clays which crop out in the southern part of Filey bay, in an area which lies entirely within the parish of Speeton. It is this coastal locality which provides the classic exposures of Speeton clay. Phillips used the term Speeton clay to include all the clays lying between the Chalk and the Corallian limestones but nowadays the term is restricted to those clays between the Kimmeridge clay and the Red Chalk.

The Speeton clay also occurs beneath the Chalk escarpment of the Wolds on the southern side of the Vale of Pickering extending in a westerly direction from its outcrop on the coast to West Heslerton, a distance of some fourteen miles. A very small exposure at West Heslerton in Albian clays is the only exposure visible at the present time along the whole of this distance; elsewhere either downwash from the Chalk or the glacial sands and Lake deposits of 'Lake Pickering' effectively mask the position where the Speeton clay should crop out and at Winteringham a mile or so from West Heslerton the Geological Survey maps Red Chalk resting upon Kimmeridge clay.

Though there had been much speculation in the early part of the last century as to the age of the Speeton clay, it was Leckenby (1859) who first attempted a subdivision of the clays and defined the range of some of the fossils. This was followed by Judd (1868) who described the sequence more precisely and by increasing the faunal list provided the basis of a general classification and correlation of the beds. Later Judd (1870) reviewed the inland exposures of Speeton clay and their equivalents in Lincolnshire and Northern Europe. The classic paper on the Speeton clay, however, is that by Lamplugh (1889) who worked out the true succession of the clays, described the lithology and put forward a palaeontological subdivision based upon belemnites.

Belemnites are the most abundant fossils at Speeton and by their very nature are usually well preserved. The fact that they were common and more widely distributed than the ammonites led Lamplugh to use them to divide the section into the following six divisions:-

A Marls with *Belemnites minimus* (Miller)

B Zone of *Belemnites brunsvicensis* (Von Strombeck)

C Zone of *Belemnites jaculum* (Phillips)

D Zone of *Belemnites lateralis* (Phillips)

E The Coprolite seam.

F Bituminous shales (Kimmeridge clay) with *Belemnites oweni*

Lamplugh lettered and numbered the beds from top to bottom, instead of following the more conventional stratigraphical practice of subdividing from the base upwards, a feature which often results in confusion on first acquaintance.

Modern work at Speeton confirms the detail and accuracy of Lamplugh's observations and his classification into A, B, C, D, and E beds has provided the framework for the study of the section. Even today this and two later papers by Lamplugh published in 1896 and 1924 and the recent paper by Kaye (1964e) remain almost the only works on the stratigraphy. The joint publication (1892) by Lamplugh and the Russian geologist Pavlow, who had an unrivalled knowledge of the equivalent beds in Russia at that date, gives a useful discussion of the Speeton clays. The work of Danford on the Belemnites and Ammonites from Speeton was recorded in two notes in 1906 and in the same year another local geologist, Sheppard, also described the belemnites from the section. Most of the belemnites in the important monograph by Swinnerton (1936 - 1955) on the British Lower Cretaceous belemnites also came from Speeton.

Workers in Germany were also active at this time on the Lower Cretaceous and in 1902 Von Koenen published a monograph 'Die Ammonitidae des Norddeutschen Neocom' and figured many forms occurring at Speeton. Similarly an important paper by Stolley (1908) gave a zonal classification of the North German Lower Cretaceous dealing in particular with the ammonoidea and belemnoidea and mentioning many of the belemnites figured by Danford from the Speeton clay.

In 1924 Spath published a partial revision of the Speeton ammonites and drew up a Zonal scheme (fig. 4.) in which he concluded that the lower part of the Valanginian is absent at Speeton and the Barremian only partially developed. The usefulness of his work at the present time is limited by the lack of illustration and the fact that the ammonites are only allocated to the broad stratigraphic subdivisions of Lamplugh. Accurate localisation of ammonite occurences is needed for it is of little use localising an ammonite as 'C 5', for example, when Lamplugh's 'C 5' subdivision is twenty-eight feet thick. Lamplugh

Stages.	Ages.	Zones.	Speeton.	Lincolnshire, Norfolk.
Lower Aptian	Parahoplitoidan	*consobrinoides*	..	..
		hambrovi	..	..
		weissi	..	..
		**bodei*	" Ewaldi " marl	Sutterby Marl.
		**bidentatus*	..	Phosphatic Sandstone.
	Parancyloceratan	*rude*	B, top	
		sparsicosta	..	
Barremian	Heteroceratan	**pingue*	Cement Beds	Fulletby Beds. Snettisham Beds.
		innexum		
		costellatum		
	Paracrioceratan	**denckmanni*		
		elegans		
		roeveri		
Hauterivian	Hoplocrioceratan	*centrifuga*	B, Lower	Upper Tealby Clay.
		rarocinctum		
		**clypeiforme*		
		**discofalcatus*	..	Tealby Limestone.
	Simbirskitan	**progredicus*	C1—3	Lower Tealby Clay.
		**phillipsi*	C4	
		**rotula*	C5	
		**speetonensis*	C6	
	Crioceratan	**capitanei*	..	
		**capricornus*	C7	Claxby Ironstone.
	Lyticoceratan	**sulcosus*	C8	
		**regalis*	C9	
		**ebergensis*	C10—11	
		**noricus*	D1—2	
		radiatus	..	
Valanginian	Hoplitidan	*psilostoma*	..	
		**heteroptychus*	..	
	Polyptychitan	**bidichotomus*	..	
		terscissus	..	
		**ramulicosta*	D3	
		**ascendens*	D4—6	..
		brancoi	..	..
		diplotomus	..	..
	Platylenticeratan	*marcoui*	..	..
		heteropleurum	..	..
		pseudograsianum	..	Spilsby Sandstone, Glauconitic sands,
Infra-valanginian	Subcraspeditan	**stenomphalum*	D6—8	
		tolli	..	..
		spasskensis	..	Basement Beds.
	Spiticeratan	*latior*	..	..
		damesi	..	..
		acutum	..	..

* Indicacts those zonal species which have been recorded for England.

Fig. 4. Spath's zonal scheme after Swinnerton (1939)

(1924) commented that "Dr. Spath, in limiting his investigation to the Ammonoidea, has hardly allowed enough for the fact that fossils of this order are absent, or at any rate unknown, from a considerable portion of the Speeton clays, and are really plentiful only in a few comparatively narrow belts. Hence in practically all large collections of these fossils, it will be found that, say, nine-tenths of the specimens have been obtained from bands lying between D 3 and C 6, covering only some 56 feet of the clays out of a total of, at least, 300 feet". This criticism is still a very valid one at the present time.

The relationship of the Speeton clays to those of similar age elsewhere in Britain has always been of interest and in 1927 Thompson compared them with their southern equivalents. Thus whilst the section received a great deal of attention in the period 1859 - 1927 little work was done after this period until the 1960's though Ennis (1937) and Wright (1955) gave additional information on the uppermost beds. Since 1960 a renewed interest in the Speeton Clay has been stimulated by Neale with his work on the distribution of ostracoda in the deep North Fordon G.1. borehole (fig. 11.) which penetrated 695 feet of Speeton clay, and on the ostracod faunas from the D beds of the coast section (1962b). Neale (1962b) further subdivided the upper D beds and later (1962c) the lower D beds. These two papers now provide the standard lithological succession of the D beds at Speeton. In an important paper by Neale (1962c) the ammonites from the lower D beds were assigned to the Berriasian stage. Since then, in a series of papers, Kaye (1963 a,b,c,d,e;, 1964a,) has described various ostracod genera and species from the Barremian, Aptian and Albian parts of the succession. The microfaunas of the cores from a deep borehole put down by Shell at Speeton in 1960 are at present being examined in the Geology department at Hull, and Neale and Sarjeant (1962) have described the microplankton from a depth of 383 feet 4 inches.

Thus the current trend is towards zonation of the Speeton clays based on detailed studies of the microfaunas, but there is an urgent necessity to tie in this work with a zonal scheme based upon ammonites. It is almost incredible that there is no monograph on British Neocomian Ammonoidea although current research work by Rawson on the Hauterivian ammonites may go some way towards remedying this; his work is eagerly awaited by all workers on the Speeton section.

General view of the Speeton section.

The Hauterivian clays of Middle Cliff. Note temporary beach exposure.

CHAPTER 3

THE STRATIGRAPHY OF THE SPEETON CLAY.

The Speeton Clay crops out in the south eastern part of Filey Bay and forms low cliffs which extend south westwards from near Reighton Gill to the sheer chalk cliffs of Bempton, a distance of one and a half miles.

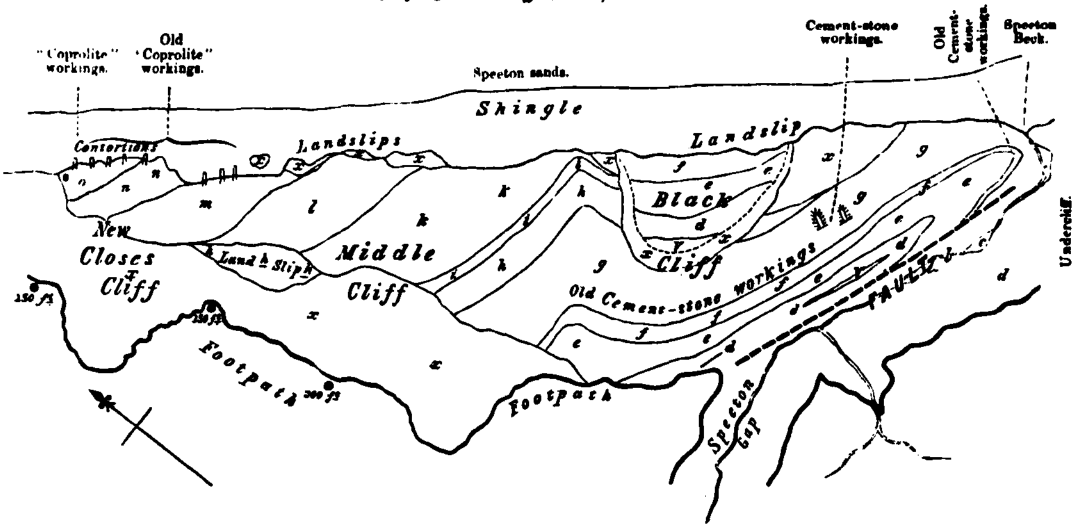
The cliff sections are far from ideal as gaps in the succession occur due to minor faulting and landslipping, whilst generally the slumping and slipping of the clays makes them difficult to interpret. In addition, the Lower Cretaceous clays are capped by the Drab, Purple and Hessle boulder clays which in wet weather flow over the face of the cliff and effectively mask the Speeton Clay. If the summer is a very wet one the cliff sections may remain poor for the greater part of the year, as it is only the high spring tides which effectively wash the slipped material from the cliff face and give good exposures of the clay beneath. This state of affairs existed after the particularly wet summer of 1963 which caused a great deterioration in the Speeton section. Both the Speeton and Boulder clays quickly became saturated and as a result slipped, flowed or trickled over and down the cliff face; mud "glaciers" began to move and quite large slips occurred. At the foot of the cliffs a thick mound of soft mud accumulated, extending out over the shore for a distance of five or six feet from the cliff face. This prevented close inspection of the lower cliff sections as the mud was too soft to support a person's weight. In wet weather many small gullies are formed by the surface run-off, but whilst ammonites and other macrofauna are washed out, the gully bottoms are usually obscured by soft clay and do not provide the 'good section' that one would expect. In fact the writer obtained no good measured sections or lithological data from these gullies which at first sight seem so attractive. It is perhaps the bad condition of the section which first impresses any geologist visiting this classic locality. Blake (1891) states that "here we find a wild tumbled slope of clay, in which at first sight it is hopeless to make out any order", whilst Wright (1937) says that "nowadays it is general to regard the section in the Cretaceous clays at Speeton as hopelessly slipped and impossible to disentangle". These are sentiments which could be echoed at the present day. By far the most reliable sections for study are not those of the cliff, but the ones which occur haphazardly and intermittently on the beach itself when favourable tides and winds have swept parts of the beach clear of sand. Though an overall general picture of the stratigraphy can be obtained from the cliffs, it is the beach exposures which provide detailed and reliable sections for measurement. An exception to this are the cliff sections of the D beds which are relatively undisturbed by faulting and slipping, and have in the past been very well exposed.

The D Beds

These beds are only 47 feet thick yet three Cretaceous stages are represented, the Ryasian or Berriasian, the Valanginian and the Hauterivian. They are first seen at the foot of New Closes Cliff (fig. 5) where a minor synclinal fold brings the lower D beds to beach

JUDD - 1868

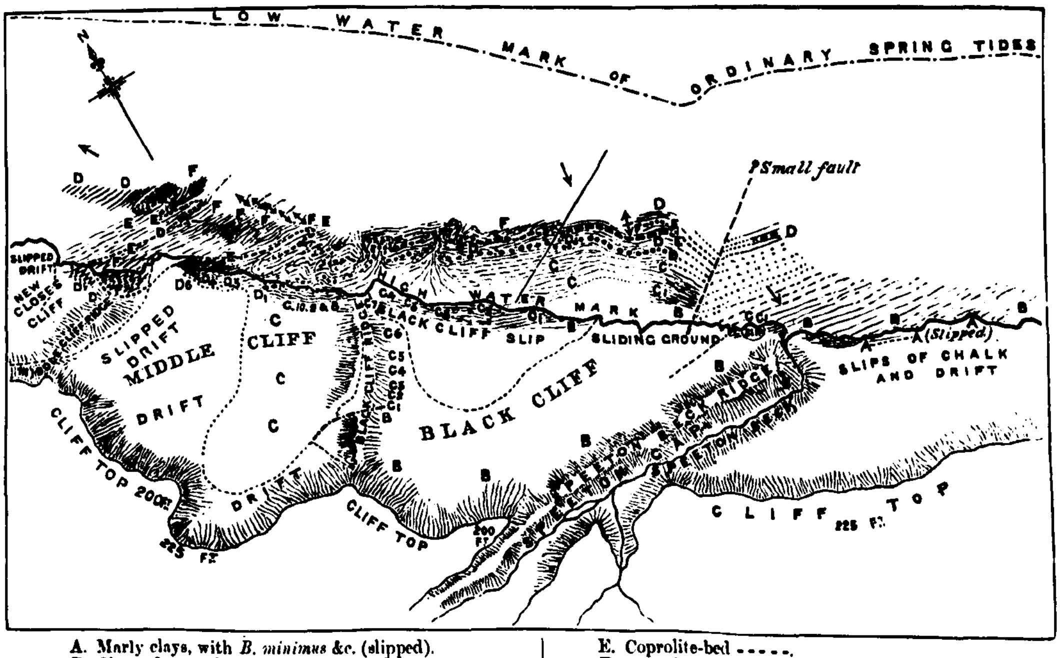
Sketch-map of Speeton Cliff (1867). *Scale 9 inches to 1 mile.*



c. Hunstanton Limestone. *d, e.* Dark-blue clays. *f.* Cement beds. *g.* Blue clays. *h.* *Pecten cinctus* beds. *i.* Ancyloceras-bed. *k.* Speetonensis-bed. *l.* Noricus-bed. *m.* Astierianus-bed. *n.* Portlandian beds. *o.* Upper Kimmeridge beds. *v.* White and red chalk rubble. *x.* Drift.

LAMPLUGH - 1889

Ground-plan of the Coast at Speeton, showing the Course of the Beds on the Shore and in the foot of the Cliff. (Scale 9 inches to 1 mile.)



A. Marly clays, with *B. minimus* &c. (slipped).
B. Clays of zone of *B. semicanaliculatus*?
C. Clays of zone of *B. jaculum*, Phil.
D. Clays of zone of *B. lateralis*, Phil.

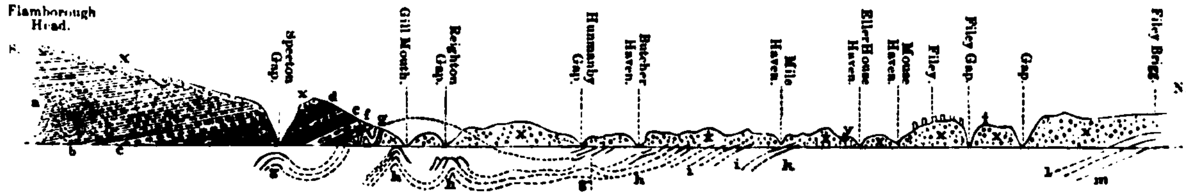
E. Coprolite-bed - - - - -.
F. Bituminous shales with *B. Owenii* and vars.
o o o o Compound Nodular Band (D^1).

(The lines show the strike; where continuous, the beds have been actually observed; where broken, they are supposititious.)

Figure 5. Published maps of the Speeton Clay

JUDD 1868, Fig.1.

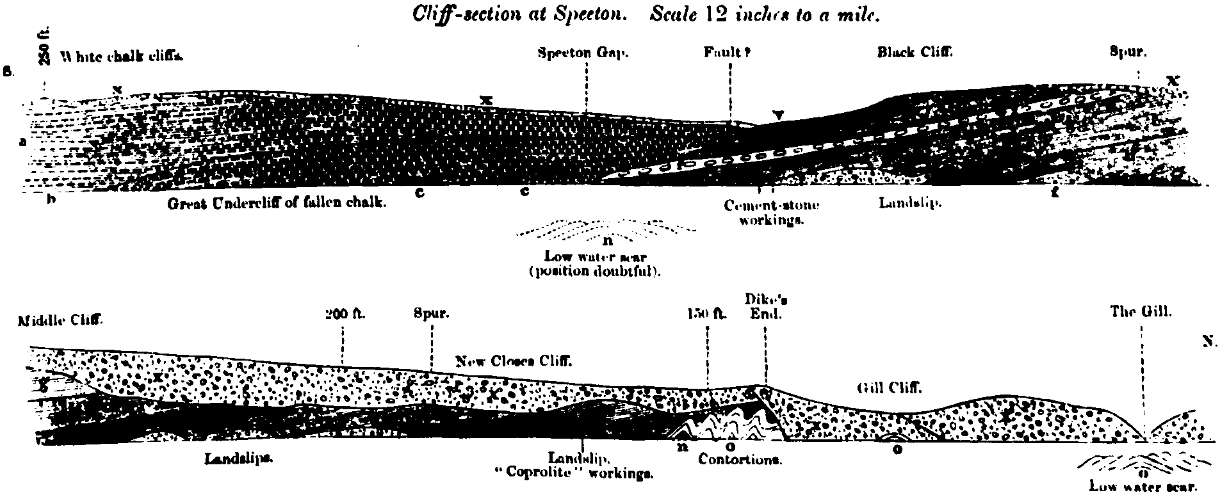
Diagrammatic Section illustrating the relations of the beds exposed in Filey Bay.



a. White chalk. *b.* Chalk with red bands. *c.* Hunstanton Limestone. *d.* Upper Neocomian. *e.* Middle Neocomian. *f.* Lower Neocomian. *g.* Portlandian. *h.* Upper Kimmeridge. *i.* Middle Kimmeridge. *k.* Lower Kimmeridge. *l.* Coral Rag. *m.* Lower Calcareous Grit. *x.* Drift. *y.* Freshwater deposit.

JUDD 1868 Fig.2.

Cliff-section at Speeton. Scale 12 inches to a mile.



a. White chalk. *b.* Chalk with coloured bands. *c.* Hunstanton Limestone. *d, e.* Dark-blue clays. *f.* Cement beds. *g.* Blue clays. *h.* *Pecten cinctus* beds. *i.* Ancyloceras-bed. *k.* Spectonensis-bed. *l.* Noricus-bed. *m.* Astierianus-bed. *n.* Portlandian beds. *o.* Upper Kimmeridge beds. *v.* White and red chalk rubble. *x.* Drift.

Figure 6. Published sections of Speeton Cliffs.

level. It is not until the dark black Kimmeridge clays of the complementary anticline to the south have been crossed, however, that the main section through the D beds is seen. The junction between the Kimmeridge clay and the Speeton clay is marked by the Coprolite bed (fig. 7). This is a four-inch thick phosphatic nodular bed, with occasional derived ammonite fragments, lamellibranchs and rotten belemnites; Casey (1963 b) equates this basal Cretaceous deposit with the mid-Spilsby sandstone nodule bed of Lincolnshire (fig. 8).

The Coprolite bed is well cemented and hard in fresh exposures but in the cliff soon weathers and breaks down. Until 1879 it was mined for phosphate by driving a series of adits into the cliff along the bedding plane. Old shoring timbers from these adits can still be seen in the cliff. The clays on either side of the bed are identical in appearance and in beach exposures where the bed is thrown into a number of tight folds, it is frequently difficult to tell which is Cretaceous and which Jurassic strata. However, in these cases the thin, pale brown, rather elongated nodules which often underlie the Coprolite bed here provide a useful guide.

Overlying the Coprolite bed are the D beds which Lamplugh (1889) divided into beds D1 to D8 from above downwards, and Neale (1960 b, 1962 a) subsequently further subdivided for purposes of detailed field collecting and localisation. It is Neale's subdivisions which are used here (figs. 9 & 10). The dark shaly clays which immediately overlie the Coprolite bed are a foot thick and are followed by the brown clays of subdivision D7E. These pass upwards into a series of pale shales, clays

Compound nodular bed - D 1.

Coprolite bed - E (white disc $1\frac{1}{4}$" diam.)

Figure 7.

and mudstones with occasional thin bright blue clay bands and a prominent stoneband (D6H). The pale beds which form the bulk of the D6 division are perhaps the most distinctive in the Speeton succession. The overlying D5 bed was called the 'Lingula bed' by Lamplugh as _Lingula ovalis_ occurs here, often in the position of growth. The term does give rise to some confusion as this lamellibranch is also common in D4C and D4D. At the boundary between D5 and D4D the clays contain numerous irregular pyrite tubes and cylinders, between one and two inches in length, resembling the pyritised burrows of some animal.

Exogyra sinuata (J. Sowerby) occurs commonly in D3 and though it is found in higher beds it is characteristic of this division. It should be pointed out that whilst _Exogyra sinuata_ is regarded by some authors as a synonym of _E. latissima_ (Lamarck) the old established and well known name is retained here. The D2 beds are mainly glauconitic, but within this subdivision a striking marker horizon occurs at the base of D2D. Here the basal two inches are packed with broken and eroded belemnites belonging to the genus _Acroteuthis_, many of which have adherent foraminifera on them. This horizon overlies the brown shaly clays of D2E which have no glauconite and provides a contrast both in lithology and colour with the bed above. A non sequence clearly exists at the top of D2E and Neale (1962) on the basis of the ostracoda suggests D2D is Hauterivian _noricus_ zone whilst D2E is equivalent to the German Ober Valendis 1. Two feet above this non sequence is the Compound Nodular bed which marks the top of the D beds. This nodular horizon has large grey calcareous nodules spaced two or three feet apart and forms a

Correlation of north-west European formations near the Jurassic–Cretaceous boundary within the framework of the Tethyan and Boreal stages

	TETHYAN	BOREAL					
	South-east France	North-west Germany	Southern England	Eastern England		Moscow synclise	
CRETACEOUS (part)	Barremian	Barremian	Wealden Beds	Tealby & Claxby Beds	SPEETON CLAY (part) (109)	Barremian (89)	CRETACEOUS (part)
	Hauterivian	(31) Hauterivian			(108) (114)	Hauterivian	
	—(88, 104)— Valanginian	'Upper & Middle Valendis'				Valanginian	
	Berriasian	'Wealden'	PURBECK: Durlston Beds	Upper Spilsby Sandstone (131)		Ryazanian (117)	
		Upper Serpulite					
		Lower Serpulite	PURBECK: Lulworth Beds	Lower Spilsby Sandstone (132)		Volgian (119, 128)	JURASSIC (part)
JURASSIC (part)	Tithonian	Münder Marls (139)					
			Portland Beds (125, 129, 129)				
		Eimbeckhausen Plattenkalk	Kimmeridge Clay (part)				
		gigas Beds		Kimmeridge Clay (part)			

Thicknesses are not to scale.
Glauconite ages (in millions of years) are shown.

Figure 8

(after Casey et al 1964)

conspicuous line in the cliffs. In beach exposures, particularly near the old shipwreck, 400 YARDS N.W OF THE MOUTH OF SPEETON BECK, the nodules are often absent for considerable distances and one has to locate the conspicuous mottled bed D2A (fig. 18) first before identifying D1.

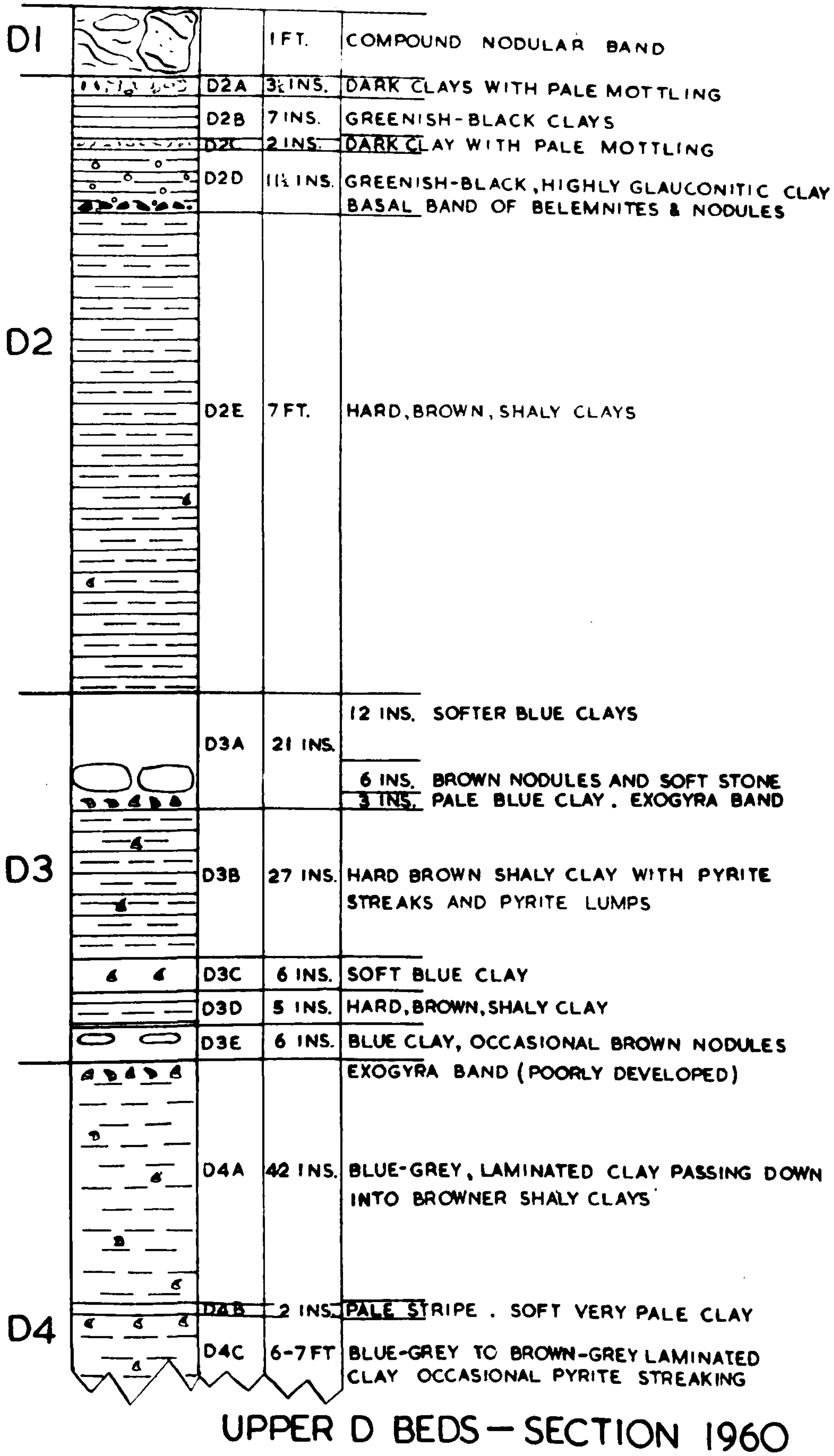
In D1 and D2 the ammonites are relatively common and belong to the genera Endemoceras Thiermann and Distoloceras. In the lower part of the D beds ammonites are rare or absent and the age of these beds has given rise to much discussion. Early workers regarded them as of Jurassic age, but Blake (1891) disagreed with the views of Nikitin, Pavlov and Lamplugh on the Portlandian age of the lower beds and stated that "there is no doubt in my own mind, that these beds are Neocomian, and that their reference to the Portlandian is founded on error".

These early views were not accepted and it was left to Spath (1924) to show that the upper part of the D beds are Valanginian and that earlier views were largely based upon the identification of Polyptychites as Gravesia a Kimmeridgian form. The lower D beds he regarded as Infra-Valanginian.

In an important paper on the ammonites from D6 and D7, Neale (1962 a) described Laugeites, Paracraspedites, Subcraspedites and Tollia which firmly places these lowest beds in the Berriasian or Ryazian.

The C Beds

The Hauterivian clays are best exposed in Middle Cliff which rises gently to a height of 225 feet O.D. The foot of this cliff is truncated by wave action and it is here, in the vertical part of the cliff, that the



TEXT-FIG. 9—Section through the Upper D Beds—1960. (after Neale 1960b)

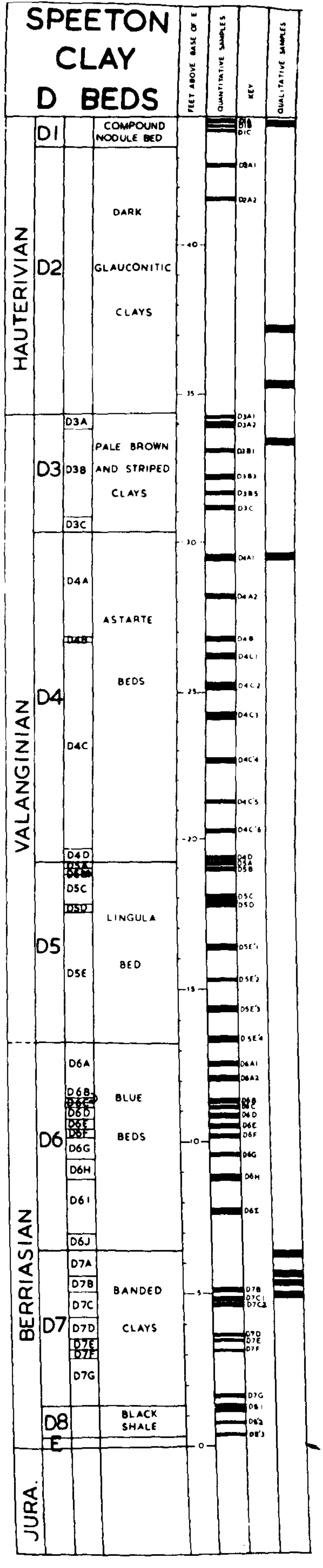


Figure 10 (after Neale 1962a)

lower C beds are generally examined. All the beds from C11 at the base, to the lowest part of C6 can be traced in the cliff, where they lie almost horizontally. The rusty brown weathering bed marking the top of C7 occurs close to the top of the lower, near-vertical part of the cliff and is overlain a short distance above by a thin one inch band of clay which weathers to a conspicuous yellow band. Above these beds, the slope of the clays to the top of the cliff is a very gradual one; they are deeply weathered, selenitic and no distinctive horizons can be traced laterally for more than a few yards. The cliff is terminated immediately to the north-west of Black Cliff Nab by the large landslip and 'mud glacier' of Black Cliff which brings C4 against C7. Beds C6 and C5 do not occur in any part of the cliff at beach level.

South-eastwards from this point the cliffs become very low and badly slumped and it is with difficulty that the remaining divisions of the C beds can be seen passing upwards into the Lower B and Cement beds.

In the cliffs immediately to the north-west of Speeton Beck a fault brings beds C4 - C1 into the cliff again. This section is unfortunately protected to some extent from the full force of wave action by concrete wartime defences, but nevertheless it is occasionally washed clean, and at these times a very rewarding section showing the passage from C to B beds can be clearly seen.

Small grey or brown calcareous and phosphatic nodules are found throughout the Speeton clay but are particularly common in the Hauterivian clays where Lamplugh noted them as 'potato stones' - an apt description. Some of these have on the outside, or contain when broken, the 'Speeton shrimp' *Meyeria ornata*, or perhaps a belemnite, ammonite or fish vertebra and are clearly of diagenetic origin. A tendency in the past to regard all nodular horizons at Speeton as marking non sequences is generally erroneous. Two types of nodular horizons can be distinguished; the small, brown, scattered, 'potato' nodules which do not represent breaks in the sequence, and the much more compact, concentrated, nodular horizons with eroded fossils which do mark a non sequence.

The lack of distinctive marker horizons in the cliff make the C beds more difficult to study than the more varied D beds, whilst hill creep and gullying often make horizons with small nodules appear to have a haphazard arrangement in the cliff. This apparently haphazard distribution of small nodules, which in actual fact occur in a very narrow bed, is well seen in C8.

Fortunately in the early part of 1963 exceptional beach exposures occurred between the old shipwreck 400 YARDS N.W OF THE MOUTH OF SPEETON BECK and the low cliffs south-east of Black Cliff Nab which enabled almost the whole of the Hauterivian to be observed. Local residents stated that the clays had not been seen on the beach like this during the last thirty years and it seems probable that the exposures were equally as good if not better than those Lamplugh was able to measure. The opportunity was taken to visit the locality frequently during the few days this exposure lasted and from the numerous sections which were measured a composite section of the C beds was drawn up (fig. 11) and the clay subdivided lithologically.

Perhaps the most striking feature of these beach exposures was the number of brown weathering silty beds which due to differential weathering stand up above the adjacent clays. The brown bands are more distinctive in the beach exposures than in the cliff sections and there is a marked tendency for them to become indurated and form stone bands. Generally very much greater lithological detail can be seen in beach exposures than is possible in the cliff, and the brown silty beds provide a framework in which to place this detail.

The three inch pale greystone band (C4A) at the top of the C4 division is also distinctive in beach exposures though can be easily confused with a similar bed eight feet below. Thin sections of this stone band show it to be an impure limestone with quartz as a very minor constituent. Small mud pellets are incorporated in the upper part of this limestone at the junction with the overlying clays.

The lowest part of the C beds at Speeton are the most fossiliferous and it is from here that the bulk of the ammonites from both private and museum collections have been obtained. Endemoceras (Syn., Lyticoceras) and Acanthadiscus are common and occasionally more southern forms are found including Lytoceras and Eodesmoceras. Division C7 is notable for the sudden appearance of the Crioceratids, Aegiocrioceras and Crioceratites and pieces of the outer whorls of these uncoiled ammonites are common. This horizon can be approximately correlated with the duvali zone of the south of France. In C6 and above the genus Simbirskites is the commonest of the ammonites though in this part of the section ammonites are relatively rare.

Whilst the upper limit of the C beds is lithologically distinctive, palaeontologically the limit of the Hauterivian is not and the two do not appear to coincide. In the type area of south-east France the zone of Pseudothurmannia angulicosta is placed in the uppermost Hauterivian though the Treatise does point out that it is sometimes placed in the Barremian. Spath (1924) in his zonal scheme places Hoplocrioceras centrifuga and H. rarocinctum as the uppermost subzones of the Hauterivian but neither of these species have been recorded from Britain. Beneath these two subzones are those of H. clypeiforme and Craspedodiscus discofalcatus which he includes in the lower B beds. From his list of ammonites from Speeton he only recognises C. discofalcatus from C.1, the form from the base of lower B being C. aff discofalcatus. Spath in his correlation chart equates the "Hopl." angulicosta zone of the south of France with H. rarocinctum. Workers in Germany however following the zonal scheme of Stolley put the fissicostatum, rarocinctum and strombecki zones in the Lower Barremian and it is interesting to note that Danford (1906, b) states "in its lower beds (lower B) C. strombecki is common".

In the south of France Crioceratites emericianus is the lowest zone of the Barremian and this has been equated with Paracrioceras strombecki.

Whilst there are a number of interpretations of the Hauterivian/ Barremian boundary, it is the difficulty of correlating zonal ammonites from the Boreal with those of the Tethyean province which is the real basis of the problem. An area where this may be resolved is in the North Caucasus and Crimea where the Lower Cretaceous shows an intermingling of Tethyean and Boreal. Here Drushchitz (1960) records C. emiricanus as appearing about the same time as P. angulicosta and Drushchitz includes

P. angulicosta in the Lower Barremian, but if it is placed in the Upper Hauterivian then the *Simbirskites* die out at the end of the Hauterivian. At Speeton Spath does not record *Simbirskites* higher than C2 i.e., the top of the C beds, though the Family *Simbirskitinae* does extend to his 'lower B base' division with his record of *Craspedodiscus* which would suggest that the Lower B division is Hauterivian in its lowest portion.

From the evidence in the Crimea it does seem clear that the uppermost range of the *Simbirskitinae* gives a close approximation to the Hauterivian/Barremian boundary. Certainly the lower B beds at Speeton have an Hauterivian aspect and until well localised ammonites have been studied from this part of the section an accurate palaeontological boundary can not be drawn. On purely lithological grounds a convenient boundary would be between LB2C and LB2D which separates black, thinly laminated clays with poor fauna from alternations of pale and dark clays with some glauconite and relatively rich fauna.

Lithological subdivision of the C beds

In such a classic section as that of Speeton it is essential that palaeontological material should be accurately localised. With this in mind from 1961 to 1964 weekly visits have been made to Speeton and the intermittent beach exposures measured and recorded.

These sections, together with the data obtained from the beach exposure off Black Cliff Nab (fig. 5) in 1963 have been used to compile the composite section (fig. 11) of the C beds, details of which are given below.

Lamplugh's original divisions (1889) have been further subdivided by

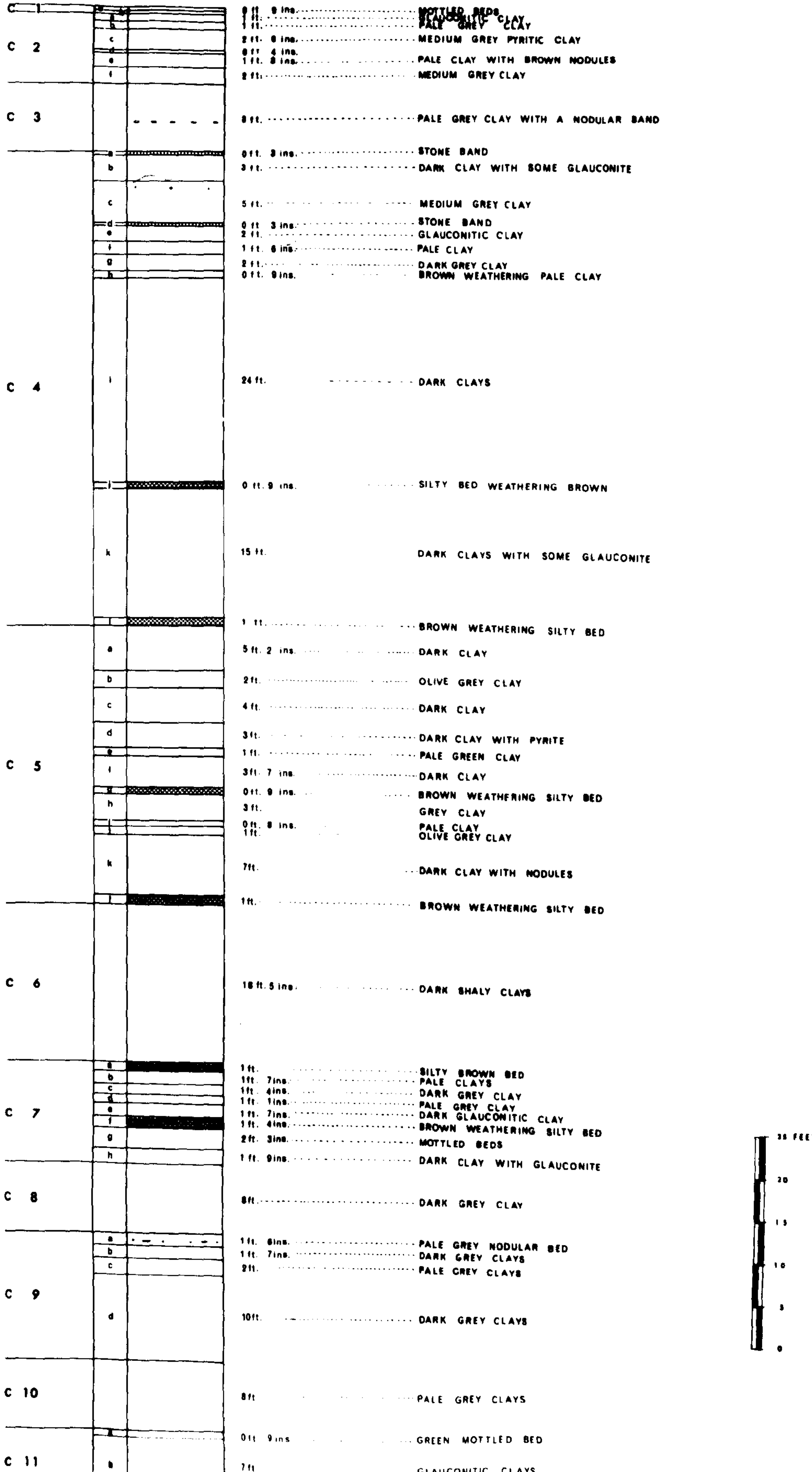

C 1
C 2
0 ft. 9 ins. MOTTLED BEDS
1 ft. GLAUCONITIC CLAY
1 ft. PALE GREY CLAY
2 ft. 6 ins. MEDIUM GREY PYRITIC CLAY
0 ft 4 ins.
1 ft. 8 ins. PALE CLAY WITH BROWN NODULES
2 ft. MEDIUM GREY CLAY
C 3
8 ft. PALE GREY CLAY WITH A NODULAR BAND
0 ft. 3 ins. STONE BAND
3 ft. DARK CLAY WITH SOME GLAUCONITE
5 ft. MEDIUM GREY CLAY
0 ft 3 ins. STONE BAND
2 ft. GLAUCONITIC CLAY
1 ft. 6 ins. PALE CLAY
2 ft. DARK GREY CLAY
0 ft. 9 ins. BROWN WEATHERING PALE CLAY
C 4
24 ft. DARK CLAYS
0 ft. 9 ins. SILTY BED WEATHERING BROWN
15 ft. DARK CLAYS WITH SOME GLAUCONITE
1 ft. BROWN WEATHERING SILTY BED
C 5
5 ft. 2 ins. DARK CLAY
2 ft. OLIVE GREY CLAY
4 ft. DARK CLAY
3 ft. DARK CLAY WITH PYRITE
1 ft. PALE GREEN CLAY
3 ft. 7 ins. DARK CLAY
0 ft. 9 ins. BROWN WEATHERING SILTY BED
3 ft. GREY CLAY
0 ft. 8 ins. PALE CLAY
1 ft. OLIVE GREY CLAY
7 ft. DARK CLAY WITH NODULES
1 ft. BROWN WEATHERING SILTY BED
C 6
18 ft. 5 ins. DARK SHALY CLAYS
C 7
1 ft. SILTY BROWN BED
1 ft. 7 ins. PALE CLAYS
1 ft. 4 ins. DARK GREY CLAY
1 ft. 1 ins. PALE GREY CLAY
1 ft. 7 ins. DARK GLAUCONITIC CLAY
1 ft. 4 ins. BROWN WEATHERING SILTY BED
2 ft. 3 ins. MOTTLED BEDS
1 ft. 9 ins. DARK CLAY WITH GLAUCONITE
C 8
8 ft. DARK GREY CLAY
C 9
1 ft. 6 ins. PALE GREY NODULAR BED
1 ft. 7 ins. DARK GREY CLAYS
2 ft. PALE GREY CLAYS
10 ft. DARK GREY CLAYS
C 10
8 ft PALE GREY CLAYS
C 11
0 ft 9 ins GREEN MOTTLED BED
7 ft GLAUCONITIC CLAYS
25 FEET
20
15
10
5
0

Figure 11

suffixes to his notation, which reads from the top downwards.

C1A 5" Dark highly glauconitic clay becoming increasingly mottled towards thd top with conspicuous pale grey markings.

C1B 4" Pale grey (N8)[1] clay with large dark glauconitic streaks giving a distinctive mottling.

C2A 1'0" A dark grey (N4-N5) highly glauconitic clay with abundant large pyrites. *Exogyra sinuata* and *Serpula* occur in this subdivision.

C2B 1'0" Pale grey (N6) clay with a brownish nodular band at the base, Lamellibranchs and Belemnites common.

C2C 2'6" A medium grey (N5) to light olive grey (5Y 6/1) clay with some pyrites but no glauconite and a pale band at the base.

C2D 4" A dark (5Y 5/2-N6) thin band of glauconitic clay with pale streaks.

C2E 1'8" Light grey (N7) clay with occasional brown nodules, when weathered the clay has a brown appearance.

C2F 2'0" A medium grey (N5-N6) clay with paler mottling at the top. The clay is shelly and contains some granular pyrites.

C3 8'0" A light grey clay (N6-N7) with, near the central portion of the subdivision, a conspicuous line of grey nodules which are fairly widely spaced apart. This is the famous *Echinospatangus* bed of Lamplugh, though their pyritised tests are only rarely found.

C4A 3" A very pale grey green impure limestone band which forms a

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1. Rock colour chart notation.

useful marker horizon in the upper C beds. It weathers to a brown colour.

C4B	3'0"	Dark grey clays (N5-N6) which are in part glauconitic. The glauconite decreases towards the base where it passes into a non glauconitic clay. A thin non glauconitic clay also occurs at the top of this subdivision.
C4C	5'0"	A pale to medium grey clay (N7) with occasional small brown nodules in the upper portion and a mottled 5" glauconitic band 1' above the base. The mottling varies from small to large, light coloured markings in the darker clay.
C4D	3"	A thin, green to yellowish grey impure limestone band. This bed is very easily confused with the stone band at the top of C4.
C4E	2'0"	Dark glauconitic clays (N5).
C4F	1'6"	Pale grey non glauconitic clay.
C4G	2'0"	Dark grey (N5-N6) clay which is glauconitic and mottled near the top with large pale grey streaks in the dark clay.
C4H	9"	A band of light grey (N6-N7) clay which weathers to a brown colour. It contains some small nodules and shows a tendency to become indurated.
C4I	24'0"	Dark shaly clays containing some pyrite.
C4J	9"	A brown weathering silty bed containing small brown nodules which are widely spaced apart. The bed is in part indurated.
C4K	15'0"	Dark grey (N5) clay which is glauconitic in its central

portion. Just beneath the C4J brown bed is a 2" band of pale grey (N6) clay which penetrates into the dark clay giving a thin band of pale mottling.

C4L	1'0"	A brown weathering silty bed containing small indurated pieces. This bed which marks the base of C4 dips at 35° to the E.S.E.
C5A	5'2"	Dark grey (N5) clays with a thin mottled seam of pale clay in darker clay at the top. Near the base the clay contains a little glauconite.
C5B	2'0"	Olive grey clay with large light coloured mottling at its base.
C5C	4'0"	Dark grey clays with occasional small brown nodules and in some parts a thin brown line developed at the base.
C5D	3'0"	Dark grey clays with granular pyrite. Near the top the clays are finely mottled.
C5E	1'0"	Pale green clay with a little glauconite and occasional nodules.
C5F	3'7"	Dark grey clays, with large pale coloured mottling near the top, and a band of small nodules in the middle.
C5G	9"	A conspicuous brown weathering silty band, becoming indurated and containing widely spaced large nodules. In beach exposures this silty bed is more resistant to weathering than the adjacent clays and tends to stand up above them.
C5H	3'0"	Pale grey clay though darker than the bed below.
C5I	8"	Pale grey clay.

C5J 1'-2'0" Olive grey clay mottled in places

C5K 7'0" Dark grey clay (N5) with some pyrite and shelly material and occasional small brown nodules.

C5L 1'0" A gritty olive grey clay band (5Y4/1) with widely spaced nodules. This bed which marks the base of C5 weathers to a brown colour and is becoming indurated.

C6 18'5" Dark grey rather shaly clays with brown nodules in the upper portion. At the top of this division and immediately beneath the basal brown bed of C5 is a mottled layer of both large and small light grey streaks in the dark clay. This division is fairly uniform throughout and has not been subdivided.

C7 A 1'0" Silty brown band containing round nodules. It is indurated in places giving an intermittent stone band which dips at 52° towards the E.S.E. Large Crioceratites are common in this bed.

C7 B 1'7" Pale grey clay (N6).

C7 C 1'4" Dark grey clay with mottling of a large size at its upper junction with the pale clay which penetrates into the dark coloured clay of this subdivision.

C7 D 1'1" Pale grey clay with a little glauconite.

C7 E 1'7" Dark black glauconitic clay. The glauconite content decreasing downwards until at the base it is absent. At the top of the subdivision the dark clays are mottled by large pale grey markings.

C7 F	1'4"	Pale grey silty clay which weathers to a distinct brown colour. Where it has become indurated it forms a brown gritty stone band. Small nodules occur in the clay together with many small indurated fragments. The small <u>Aegiocrioceras</u> <u>quadratum</u> is common.
C7 G	2'-2'3"	Mottled beds; a pale clay penetrates into darker clay giving large mottlings.
C7 H	1'9"	Dark black clay which is glauconitic particularly in its upper portion. Occasionally a fine grained lenticular stone is seen between this bed and the bed above.
C8	8'	Dark grey pyritic clay (N5) with a band of small brown nodules in a pale clay at the top. This nodular band is associated with an 8" mottled band of both large and small light coloured markings in the dark clay. In the lower half of this division are some very small brown nodules.
C9 A	1'6"-2'0"	The top of C9 is marked by a pale grey bed containing a line of small brown nodules with occasional larger and more widely placed grey ones. The whole band tends to have a brown appearance when weathered.
C9 B	1'7"	Dark grey clays
C9 C	2'0"	Pale grey clay with occasional small brown nodules.
C9 D	10'0"	Dark grey to black clays with a seam at the top of large light coloured mottling in dark. The dark clays of this sub-division are non glauconitic at the top but become increasingly glauconitic towards the base near which another

		mottled bed (large markings, light in dark) occurs. At the very base the glauconite again decreases in quantity and small nodules occur which are widely spaced apart.
C10	8'0"	Pale grey clay (N7)
C11 A	9"	A strongly mottled bed with large pale grey, rather lenticular shaped mottling in a green glauconitic clay (N6-N7)
C11 B	7'0"	Dark grey very glauconitic and gritty clay (N5) with some nodules. The glauconite content increases towards the base.
D1		Compound Nodular Bed.

The thicknesses of the beds in these subdivisions compare closely with those determined by Lamplugh, with the exception of bed C4 where 55 feet of clay were measured whilst Lamplugh records 25 feet. This discrepancy may be due to the fact that Lamplugh, in his composite section, was not aware that so many similar brown silty bands occurred in this division.

The B beds

These beds were divided by Lamplugh into Lower, Middle and Upper B beds; the lower and upper beds being separated by the 'cement' beds, so called because prior to 1869 they were quarried on a small scale to make cement.

The beds are for the most part of Barremian age but near the top a small thickness of clay of Aptian age occurs.

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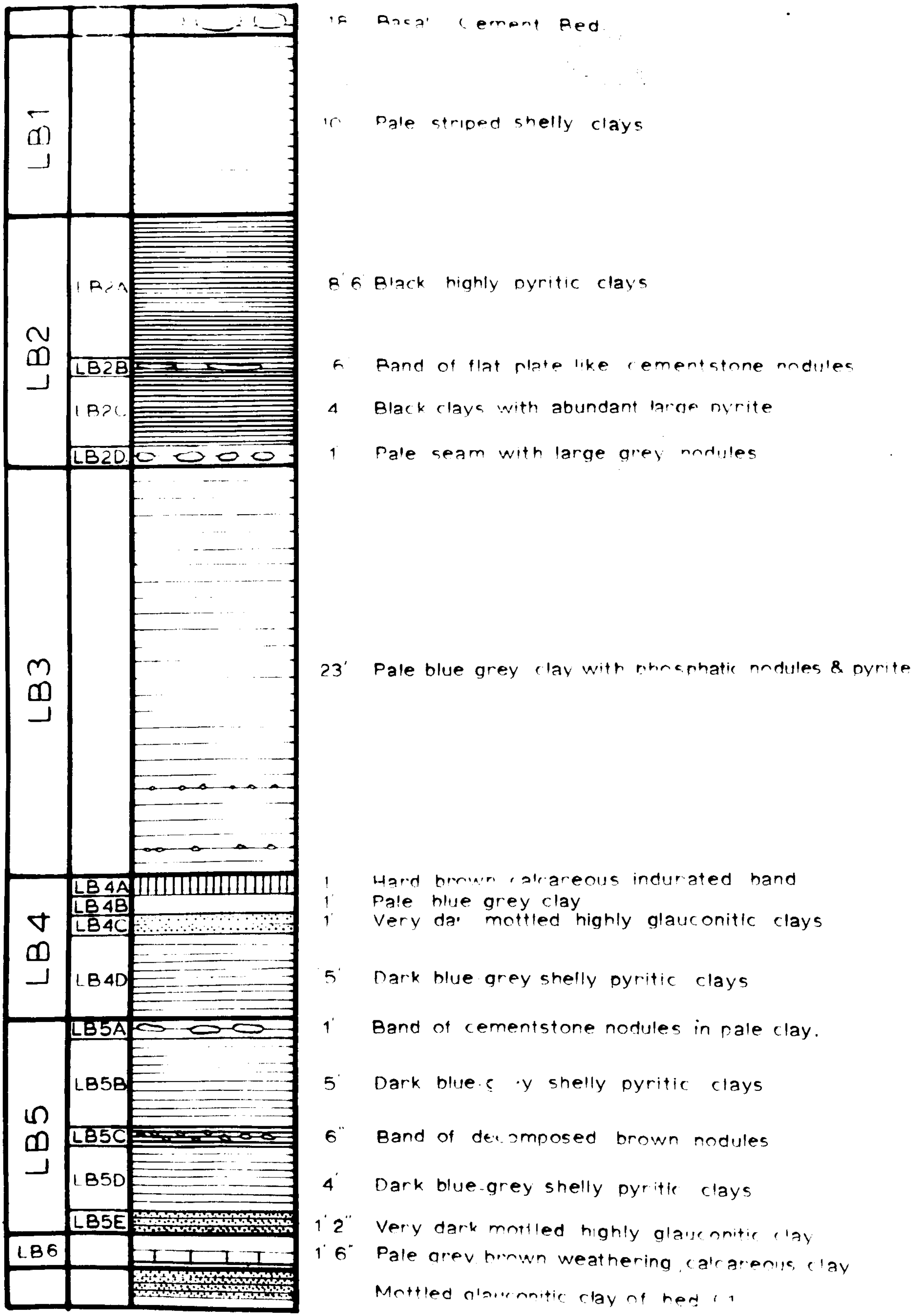
The lowest part of the Lower B beds was well exposed in 1961 when Kaye and the writer spent some time measuring the beds which were exposed at the foot of Black Cliff Nab. At the same time the higher beds of the Lower B division were patchily exposed on the beach to the south-east of Speeton Beck. As a result of these measurements a lithological scheme was drawn up (fig. 12) which was published by Kaye (1964 e). This published section is thus a composite one from two widely spaced apart sections measured on the 15. 11. 61 and 21. 11. 61., and as the sections are joined together with no good points of lateral stratigraphic control the possibility of a few feet of clay being either missing or overlapping in the LB3 subdivision should not be overlooked.

The lowest twenty-three feet of the B beds are very similar in lithology to the Hauterivian beds in that they consist of alternations of dark and light coloured clays, with occasional glauconitic and mottled horizons. Above these beds the clays are very dark in colour with massive pyrite crystals on the surface and thin layers of pyrite along bedding planes emphasising the delicate laminations so characteristic of this section; clearly here the environment of deposition was a reducing one.

The Middle B beds or 'Cement' beds are characterised by grey calcareous nodular layers of which Kaye (1964 e) recognises seven. The nodules are frequently septarian with well developed calcite veining. They may be very large and often form continuous beds. Large Crioceratids are often seen in these 'cement' nodules though are difficult to extract. The Middle B beds appear to have been deposited under slightly more oxygenated conditions than the Lower B beds. They are paler in colour,



LITHOLOGICAL SECTION IN "LOWER B"

Figure 12

shelly, not as pyritic and contain a more varied microfauna than the lower beds.

Recent exposures near Speeton Beck and in the low cliff extending south-eastwards from Speeton Beck to a wartime pillbox (300 YARDS S.E OF SPEETON BECK) have enabled a lithological section to be measured through the cement beds and part of the upper B divisions for the first time (fig. 13). In the upper part of the cement beds are a number of iron rich clay bands which weather to a rich chocolate brown colour.

Exposures in the Upper B beds are everywhere very poor, small, and occur only intermittently between the chalk boulders on the beach south-east of Speeton Beck. The clays are extremely black and fossils rare, though near the top of the upper B beds small fragments of Parancyloceras bidentatum are relatively common in the washed residues. Continental workers would regard this as the uppermost zone of the Barremian though Spath takes P. bidentatum, P. rude and P. sparsicosta as indicative of Lower Aptian age. Aconiceras nisoides (Sarasin) has also been recorded in Upper B (Casey, 1961, p. 126) and this is typically a Lower Aptian form. Only a few feet above this bed at the top of the B beds, the ammonite genus Deshayesites has been found which would suggest Lower Aptian strata.

The 'A' beds

Overlying the dark black clays of Upper B are nine feet of brown clay with a nodular band at the base. These clays contain Neohibolites ewaldi and are the so-called "Ewaldi Marls" which Swinnerton (1936)

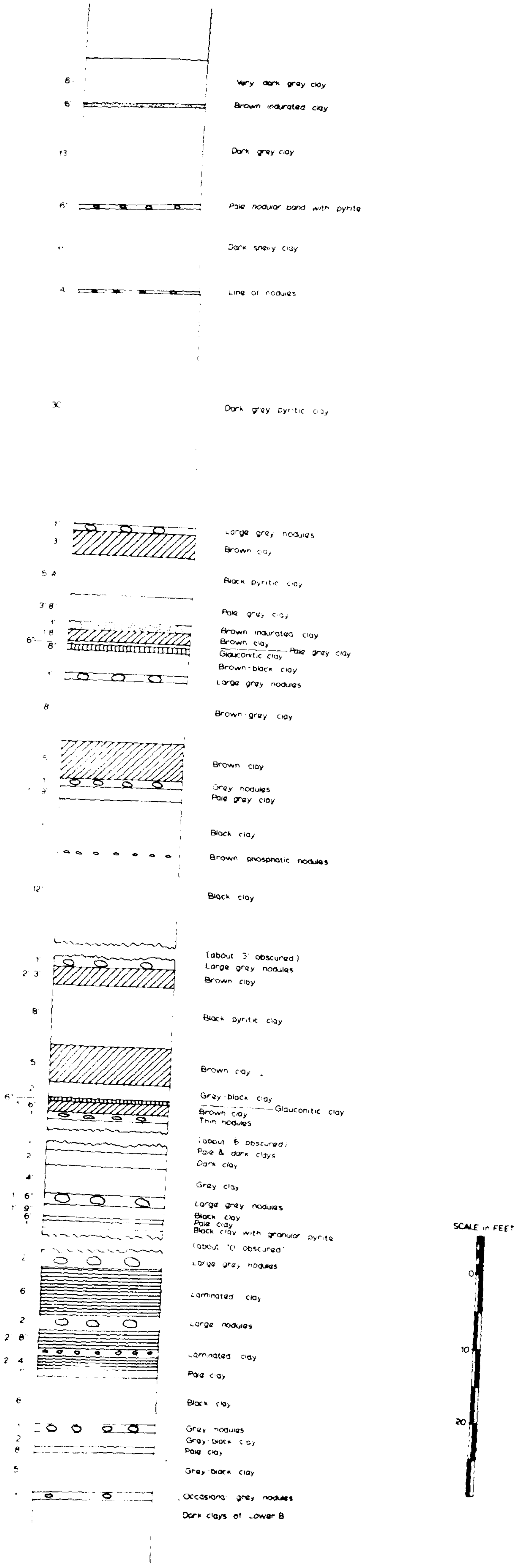


FIG.13 Section through the Cement beds and Upper B beds.
(MEASURED SOUTH-EASTWARDS FROM SPEETON BECK IN THE LOW CLIFF)

equates on the evidence of belemnites with the Sutterby marl of Lincolnshire. Their exact zonal position has not been determined though Kaye (1964 e) states that the upper part of these beds can be correlated by means of the ostracoda with the Lower Albian of Germany. It would certainly be very convenient to regard this marked change in colour from black to brown clays, with nodules at the base of the brown, as the change from Aptian to Albian strata.

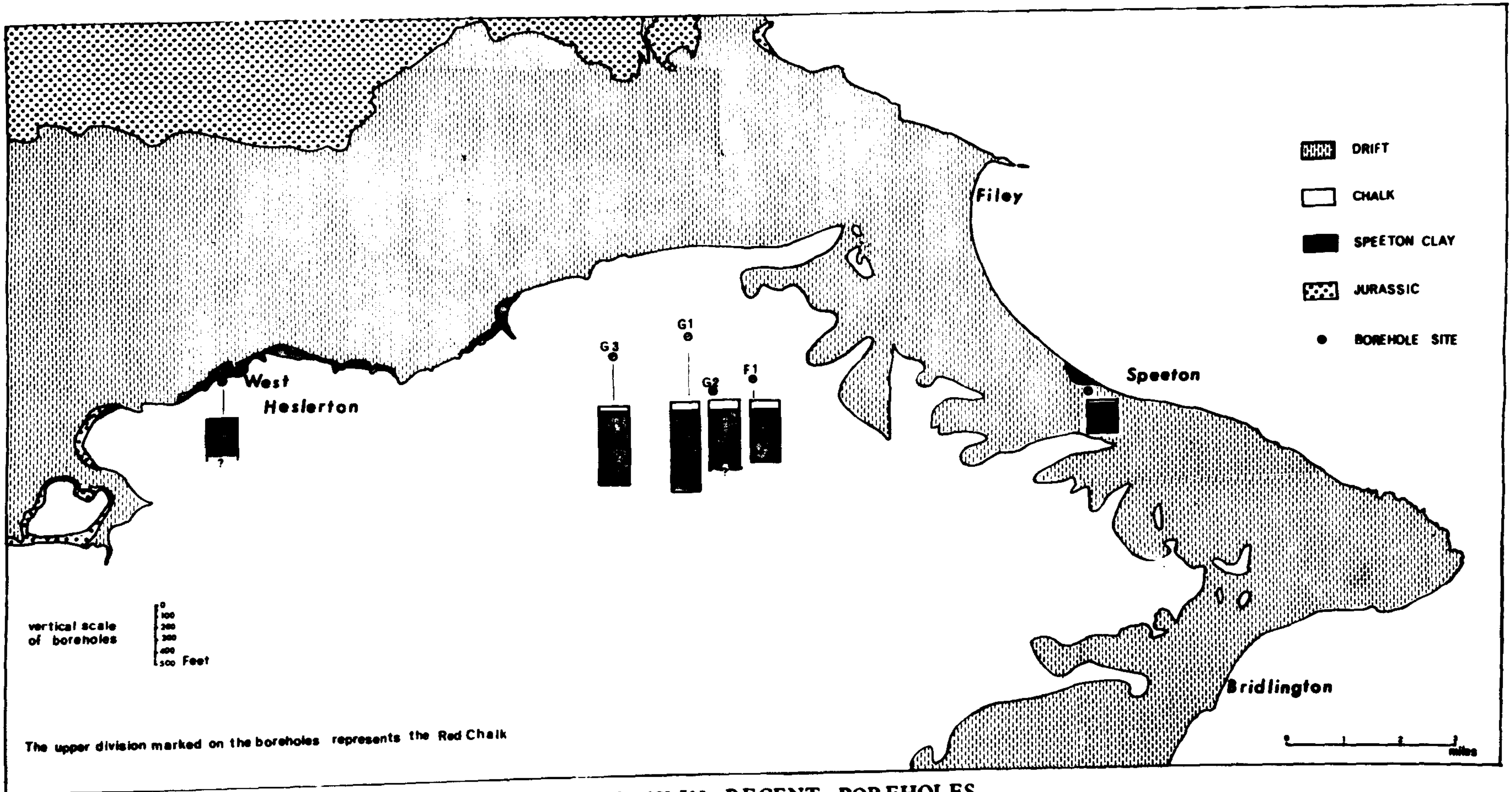
A non-sequence represented by an eight inch band of glauconite with small black nodules overlies the Ewaldi Marls and Wright (1935) has recorded fragments of *Leymeriella* cf. *hitzeli* (Jacob) and *Gaudryceras* cf. *aeolum* (d'Orb) from it. The glauconitic horizon is followed by about eleven feet of Middle Albian brown and green clays, beds A2 and A3 of Wright (1935).

The Albian beds with *Neohibolites minimus* become increasingly harder and more calcareous and pass up gradually into the Red Chalk which is extremely well seen at Speeton. The junction between the Speeton Clay and the Red Chalk is a very nebulous one with Wright (1935) stating that "the junction is taken as roughly where the chalky marl becomes Marly chalk". *Euhoplites* and *Mortoniceras* from the lowest part of the Red Chalk indicate an Albian age and these beds merge very gradually with the Cenomanian.

Though the Lower Cretaceous clays extend inland from the coast along the south side of the Vale of Pickering they are at the present time, except for a small exposure at West Heslerton, everywhere totally obscured. At the beginning of this century a number of shallow pits were dug between West Heslerton and Speeton to provide clay for brick making and also for marling the sandy soils of the Vale of Pickering, but although some were re-excavated by Sheppard and Ennis (1927, 1932) none are now visible.

The small exposure (913769) at West Heslerton lies just to the east of the village and shows Red Chalk overlying yellow and grey Albian clays which contain some glauconitic horizons. Kaye (1964 B) records Middle Barremian ostracoda from a very small exposure at Knapton (905757).

A number of boreholes have been put into or through the Speeton Clay (fig. 14) and these show that considerable differences in thickness occur (fig. 15). The greatest thickness of Speeton Clay so far proved is that in the Fordon borehole G 1 which showed 695 feet of Speeton clay, suggesting a basin of deposition in this area. The evidence of this borehole showed that Lamplugh's belief that higher beds overstepped lower ones and thinned in a westerly direction from the shore exposures to where it finally disappeared at Winteringham, needed revision. At Winteringham the Geological Survey map Red Chalk resting upon Kimmeridge clay. A borehole at West Heslerton (913759) was drilled in 1960 and stopped at a depth of 385 feet still in Speeton clay after proving 348 feet 6 inches of Speeton clay. This was a surprise as where the division was mapped as thinning, 90 - 100 feet of clay would be anticipated at this point, in actual fact the considerable thickness shown in the Fordon G 1 and G 3 holes seems to be maintained westwards for longer than would be expected.



THE LOCATION AND THICKNESS OF SPEETON CLAY IN RECENT BOREHOLES

Figure 14

In the Fordon area Neale (1960 p. 218) suggests that "the Hunmanby fault may have already been in existence in Lower Cretaceous times and had a controlling effect on the sedimentation to the west". Whilst this is certainly a possibility I see no need to postulate the development of a fault contemporaneous with sedimentation. Isopachyte maps of the Lower Cretaceous beds in North Germany show a number of basins where sedimentation is greater than in the surrounding areas and I would expect variations in thickness of the Speeton Clay of this order without invoking local tectonic control.

It is interesting that Versey (1947) recognised that "there is a dip of the rocks to the south towards the Vale of Pickering which may be considered as synclinal with its opposite limb in the N.E. dip of the Howardian Hills. This syncline closes to the northwest and trends W.S.W. - E.N.E. and must pass under the Chalk near West Heslerton. It is not clear whether the Speeton Clay is involved in this syncline but as only A beds have been recorded under this northern escarpment, it is probable that the syncline is pre-Cretaceous".

The recent borehole at West Heslerton shows the equivalent beds at the coast to be thinner and very much finer in grain size. It seems likely that these coarser beds at West Heslerton are derived from the weathering of arenaceous Jurassic rocks and that here we are nearing a shoreline.

In Lincolnshire the Spilsby sandstone and Tealby beds show a much greater lithological diversity than those of Yorkshire with generally coarser material and the occurrence of oolitic ironstones. A lithology

	W. West Heslerton SHELL 1960	Fordon B.P. 1955 - 1956				Speeton SHELL 1960 E.
		G.3.	G.1.	G.2.	F.1.	
Surface Elevations OD	200	537	300	245	429	230
Chalk Base (below surface)	17	285	160	295	523	79
Red Chalk thickness.	18	52	75	100	91	37
Speeton Clay thickness.	348 +	610	695	520 +	446	246

(ALL MEASUREMENTS IN FEET.)

FIG. 15 Thickness of the Lower Cretaceous in Recent Boreholes.

different from that at Speeton is also seen in a large mass of glacially transported Lower Cretaceous sandstone in Caithness, which measures 240 by 150 yards and is up to 26 feet thick. Phemister (1948) states, "the sandstone has disintegrated into sand but contains hard concretionary masses from which Craspedites and Crioceras have been obtained. In view of the known north-westerly direction of ice-carry it is thought that this great erratic has been removed from the sea-floor off Lybster or Dunbeath". These two genera of ammonites would indicate that this sandstone belongs to a stage not higher than mid-Hauterivian.

Further afield, Spath (1947) suggested that there was an extraordinary lithological resemblance of the East Greenland rocks of Kuhn and those of Spilsby.

The Lower Cretaceous beds of Greenland would appear to be coarser and more varied than the equivalent beds at Speeton. The Sandringham Sands of Norfolk have been shown (Donovan 1964) to be equivalent in part to the Lower Niesen Beds of East Greenland and the upper part of the Spilsby Sandstone. It is interesting to note that whilst the ammonite fauna of East Greenland is dominantly boreal with close similarities to that of Russia the occurrence (Donovan 1957) of Lytoceras and Phylloceras show that occasional southern forms were able to migrate to this area.

Remarking on an exposure east of Speeton, Judd (1870) states "We have seen that at Speeton the Neocomian strata, even before their full emergence from beneath the overlapping Chalk strata, are cut off by the denuding action of the North Sea. Intermediate between this section and those of North Germany, an important and extremely interesting link is afforded by the beds exposed in the little island of Heligoland"..... "The agreement of these strata with certain portions of the Yorkshire series is very striking and remarkable."

The writer visited Heligoland in 1960 but the Lower Cretaceous clays now outcrop only in shallow water offshore and are not visible. Practically the whole of the Lower Cretaceous is represented and it seems remarkable that in spite of the detailed micropalaeontological work on the Lower Cretaceous of Germany no attempt has been made to obtain samples from this outcrop. Heligoland is 325 miles due east of Speeton and some 150 miles to the nearest exposure of the Neocomian beds on the continent.

There is certainly a possibility that the Red Chalk and Speeton Clay may crop out beneath the North Sea between Speeton and Heligoland and this might be revealed by the current research programme on the submarine geology of the North Sea being undertaken in the Geology department at Hull.

It is interesting that Lamplugh regarded *Polyptychites* and other derived ammonites described by Thompson (1913) from the Holderness drift to have been derived from submarine outcrop eastward of Speeton.

The local palaeogeography of the Lower Cretaceous is far from clear. To the west of Speeton the beds appear to become coarser, as they do northwards in Caithness and in Greenland, and similarly to the south in Lincolnshire and Norfolk. The clays of Speeton are lithologically very similar to those of North Germany and Denmark whilst the coarser iron rich beds of Lincolnshire and Norfolk show marked similarities with the Lower Cretaceous shoreline deposits south of Hannover and in the Salzgitter area. We have at Speeton a depositional basin, some distance from a shoreline receiving little sediment, extending eastwards into Germany and Russia and bordered in Britain to the north, west and south by coarser thicker deposits and a tendency for enrichment in iron along the southern littoral margin.

Structure.

The Speeton section is structurally very simple with the beds striking at 285 degrees magnetic and dipping into the cliffs in a south-south-westerly direction. The regional dip is between 15 and 30 degrees though slumping, hill creep and glacial tectonics superimpose anomalous dips on the clays; dips of 80 degrees have been recorded in beach exposures in the Hauterivian clays opposite Black Cliff. The Kimmeridge clay and the lower part of the D beds are strongly folded into a number of small tight folds with their fold axes parallel to the strike of the rocks. In beach exposures these tight folds are seen to be superimposed on a rather larger scale of folding with many of the minor folds pitching in varying degrees and direction. Whilst minor plications at Speeton may be the result of glacial processes the folding of the Kimmeridge clay and lower D beds is very symmetrical and not the type one would expect to result from the effect of ice movement, with its strong directional component, or from frost heaving. Whilst the axes of the folding are approximately parallel to the strike of the beds they are also parallel

Fault at Middle Cliff affecting the basal C beds - lowest stone band is the 'Compound nodular' bed.

Close-up of same fault plane.

Figure 16

to the Chalk escarpment and the folding may be superficial structures related to the retreat of the escarpment.

The folding is generally more intense in the Kimmeridge clays than in the lowest part of the Speeton clays and though this might reflect its more brittle nature I would rather ascribe the folding to the Kimmerian movements.

Faulting at Speeton is difficult to separate from superficial slipping. A number of small faults occur which have little throw but quite large lateral displacements. This lateral shifting of beds is well seen in beach exposures and makes the succession difficult to follow.

A small reverse fault affects the lowest C beds (fig. 16) with calcite crystals lining the fault plane. A similar occurrence of calcite is seen in a fault plane in the Lower B beds in the cliff north-west of Speeton Beck. In the beach exposures opposite the north-west end of Black Cliff the C beds are seen to take an almost right-angled bend, striking out towards the sea. This dragging which can be seen in Fig. 17 is due to a combination of faulting and the effects of the movement of a large slip and 'mud glacier' in the cliff at this point.

The fault which causes the greatest lateral displacement runs almost north-south some 200 yards, north-west of Speeton Beck bringing bed C1 against the Cement beds.

Conditions of Deposition

Whilst the Lower Cretaceous rocks of Speeton form an essentially argillaceous unit, variation in the mineral constituents make the

Beach exposure in the Lower C beds - note the change in strike.

The Kimmeridge Clay and Lower D beds. Hammer is resting on the Coprolite bed (E).

Figure 17

succession a far from monotonous one. The clays are for the most part dark grey or black, though thin bright blue clay bands occur in D6 and brown clay is seen frequently, particularly in the higher beds. Stone bands, silty clays, pyrite and the conspicuous glauconitic horizons all reveal the varying depositional histories of the Speeton Clay.

The 300 feet of Lower Cretaceous beds at Speeton span a period of about 36 million years and nowhere in this thickness is there any evidence of rapid deposition. Apart from small lenticles and pieces of brown clay of the D2E division which have been incorporated by current action in the grey clays of D2D, there is no direct evidence of currents given by any sedimentary structures. The lack of bottom currents is also confirmed by undissociated Pentacrinus stems and a complete Ichthyosaur skeleton in the Lower Hauterivian.

Worn fossils at two non sequences in the D beds and at one in the A beds do give indirect evidence that at these times currents existed. All evidence however points to a very slow rate of sedimentation during the deposition of the Speeton Clay.

The surrounding Jurassic land area was probably a low lying one with the clays and arenaceous beds providing only a small quantity of sediment to the Cretaceous sea. Thin laminations in the clays indicate that they were formed in very still water at a depth beyond even the slightest effect of surface wave action. An exception to this being parts of the D beds where the occurrence of Lingula ovalis and Exogyra sinuata would suggest shallow water.

The general variation in the character of the beds is a reflection of the differing mineral constituents other than the clay minerals and these in turn reflect alternations of reducing and oxidising conditions and not of the direction of current or source of material. Pyrite is common at Speeton in all shapes and sizes and is the result of strongly reducing conditions at, or just below the water/clay interface. Pieces of wood are common throughout the clays and are frequently pyritised. This drifting wood, the bulk of which would be derived from the adjacent land, contributed to the decaying organic matter accumulating at the bottom of the sea, and this together with the associated anaerobic bacteria would favour the conditions necessary for pyrite formation.

Glauconite is also very common at Speeton though is concentrated in more well defined bands than the pyrite. The origin and depositional environment necessary for its formation continue to give rise to numerous and diverse opinions with perhaps the only agreement being its essentially marine nature with water of normal salinity. Hadding (1932) Galliher (1935) and Takahashi (1939) all conclude that a moderately anaerobic environment is essential for glauconite formation. In view of the frequency of mottled beds at Speeton, which are discussed later in this chapter, it is interesting to note that Galliher in discussing recent glauconite which was forming in black muds and sands in an aerobic environment says that oxidation may occur at the surface of the sediment and that "organisms, principally worms are apparently continually stirring the sediments.......". Glauconite has been regarded as originating as an alteration product of biotite but this does not seem likely in the case of the Speeton material. Takahashi (1939) regards it as originating from "clayey materials or colloidal silica with a little organic matter". More recently Ehlmann, et al (1963) working on recent glauconite forming off the south-east coast of North America in the shells of foraminifera have shown a complete transition from clay to glauconite. The clay is an expandable mica type with some Kaolinite. The process of glauconitization taking place by the fixation of potassium in the interlayer sites of the mica type clay mineral.

Unfortunately glauconite does not give any idea of depth of water and has been observed at depths as shallow as 30 feet and as deep as 14,000 feet. It does seem to be more common at depths of less than 2,400 feet, and off the south-east coast of the United States it commonly occurs at and just below the 100 fathom contour. The temperature of the water is also not critical, for glauconite forms within a wide range. Most authors agree that glauconite is associated with a very slow rate of sedimentation and one can concur with this at Speeton. With very slow sedimentation however one would expect a high proportion of foraminiferal shells in the sediment and this is not the case. At Speeton the glauconitic clays generally have fewer foraminifera than the non glauconitic ones.

Glauconite may be formed just below the sediment/water interface and though reducing conditions can occur here, the seawater above may be well oxygenated. Emery (1960) records glauconite off Southern California and Van Andel and Postma (1954) off Trinidad both in areas of slow deposition but where bottom sediments were well oxygenated.

Certainly at Speeton the glauconite is clearly autochthonous yet did not form in conditions which inhibit in any way a wide variety of benthonic organisms.

Lochman (in Ladd 1957) reviewing the conditions necessary for the presence of abundant glauconite states that the essential conditions are:-

1. The presence of saline, probably marine, waters.
2. A very slow rate of sedimentation.
3. A moderately anaerobic environment in the bottom sediments.
4. A large amount of putrefying organic material.

Mottling in the Speeton Clays

The Cretaceous clays of Speeton, whilst showing a variable lithology and colour, are characterised by an almost complete absence of sedimentary structures apart from mottling and thin laminations.

The mottled beds have been examined frequently as, apart from speculation as to their origin, they provide useful stratigraphic horizons in the field. Whenever mottled beds have been observed their position has been noted and it soon became easy to postulate where these beds would occur. The mottling is always found at the junction between clays of different colour or lithology, such as a pale clay overlying a darker one or vice versa. It is also clear that the mottling is due to the overlying clay penetrating the clay beneath. This is particularly well demonstrated in the case of a dark glauconite clay overlying a pale non glauconitic clay, where the mottling is of glauconitic clay within the paler non glauconitic clay.

The mottling is due to the infilling of small branching tubes which

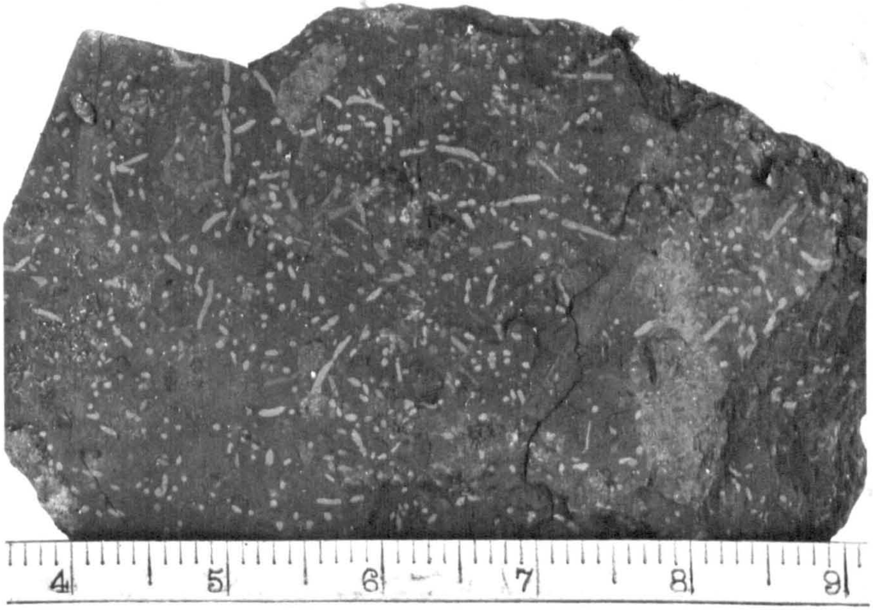


Fig. 18a - Bedding plane surface of bed D2A showing dominant small mottling due to the infilling of branching tubes by the paler clays of the overlying bed. (Scale in inches)

Fig. 18b - Surface at right angles to the bedding plane showing pale, infilled, branching tubes of bed D2A are probably formed by the activity of worms or other organisms burrowing and scavenging into the sediments of the ocean floor. With renewed sedimentation this overlying material penetrated the open 'worm' holes and burrows.

It could be suggested that the markings in the clays are due to the ingestion of mud by the burrowing organism, and the consequent alteration in colour after passing through the ALIMENTARY TRACT ~~alimentation track~~. This suggestion however does not fit the facts; mottling does not occur in beds of uniform colour but only at the junction of clays of differing colour or lithology and the mottling is always lithologically identical with the overlying bed.

The mottlings are of two sizes, (figs. 18 & 19) large and small which commonly, though not always, occur together. Their form is that of a downwardly directed branching tube of circular cross-section but slightly varying diameter. To this trace-fossil K. van Sternberg in 1833 gave the name Chondrites.

Simpson (1957, Plate XXI, figs. 1 and 2) illustrates the "Mottled marl" in the Belemnite Marls of the Lower Lias at Westhay Cliff, Dorset which appears identical to the Chondrites at Speeton. He also states (pg. 493) that "a bed with Chondrites is of marine origin and sedimentation was rapid, otherwise the tunnels would have collapsed before being infilled. Further the water was not greatly agitated by wave action....".

Middlemiss (1962) also suggests that vermiform markings are preserved by rapid deposition. He says that if the sedimentation was slow then the sediments would become a "churned sediment" whereas if

Fig. 19 - Surface at right angles to the bedding plane showing two sizes of pale grey mottling in the green glauconitic clay of bed C11a.

sedimentation was rapid then there would be insufficient time for the organism to bore into the mud very frequently, before the depth of sediment would inhibit its activities. Middlemiss also suggests that this criterion can be used to estimate the rapidity of sedimentation.

The writer cannot accept the views of Simpson or Middlemiss regarding the need for rapid sedimentation to preserve the trace fossil Chondrites. All the evidence at Speeton points to an extremely quiet and slow rate of deposition of sediment. Whether a sediment becomes a churned one by the activity of worms is not just a simple function of time but also one involving the number of organisms burrowing in the mud. It is certainly difficult to envisage an unoccupied burrow in unconsolidated mud not collapsing, whatever the rate of sedimentation, without invoking some sort of mucus lining which prevented them collapsing.

There is generally no evidence of any current action at Speeton which would truncate these structures or incorporate part of the underlying sediment in the overlying bed. Consequently, it is concluded that in the Speeton clay these mottled beds point to a very slow rate of deposition, or even a period of non deposition, during which time bottom grubbing organisms were active.

Nevertheless, it should not be thought that conditions favourable for the activity of burrowing organisms occurred only intermittently in the Speeton clay; burrowing could well occur almost throughout the succession. It is simply because the burrows are plainly visible when beds of different colour or lithology are adjacent to each other that there is an apparent intermittent occurrence of the mottling.

Moore and Scruton (1957), studying the internal structures of modern sediments in the Mississippi Delta, show that there is a decrease in the effect of burrowing organisms with an increasing rate of deposition. They also state that on the north side of the Mississippi Delta the "effects of burrowing organism can not be recognised when the rate of deposition is greater than about 0.15 foot per year".

In the Lower Barremian beds of Speeton there occurs a series of very finely laminated black shaly clays with pyrite commonly occurring along the partings between the clay laminae. Macrofossils are rare and the microfauna is a very impoverished one with a virtual absence of ostracoda. It seems clear that reducing conditions prevailed at this time, with bottom conditions inimicable to life. The finely laminated beds indicate quiet conditions with the absence of any currents or turbulence which would disturb them but it is significant that in these beds mottling does not occur, for primary mottling occurs only in a favourable environment for life.

Love (1964) in discussing the environment of formation of shales with plentiful early diagenetic pyrite says that the preservation of organic material, together with fine laminations in the rock and plentiful early diagenetic pyrite all point to conditions indicative of the establishment of anaerobic conditions. "Benthonic faunas are not necessarily affected but burrowing may be inhibited".

Important evidence of the geochemical control of the environment of deposition at Speeton is given by the brown silty bands so conspicuously seen in the Hauterivian clays. Analysis of the mineral content shows that they are composed of 95% (+) siderite which occurs as small granules, clear when fresh, but usually with a brown oxidised surface. The constituents of the brown bands are almost identical in each case, two typical ones are given below:-

Sample 8" (C7 A)

95% (+) Siderite

Remainder: Quartz
Glauconite
Pyrite
Calcite
Haematite
Limonite

Sample 60" (C5G)

95% (+) Siderite

Remainder: Quartz
Chlorite
Pyrite
Limonite

Iron is a relatively common precipitate from marine waters and it may be precipitated as:-

1. the OXIDE giving Limonite or Haematite
2. in the FERROUS state as (a) Carbonate - Siderite
   (b) Silicate - Chamosite
3. as the SULPHIDE - Pyrite
4. as the SILICATE - Glauconite.

In modern normal marine environments the oxidation - reduction potential Eh, can range from + , i.e. oxidising at the surface to negative or reducing at depth. Whilst the pH can range from 8.4 at the surface to 7.5 at the bottom.

In typical marine environments with a good current circulation the sea water is weakly alkaline and oxidising but if the environment is a restricted one, with little or no currents, then the surface waters will be alkaline and oxidising but the bottom waters may be reducing and acid.

The nature of the iron that is formed is dependent on the Eh and pH values and the relationships are shown in fig. 20. The iron minerals are thus dependent upon the type of depositional basin and the circulation in it. In stagnant bottom areas the oxygen is present in insufficient quality to remove the organic debris and H_2S is formed by bacterial action, giving Pyrites. Between this deep zone and the coastline or shallow seas, where the water is well oxygenated, is a zone of reducing conditions or alternations of reducing and oxidising conditions. The oxygen content is sufficient to prevent much pyrite from forming but the conditions are still reducing ones and iron is precipitated as the carbonate (siderite), with insufficient oxygen for the oxidation of the ferrous compounds. The occurrence of limonite and haematite in these bown bands at Speeton is probably not primary but as oxidation products due to the weathering of the clays. It is this oxidation which causes these beds of siderite to become indurated and form stone bands.

The siderite probably accumulated as a fine silty mud in quiet waters below wave and current action as there are no ooliths or sedimentary structures.

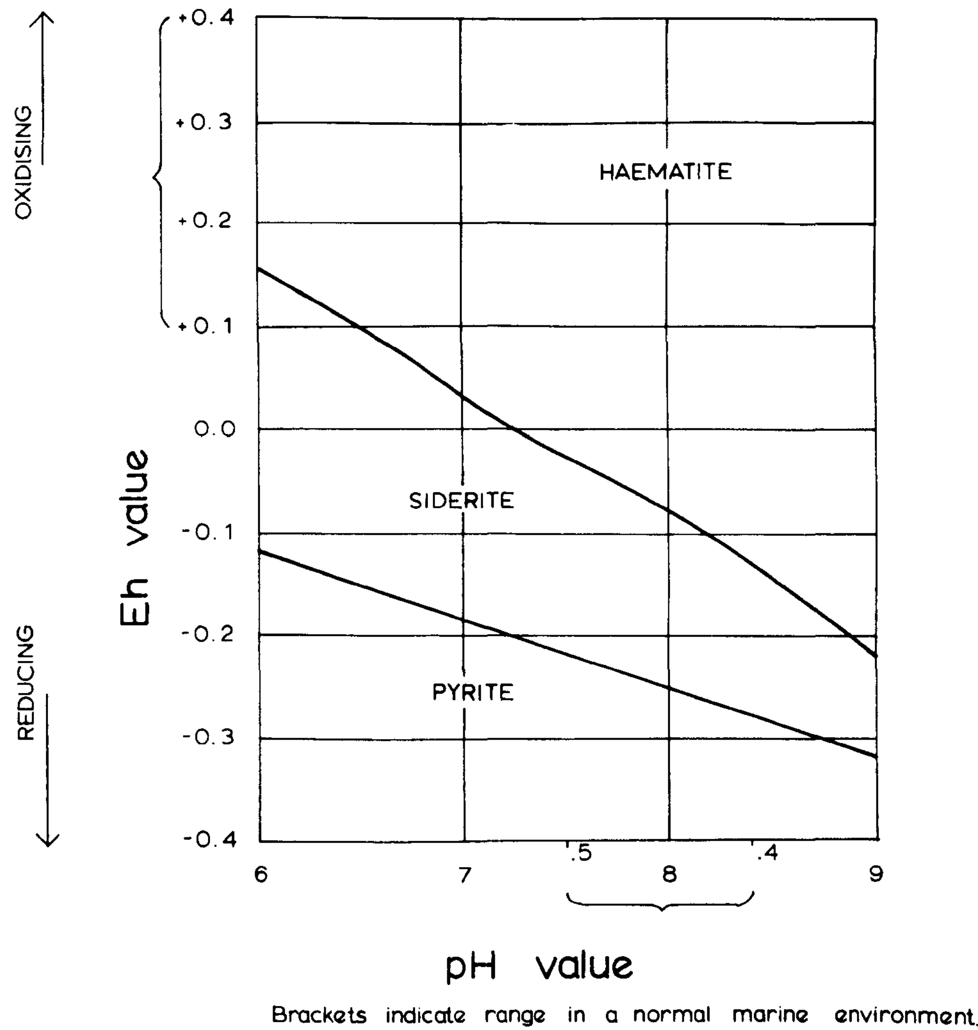


FIG. 20 Stability fields of Haematite, Siderite and Pyrite.

(modified from Krumbein and Garrels 1952.)

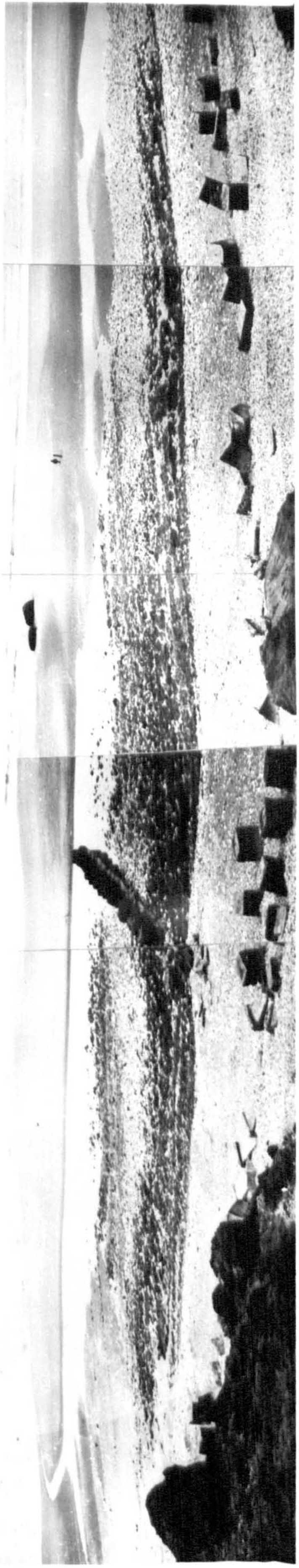
The Speeton clay is thus seen to be a geochemical facies in which pyrite, siderite and glauconite are involved. It is proposed at a future date to examine the clays critically to determine whether cyclical processes are involved.

It can be concluded that the Speeton clay accumulated very slowly with the complete absence of coarsed grained sediments or current structures pointing to quiet conditions of sedimentation probably some distance from a low shoreline.

The environment was generally not a normal marine one but for long periods of time was one of restricted circulation. An alternation of reducing and more oxygenated environments of deposition was sufficient to give the variety and character to the 300 feet of Speeton Clay. Reducing conditions were dominant but did not inhibit benthonic life though semi-toxic conditions were approached in Lower Barremian times. From then until the end the Neocomian conditions improved; the sea became less muddy and more open, and was probably clear when the deposition of the Chalk commenced.

Exceptional beach exposure of the D and C beds

1963



CHAPTER 4

HISTORICAL REVIEW OF WORK ON THE LOWER CRETACEOUS FORAMINIFERA OF EUROPE

The pioneer worker on Cretaceous foraminifera was Roemer, who published his 'Versteinerungen des Norddeutschen Kreidegebirges' in 1841 and in 1842 'Neue Kreide Foraminiferen'. This was followed in 1848 by Cornuel with the description of foraminifera from the Lower Cretaceous of Haute-Marne, and by Koch (1851) on the Hils clay and Elligser Brink beds. Albian foraminifera were described by Berthelin (1880) in his now famous memoir of Moncley.

All these workers dealt with the foraminifera systematically and it was Reuss (1860, 1863) who first approached the foraminifera from the view point of stratigraphical palaeontology. In England Burrows, Sherborn and Bailey (1888, 1890) described and illustrated the foraminifera of the Red Chalk of Yorkshire, Norfolk and Lincolnshire and this was soon followed by the excellent series of papers by Chapman (1891 - 1898) on the 'Foraminifera of the Gault of Folkestone'. Chapman stressed the importance of accurately localised samples, collected not only at regular intervals but also from different lithological divisions within a zone.

With the exception of the paper by Sherlock (1914) little work was undertaken on the micropalaeontology of the Lower Cretaceous either in Europe or elsewhere during the period 1900 - 1929. It is this exception however which is important to the present thesis as it was

Sherlock who first systematically described the foraminifera of the Speeton clay, and his paper is still the only publication figuring foraminifera from these beds. Their distribution in the various subdivisions of the Speeton clay was shown and an attempt made to compare the distribution of species recorded at Speeton with those of the Gault of Folkestone, the Hils clay of Germany, the Gault of Montcley, and modern foraminifera recorded by the Challenger expedition.

It is interesting to read Sherlock's conclusion that the Speeton clays 'except for a few horizons are almost without Microzoa', for the writer has an abundance of material and only in the lower D beds do samples barren of foraminifera occur. It seems likely that his view was due both to the small size of his samples (1 to 2 cubic inches), and to his washing techniques, as he states 'the sediment was washed free from fine mud and the residue dried and passed through a sieve' (Fine muslin). It seems probable that the bulk of the foraminifera were either lost in the 'fine mud' which was washed away, or because they were too small to be retained by the muslin.

From 1930 to the present day there has been a great surge of activity in the micropalaeontology of the Lower Cretaceous sediments, much of the work being on the German Cretaceous. This was particularly stimulated by the search for oil in Germany and the subsequent exploitation of the North German oilfield. Eichenberg wrote five papers between 1933 - 1935 dealing with Hauterivian, Barremian, Aptian and Albian foraminifera of Germany and Hecht (1938) used foraminifera for a biostratigraphic classification of the Lower Cretaceous of North West Germany. Hecht's work has become increasingly important with Bartenstein's (1952, 1962) careful revision of the material.

In Russia the gradual passage from Jurassic to Lower Createaceous has always made publications on this part of the stratigraphic column of special interest and Mjatliuk's (1939) work on the Upper Jurassic and Lower Createaceous foraminifera of the Middle Volga region is important to the stratigraphical micropalaeontologist.

In a series of papers, ten Dam (1946, 1947, 1948, 1950) has described the foraminifera of the Lower Cretaceous of the Netherlands.

The micropalaeontological results of samples collected from the Flysch zone of the Northern Alps are given by Noth (1951) who remarked on the similarities of the Hauterivian fauna of the area with that of Germany. The most active worker on the Lower Cretaceous foraminifera from 1950 to the present day has been Bartenstein (1950a,b, 1952, 1954, 1959, 1962) whose work has been mainly confined to the Valanginian and Hauterivian of Germany. A comprehensive account of the Valanginian microfauna of Germany was given by Bartenstein and Brand (1951).

Biometric studies had been neglected until Albers (1952) dealt with genus Vaginulina D'Orbigny and Grabert (1959) the genera Gaudryina and Spiroplectinata. The study of toothplates in foraminifera by Hofker (1954) has given an interesting but controversial classification of the Epistomininae.

The foraminifera of the Tealby clay of Lincolnshire, which is equivalent to part of the Speeton Clay, was described by Bartenstein (1956) and this paper is important in that it showed the similarities of the fauna in Lincolnshire with that of Germany for the first time. The paper however is the result of a single sample sent to Bartenstein by Macfadyen. Detailed sampling by the writer from the Lower Cretaceous of Lincolnshire shows a larger fauna than that recorded by Bartenstein and whilst the similarities to the Speeton fauna are obvious, it also shows quite distinctive features which will be important in the interpretation of the palaeocology and palaeogeography of the Marine Lower Cretaceous of Britain.

Lower Cretaceous strata also crops out in Poland and our knowledge of the foraminifera from that country is mainly due to the work of Sztejn (1958, 1960, 1964).

Barremian foraminifera of Germany have been described by Bettenstaedt (1952, 1958, 1960) and he has paid particular attention to evolutionary trends. During the past ten years statistical studies of the morphological features of Cretaceous foraminifera have been used to illustrate evolutionary trends and also to enable the zoning of strata (Zedler 1959, 1960).

Khan (1962) compared some of the foraminifera from Speeton with those of Germany and this paper is important in that it is the first paper dealing with foraminifera from the Speeton clay since Sherlock's in 1914. Khan's obvious lack of stratigraphic knowledge of the section and his consequent imprecise location of his samples makes his study of limited value.

During the past few years the Cretaceous foraminifera from the South of France have received attention by Moullade (1960 a,b, 1961) and Flandrin, Moullade and Porthault (1962) and their stratigraphical importance was shown in the conclusions of the colloquium on Lower Cretaceous stratigraphy of France held at Lyons (1963).

Workers on the Lower Cretaceous foraminifera are, of course, not confined to Europe, but a review on a world basis is outside the scope of the present investigation. Brief reference however may be made of the works of Loeblich and Tappan (1941, 1946, 1949 a,b, 1950), Loeblich (1946), Tappan (1940, 1941, 1943, 1944, 1962) and Frizzell (1954) on the North American Cretaceous; Bartenstein, Bettenstaedt and Bolli (1957) on Trinidad; Takayangi (1960 a,b, 1961, 1962) on Japan; Crespin (1953, 1963) on Australia; Grader, Reuss and Klug (1960) on Israel, and Sigal (1963) on Madagascar.

The faunas described in many of these papers show a remarkable similarity to those of North-West Europe and go some way towards providing a basis for world wide correlation.

Slipping in the upper C beds at Black Cliff Ridge.

CHAPTER 5

TECHNIQUES

The techniques used are, for the most part, the standard ones used in any micropalaeontological laboratory. They are described under three headings:- 1. Sampling, 2. Processing and Preparation for study, 3. Illustration.

1. SAMPLING

The sampling was not a straightforward procedure due to the inherent difficulties of the Speeton section. Large parts of the section are not exposed in the low cliffs and elsewhere it is often difficult to localise samples accurately. The most satisfactory sections are those exposed on the beach from time to time when the sea removes the beach sand. These intermittent exposures allow the collection of accurately localised samples and the locality was visited every week throughout the three year period of research in order that any chance beach exposure could be accurately measured, their varying lithology noted and samples taken. Composite sections were thus built up and samples for testing faunal variation along the stike of the beds were obtained.

Before samples can be taken it is necessary for a bed to be well exposed and recognisable with certainty and at Speeton, where this depends to a large extent on favourable tides, currents and winds, it is often necessary to wait for a considerable period, sometimes years, before a particular portion of the section is available for study.

The samples taken usually weighed between four and five pounds. During sampling every precaution was taken to avoid any contamination and to obtain fresh material free from surface weathering and oxidation.

The description of the colour of the clays

At Speeton the clays are predominantly grey in colour, but variations in shade provide a basis for describing the clays and building up a lithological classification. It has been found that in the past various authors have given such a variety of colour descriptions for the same bed, that their descriptions are of limited use only.

In order to eliminate the human element as far as possible from the description of the colour, the colours used in this thesis are those of the Rock Colour Chart published by the Geological Society of America.

In the field the colour of the clays was found to be controlled to some extent by the water content, which in turn was dependent upon the weather. In order to minimise this the colour was determined after the sample had been thoroughly dried in the laboratory. Whilst a wet sample is merely darker than a dry sample, and retains the same CHROMA on the chart, the variation for any chroma is itself quite large. Only strictly comparable results can be obtained by using dried samples of the clays.

After drying the determination of colour was made on a fresh surface and not one that might have changed colour due to surface oxidation.

In the lithological descriptions in this thesis the Munsell notation of the Rock Colour Chart follows any reference to clay colour e.g. Olive grey (5 Y 4/1)

2. <u>PROCESSING</u> - (a) Preparation for study

After noting any lithological details the whole sample was placed in a basin and dried slowly in an oven. This drying period usually extended over a period of eight hours but varied according to the sample. When thoroughly dry a colour reading was taken and 4lb (1920 grms) were weighed out and set aside for processing, any remainder being stored as a 'reserve' sample.

The 4lb. sample was placed in a stainless steel basin, covered with water and allowed to stand for 12 hours. Being warm and dry, the sample rapidly takes up water which considerably helps deflocculation. This was followed by wet sieving on a 200 British Standard mesh sieve (mesh aperture .076mm.). The majority of the sample would usually be retained in the sieve and this material was then returned to the stainless steel basin, water together with Sodium Carbonate to aid deflocculation being added, and the sample boiled. The process of alternately sieving and boiling was continued until a clean residue was obtained.

As an alternative to Sodium Carbonate a small amount of detergent (Teepol) was used in the water of certain samples. Although this produced a clean residue, frothing on boiling and again when sieving caused froth flotation of the finer particles of the residue which rendered this method unsatisfactory. The amount of froth could be lessened by reducing the quantity of Teepol used but it was found that for optimum deflocculation the amount needed was such that frothing resulted during the processing. After an initial period of experiment the use of Teepol was abandoned.

When a clean residue was obtained it was placed in a porcelain basin and allowed to dry slowly at room temperature or in a very gently heated oven.

The dry residue was dry sieved and the 'held 100' and 'through 100, held 200' fractions weighed and bottled separately.

(b) Picking

The residues were placed on a black or green tray with a white grid pattern, and picked under a binocular microscope (magnification X 30) using an '0' sable brush.

The bulk of the foraminifera occurred in the held 100 fraction and were initially picked into Franke slides labelled Foraminifera and Miscellaneous. These were further split at the generic level. The nature of the residue and the relative abundance of the different components in each sample were noted.

In the early stages of the work experiments were made with the use of heavy liquids, i.e. carbon tetrachloride, bromoform and methylene iodide, as an aid to separation of the microfauna. Whilst carbon tetrachloride proved useful in dealing with Recent material, it was found that no satisfactory short cuts to picking could be used with

Cretaceous material except for those samples rich in glauconite. These residues were passed through a magnetic separator which effectively separated the weakly magnetic glauconite from the non-magnetic microfauna and shelly material.

A current of 1 ampere was used, the material vibrating down a non-magnetic split track with a forward inclination of 30 degrees, and a transverse slope of 10 degrees towards the non-magnetic side. In order to speed up this process a high concentration was first obtained using a fast flow, and the fractions were then passed through using a much slower feed whilst retaining the same inclination of the track. The rate of flow was controlled by adjusting the hopper.

3. ILLUSTRATION

Coating for Photomicrography

Whilst many of the foraminifera needed no coating in order to photograph successfully, coating usually proved beneficial in forms with surface ornament. Various standard coating techniques were tried, Malachite green stain, Ammonium Chloride and Silver Nitrate, of which the most satisfactory proved to be Silver Nitrate.

Ammonium Chloride - This was applied as a fine sublimate by strongly heating solid Ammonium Chloride on a wire gauze over a Bunsen burner until white fumes were given off. A glass slide with the foraminifer attached was then passed quickly through the fumes depositing a white coating on it. The main disadvantage of this method was the coarseness of grain.

Silver Nitrate - Two methods were tried using Silver Nitrate. In the first method a solution of Silver Nitrate was painted on the specimen and allowed to dry. It was then lightly painted with photographic developer which 'developed' the silver nitrate and coated the specimen. The control of the intensity of the coating was difficult with this method and was found to be impracticable.

The second Silver Nitrate method was perfected after visiting Dr. Triebel at the Senckenberg Museum, Frankfurt where he demonstrated his photographic techniques to the author.

The specimen to be photographed was first carefully cleaned using a wet sable brush. It was then placed on a piece of absorbent paper, such as filter or blotting paper, on the binocular microscope stage. A small quantity of 2% Silver Nitrate was used to wet the specimen, any surplus being absorbed by the paper beneath. The specimen was now heated by touching it with a heating element. The Silver Nitrate oxidised leaving an extremely fine coating, the degree of which could at all times be varied from light golden brown to almost black by the varying duration of the heating of the specimen. Dr. Triebel used an electric heating element, but the author found that a piece of wire from an old electric fire element attached to a wooden holder and heated in a Bunsen burner was quite satisfactory. The element glowed long enough for it to be transferred from the flame to the specimen which was lightly touched with it. It was usually found that a light golden coating was the finest grained and the most satisfactory for photography.

A quicker method is to attach the specimen with Gum Tragacanth to a glass slide, coat the specimen with a 2% solution of Silver Nitrate and then pass it quickly through a Bunsen flame. In this process however, the degree of coating cannot be adequately controlled, and generally the author coated his specimens under the microscope using the hot wire technique. This has the great advantage that the coating of the specimen can be observed continuously and its intensity controlled.

Photography

A fully automatic Leitz - Orthomat camera for 35mm. photomicrography was used on a Leitz Labrolux microscope. The specimens were illuminated using two or three focussing microscope lamps. A tube of tracing paper or 'Kodatrace' was placed around the specimen to diffuse the light, one spot light being used to highlight the ornament whilst the others softened the strong shadow areas.

Line drawings

An industrial measuring projector, the Watson Manasty 'Shadowmaster', was used as an aid to line drawings and outlines. This instrument projects the foraminifera on to a finely etched screen from which accurate tracings can readily be made. An overlay grid screen for the projector was used to obtain precise measurements of specimens.

Cliff exposures of the mid-D beds after rainy weather.

Beds C7 and C8 exposed at the foot of Middle Cliff.

CHAPTER 6

SYSTEMATICS

The classification adopted here is that of the 'Treatise on Invertebrate Paleontology Part C, Protista' (Loeblich & Tappan, 1964). In the case of the genus Lenticulina Lamarck 1804 the subgenera suggested by Bartenstein (1948b) have been used. Adherent foraminifera occur only occasionally in the residues of the Speeton clay and are not described here.

All the specimens of foraminifera are catalogued and deposited in the collections of the Department of Geology, University of Hull (HU.).

Suborder TEXTULARIINA Delage & Herouard 1896

Superfamily AMMODISCACEA Reuss 1862

Family SACCAMMINIDAE Brady 1884

Subfamily SACCAMMININAE Brady 1884

Genus THURAMMINA Brady 1879

Type species *Thurammina papillata* Brady 1879

Brady described the type as "Test free or adherent; either consisting of a single round chamber, sometimes enveloping a similar one of smaller size, or of two or more (apparently) independent chambers adhering to each other. Texture thin; arenaceous or chitino-arenaceous. Surface beset with numerous, nipple shaped protuberances".

Thurammina albicans Brady

Plate 1, figure 5

Thurammina albicans BRADY, 1884, Challenger, p. 323, pl. 37, figs. 2-7.

Thurammina albicans BRADY - CHAPMAN, 1892, Folkestone, 2, p. 7, pl. 6, fig. 9.

Thurammina albicans BRADY,- NEAVERSON, 1921, Hartwell clay, p. 458, pl. 9, fig. 11.

Thurammina D1 - HECHT, 1939, Unterkreide, pl. 24, figs. 118, 120.

Thurammina albicans BRADY - BARTENSTEIN & BRAND, 1951, Valendis, p. 265, pl. 1, fig. 5.

Material; Twenty-nine specimens.

Dimensions of figured specimen:

HU.21.C.5. maximum diameter 0.46 mm

Description: Test free, spherical but more commonly found compressed to a disc shape. The wall of the test is finely arenaceous and may be smooth or have an irregular reticulate pattern on the surface. Tube-like projections are regularly, though widely, spaced on the surface of the test. It is difficult to determine whether these protuberances have apertures.

Remarks: This species differs from *Thurammina papillata* in having fewer protuberances. The reticulate nature of the wall in some of the specimens from Speeton is very similar to *T. papillata* Flint but is distinguished from it by its fewer papillae. Heron-Allen and Earland (1917) proposed, in view of the variability of *Thurammina*, that all species should be referred to *T. papillata* Brady, the earliest described and figured species. *T. albicans* is, however, distinct from *T. papillata* and until the width of variation of this latter species is determined it is not felt prudent to accept their suggestion.

Occurrence: C2, C4, LB5, LB4, LB3.

Family **AMMODISCIDAE** Reuss, 1862

Subfamily **AMMODISCINAE** Reuss, 1862

Genus **AMMODISCUS** Reuss, 1862

Type species _Ammodiscus_ _infimus_ Bornemann, 1874

Ammodiscus _tenuissimus_ (Gümbel, 1862)

Plate 1, figures 6-7

Spirillina _tenuissima_ GÜMBEL, 1862, Streitberg. Schwammlag., p. 214, pl. 13, fig. 2.

Ammodiscus _tenuis_ CHAPMAN (non BRADY) 1892, Folkestone 2, p. 326, pl. 6, fig. 12.

Ammodiscus _tenuissimus_ (GÜMBEL) - PAALZOW, 1922, Parkinsoni - Mergel p. 9.

Ammodiscus _tenuissimus_ (GÜMBEL) - BARTENSTEIN & BRAND, 1937, Lias u. Dogger, p. 130, pl. 8, fig. 6; pl. 11A, fig. 4.

Ammodiscus _tenuissimus_ (GÜMBEL) - MJATLIUK, 1939, Middle Volga, p. 39, pl. 2, fig. 14.

Ammodiscus _tenuissimus_ (GÜMBEL) - BARTENSTEIN & BRAND, 1951, Valendis, p. 267, pl. 1, fig. 14.

Ammodiscus _tenuissimus_ (GÜMBEL) - BRAND & FAHRION, 1962, Leitfossilien, p. 153, pl. 20, fig. 18.

Material: One hundred and seventy-four specimens

Dimensions of figured specimens:

		Maximum diameter
Figure 6	HU.21.C.6.	0.270 mm
Figure 7	HU.21.C.10.	0.252 mm

Description: Test free, consisting of a proloculus and a long tubular planispirally coiled, undivided chamber. Test commonly strongly compressed. Wall very finely agglutinated with considerable cement; surface smooth, colour white or grey. Aperture simple, at the open end of the chamber.

Remarks: The specimens from Speeton are commonly very compressed in preservation.

Occurrence: D4, D3, D2, C11, C9, C8, C7, C1, LB5, LB4, LB3, LB2.

Genus GLOMOSPIRA Rzehak, 1885

Type species *Trochammina gordialis* Jones & Parker, 1860

Glomospira gordialis (Jones & Parker, 1860) Cushman.

Plate 1, figures 12-13

Trochammina squamata gordialis JONES & PARKER, 1860, Mediterranean, p. 304.

Ammodiscus gordialis (JONES & PARKER) - CHAPMAN, 1892, Folkestone 2, p. 327, pl. 6, fig. 13.

Ammodiscus gordialis (JONES & PARKER) - SHERLOCK, 1914, Speeton, p. 221, pl. 18, fig. 5.

Glomospira gordialis (JONES & PARKER) - BARTENSTEIN & BRAND, 1937, Lias und Dogger, p. 133, pl. 4, fig. 5.

Glomospira gordialis (JONES & PARKER) CUSHMAN - CUSHMAN, 1946, Gulf coast, p. 18, pl. 1, figs. 38-40.

Glomospira gordialis (JONES & PARKER) - DAM, 1950, Albien, p. 7.

Glomospira gordialis (JONES & PARKER) - BARTENSTEIN & BRAND, 1951, Valendis, p. 267, pl. 1, figs. 15-16.

Material: Five specimens.

Dimensions of figured specimen:

H.U.21.C.14 Maximum diameter 0.28 mm

Description: Test, free, with a sub-spherical proloculum followed by a large undivided spirally coiled tubular chamber. The rather high spire gives a test approaching a globular shape. The wall is finely arenaceous with much cement. The spiral suture is distinct and depressed.

Remarks: This species is very similar to Glomospira improcera Harris and Jobe, 1952 but differs in that the last coils are not located at the median area. Its range is from Jurassic to Recent, and occurs rarely in the Valanginian of North-west Germany.

Occurrence: D2, D3. D4B

Genus GLOMOSPIRELLA Plummer, 1945

Type species Glomospirella umbilicata (Cushman & Waters) 1927.

Type description: The earliest part of the undivided, finely arenaceous tube in this structure winds compactly in different directions like a ball of twine, as in Glomospira Rzehak, beyond which it becomes more and more nearly planispiral until in maturity it is perfectly planispiral. The aperture is the open end of the tube.

Glomospirella gaultina (Berthelin)

Plate 1, figures 9 - 11

Ammodiscus gaultinus BERTHELIN, 1880, Montclay, p. 19, pl. 1, fig. 3.

Ammodiscus D2 - HECHT, 1938, Unterkreide, pl. 2a, figs. 78-81; pl. 2b, figs. 40-43; pl. 3a, figs. 18-20; pl. 3b, figs. 16-22; pl. 4b, figs. 7-10; pl. 5a, 26-29, pl. 6a, figs. 65-67, pl. 8b, fig. 26; pl. 9b, figs. 44-48; pl. 10a, figs. 7-11; pl. 10b, figs. 88-90; pl. 13b, figs. 1-2.

Ammodiscus gaultinus BERTHELIN - TAPPAN, 1943, Duck Creek, p. 481, pl. 77, fig. 6.

Ammodiscus gaultinus BERTHELIN - DAM, 1950, Albien, p. 7.

Ammodiscus gaultinus BERTHELIN - BARTENSTEIN & BRAND, 1951, Valendis, p. 267, pl. 1, fig. 13.

Material: Two hundred and twenty-two specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 9	HU.21.C.11	0.450 mm
Figure 10	HU.21.C.12	0.414 mm
Figure 11	HU.21.C.13	0.414 mm

Description: Test free, disc shaped. The proloculus is followed by a long tubular chamber which initially is irregularly coiled but later becomes planispirally coiled. There are four to six convolutions increasing very slightly in width. The periphery is rounded; the wall very finely arenaceous with much cement giving a white colour. The aperture is formed by the open end of the tube.

Occurrence: D7, D6, D4, D3, D2, C11, C10, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB6, LB5, LB4, LB3.

Subfamily TOLYPAMMININAE Cushman, 1928

Genus AMMOVERTELLA Cushman, 1928

Type species *Psammophis inversus* Schellwein, 1898

Ammovertella cellensis Bartenstein & Brand.

Plate 1, figures 2-4.

Ammovertella celleneis BARTENSTEIN & BRAND, 1951, Valendis, p. 267, pl. 1, fig. 18-22; pl. 13, fig. 359.

Ammovertella cellensis BARTENSTEIN & BRAND - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 254, pl. 35, figs. 6-7.

Material: One hundred and fifty-four specimens, all incomplete.

Dimensions of figured specimens:

		Length
Figure 2,	H.U.21.C.2	1.560 mm
Figure 3,	H.U.21.C.3	1.690 mm
Figure 4,	H.U.21.C.4	1.690 mm

Description: Test free or attached. The proloculus is followed by a long tubular test with numerous constrictions and bends. The tube may or may not be branching; when branching occurs (fig. 4) it is very irregular. The wall is arenaceous with a large proportion of cement, giving a fairly smooth light brown coloured test. The aperture is at the end of the open tube and in branching forms at the end of each branching tube.

Remarks: The specimens from Speeton have been compared with the type material in the Senckenberg Museum, Frankfurt and they agree closely. In North-west Germany this species is a zone fossil from Mittel Valendis 2 to Ober Valendis 1. Bartenstein (1951) points out that branching forms occur particularly in the Ober Valendis. At Speeton the higher D beds contain more branching forms than the lower D beds.

Occurrence: D5, D4, D3, D2, C8.

Genus LITUOTUBA Rhumbler, 1895

Type species *Trochammina lituiformis* Brady.

The genus is described by Cushman as "test free, with a proloculum and long, tubular, second chamber, sometimes constricted externally but not divided, early portion irregularly coiled, later uncoiling; wall arenaceous with much cement; aperture at the end of the tube".

Lituotuba sp.

Plate 1, figure 1

Material: Thirty-nine specimens, all incomplete.

Dimensions of figured specimen:

H.U.21.C.1. Maximum length 2.210 mm

Description: Test free, with a long tubular chamber initially loosely and irregularly coiled but later becoming straight. Wall arenaceous and well cemented. Aperture at the end of the tube.

Remarks: All the specimens are incomplete, with the proloculus and early stages missing; consequently a firm specific determination is not possible. Bartenstein has examined examples from Speeton and confirms that they are similar to forms referred to *Lituotuba* from the Ober-Valendis of N.W. Germany.

Occurrence: C6, C5, C2, L.B.5

Family LITUOLIDAE de Blainville, 1825

Subfamily HAPLOPHRAGMOIDINAE Mayne, 1952

Genus HAPLOPHRAGMOIDES Cushman, 1910

Type species Nonionina canariensis d'Orbignyi, 1839

Cushman described the genotype as "test free, planospiral, composed of several coils each composed of a number of chambers, wall arenaceous, varying much in texture and in relative amount of cement in the different species, aperture at the ventral border or on the lower portion of the apertual face of the chamber". Cushman included in this genus forms assigned to Haplophragmium and Trochammina. Höglund (1947) emended the limit of Cushman's genus to include only those species with an interio-marginal aperture.

Haplophragmoides nonioninoides (Reuss)

Plate 1, figures 14-17.

Haplophragmium nonioninoides REUSS, 1863, Hilsund Gault, p. 30, pl. 1, fig. 8.

Haplophragmium nonioninoides REUSS - CHAPMAN, 1892, Folkestone, p. 321, pl. 5, figs. 9a-b.

Material: Twenty-five specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 14,	HU.21.C.15	0.810 mm
Figures 15-17,	HU.21.C.16	0.80 mm

Description: Test free, planispiral, involute, biumbilicate with small umbilici, peripheral margin broadly rounded. Chambers may be very slightly inflated with eight to twelve chambers in the last whorl; they increase very gradually in size as added. Sutures distinct, straight, radial, slightly depressed; wall finely agglutinated with much cement and is light brown in colour. Aperture a low interiomarginal arch, but preservation of specimens is such that aperture only rarely visible.

Remarks: Test commonly distorted due to compression in preservation. Differs from Haplophragmoides globosa Lozo in its greater size, lacks the curved sutures between the final two or three chambers and in cross-section the outer walls are straight and converge. The specimen in figs. 15-17 agrees very closely with Chapman's H. nonioninoides from the Gault of Folkestone (British Museum Catalogue No. P.4690) though the Speeton specimen is larger and the umbilicus is very slightly more depressed.

Occurrence: D7, D6.

Haplophragmoides cushmani LOEBLICH & TAPPAN

Plate 2, figures 17-18

Haplophragmoides cushmani LOEBLICH & TAPPAN, 1946, Washita, p. 244, pl. 35, fig. 4.

Haplophragmoides cushmani LOEBLICH & TAPPAN - BARTENSTEIN & BRAND, 1951, Valendis, p. 268, pl. 1, fig. 23

Haplophragmoides cushmani LOEBLICH & TAPPAN - BARTENSTEIN, 1956, Hauterive, p. 512, pl. 3, fig. 62.

Material: One hundred and thirteen specimens.

Dimensions of figured specimen:

HU.22.C.1.	Greatest diameter 0.252 mm

Description: Test free, small, planispiral, involute, biumbilicate, with small umbilici, peripheral margin rounded, outline slightly lobulate. Chambers slightly inflated with five or six in the last whorl; increase gradually in size as added. Sutures distinct, straight or gently curved, radial, depressed, compressed giving a weak lobulate outline. Wall finely arenaceous with calcareous cement. Aperture a low arch at base of apertual face.

Remarks: Though smaller than the holotype it falls within the diameter range of the Washita specimens. It differs from *H. Globosa* Lozo in its slightly larger size, fewer chambers in the last whorl and more inflated chambers. H. latidorsatus (Borneman) is larger, has a thicker cross-section and very poorly developed sutures. It also lacks the lobulate outline of H. cushmani.

Occurrence: D6, D5, D4, D3, D2, C9, C8, C7.

Haplophragmoides spp.

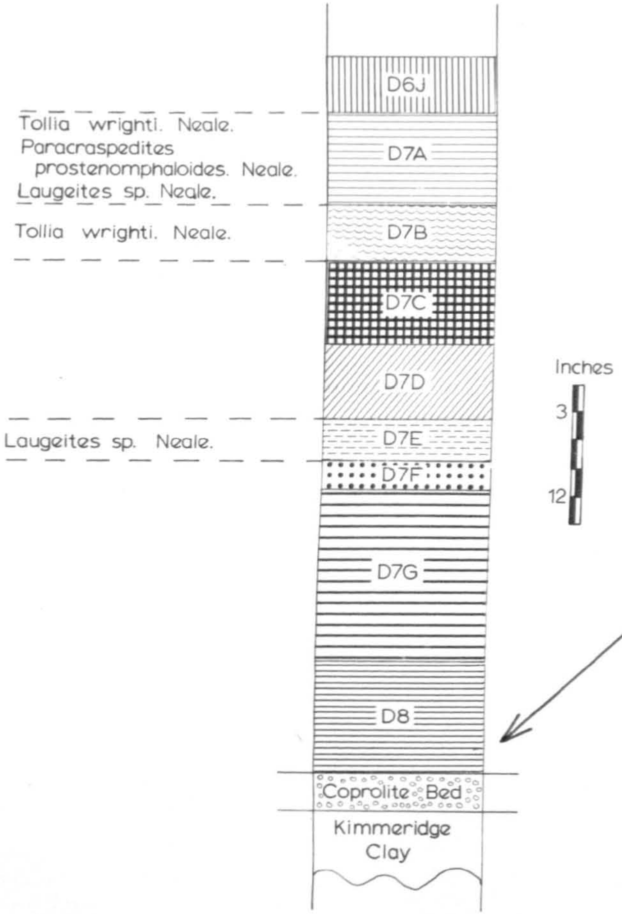
Text-figure.

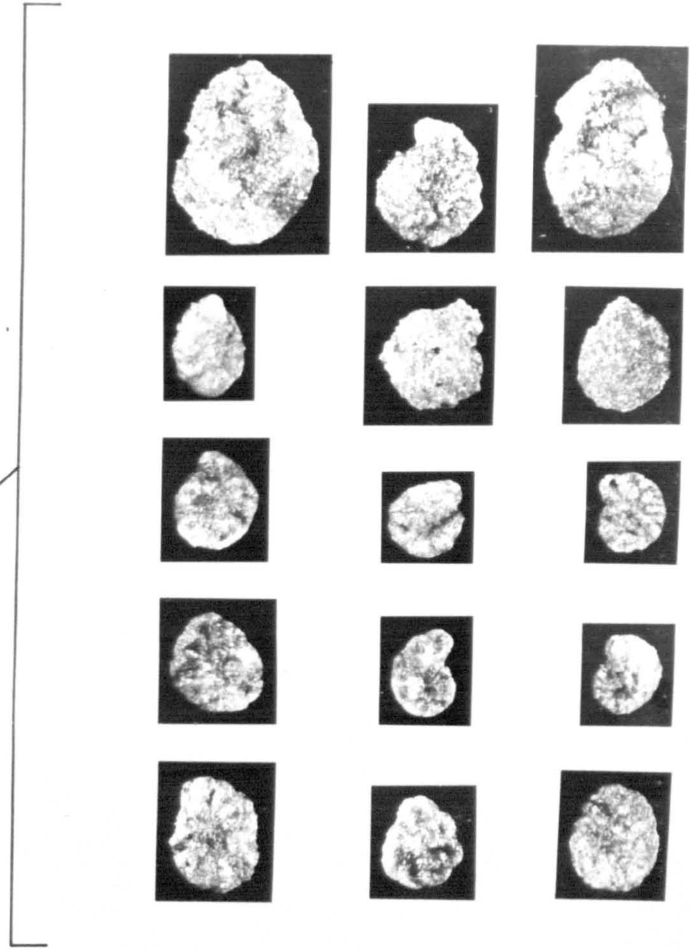
Material: Ninety-four specimens.

Dimensions: Maximum diameter 0.306 mm - 0.720 mm.

Description: Test free, planispiral, involute. Peripheral margin smoothly rounded; occasionally lobulate but this may be due to being crushed during fossilization. Under glycerine seven to fourteen small chambers are visible in the last whorl. Sutures indistinct, straight or slightly curved, generally flush with the surface. Wall fine to coarsely arenaceous with much cement, giving a light brown coloured test.

Remarks: All the specimens obtained from the Lower D beds are very crushed and their preservation such that specific determination can not





HAPLOPHRAGMOIDES spp.
from the Basal Speeton Clay.

be made with any certainty. There is a wide variation both in the size of the test and in the number of chambers and it seems likely that more than one species is represented. They can be compared with *H. concavus* (Chapman), *H. neocomiensis* (Chapman) and *H. fontinensis* (Terquem). *H. concavus* has been recorded from Wealden 6 to Mittel Valendis in Germany. A selection of specimens from the lowest part of the Speeton clay is shown in the accompanying figure together with the position of ammonites that are known from this part of the succession. It is unfortunate that the preservation is so poor as this is the first record of microfauna from bed D8. No ammonites have been found below bed D7E and these lowest beds are regarded as part of the Infra-Valanginian or Berriasian.

Occurrence: D8, D7, D6, D5.

Subfamily LITUOLINAE De Blainville, 1825

Genus AMMOBACULITES Cushman, 1910.

Type species *Spirolina agglutinans* d'Orbigny

The type is described by Cushman as "Test free, chambered, early portion close coiled in one plane, later portion uncoiled and made up of a more or less linear series of chambers; wall coarsely arenaceous, fairly thick; aperture single at the centre of the terminal face of the uncoiled portion, but in the coiled portion at the base of the apertual face".

Ammobaculites reophacoides Bartenstein

Plate 2, figure 7.

Ammobaculites reophacoides BARTENSTEIN 1952, Barreme, p. 307, fig. 1.

Ammobaculites reophacoides BARTENSTEIN - BARTENSTEIN & BETTENSTAEDT 1962, Marine Unterkreide, p. 279, pl. 36, fig. 9.

Material: One hundred and fifty specimens.

Dimensions of figured specimen:

HU.21.C.20 Length 0.504 mm.

Description: Test free, small elongate, with a small initial coiled portion followed by two to four uniserial chambers. Coiled portion, when well developed, small with three chambers; this portion commonly supressed giving a *Rheophax*-like form. All chambers in the uniserial part a little broader than high; elliptical in cross-section. Sutures radial, indistinct in coiled portion; distinct, horizontal, depressed in linear series. Wall coarsely agglutinated. Aperture terminal, rounded.

Remarks: All chambers commonly crushed and distorted.

Occurrence: D6, D5, D4, D3, C10, C9, C6, C5, C2, LB5, LB4, LB3.

Ammobaculites subcretaceus Cushman and Alexander

Plate 2, figures 3-6

Ammobaculites subcretaceus CUSHMAN & ALEXANDER, 1930, Texas Lower Cretaceous, p. 6, pl. 2, figs. 9, 10.

Ammobaculites subcretaceus CUSHMAN & ALEXANDER - CUSHMAN, 1946, Gulf Coast, p. 23, pl. 3, figs. 18 and 19.

Ammobaculites subcretaceus CUSHMAN & ALEXANDER - LOEBLICH & TAPPAN, 1949, Walnut clay, p. 251, pl. 46, figs. 9-13.

Ammobaculites subcretaceus form A, CUSHMAN & ALEXANDER - SZTEJN, 1958, Middle Poland, pg. 13, fig. 176.

Material: Eighty-two specimens.

Dimensions of figured specimens:

		Length	Diameter of coiled portion	Thickness
Figure 3	HU.21.C.17	0.90 mm	0.378 mm	0.180 mm
Figure 4	HU.21.C.18	0.65 mm	0.306 mm	0.216 mm
Figure 6	HU.21.C.19	0.45 mm	0.216 mm	0.144 mm

Description: Test free, medium to small in size, laterally compressed, early portion closely coiled, four to six chambers, followed by two to four uncoiled chambers in a straight or slightly curved linear series. The diameter of the chambers in the linear part remains constant or increases only very slightly as added. The greatest diameter of the chambers is often slightly below the mid point. Sutures indistinct in the coiled portion, depressed and arched upwards in the uncoiled portion. Periphery rounded, slightly lobulate. Wall coarsely arenaceous; aperture terminal, round to oval.

Remarks: This species was originally described from the Lower Cretaceous of Texas. It is very similar to A. cobbani Loeblich & Tappan but can be distinguished from it by its irregular chambers in the uniserial portion. Some of the forms closely approach A. agglutinans (d'Orbigny) but the chambers of this latter species are more inflated and the sutures of the coiled portion distinct. It is distinguished from A. goodlandensis (Cushman & Alexander) by being much smaller and less nodose.
The microspheric is very slightly evolute whilst the early stages of the megalospheric form are involute.

Occurrence: D4, D3, C11, C10, C9, C8, C5, C2, LB5, LB4, LB3.

Genus HAPLOPHRAGMIUM Reuss, 1860

Type species *Spirolina aequalis* (Roemer)

Haplophragmium aequale (Roemer)

Plate 1, figures 8, 18 - 19.

Plate 2, figures 1 - 2.

Spirolina aequalis ROEMER, 1841, Kreidegeb. p. 98, pl. 15, fig. 27

Haplophragmium aequale ROEMER - REUSS, 1863, Hilo u. Gault, p. 29, pl. 1, figs. 1-7.

non *Haplophragmium aequale* ROEMER - CHAPMAN, 1892, Folkestone, pl. 5, fig. 14

Haplophragmium aequale ROEMER - EICHENBERG, 1933, Barreme, p. 170, pl. 17, fig. 7.

Haplophragmium aequale ROEMER - EICHENBERG, 1935, Unterkreide, pl. 8, figs. 1-3.

Haplophragmium D13 - HECHT, 1938, Unterkreide, pl. 15a, figs. 86-92, pl. 16a, figs. 63-69.

Haplophragmium aequale (ROEMER) - DAM, 1946, Neocom. p. 570, pl. 87, figs. 3-4.

Haplophragmium aequale (ROEMER) - BARTENSTEIN, 1952, Taxonomische Bem., p. 352, pl. 2, figs. 17-26; pl. 3, figs. 1-6.

Haplophragmium aequale (ROEMER) - LUTZE, 1960, Callovien, p. 438, pl. 26, figs. 1-2, 5-6; pl. 27, figs. 1-2.

Haplophragmium aequale (ROEMER) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 269, pl. 38, fig. 9.

Material: Four hundred and ninety-nine specimens.

Dimensions of figured specimens:

		Length
Figure 8	HU.21.C.7	1.430 mm
Figure 18	HU.21.C.8	1.690 mm
Figure 1	HU.21.C.9	2.340 mm

Description: Test free, large, elongate and slightly compressed. The early stage is close coiled, planispiral, with three to five chambers. Later portion uncoiled, uniserial, three to five chambers; chambers increase only very gradually in size as added. Chambers distinct, inflated, of fairly constant diameter; height of chambers tends to increase as added, though sometimes a very low chamber is intercalated between ones of normal height. Sutures distinct, depressed, generally straight. Wall coarsely arenaceous, well cemented, brown, grey or white in colour. Aperture rounded, terminal.

Variation: There is considerable variation in the outline of the test particularly in the smaller specimens in which the uncoiled part has not developed. In these the outline may be circular or smoothly rounded, oval, lobulate or even angular. The aperture often appears slit-like but this may be due to compression.

Remarks: From H. subaequale Mjatliuk it differs in having a greater number of chambers in the coiled portion. The specimen Chapman referred to H. aequale has been examined in the Br. Museum; it is very small and is not regarded by the writer as belonging to this species. The nature and the degree of coarseness of the particles in the agglutinated test is seen to be greatly influenced by the local sedimentary environment. The quartz grains vary from fine with much cement to quite coarse, and at several horizons where glauconite was available large grains of this mineral are incorporated in the wall. When glauconite is used to any extent the large size of the grains makes morphological features difficult to interpret.

In the Lower Cretaceous of the Hanover area this species is very coarsely agglutinated, though much of Hecht's and Bartenstein's material in the Senckenberg Museum (e.g. SMF. 3250) is identical with the Speeton forms.

Occurrence: C11, C10, C9, C8, C7, C5, C4, C3, C2, C1, LB6, LB5, LB4.

Family TEXTULARIIDAE Ehrenberg, 1938

Subfamily TEXTULARIINAE Ehrenberg, 1938

Genus TEXTULARIA Defrance, 1824

Type species *Textularia sagittula* Defrance.

Textularia foeda Reuss

Plate 2, figure 14

Textularia foeda REUSS, 1846, Böhm. Kreide, p. 109, pl. 43, figs. 12-13.

Textularia jurassica GÜMBEL, 1862, Streitberg, p. 228, pl. 4, fig. 17.

Textularia foeda REUSS - FRANKE, 1928, Oberkreide, p. 133, pl. 12, fig. 6.

Gaudryina foeda (REUSS) - CUSHMAN, 1932, 8, 90, pl. 11.

Textularia foeda REUSS - LUTZE, 1960, Callovien and Oxfordian, p. 443, pl. 27, figs. 10-11.

Textularia foeda REUSS - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 270, pl. 37, fig. 10; pl. 39, fig. 19.

Material: Forty-four specimens.

Dimensions of figured specimen:

HU.21.C.25 Length 0.594 mm Greatest width 0.234 mm.

Description: Test free, elongate, narrow, compressed. Biserial, with about ten chambers per side; chambers inflated especially in the later portion but more commonly crushed and distorted during fossilization;

chambers wide and narrow, increasing rapidly in width as added giving a tapering test. Sutures distinct, straight, depressed, characteristically emphasized by black pyrite (?) particles. Wall arenaceous, medium grained clear quartz. Aperture terminal, a small slit at inner margin of the last chamber.

Remarks: Textularia foeda was originally described from the Cenomanian of Bohemia. The figure of Reuss, which is a compressed specimen, shows some slight differences from the specimens from Speeton and North Germany but his description agrees closely with the Lower Cretaceous forms. The black pyrite (?) particles concentrated along the sutures are very characteristic of this species in the Lower Cretaceous, not only at Speeton but also in Germany. The range of variability of Textularia foeda in Bohemia is not known and the figured holotype of Reuss might not be representative. It is not possible to say whether the Lower Cretaceous forms are distinct from Textularia foeda until the range of variation of topotype material is established. Textularia foeda is also found in the Upper Callovian and Lower Oxfordian of North-west Germany. Specimens of Textularia foeda from the Oxfordian of Blumberg in southern Germany have been examined and Dr. Lutze has supplied topotype material of Textularia jurassica Gümbel 1862, from the middle Oxfordian of Streitberg (south-west of Bayreuth). All these forms agree closely with those from Speeton. The Jurassic and Upper Cretaceous specimens of this species also have black pyrite (?) incorporated in the arenaceous test but it is not as concentrated along the sutures as in those from the Lower Cretaceous.

The range of this species in Europe is Upper Callovian to Albian. Cushman puts this species in the genus Gaudryina but no early triserial portion has been observed in the Speeton specimens.

Occurrence: C8, C7, C6, C5, C4, C2, LB4.

Genus BIGENERINA d'Orbigny, 1826

Type species *Bigenerina nodosaria* d'Orbigny

Bigenerina clavellata Loeblich and Tappan

Plate 2, figures 15-16.

Bigenerina clavellata LOEBLICH & TAPPAN, 1946, Washita p. 245, pl. 35, figs. 7-8.

Bigenerina clavellata LOEBLICH & TAPPAN - BARTENSTEIN & BRAND, 1951, Valendis, p. 275, pl. 4, figs. 75-76.

Material: Twenty-two specimens.

Dimensions of figured specimens:

		Length	Greatest breadth
Figure 15	HU.21.C.26	0.566 mm	0.162 mm
Figure 16	HU.21.C.27	0.566 mm	0.144 mm

Description: Test free, small, narrow, elongate, initial portion biserial later uniserial; the uniserial portion forming the greater part of the test. The round proloculum is followed by two to four small biserial chambers; the uniserial portion consists of three to five larger chambers, rounded and slightly inflated in well preserved specimens (fig. 16) but more commonly collapsed; rather variable in size in the uniserial portion though generally higher than broad. Sutures distinct, depressed, nearly straight. Wall arenaceous, very fine grained with much cement giving a white, smooth test. Aperture terminal, rounded.

Alternation of Generations: The figured specimens are both megalospheric individuals with a large proloculus followed by only a small biserial portion. Microspheric specimens have a much longer test, a very small proloculus, and a better developed biserial portion.

Remarks: The species was first described from the Washita formation of Oklahoma and Texas. The constriction at the end of the biserial series is not so pronounced in the forms from Speeton but in every other respect agrees closely with the figures of the holotype and paratype.

Occurrence: C11, C9, C8, C7, C5, C4, LB3.

Family TROCHAMMINIDAE Schwager, 1877

Subfamily TROCHAMMININAE Schwager, 1877

Genus TROCHAMMINA Parker & Jones, 1859

Type species Nautilus inflatus Montagu

Trochammina depressa LOZO

Plate 2, figures 19-22.

Trochammina depressa - LOZO, 1944, Trinity, p. 552, pl. 2, figs. 4a-b, 5.

Trochammina depressa - LOZO - LOEBLICH & TAPPAN, 1949, Walnut, p. 256, pl. 49, figs. 1 & 2.

Trochammina depressa LOZO - BARTENSTEIN & BRAND, 1951, Valendis, p. 280, pl. 4, fig. 9b.

Material: One hundred and fifty-two specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 19	HU.22.C.2	0.432 mm
Figure 21	HU.22.C.3	0.360 mm

Description: Test free, compressed, trochoid, periphery lobulate; chambers distinct in well preserved specimens. All chambers visible on dorsal side; five or six chambers of the last whorl visible ventrally. Chambers very slightly inflated, increase rapidly and uniformly in size as added. Sutures distinct, depressed, constricted at the margin giving the lobulate periphery. Wall finely arenaceous. Aperture a small opening at the base of apertual face of last chamber; not visible in most specimens due to poor preservation.

Remarks: Originally described from the Kiamichi formation (Albian) of America. In Germany is found in the Middle and Upper Valanginian and Lower Hauterivian. It differs from Trochammina inflata (Montagu) by being much more compressed and having five or six chambers visible ventrally.

Occurrence: D7, D6, D5, C11, C9, C8, C7, C6, C5, C4, C3, C2, LB5, LB3, LB2.

Family ATAXOPHRAGMIIDAE Schwager, 1877

Subfamily VERNEUILININAE Cushman, 1911.

Genus GAUDRYINELLA Plummer, 1931

Type species Gaudryinella delrioensis Plummer, 1931

Gaudryinella sherlocki Bettenstaedt

Plate 3, figure 1.

Bigenerina nodosaria D'ORBIGNY - SHERLOCK, 1914, Speeton, p. 222, pl. 18, fig. 2.

Gaudryina cf. siphonella REUSS - EICHENBERG, 1933, Barreme, p. 170, pl. 17

figs. 1-3.

Gaudryina cf. siphonella REUSS - EICHENBERG, 1935, Unterkreide, p. 170, pl. 17, figs. 1, 3.

Bigenerina D2 - HECHT, 1938, Unterkreide, pl. 9b, figs. 27-31.

Gaudryinella sherlocki BETTENSTAEDT, 1952, Barreme, p. 268, pl. 1, figs. 1-5.

Gaudryinella sherlocki BETTENSTAEDT - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 272, pl. 38, fig. 14.

Material: One hundred and forty-six specimens.

Dimensions of figured specimen:

		Maximum width	Length
Figure 1	HU.22.C.4	0.198 mm	0.423 mm

Description: Test free, elongate subcylindrical, tapering very slightly towards the initial portion, sub-circular in cross-section. The earliest portion of the test is triserial and occupies about a third of the length, it is followed by a well developed biserial portion which forms the main part of the test; the biserial part shows a tendency to become uniserial. The chambers are subglobular, slightly inflated and increase very gradually in size as added. The inflated nature of the chambers gives a lobulate periphery. The sutures are indistinct in the early triserial portion but are distinct and depressed in the biserial and uniserial portions. Wall arenaceous formed of medium to coarse grains of quartz in a dark brown or black cement. Aperture terminal, central, flush with the surface, circular or ovate though the latter shape may be due to compression.

Remarks: This species has only been recorded from North-west Germany and Speeton where Sherlock recorded one specimen from the base of the B beds. Material examined from the Middle Barremian of Berenbostal, Germany is identical with the Speeton forms. In Germany it ranges from the Upper Hauterivian to the Middle Albian but is numerically strongest in the Lower and Middle Barremian.

Occurrence: Common in the Lower B beds; occurs very rarely in the C beds.

Genus TRITAXIA Reuss, 1860

Type species *Textularia tricarinata* Reuss, 1844

Tritaxia pyramidata Reuss

Plate 3, figures 2-10

Tritaxia pyramidata REUSS, 1863, Hils u. Gault, p. 32, pl. 1, fig. 9.

Tritaxia pyramidata REUSS - FRANKE, 1925, Pommerschen Kreide, p. 18, pl. 2, fig. 1.

Tritaxia pyramidata REUSS - FRANKE, 1928, Ober. Kreide, p. 138, pl. 12, fig. 18.

Tritaxia tricarinata CHAPMAN (non REUSS), 1892, Folkestone, p. 1, pl. 11, fig. 1.

Tritaxia pyramidata REUSS - CHAPMAN, 1892, Folkestone, p. 1, pl. 11, fig. 2.

Tritaxia pyramidata REUSS - PLUMMER, 1931, Texas, p. 133, pl. 10, figs. 18-20

Tritaxia pyramidata REUSS - BARNARD & BANNER, 1953, u. Cretaceous, p. 195, pl. 7, fig. 1.

Tritaxia pyramidata REUSS - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 19, pl. 2, fig. 37.

Material: Two hundred and seventy-six specimens.

Dimensions of figured specimens:

		Length	Maximum width
Figure 2	HU.22.C.5	0.900 mm	0.486 mm
Figure 5	HU.22.C.6	0.910 mm	0.432 mm
Figure 6	HU.22.C.7	0.900 mm	0.648 mm
Figure 10	HU.22.C.8	0.720 mm	0.432 mm

Description: Test free, pyramidal, triserial, triangular in cross-section. Sides usually concave but may be flat particularly in the initial portion. Angles of the test extended into thin wing-like flanges. Up to nine triserially arranged chambers which overlap a quarter to a half of their width; their size increases as added giving a strongly divergent outline. Chambers usually flush with the surface but may be depressed. Sutures indistinct in initial portion becoming depressed, and consequently more visible, in later portions. Wall smooth, finely agglutinated quartz in a white calcareous cement; some specimens incorporate pyrite. Aperture circular, central, sunken.

Variation: There is a wide range of variation in shape and size of the test. The flanges are frequently not straight but sinuous giving the test a bent appearance. The type figure by Reuss is a rather idealized one with perfectly straight edges. At Speeton many of the forms show a tendency for the last few chambers to become uniserial, a trend also noted by Barnard and Banner (1953) in Upper Cretaceous material. The angles between the planes of the flanges is also very variable. An extreme variant is seen in figure 5 where the last few chambers have lost their distinctive triangular arrangement and a *Gaudryina*-like form has resulted.

Occurrence: C11, C5, C4, C3, C2, C1, LB6, LB5, LB4.

Genus VERNEUILINOIDES Loeblich & Tappan, 1949

Type species *Verneuilina schizea* Cushman & Alexander

Verneuilinoides neocomiensis (Mjatliuk)

Plate 2, figures 8-13

Verneuilina D5 - HECHT, 1937, Unterkreide, pl. 20b, figs. 58-60; pl. 13a, fig. 45; pl. 13b, fig. 3; pl. 14a, fig. 13; pl. 16a, figs. 70-71; pl. 18b, figs. 61-62; pl. 19b, fig. 73-74.

Verneuilina neocomiensis - MJATLIUK, 1939, Middle Volga, p. 50, pl. 1, figs. 12-13.

Verneuilina chapmani - DAM, 1946, Neocomian, P. 572, pl. 87, fig. 8.

Verneuilinoides neocomiensis (MJATLIUK) - BARTENSTEIN & BRAND, 1951, Valendis, p. 276, pl. 4, figs. 77, 328; pl. 16, figs. 1-2; pl. 19, figs. 3-5; pl. 19b, figs. 10, 13-17.

Verneuilinoides subfiliformis BARTENSTEIN, 1952, Barreme 2, p. 308, pls. 8-12.

Verneuilinoides neocomiensis (MJATLIUK) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 19, pl. 2, figs. 39, 40a,b.

Verneuilina neocomiensis MJATLIUK - SZTEJN, 1958, Middle Poland, p. 15, fig. 23.

Material: Eight hundred and forty-one specimens.

Dimensions of figured specimens:

		Length	Greatest width
Figure 8	HU.21.C.21	0.648 mm	0.234 mm
Figure 10	HU.21.C.22	0.558 mm	0.198 mm
Figure 11	HU.21.C.23	0.566 mm	0.180 mm
Figure 12	HU.21.C.24	0.680 mm	0.198 mm

Description: Test free, narrow, elongate, trilobed in cross-section. Chambers arranged triserially, with seven to eight rows of chambers, increasing rapidly in size as added; normally inflated but in many specimens the tests are crushed in preservation. Chambers distinct and give a lobulate outline to the test. Early chambers low and wide but last formed chambers higher than wide. Sutures distinct, depressed; wall finely arenaceous with a large proportion of cement. Aperture a slit at the base of the last chamber.

Variation: There is quite a breadth of variation in size and in the degree of taper of the test. Commonly the test in its earlier portion is twisted or bent.

Remarks: The specimens are commonly crushed and distorted. The species is very similar to *V. subfiliformis* Bartenstein 1952 and according to him differs only in being shorter and broader. The range of *V. neocomiensis* in Germany is Valanginian to Barremian, whilst that of *V. subfiliformis* is Lower Hauterivian to Middle Albian. The forms at Speeton are variable in length, greatest width, twist of test and inflation of chambers, and it has been found impossible to distinguish these two species satisfactorily in the Speeton succession. _V. subfiliformis_ probably falls within the range of variation of _V. neocomiensis_.

Occurrence: D7, D6, D5, D4, D3, D2, C11, C10, C9, C8, C7, C5, C4, C3, C2, LB5, LB4, LB3.

Subfamily GLOBOTEXTULARIINAE Cushman, 1927

Genus DOROTHIA Plummer, 1931

Type species Gaudryina bulletta Carsey, 1926

Dorothia kummi (Zedler)

Plate 3, figures 11 - 17

Gaudryina oxycona REUSS - EICHENBERG, 1934, Hauterive, p. 153, pl. 17, fig. 7.

Gaudryina oxycona REUSS - EICHENBERG, 1935, Unterkreide, pl. 11, fig. 26.

Textularia D 14 - HECHT, 1938, Unterkreide, pl. 18a, figs. 1 - 19.

Marsonella oxycona (REUSS) - DAM, 1946, Neocomian, p. 572, pl. 87, fig. 9.

Marsonella oxycona (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 277, pl. 4, fig. 80.

Marsonella oxycona (REUSS) - BETTENSTAEDT & WICHER, 1955, Tethys und Boreal, p. 505, pl. 4, fig. 30.

Marsonella cf. oxycona (REUSS) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 20, pl. 2, figs. 42-43.

Marsonella kummi ZEDLER, 1961, Oberhauterive, p. 31, pl. 7, fig. 1.

Material: Thirty specimens.

Dimensions of figured specimens:

		Height	Diameter
Figure 11	HU.22.C.9	0.558 mm.	0.242 mm.
Figure 13	HU.22.C.10	0.414 mm.	0.270 mm.

		Height	Diameter
Figure 16	HU.22.C.11	0.414 mm.	0.378 mm.

Description: Test free, conical, subcircular in cross-section. The globular proloculum is followed by whorls of three chambers which give way quickly to a biserial stage. The chambers are distinct and increase in height slowly as added; the diameter, however, increases rapidly giving a diverging test. Sutures distinct, straight, may be flush or depressed. Test smooth, wall finely arenaceous with a large amount of calcite cementing the quartz grains. Apertual face crescentic, may be inflated, flat or depressed. Aperture a broad low slit, often deeply set, at the base of the inner margin of the last chamber.

Variation: Test varies in shape, size and angle of divergence. A rapid increase in the diameter of the last series of chambers, giving a distinctly lipped or flanged test, is commonly seen (figure 16). The specimen illustrated in figures 11-12, is probably an extreme variant; the chambers are distinctly inflated giving a lobulate outline to the test, the size of the quartz grains in the wall are larger and the cement not so dominant when compared with typical examples of this species.

Remarks: It has been realised for some time (Bettenstaedt & Wicher, 1955, Bartenstein, Bettenstaedt & Bolli, 1957) that the Lower Cretaceous forms referred to as *M. oxycona* (REUSS) were morphologically different from this typically Upper Cretaceous species. Zedler (1961) gave the name M. kummi to these Lower Cretaceous forms which are smaller and thinner than M. oxycona and have slightly narrower chambers. D. kummi (Zedler) probably gives rise to M. turris (d'Orbigny) in the Cenomanian which Barnard (1963) states is the main root stock from which M. trochus (d'Orbigny) and M. oxycona (Reuss) develop.

Occurrence: C9, C7, C5, C3, C2.

Suborder	MILIOLINA	Delage & Herouard, 1896
Superfamily	MILIOLACEA	Ehrenberg, 1839
Family	NUBECULARIIDAE	Jones, 1875
Subfamily	NODOBACULARIINAE	Cushman, 1927
Genus	NODOBACULARIA	Rhumbler, 1895

Type species Nodobacularia tibia (Jones & Parker) 1860.

Nodobacularia nodulosa (Chapman)

Plate 3, figures 18 - 20.

Nubecularia nodulosa CHAPMAN, 1891, Folkestone p. 9, pl. 9, fig. 2.

Pseudonubeculina nodulosa (CHAPMAN) - BARTENSTEIN & BRAND, 1949, Lower Cret., p. 670, figs. 3 - 5.

Nubeculina nodulosa (CHAPMAN) - DAM, 1950, Albien, p. 18, pl. 1, fig. 20.

Pseudonubeculina nodulosa (CHAPMAN) - BARTENSTEIN & BRAND, 1951, Valendis, p. 278, pl. 4, figs. 82-84.

Material: Eighty-four specimens, initial part missing in every case.

Dimensions of figured specimens:

		Length
Figure 18	HU.22.C.12	0.810 mm.
Figure 19	HU.22.C.13	0.720 mm.
Figure 20	HU.22.C.14	1.170 mm.

Description: Test free, calcareous, imperforate porcellaneous. Initial portion missing in all the material examined. Fragments are of a linear portion with one to three chambers joined by a narrow tube. Chambers variable in shape, nodulose to pyriform, may taper equally in both directions but the majority of forms are widest proximally and taper very gradually distally. Chambers frequently have small flattened or concave surfaces. Aperture terminal, simple, round.

Variation: There is a wide variation in shape and distance apart of the chambers, as well as in the size of the test.

Remarks: Chapman's syntypes (Br. Mus. Nat. Hist. P.4597) are very much smaller and more delicate than those from the Lower Cretaceous of Yorkshire but are similar in every other respect. In some specimens from Speeton the white porcellaneous material is eroded showing solid brown vitreous calcite beneath.
Bartenstein and Brand (1949) proposed the new generic name *Pseudonubeculina* for Chapman's species as it had a simple round aperture and lacked the phialine lip and inwardly pointing teeth of *Nubeculina*. The Treatise is followed here in placing this species in the genus *Nodobacularia* though evidence of attachment is lacking.

Occurrence: D2E, D2D, D2C, D1A, C11, C10, C7, C3, C2, LB6, LB4. Numerically strongest in C4.

Suborder	MILIOLINA	Delage & Herouard, 1896.
Superfamily	MILIOLACEA	Ehrenberg, 1839
Family	MILIOLIDAE	Ehrenberg, 1839
Subfamily	QUINQUELOCULININAE	Cushman, 1917
Genus	QUINQUELOCULINA	d'Orbigny, 1826.

Type species Serpula seminulum Linne

Quinqueloculina speetonensis sp. nov.

Plate 4, figures 1 - 4.

Derivation of name: Referring to the Speeton clay, the strata from which it has first been found.

Holotype: HU.22.C.15, from horizon LB5D at Speeton.

Material: Six specimens all from sample No. 17.

Dimensions of figured holotype:

		Length	Breadth	Thickness
Figures 1-4	HU.22.C.15	0.504 mm	0.306 mm	0.216 mm

Diagnosis: Test free, oval to fusiform with rounded ends; subtriangular in apertual view. About 1.6 times as long as broad. Periphery rounded or slightly subangular. Chambers distinct, rounded, early ones very slightly inflated. Chambers equal in diameter throughout their length; four chambers visible on the multichambered side. Final chamber overlaps the previous one at the apertual end. Sutures distinct. Aperture large, rounded, at the truncated end of the final chamber. No tooth has been observed. Wall smooth.

Variation: Apart from differences in size no variation has been observed.

Remarks: From *Quinqueloculina triangulata* Stead, from the lower Albian of Texas, it differs in lacking the pointed ends and in being smaller. *Quinqueloculina coonensis* Berry from the Upper Cretaceous of Tennessee differs in having a more rounded outline, a greater length and a prominent ridge of costae on the peripheral margin. The specimens from Speeton do not show the produced apical and apertual ends seen in *Quinqueloculina stolleyi* Brotzen from the Senonian of Sweden. It differs from *Miliammina valendis* Bartenstein & Brand in lacking the strongly produced apical and apertual portions, the coarse wall structure and in general shape.

The genus *Quinqueloculina* is rare in the Cretaceous of Western Europe, and no species have been recorded from the Lower Cretaceous of N.W. Germany. All the specimens referred to the genus *Miliolina* by Chapman from the Gault of Folkestone differ markedly from the one described here. No attempt has been made to obtain thin sections due to the limited number of specimens and the fact that some of them are infilled with pyrite. The length of the specimens vary from 0.360 mm to 0.504 mm and the breadth from 0.216 mm to 306 mm.

Paratypes: Four in the author's collection.

Occurrence: Only in sample No. 17 from bed LB5D.

Genus WELLMANELLA Finlay, 1947

Type species Wellmanella kaiata Finlay 1947

Finlay describes the type as "Test mainly triloculine (perhaps quinqueloculine), in the adult more flattened, with usually three chambers in a cycle, aperture a narrow slit bordered by thin projecting flanges, not cribate and with no trace of a tooth".

Wellmanella antiqua (Reuss)

Plate 4, figures 5 - 7.

Hauerina antiqua REUSS, 1863, Hils und Gault, p. 35, pl. 2, fig. 1.

Quinqueloculina D5 - HECHT, 1938, Unterkreide, pl. 15a, figs. 61-64.

Hechtina antiqua (REUSS) - BARTENSTEIN & BRAND, 1949, Lower Cretaceous, p. 670, fig. 10.

Hechtina antiqua (REUSS) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 269, pl. 38, fig. 8.

Material: Two hundred and eight specimens.

Dimensions of figured specimen:

		Length	Width	Thickness
Figure 5	HU.22.C.16	0.594 mm	0.540 mm	0.360 mm.

Description: Test free, imperforate, porcellaneous, broadly ovate, periphery rounded. Chambers often indistinct, inflated, strongly curved, generally triloculine but may have four chambers to a whorl. Sutures when depressed are distinct but often are indistinct. Thick calcareous wall. Aperture close to the margin at the base of the last chamber, slit-like or semicircular with a thickened lip. No tooth.

Variation: Considerable variation in shape and arrangement of the chambers also in the size and shape of the aperture.

Remarks: The triloculine plan is often difficult to interpret. This is the first record of this species outside N.W. Germany, where it ranges from Lower Hauterivian to Middle Barremian but occurs abundantly only in the seeleyi and tenuis zones.

Occurrence: C4, C3, C2, LB5, LB4, LB3.

Suborder ROTALIINA Delage & Herouard, 1896

Superfamily NODOSARIACEA Ehrenberg, 1838

Family NODOSARIIDAE Ehrenberg, 1838

Subfamily NODOSARIINAE Ehrenberg, 1838

Genus LENTICULINA Lamarck, 1804

Type species Lenticulites rotulata Lamarck, 1804

Lenticulina (Lenticulina) münsteri (ROEMER)

Plate 4, figures 10-14.

Robulina münsteri - ROEMER, 1839, Oolith. Geb., p. 48, pl. 20, fig. 29.

Robulina ehrenbergii ROEMER, 1841, Kreidegeb., p. 98, pl. 15, fig. 31.

Cristellaria münsteri (ROEMER) - REUSS, 1863, Hils u. Gault, p. 77, pl. 9, figs. 3-4.

Cristellaria gaultina BERTHELIN - SHERLOCK, 1914, Speeton, p. 262, pl. 18, fig. 27.

Cristellaria (Lenticulina) münsteri (ROEMER) - BARTENSTEIN & BRAND, 1937, Lias u. Dogger, p. 174, pl. 9, figs. 49a-c.

Cristellaria D104 - HECHT, 1938, Unterkreide, pl. 19a, figs. 20-26.

Cristellaria D91 - HECHT, 1938, Unterkreide, pl. 15a, figs. 8-34.

Cristellaria münsteri (ROEMER) - MJATLIUK, 1939, Middle Volga, p. 54, pl. 3, fig. 36.

Lenticulina (Lenticulina) münsteri (ROEMER) - BARTENSTEIN & BRAND, 1951, Valendis, p. 283, pl. 5, fig. 109; pl. 14a, figs. 13-14; pl. 14b, figs. 3-6; pl. 14c, figs. 37-39; pl. 15a, fig. 7; pl. 15c, figs. 17-20; pl. 16, figs. 16-18; pl. 18, figs. 39, 59, 60.

Lenticulina (Lenticulina) münsteri (ROEMER) - BARTENSTEIN, 1956, Hauterive, p. 514, pl. 1, figs. 1-4.

Lenticulina (Lenticulina) münsteri (ROEMER) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, pl. 3, fig. 54 a-b; pl. 4, figs. 80-81.

Material: Several thousand specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 10	HU.22.C.18	1.300 mm
Figure 12	HU.22.C.19	0.910 mm
Figure 13	HU.22.C.20	0.738 mm
Figure 14	HU.22.C.21	1.280 mm

Description: Test free, biconvex; periphery generally smoothly curving but sometimes is subangular to polygonal, acute but not keeled. The test is usually involute but there is a marked tendency for some individuals to become uncoiled in the final stage. There are 9-13 gently curved chambers, of uniform shape, which increase very gradually in size as added. Sutures limbate, flush with the surface, and curve with the convex side facing the apertual margin. At the umbilicus a boss of clear calcite occurs, which is usually flush with the surface though can be slightly raised. Aperture radiate, at the peripheral angle, sometimes on a small extension. Apertual face varies from flat to slightly inflated. Surface of test smooth and without ornamentation.

Variation: This species is a very plastic one and the range of variation is great. The commonest variation is the tendency of the last few chambers to become uncoiled and form a straight or curving series.

Occurrence: Occurs first in bed D7D and apart from being rare in D5 and D4 occurs abundantly throughout the succession.

Lenticulina (*Lenticulina*) *nodosa* (REUSS)

Plate 4, figure 16 - 17.

Robulina nodosa - REUSS, 1863, Hils und Gault, p. 78, pl. 9, fig. 6.

Cristellaria nodosa (REUSS) - CHAPMAN, 1896, Folkestone, p. 4, pl. 1, fig. 5.

Cristellaria D92 (pars) - HECHT, 1938, Unterkreide, pl. 20a, figs. 50, 52; pl. 20b, fig. 46.

Lenticulina nodosa (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 281, pl. 4, fig. 103.

Lenticulina (*Lenticulina*) *nodosa* (REUSS) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 24, pl. 3, fig. 49; pl. 4, fig. 6.

Lenticulina (*Lenticulina*) *nodosa* (REUSS) - BARTENSTEIN & BETTENSTAEDT, 1962, p. 256, pl. 35, fig. 10.

Lenticulina nodosa (REUSS) - FLANDRIN, MOULLADE & PORTHAULT, 1962, Vocontien, p. 218, pl. 2, fig. 10.

Material: Six specimens.

Dimensions of figured specimen:

		Maximum diameter	Thickness
Figure 16	HU.22.C.23	0.846 mm	0.432 mm

Description: Test free, biconvex; the periphery is subangular to lobulate with nodes where the sutures meet it, acute but not keeled. Test involute with nine to eleven gently curving chambers in the last whorl which increase gradually in size. The sutures are limbate slightly raised above the surface of the test and curve backwards to meet the periphery tangentially. At the umbilicus is a clear calcite plug which is usually flush with the surface or only slightly raised. The apertual face is triangular and gently inflated. Aperture radiate at the peripheral angle.

Remarks: This species is characterised by the nodes at the periphery. It differs in this respect from L. heiermanni Bettenstaedt and also from the latter in that both the umbilical boss and the sutures are not so elevated above the surface of the test. The forms at Speeton have not the strong nodes so characteristic of this species. Chapman's specimen (Br. Mus. P.5205) has the strong, prominent nodes that are so well seen in the German Lower Cretaceous. Cristellaria secans Reuss var. angulosa Chapman (Br. Mus. P.5215) is very similar and is probably a variant of L. nodosa.

Occurrence: C9, C5, C1.

Lenticulina (Lenticulina) ouachensis (Sigal) subsp. wisselmanni (BETTENSTAEDT

Plate 6, figures 3 - 11.

Cristellaria sp. 4 - EICHENBERG, 1935, Unterkreide, p. 396, pl. 8, fig. 8.

Cristellaria D 114 - HECHT, 1938, Unterkreide, pl. 22, figs. 34-37.

Cristellaria ouachensis SIGAL, 1952, Cretace, p. 16, fig. 10.

Lenticulina (Lenticulina) wisselmanni BETTENSTAEDT, 1952, Barreme, p. 269, pl. 1, fig. 6.

Lenticulina (Lenticulina) ouachensis wisselmanni (BETTENSTAEDT) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 26, pl. 4, fig. 70.

Lenticulina (Lenticulina) ouachensis wisselmanni (BETTENSTAEDT) BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 270, pl. 38, fig. 15.

Material: Two hundred and ninety-nine specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 3	HU.23.C.15	1.430 mm
Figure 5	HU.23.C.16	1.300 mm

		Maximum diameter
Figure 7	HU.23.C.17	1.170 mm
Figure 9	HU.23.C.18	1.230 mm
Figure 10	HU.23.C.19	1.170 mm
Figure 11	HU.23.C.20	2.080 mm

Description: Test robust, planispiral, lenticuline, oval to subcircular in outline, involute except for the last portion which may tend to become uncoiled. Periphery acute with well developed keel except on the last chamber. Chambers curved, broad, low with seven to twelve chambers in the final whorl. Sutures limbate, raised well above the surface of the test. The umbilical area is surrounded by a thin prominent rib which encloses an ovate depressed area. This area may be crossed by other ribs which divide this 'hollow' into two or three portions. The sutural ribs are gently curved, convex on the apertual side, extending from the umbilical ornamentation to the periphery. These ribs meet the periphery tangentially or at a small angle. Wall calcareous. Aperture radiate, at the peripheral angle of the final chamber which is produced to form a small neck-like extension. Apertual face subtriangular, slightly inflated.

Remarks: This species is distinguished from all others by the characteristic high sharp rib enclosing an oval area in the umbilical region. Cristellaria ouachensis Sigal was originally described in 1952 from the Hauterivian of Algeria and in November of the same year

Bettenstaedt erected a new species _Lenticulina_ (_Lenticulina_) _wisselmanni_ from the Barremian of N.W. Germany. These forms are clearly synonymous, with Sigal's species having priority. Sigal's diagnosis was very short and poor and it is a pity that Bettenstaedt's better illustrated and better described species became invalid. Bartenstein, Bettenstaedt and Bolli (1957) erected the following three subspecies of _Lenticulina_ (_Lenticulina_) _ouachensis_ (Sigal):- _ouachensis_ sensu stricto - in which a rib completely or partially encloses a single umbilical pit.

wisselmanni - in which there are up to three umbilical pits.

multicella - in which there is one umbilical pit but the radiating sutures do not extend to the periphery.

All the specimens of this species from Speeton fall within the subspecies _wisselmanni_.

The species is morphologically related to _Lenticulina_ (_L_) _heiermanni_ Bettenstaedt but is distinguished by the sharp rib or ribs forming a high 'wall' around oval depressions in the umbilical region. It is also close to _Lenticulina_ (_L_) _saxonica_ Bartenstein but in this species the sharp ribs meet at the centre. In N.W. Germany it is found from high upper Hauterivian to Aptian.

Occurrence: D2D, D1A, C11, C9, C8, C7, C5, C4, C3, C2, C1, LB5.

Lenticulina (Lenticulina) saxonica Bartenstein

Plate 6, Figures 1 - 2, 12.

Cristellaria D 107 - HECHT, 1938, Unterkreide, pl. 18b, figs. 43-49; pl. 22, figs. 28 - 30.

Cristellaria D86 - HECHT, 1938, Unterkreide, pl. 20b, fig. 16.

Lenticulina (Lenticulina) Saxonica saxonica BARTENSTEIN & BRAND, 1951, Valendis. pl. 5, fig. 115.

Lenticulina (Lenticulina) saxonica BARTENSTEIN & BRAND - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 259, pl. 36, fig. 11.

Material: Ninety-seven specimens.

Dimensions of figured specimen:

		Maximum diameter
Figure 1.	HU.23.C.14	0.650 mm

Description: Test planispiral, involute, biconvex, slightly compressed. Peripheral outline subcircular to ovate. The periphery is acute and distinctly carinate. There are seven to ten small, gently curved and tapering chambers in the last whorl. The sutures are limbate, with thin ribs strongly raised above the surface of the test. They curve with the convex side towards the aperture and meet the periphery at a low angle. Typically the sutures all meet at the centre but in some individuals they finish short of the umbilicus. The apertual face is curved and the aperture is marginal, terminal, radiate and on a very small extension.

Variation: Only a very small amount of variation is seen and this is confined to the ornamentation of the sutures in the region of the umbilicus.

Remarks: The species is characterised by the prominent thin teel and the thin raised sutures. This ornamentation is very fragile and is soon broken giving a ragged appearance. *Lenticulina* (*L*) *saxonica bifurcilla* Bartenstein & Brand differs from it only in having ribs which bifurcate. *L.* (*L*) *saxonica* was originally described from the Upper Valanginian of N.W. Germany where it ranges from Upper Valanginian to Lower Hauterivian and is plentiful in the *bivirgatus* zone. Its only record outside N.W. Germany is that by Khan (1962) from Speeton.

Occurrence: D1A, C10, C9, C7, C4, C3, C2, C1, LB6, LB5, LB4, LB3, LB2. Numerically strongest in the lower B beds.

<u>Lenticulina</u> (<u>Lenticulina</u>) <u>subalata</u> (REUSS)

plate 4, figures 8 - 9.

<u>Cristellaria</u> <u>subalata</u> REUSS, 1854, Ostalpen, p. 68, pl. 25, fig. 13.

<u>Cristellaria</u> <u>subalata</u> REUSS - REUSS, 1863, Hils u. Gault, p. 76, pl. 8, fig. 10; pl. 9, fig. 1.

<u>Cristellaria</u> <u>subalata</u> REUSS - CHAPMAN, 1895, Folkestone, p. 3, pl. 1, fig. 3.

<u>Cristellaria</u> <u>subalata</u> REUSS - FRANKE, 1928, Oberkreide, p. 110, pl. 10, fig. 5.

<u>Cristellaria</u> (<u>Lenticulina</u>) <u>subalata</u> REUSS - DAM, 1950, Albien, p. 21, pl. 2, fig. 1.

<u>Lenticulina</u> (<u>Lenticulina</u>) <u>subalata</u> (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 283, pl. 5, figs. 112-113.

<u>Lenticulina</u> (<u>Lenticulina</u>) <u>subalata</u> (REUSS) - BARTENSTEIN, 1956, Hauterive, p. 515, pl. 1, fig. 8.

<u>Lenticulina</u> (<u>Lenticulina</u>) <u>subalata</u> (REUSS) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 23, pl. 5, fig. 92.

<u>Material</u>: Eighty-eight specimens.

<u>Dimensions of figured specimen</u>:

		Maximum diameter
Figure 8	HU.22.C.17	1.170 mm

Description: Test free, biconvex; periphery gently curving, keeled. The test is involute with up to eleven, broad, low chambers which enlarge gradually as added. Sutures distinct, gently curved, slightly raised above the surface of the test. At the umbilicus is a clear calcite plug, usually flush with the surface but may be slightly raised. Aperture radiate, at the peripheral angle; apertual face very slightly inflated.

Remarks: This species is distinguished from *Lenticulina* (*Lenticulina*) *circumcidanea* (Berthelin) in having less prominent sutures and a distinctly umbonal cross-section.

Occurrence: D6G, D4, D2, D1, C10, C8, C7, C5, C2, LB5, LB4, LB3, LB2, LB1.

Lenticulina (*Lenticulina*) *subangulata* (REUSS)

Plate 4, figure 15.

Cristellaria *subangulata* REUSS, 1863, Hils u. Gault, p. 74, pl. 8, fig. 7.
Robulus *subangulatus* REUSS - EICHENBERG, 1934, p. 157, pl. 16, fig. 4.
Cristellaria D81 - HECHT, 1938, Unterkreide, pl. 16a, fig. 55.
Lenticulina (*Lenticulina*) *subangulata* (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 283, pl. 5, fig. 111.

Material: Fifty specimens.

Dimensions of figured specimen:

		Maximum diameter	Thickness
Figure 15	HU.22.C.22	0.630 mm	0.360 mm

Description: Test free, biumbonate; peripheral outline polygonal, with the angles where the suture meets the periphery. Periphery acute but not keeled. Test involute and planispiral. There are 8-10 chambers in the final whorl which increase gradually in size as added; sutures distinct, gently curved, generally flush with the surface. Aperture radiate and at the peripheral angle. Apertual face flat to slightly inflated. Surface of test smooth, without ornamentation. Wall calcareous.

Variation: Slight variation in outline; it may be distinctly polygonal or only weakly polygonal and it then passes almost imperceptibly into *L. munsteri*.

Occurrence: D2, C9, C8, C5, C4, C3, C2, LB5, LB4, LB2, LB1.

Lenticulina (Lenticulina) guttata (Dam)

Plate 5, figures 3, 5-8, 12.

Text figures 8 - 10.

Planularia guttata DAM, 1946, Netherlands, p. 574, pl. 88, fig. 2.

Lenticulina (Lenticulina) guttata guttata (DAM) - BARTENSTEIN & BRAND, 1951, Valendis, p. 284, pl. 5, fig. 116.

Lenticulina (Lenticulina) guttata (DAM) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 27, pl. 5, fig. 98.

Lenticulina guttata (DAM) - SZTEJN, 1958, Middle Poland, p. 19, fig. 33.

Lenticulina (Lenticulina) guttata (DAM) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 261, pl. 36, fig. 4; pl. 41, fig. 1.

Lenticulina eichenbergi BARTENSTEIN & BRAND - SORGENFREI & BUCH, 1964, Denmark, p. 117, pl. 1, fig. 6.

Material: Four hundred and thirteen specimens.

Dimensions of figured specimens:

		Maximum Diameter	Thickness
Figure 3	HU.23.C.1	0.910 mm	0.45 mm
Figure 5	HU.23.C.3	1.560 mm	0.486 mm
Figure 6	HU.23.C.4	1.300 mm	0.450 mm
Figure 7	HU.23.C.5	1.430 mm	0.450 mm
Figure 8	HU.23.C.6	1.820 mm	0.504 mm
Figure 12	HU.23.C.10	1.040 mm	0.432 mm
Figure 14	HU.23.C.12	1.170 mm	0.468 mm

Description: Test free, compressed, lenticuline, distinctly keeled, close coiled but with a tendency for the last chambers to become uncoiled. Chambers subtriangular, curved, up to thirteen in number in the last whorl in uncoiled specimens, generally up to ten in completely coiled forms. Sutures curved, with the convex side towards the aperture, limbate, raised, each ornamented with numerous guttiform pustules of small size. In some specimens the sutures between the last one or two chambers may be without ornament. The tubercles are generally of similar size along the length of any suture. Aperture at the peripheral angle, terminal, radiate, sometimes on a small neck.

Remarks: In some individuals there is a marked uncoiled stage with five or six chambers in this portion (Plate 5, figure 8; text-figure 9). This species differs from *Lenticulina guttata* var. *eichenbergi* in having much smaller and more regularly spaced tubercles.

Occurrence: D2C, D2B, D1, C11, C10, C9, C8, C7, C6, C5, C4, C3, C2, LB5D.

Lenticulina (*Lenticulina*) *guttata* (Dam) var. *eichenbergi* Bartenstein & Brand

Plate 5, figures 1, 4.

Text-figures 1-4.

Lenticulina (*Lenticulina*) *eichenbergi* BARTENSTEIN & BRAND, 1951, Valendis, p. 285, pl. 5, figs. 118-119; pl. 19A, fig. 24.

Lenticulina (*Lenticulina*) *eichenbergi* BARTENSTEIN & BRAND - BARTENSTEIN, 1956, Hauterive, p. 514, pl. 1, figs. 9-10.

Lenticulina (*Lenticulina*) *eichenbergi* BARTENSTEIN & BRAND - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 27, pl. 3, fig. 51a, b; pl. 4, figs. 72-75.

Lenticulina *eichenbergi* BARTENSTEIN & BRAND - FIANDRIN, MOULIADE & PORTHAULT, 1962, Vocontien, p. 217, pl. 2, fig. 9.

Material: One hundred and one specimens.

Dimensions of figured specimens:

		Maximum Diameter	Thickness
Figure 1	HU.22.C.26	1.170 mm	0.630 mm
Figure 4	HU.23.C.2	1.170 mm	0.450 mm
Text-figure 4	HU.27.C.27	1.430 mm	0.566 mm

Description: Test free, biconvex, slightly compressed, periphery curving, distinct delicate keel. Up to ten subtriangular curved chambers in the last whorl. Sutures, curved, limbate and ornamented by large elevated pustules of various size and shape. The sutures of the last one or two chambers may be without ornament (text-fig. 1, 4; pl. 5, fig. 1, 2). The guttiform pustules are mainly confined to the sutures, but some do occur placed irregularly on the chamber walls between the sutures, particularly on the oldest chambers. The apertual face is flat or gently convex with a limbate rim; aperture at the peripheral angle radiate and sometimes on a small neck.

Remarks: Bartenstein and Brand erected the species Lenticulina (Lenticulina) eichenbergi giving the diagnosis as:- 'a species of the subgenus Lenticulina with separately standing thick or partial knobs superimposed upon the sutures. These knobs only usually occur on the sutures of the oldest chambers and are missing from at least the last suture where a ridge is sometimes developed from one end to the other'. They regarded the species as intermediate between Lenticulina guttata and Lenticulina saxonica the latter having raised, limbate sutures but no guttiform pustules or knobs. In publications by various authors since 1951 Lenticulina guttata and Lenticulina eichenbergi have been regarded as distinct species. After examining a large number of these forms from the Speeton Clay it was found that a number of specimens could not be assigned, with any degree of confidence, to either species as every gradation from one species to the other could be found. Here we have not two different species but a single species showing intra-specific variation. Lenticulina guttata was first recorded by Dam (1946) from the Hauterivian of Glanerbrug and in describing the sutures he said, "they are distinct, curved, limbate and thickened, slightly elevated, ornamented with numerous guttiform pustules. Only the sutures of the last 2 or 3 chambers do not show this ornamentation". (His drawing of the holotype does show that the last two sutures are in fact ornamented by being split up into elongated pustules.) Both _Lenticulina guttata_ and _Lenticulina eichenbergi_ occupy the same stratigraphic range and the writer believes that here we have normal variation of one species in an interbreeding community and that _Lenticulina eichenbergi_ should not be given specific status but be regarded as a variety of _Lenticulina guttata_.

In Germany _L. eichenbergi_ ranges from Ober-Valendis 3 & 4 to Hauterivian. At Speeton the lowest bed in which it is found is D2E and it extends to LB5D.

Occurrence: D2D, D1A, C11, C9, C8, C7, C5, C4, C3, C2, C1, LB5E, LB5D.

Lenticulina (Lenticulina) guttata (Dam) var. _intermedia_ n. var.

Plate 5, figures 2, 9, 15.

Text-figure 5-7.

Material: Fifty-four specimens.

Dimensions of figured specimens:

		Maximum diameter	Thickness
Figure 2	HU.22.C.27	1.040 mm	0.432 mm
Figure 9	HU.23.C.7	1.560 mm	0.630 mm
Figure 15	HU.23.C.13	1.560 mm	0.450 mm

Diagnosis: Test free, biconvex or slightly compressed, initially planispirally coiled but tendency to become uncoiled later. Up to twelve subtriangular chambers in the last whorl. Similar in most respects to Lenticulina guttata but differs from the typical members of the species in the ornament. It has large pustules in the umbilical area which are often of irregular shape, whilst nearer the periphery they are much smaller and of regular disposition. The ornamentation along the last formed sutures is small and fairly regularly spaced apart, particularly if an uncoiled stage is developed.

Variation: Tests vary in the degree of ornamentation, the amount of compression and the tendency for an uncoiled stage to be developed.

Remarks: This variety lies between Lenticulina guttata and Lenticulina guttata var. eichenbergi having large pustules in the umbilical area and smaller ones nearer the periphery.

Occurrence: D2E, D1A, C11, C9, C8, C7, C5, C4, C3, C2, LB5D.

Lenticulina (Lenticulina) guttata var. striata Bartenstein & Brand.

Plate 5, figures 10, 11, 13.

Lenticulina (Lenticulina) guttata striata BARTENSTEIN & BRAND, 1951, Valendis, p. 285, pl. 5, fig. 117.

Material: Thirty-four specimens.

Dimensions of figured specimens:

		Maximum diameter	Thickness
Figure 10	HU.23.C.8	1.300 mm	0.566 mm
Figure 11	HU.23.C.9	1.300 mm	0.414 mm
Figure 13	HU.23.C.11	1.430 mm	0.450 mm

Description: This form agrees with both the typical members of this species and of Lenticulina guttata var. eichenbergi, but differs in having costae running parallel to the periphery which cross the face of the chambers near the peripheral margin. These costae, which are from two to seven in number, may be confined to the last two or three chambers (fig. 13), or may be continuous around the whole periphery of the chambers with the exception of the last one (figures 10-11).

Remarks: Bartenstein and Brand placed this form as a subspecies of Lenticulina guttata but it is here regarded as of varietal status only. The specimen illustrated as figure 13 is identical with the holotype of

Bartenstein and Brand. The other two specimens figured here as *Lenticulina guttata* var. *striata* are different from any other described forms in that the costae are continuous over almost the entire last whorl.

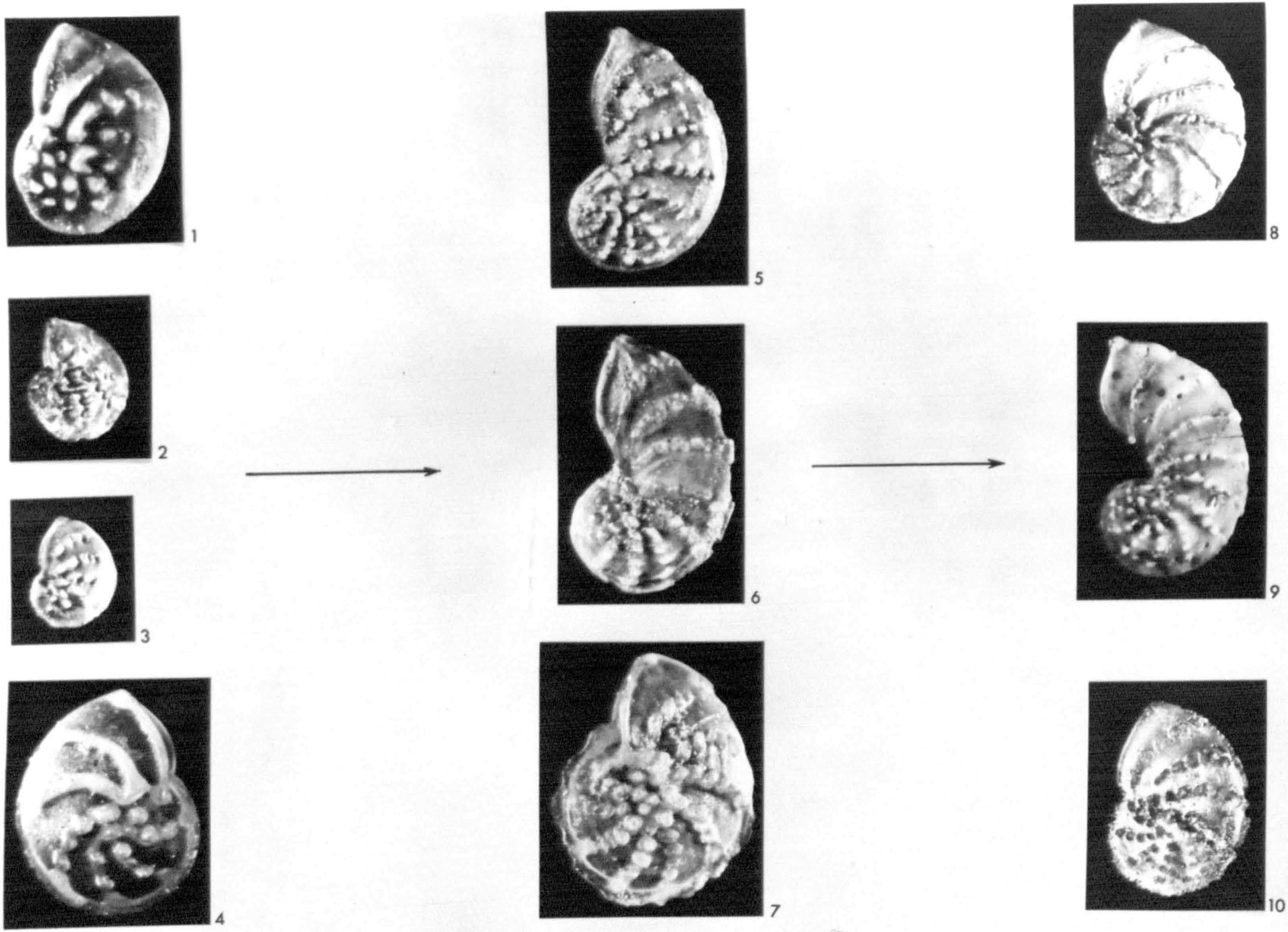
Occurrence: D1A, C11, C10, C8, C5, C4, C3, C2, LB5E

SUMMARY OF THE MAIN MORPHOLOGICAL FEATURES OF *Lenticulina* (*Lenticulina*) *guttata* AND ITS VARIETIES.

L. (*L.*) *guttata* - - - - - - - - Raised sutures have small closely spaced tubercles along the whole of their length, from umbilical area to periphery.

L. (*L.*) *guttata* var. *eichenbergi* Large tubercles generally aligned along sutures. Pustules may be absent along the last two sutures which are limbate and raised well above the surface.

L. (*L.*) *guttata* var. *intermedia* - Large tubercles in the umbilical area but these become smaller towards the periphery in the coiled portion. In the uncoiled portion the pustules remain small along the sutures.



Lenticulina guttata (DAM) VAR. eichenbergi BARTENSTEIN & BRAND

Lenticulina guttata (DAM) VAR. intermedia N. VAR.

Lenticulina guttata (DAM)

L. (L.) guttata var. striata - - - - - Typically has costae on the final two or three chambers, but they may extend over the entire last whorl. Costae marginal and following the peripheral outline.

Lenticulina (Lenticulina) heiermanni BETTENSTAEDT.

Plate 4, figures 18 - 19.

Cristellaria D113, HECHT, 1938, Unterkreide, pl. 17b, fig. 38.

Lenticulina (Lenticulina) heiermanni BETTENSTAEDT, 1952, Barreme, p. 270, pl. 1, figs. 9-11.

Lenticulina (Lenticulina) heiermanni BETTENSTAEDT - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 272, pl. 39, fig. 1.

Material: One hundred and twenty-three specimens.

Dimensions of figured specimens:

		Maximum diameter	Thickness
Figure 18	HU.22.C.24	1.170 mm	0.612 mm
Figure 19	HU.22.C.25	1.300 mm	0.720 mm

Description: Test free, biconvex; periphery gently curving or slightly subangular, keeled. The test is involute with ten or eleven gently curving chambers in the last whorl. They are of uniform shape and increase very gradually in size as added. Sutures limbate, raised above the surface of the test and curve backwards towards the peripheral margin; apertual side of the sutures convex. At the umbilicus there is a clear calcite boss which is raised above the surface; all sutures are fused to this boss. Aperture at the peripheral angle, distinctly radiate and may be on a small neck. Apertual face very slightly inflated.

Variation: Appears to be little variation apart from the degree of elevation of the limbate sutures above the general surface of the test.

Remarks: The characteristic feature of this species is the biconvex test with the raised limbate ribs which meet the raised umbilical boss. The keel is easily broken giving a ragged outline.

Occurrence: C5, C4, C1, LB5, LB4, LB3, LB2. Numerically strongest in the Lower B beds.

Lenticulina (Astacolus) pachynota (DAM)

Plate 6, figures 16 - 18.

Plate 7, figures 3 - 5, 9, 11.

Cristellaria D115 - HECHT, 1938, Unterkreide, pl. 15b, fig. 1-13.
Vaginulinopsis pachynota DAM, 1946, Netherlands, p. 575, pl. 88, figs. 5 - 6.
Lenticulina (Vaginulinopsis) pachynota (DAM) - BARTENSTEIN, 1956, Hauterive, p. 516, fig. 55.
Lenticulina (Astacolus) pachynota (DAM) - ZEDLER, 1961, p. 37, pl. 8, fig. 7.

Material: Two hundred and fifty-three specimens.

Dimensions of figured specimens:

		Length
Figure 16.	HU.23.C.22	0.630 mm
Figure 3.	HU.23.C.24	0.756 mm
Figure 9	HU.23.C.27	0.540 mm
Figure 11.	HU.24.C.1	0.720 mm

Description: Test free, elongate, much compressed, oval in cross-section. Initially planispirally coiled with three to four triangular chambers; later portion uncoiled with four to five low, broad, triangular chambers. The dorsal periphery is convex, not lobulate, and the ventral periphery concave. Chambers distinct, depressed, increasing gradually in size as added. Sutures distinct, oblique, slightly curved, limbate, elevated. Wall smooth; aperture radiate, at the outer peripheral angle.

Remarks: Recorded from the Upper Hauterivian to Barremian in north-west Germany, from the middle Hauterivian of Holland and from the Hauterivian of Lincolnshire. At Speeton it occurs in the upper D beds but is found mainly in the upper Hauterivian.

Occurrence: D4, D3, D2, C6, C5, C4, C2, C1, LB3.

Lenticulina (Astacolus) cf. pachynota (Dam)

Plate 7, figures 6 - 8.

Material: Three specimens.

Dimensions of figured specimen:

		Length
Figure 7	HU.23.C.25	0.504 mm

Remarks: This figured specimen is clearly closely related to Lenticulina (Astacolus) pachynota (Dam) and agrees in every respect except for its less compressed cross-section and the fact that the later chambers extend back nearly to the coil on the ventral margin. In this respect it is similar to L. (A.) grata (Reuss) though this latter species has a more pronounced, narrower, initial coiled portion and a more elongate slimmer test.

Occurrence: D2E, C11, C8.

Lenticulina (Astacolus) schlönbachi (Reuss)

Plate 6, figures 13 - 15.

Plate 7, figures 1 - 2.

Cristellaria schlönbachi REUSS, 1863, Hils und Gault, p. 65, pl. 6, figs. 14-15.

Cristellaria schloenbachi REUSS - CHAPMAN, 1894, Folkestone, p. 649, pl. 9, fig. 9.

Astacolus schloenbachi (REUSS) - EICHENBERG, 1935, Unterkreide, pl. 12, fig. 6.

Cristellaria D102 HECHT, 1938, Unterkreide, pl. 19b, figs. 20-21.

Lenticulina (Astacolus) schlönbachi (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 286, pl. 5, fig. 124, 125.

Material: One hundred specimens.

Dimensions of figured specimens:

		Length
Figure 13	HU.23.C.21	0.504 mm
Figure 1	HU.23.C.23	0.630 mm

Description: Test free, elongate, early portion close coiled becoming uncoiled in the adult portion, compressed oval in cross-section. Chambers indistinct in the initial portion, distinct in the coiled portion which has five to six, broader than high chambers, the last few of which may be inflated. Sutures indistinct in early coiled portion but later becoming distinct, oblique and sometimes depressed. Wall smooth; aperture radiate, at the peripheral angle, slightly projecting.

Remarks: This species is similar to L. (A.) pachynota but lacks the limbated elevated sutures and is slimmer and often not so compressed. Bartenstein records Lenticulina (Astacolus) schlönbachi from the Middle and Upper Valanginian of North-West Germany, whilst Bartenstein & Bettenstaedt (1962) give the range of Lenticulina (Astacolus) cf. schloenbachi up to midde Albian.

Occurrence: D6, D2, D1, C8, C5, C4, C3, C2, C1, LB5, LB3, LB2.

Lenticulina (*Astacolus*) *schreiteri* (Eichenberg)

Plate 9, figures 9 - 14.

Elphidium schreiteri EICHENBERG, 1935, Unterkreide, p. 398, pl. 13, fig. 11.

Vaginulinopsis reticulosa DAM, 1946, Netherlands, p. 574, pl. 88, fig. 4.

Lenticulina d'orbignyi schreiteri (EICHENBERG) - BARTENSTEIN & BRAND, 1951, Valendis, p. 281, pl. 4, figs. 104-105.

Lenticulina d'orbignyi multireticulosa BARTENSTEIN & BRAND, 1951, Valendis, p. 282, pl. 5, figs. 133-134.

Lenticulina (*Astacolus*) *schreiteri* (EICHENBERG) - ZEDLER, Hauterive, p. 38, pl. 8, figs. 5-6.

Material: Three hundred and twelve specimens.

Dimensions of figured specimens:

		Length.
Figure 9	HU.24.C.23	0.566 mm
Figure 10	HU.24.C.24	0.414 mm
Figure 11	HU.24.C.25	0.756 mm
Figure 12	HU.24.C.26	0.720 mm
Figure 13	HU.24.C.27	0.882 mm
Figure 14	HU.25.C.1.	1.040 mm

Description: Test free, elongate, compressed. Initially coiled, planispiral, evolute soon becoming uncoiled. The coiled arcuate portion has three to eight low, broad, subtriangular chambers; those in the coiled proximal portion are not visible due to the ornamentation. The whole test has a strong reticulate ornament standing up well above the surface of the test. Longitudinal costae extend the length of the test and are intersected by transverse straight or gently curved sutures. The ornament in the coiled portion is not as geometrically regular as that in the remaining part of the test. The longitudinal ornament is curved and follows the outline of the test. Distinct keel on the early coiled portion but this may become indistinct later. The apertual face is narrow, curved, flat or may be depressed with a surrounding sutural rim. The aperture is radiate, on a distinct neck at, or close to, the peripheral margin.

Variation: Mainly occurs in the ornament where it varies from strong and regular to a very irregular and sometimes weak reticulate pattern. To a lesser extent the degree of coiling is variable.

Remarks: This species is probably synonymous with Lenticulina d'Orbigny (Roemer) from the German Jurassic. Roemer's illustration however appears to be a schematic one, with very regular ornament. The figure shows a coiled form with no tendency to become uncoiled. The description is poor and no depository of the type is given. Until topotype material has been examined it has been assigned to Lenticulina schreiteri which Eichenberg (1939) described from the Neocomian of Germany.

Eichenberg's description is much better than that of Roemer but the illustration is too poor to allow detail of ornament to be seen. Vaginulinopsis reticulosa Dam has weak ornament but falls within the observed range of variation of Lenticulina (A) schreiteri. The species in N.W. Germany ranges from Upper Valanginian to Barremian and the distribution at Speeton is very similar with the maximum number occurring in the Upper Hauterivian.

Occurrence: D2, D1, C11, C10, C9, C8, C5, C4, C3, C2, C1, LB3.

Lenticulina (Marginulinopsis) foeda (Reuss)

Plate 9, figures 15 - 18.

Cristellaria foeda REUSS, 1863, Hils und Gault, p. 64, pl. 6, figs. 11-12.

Marginulina foeda (REUSS) - EICHENBERG, 1933, Unterkreide, p. 8, pl. 5, fig. 6.

Lenticulina (Marginulinopsis) foeda (REUSS) - BARTENSTEIN, 1956, Hauterive, p. 516, pl. 2, figs. 57, 58.

Material: Nine hundred and fifteen specimens.

Dimensions of figured specimens:

		Length
Figure 15	HU.25.C.2	0.864 mm
Figure 16	HU.25.C.3	0.918 mm
Figure 17	HU.25.C.4	0.684 mm
Figure 18	HU.25.C.5	0.720 mm

Description: Test small, elongate, circular in cross-section. Microspheric and megalospheric forms recognised. The microspheric form has the early chambers coiled followed by an uncoiled portion of three to four chambers in a linear series. The megalospheric form (fig. 15) has no initial series of coiled chambers, the large globular proloculus being followed by three or four chambers either in a linear series or a gently curving one. The chambers are about twice as wide as high, slightly inflated except for the last one which is distinctly inflated. They increase gradually in height as added but the width remains nearly constant. The sutures are distinct except when obscured by the ornamentation, straight or oblique, contricted, giving a lobulate outline to the test. Surface of the test strongly hispid and this may mask the individual chambers and sutures. The aperture is terminal, marginal, radiate, on a long tubular lipped neck. The surface of the chambers, which is subglobular, is frequently smooth.

Variation: Apart from the variation due to dimorphism, considerable variation is seen in the ornamentation which ranges from very finely hispid to very prominent and densely hispid.

Occurrence: D6I, D4, D3, D2, D1, C11, C5, C4, C2, C1, LB6, LB5, LB4, LB3, LB2.

Lenticulina (Marginulinopsis) gracilissima (Reuss)

Plate 9, figures 19 - 21.

Cristellaria gracilissima REUSS, 1863, Hils und Gault, p. 64, pl. 6, figs. 9-10.

Cristellaria gracilissima REUSS - SHERLOCK, 1914, Speeton, p. 260, pl. 2, fig. 26.

Cristellaria (Astacolus) gracilissima REUSS - EICHENBERG, 1933, Barreme, p. 175, pl. 2, fig. 8.

Astacolus gracilissima REUSS - EICHENBERG, 1935, Unterkreide, pl. 11, fig. 8.

Marginulina D21 - HECHT, 1938, Unterkreide, pl. 76, fig. 66; pl. 8a, fig. 19; pl. 9a, fig. 29; pl. 10a, fig. 15; pl. 11b, figs. 1-9; pl. 19b, figs. 31-50.

Marginulinopsis gracillissima (REUSS) - DAM, 1948, Neocomian, p. 184, pl. 32, figs. 7-8.

Lenticulina (Marginulinopsis) gracilissima (REUSS) - BRAND, 1951, Valendis, p. 288, pl. 6, fig. 139.

Lenticulina (Marginulinopsis) gracilissima (REUSS) - BARTENSTEIN, 1956, Hauterive, p. 516, pl. 2, fig. 59.

Lenticulina (Marginulinopsis) cf. gracilissima (REUSS) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 31, pl. 6, fig. 121.

Lenticulina (Marginulinopsis) gracilissima (REUSS) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 256, pl. 38, fig. 2.

Material: Seven hundred and twenty-five specimens.

Dimensions of figured specimens:

		Length
Figure 19	HU.25.C.6	0.594 mm
Figure 20	HU.25.C.7	0.630 mm
Figure 21	HU.25.C.8	0.540 mm

Description: Test is elongate, slender, circular in cross-section. Early portion has four to five coiled chambers followed by an uncoiled portion with three or four chambers in a linear series. The chambers are inflated ventrally, as broad as high and increase gradually as added. The last chamber is higher than wide and frequently considerably inflated. The sutures are distinct, depressed, constricted, slightly curved, oblique in the uncoiled portion of the test. The surface of the test is without ornamentation, smooth, calcareous. The aperture is radiate, on a distinct neck at the dorsal angle. The neck may be vertical or tilted outwards.

Variation: In the general outline and robustness of the test, the curvature of the dorsal margin and the degree of initial coiling. The microspheric form always has an early coiled portion but in the megalospheric form the initial coiled portion is often absent.

Remarks: Zedler (1961) regards *Lenticulina* (*Marginulinopsis*) *gracilissima* and *Lenticulina* (*Marginulinopsis*) *foeda* as synonymous. The writer does not agree with this view as the hispid surface of this latter makes it distinctive from *L.* (*Marginulinopsis*) *gracilissima*, and their stratigraphic distribution is different.

Occurrence: D7C, D7A, D6, D4, D2, C9, C7, C6, C4, C3, C2, C1, LB5, LB4, LB3, LB2, LB1.

Lenticulina (*Marginulinopsis*) *robusta* (Reuss)

Plate 8, figures 1 - 6.

Marginulina robusta REUSS, 1863, Hils und Gault, p. 63, pl. 6, figs. 5-6.

Marginulina robusta REUSS - CHAPMAN, 1894, Folkestone, p. 163, pl. 4, fig. 23.

Marginulina jonesi REUSS - SHERLOCK, 1914, Speeton, p. 259, pl. 18, fig. 15.

Marginulina robusta REUSS - EICHENBERG, 1932, Unterkreide, p. 6, pl. 3, fig. 4.

Marginulina D13 - HECHT, 1938, Unterkreide, pl. 10b, figs. 67-69; pl. 11b, figs. 10-16.

Marginulina robusta REUSS - DAM, 1948, Neocomian, p. 158, pl. 32, fig. 6.

Marginulina jonesi REUSS - DAM, 1950, Albien, p. 22, pl. 2, fig. 4.

Lenticulina (Marginulinopsis) robusta (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, pl. 6, figs. 142-143; pl. 14B, fig. 9; pl. 15C, fig. 14; pl. 15D, fig. 7.

Lenticulina (Marginulinopsis) robusta robusta (REUSS) - BARTENSTEIN, 1956, Hauterive, p. 515, pl. 1, figs. 11, 17, 25.

Material: One thousand two hundred and seventy-seven specimens.

Dimensions of figured specimens:

		Length	Width
Figure 1	HU.24.C.8	0.810 mm	0.252 mm
Figure 2	HU.24.C.9	0.720 mm	0.263 mm
Figure 3	HU.24.C.10	0.630 mm	0.270 mm
Figure 5	HU.24.C.11	0.540 mm	0.216 mm

Description: Test free, robust, elongate, early portion coiled but later portion uncoiled and arcuate. In cross-section it is slightly compressed, subcircular or oval though some specimens are circular. The subglobular proloculum is followed by three coiled chambers which are succeeded by four or five subtriangular, curved chambers. The sutures are narrow, oblique sometimes slightly constricted distally, usually indistinct due to ornament. Ornament is strong and consists of eight to thirteen longitudinal ribs which run the whole length of the test, gently curving as they cross the initial coiled part. Aperture radiate, marginal on a distinct neck.

Remarks: Closely related to Lenticulina jonesi (Reuss) but this species lacks costae on the last one or two chambers. Some of the forms at Speeton are rather elongate and slim compared with the more typical examples of the species.

Occurrence: D7C, D7A, D6, D5, D4, D3, D2, D1, C11, C10, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB6, LB5, LB4, LB3, LB2.

Lenticulina (Marginulinopsis) striatocostata (Reuss)

Plate 8, figures 13 - 17.

Marginulina striatocostata REUSS, 1863, Hils und Gault, p. 62, pl. 6, fig. 2.

Marginulina striatocostata REUSS - CHAPMAN, 1894, Folkestone, p. 163, pl. 4, fig. 21.

Marginulina D18 HECHT, 1938, Unterkreide, pl. 23, figs. 82-83.

Lenticulina (Marginulinopsis) striatocostata (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 289, pl. 6, fig. 141.

Material: Forty-two specimens.

Dimensions of figured specimens:

		Length
Figure 13.	HU.24.C.14	0.810 mm
Figure 16	HU.24.C.15	0.792 mm

Description: Test elongate, circular in cross-section. Early portion coiled but main part of test uncoiled and gently arcuate. Chambers inflated, drum shaped, distinct except in the initial coiled portion; width of chambers remains fairly constant as added but the increase in height is rather irregular. Sutures slightly oblique, depressed, constricted giving a lobulate outline to the test. Ornament consists of up to twenty, fine, longitudinal, straight or slightly twisted ribs extending across the whole length of the test. Aperture marginal, terminal, and on a small neck.

Alternation of Generations: The microspheric form has (figs. 15-17) a small proloculum, better developed initial coiled portion, more chambers and apparently a greater number of ribs. The commoner megalospheric individual (figs. 13-14) has a larger proloculum and the initial coiled portion is not so clearly developed.

Remarks: This species differs from *Lenticulina* (*Marginulinopsis*) *robusta* (Reuss) in having much finer ribs, a less compressed cross-section, distinct depressed sutures and the irregular shape of the test. There appears little variation in individuals except in the number and curvature of the ribs.

Occurrence: Confined to D6 (D6H - D6A)

Lenticulina (Planularia) crepidularis (Roemer)

Plate 9, figures 1 - 8 & text-figure.

Plate 22, figure 6.

Planularia crepidularis ROEMER, 1842, Neue Kreide, p. 273, pl. 7B, fig. 4.

Cristellaria crepidularis (ROEMER) - REUSS, 1863, Hils und Gault, p. 69, pl. 7, fig. 10.

Cristellaria tricarinella REUSS, 1863, Hils und Gault, p. 68, pl. 7, fig. 9; pl. 12, figs. 2-4.

Cristellaria chapmani SHERLOCK, 1914, Speeton, p. 261, pl. 19, fig. 7.

Planularia tricarinella REUSS - EICHENBERG, 1934, Hauterive, p. 159, pl. 13, fig. 6.

Planularia tricarinella REUSS - EICHENBERG, 1935, Unterkreide, p. 159, pl. 13, fig. 6.

Cristellaria D66 HECH T, 1938, Unterkreide, pl. 15a, figs. 1-7; pl. 15b, row 1; pl. 13b, fig. 15; pl. 14a, figs. 1-4; pl. 14b, figs. 5-11; pl. 16a, figs. 44-48; pl. 16b, figs. 12-21; pl. 19a, figs. 73-80;

pl. 20b, figs. 19-27; pl. 21, fig. 19.

Lenticulina crepidularis (ROEMER) - BARTENSTEIN & BRAND, 1951, Valendis, p. 282, pl. 5, figs. 106-108; pl. 16, figs. 19-20; pl. 17B, fig. 8; pl. 19B, figs. 55-56.

Lenticulina crepidularis (ROEMER) - BETTENSTAEDT & WICHER, 1955, Tethys & Boreal, p. 504, pl. 4, fig. 32.

Lenticulina (Astacolus) crepidularis (ROEMER) - BARTENSTEIN, 1956, Hauterive, p. 515, pl. 1, figs. 14-16.

Lenticulina (Astacolus) crepidularis (ROEMER) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 29, pl. 3, fig. 55; pl. 4, figs. 82-83.

Lenticulina (Astacolus) tricarinella (REUSS) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 30, pl. 3, fig. 56; pl. 4, figs. 84-85.

Planularia crepidularis ROEMER - SZTEJN, 1958, M. Poland, p. 23, fig. 44.

Lenticulina (Planularia) crepidularis (ROEMER) - ZEDLER, 1961, Hauterive, pp. 34-37, pl. 8, figs. 1-4.

Lenticulina (Planularia) crepidularis (ROEMER) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 260, pl. 36, fig. 7.

Planularia crepidularis (ROEMER) - SORGENFREI & BUCH, 1964, Denmark, p. 122, pl. 1, fig. 4.

Material: One thousand, two hundred and seven specimens.

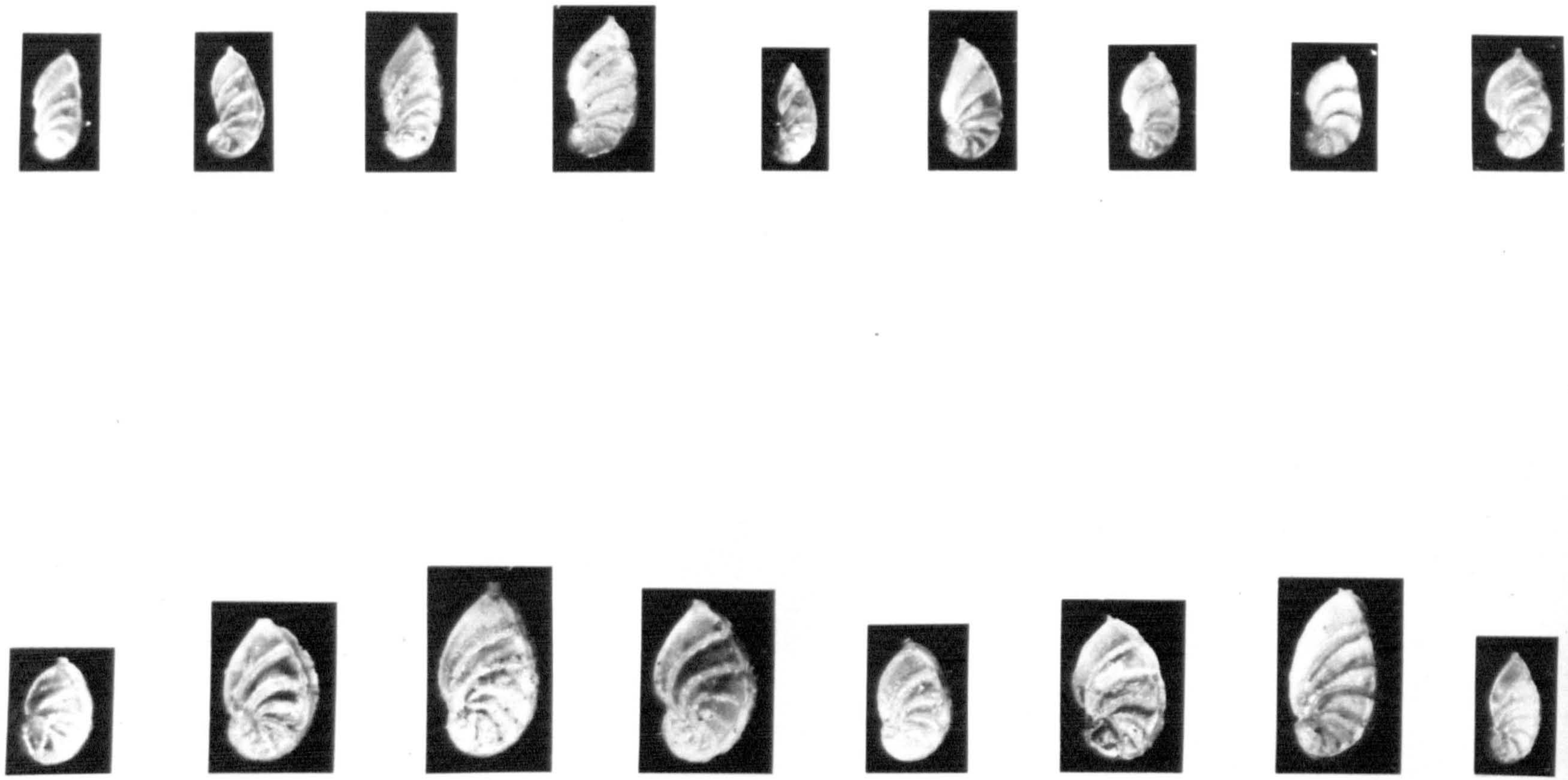
Dimensions of figured specimens:

		Length
Figure 1	HU.24.C.16	0.540 mm

		Length
Figure 2	HU.24.C.17	0.666 mm
Figure 3	HU.24.C.18	1.300 mm
Figure 4	HU.24.C.19	1.430 mm
Figure 6	HU.24.C.20	1.310 mm
Figure 7	HU.24.C.21	1.040 mm
Figure 8	HU.24.C.22	1.040 mm

Description: Test free, much compressed with nearly parallel sides; initially coiled, involute, later becoming uncoiled. In the uncoiled portion the chambers are in a straight or curving series. In completely coiled individuals there are six to eight chambers in the last whorl whilst in the uncoiled forms ten to twelve may be visible. The chambers in side view are low and broad, wedge shape, tapering towards the proloculus, at first curving but later becoming straighter. Sutures distinct, limbate and raised considerably above the surface of the test. These sutural ribs may be either robust or extremely delicate, and may meet the periphery tangentially, fusing to form a thickened peripheral margin. In the initial coiled portion the sutures do not meet at the centre. The periphery is smoothly curving, carinate and frequently has three distinct keels. The apertual face is smooth with a radiate aperture, on a small neck, at the peripheral angle.

Alternation of generations: Two generations have been observed with the microspheric form coiled throughout and the megalospheric form uncoiling.



Lenticulina crepidularis (ROEMER, 1842) Variation in one sample at horizon LB4D

x26

Variation: This species shows a wide range of variation, principally in the degree of coiling. This is illustrated in the accompanying text-figure of individuals from a sample taken from bed LB4D. In addition considerable differences occur in the size and shape of the test and also in ornamentation. The peripheral margin of the form in figure 7 has a normal keel in the earlier portion but on the last three chambers the keel is not continuous and twists to almost joining the sutures. An extreme variant is shown in plate 22, figure 6, which has an umbilical area similar to L. wisselmanni. This specimen is very close to one figured by Bartenstein, Bettenstaedt & Bolli (1957, pl. 3, fig.5).

Remarks: Lenticulina (Planularia) crepidularis is a very common species in the Lower Cretaceous throughout Europe, North America, Trinidad and North Africa. It also occurs in the Jurassic where it is usually referred to as Lenticulina (Planularia) tricarinella REUSS.

Occurrence: D2, D1, C11, C10, C9, C6, C5, C4, C3, C2, C1, LB6, LB5, LB4, LB3, LB2.

Lenticulina (Saracenaria) bronnii (ROEMER)

Plate 8, figures 7 - 12.

Planularia bronnii ROEMER, 1841, Kreidegeb., p. 97, pl. 15, fig. 14.

Cristellaria bronni ROEMER - REUSS, 1863, Hils und Gault, p. 70, pl. 7, fig. 13.

Cristellaria bronni ROEMER - CHAPMAN, 1894, Folkestone, p. 649, pl. 9, fig. 12-13.

Cristellaria D95 - HECHT, 1938, Unterkreide, pl. 22, figs. 21-22.

Cristellaria D82 - HECHT, 1938, Unterkreide, pl. 11b, figs. 64-77.

Lenticulina (Saracenaria) bronnii (ROEMER) - BARTENSTEIN & BRAND, 1951, Valendis, p. 290, pl. 6, fig. 148.

Lenticulina (Saracenaria) bronnii (ROEMER) - BARTENSTEIN, 1956, Hauterive, p. 516, pl. 1, figs. 7, 12.

Lenticulina (Saracenaria) cf. *bronnii* (ROEMER) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 33, pl. 3, fig. 61.

Saracenaria bronnii (ROEMER) - SZTEJN, 1958, Middle Poland, p. 35, fig.77.

Lenticulina (Saracenaria) bronnii (ROEMER) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 257, pl. 36, fig. 3; pl. 38, fig. 3.

Material: One hundred and fifty-three specimens.

Dimensions of figured specimens:

		Maximum Length	Maximum Width
Figure 7	HU.24.C.12	0.566 mm	0.288 mm
Figure 10	HU.24.C.13	0.630 mm	0.270 mm

Description: Test free, robust, arcuate with the early portion coiled, later chambers becoming uncoiled. The uncoiled portion is triangular in transverse section with rounded angles. The chambers are distinct, inflated and are nearly twice as broad as high. They increase in size quite rapidly as added and the last chamber may be much larger and more inflated than the preceding one. The proloculum is followed by three to four coiled chambers which give rise to two to four chambers arranged in a linear series. The sutures are distinct, depressed, constricted, curved in the initial coiled portion but oblique and becoming straighter in remaining part of the test. The wall is calcareous, smooth and without ornamentation. The radiate aperture is at the peripheral angle and may be either produced on a very slight neck or be flush with the surface of the test.

Variation: Though some variation exists the total range is small. The degree of angularity of the test in cross-section is variable, as seen when figure 8 is compared with figure 11. The sutures are also variable in the amount they are depressed (figure 9 and figure 12). In figure 7 the chambers are seen to increase rapidly in breadth giving a test which diverges rapidly.

Remarks: It is closely related morphologically to Lenticulina (Saracenaria) italica (Defrance) but is distinguished from it by the more rounded angles to the test. It has been recorded from Upper Valanginian to Lower Aptian in Europe and from the Middle Barremian of Trinidad.

Occurrence: D7A, D6, D5, D4, D1, C11, C7, C5, C4, C3, C2, C1, LB6, LB5, LB4.

Lenticulina (Saracenaria) cf. jarvisi (Brotzen)

Plate 7, figures 15 - 22.

Astacolus jarvisi BROTZEN, 1936, Senon, p. 57, pl. 3, fig. 5; text fig. 17.

Material: Ninety specimens.

Dimensions of figured specimens:

		Length
Figure 15	HU.24.C.3	0.504 mm
Figure 17	HU.24.C.4	0.954 mm
Figure 21	HU.24.C.5	0.846 mm

Description: Test fairly large, elongate with an early coiled portion which is umbonate. Later chambers uncoiled and the test becoming triangular in transverse section. The early coiled portion has up to six chambers followed by five or six in a gently curving, uncoiled series. The sutures are distinct, limbate, raised above the surface, radial and curved initially, oblique and curved later, reaching down towards the umbonal area. Apertual face may be depressed and the sides thickened, triangular in shape. Aperture radiate, at the outer peripheral angle.

Variation: This occurs in the size of the test, the degree of coiling and the breadth of the test across the apertual face.

Remarks: Brotzen (1936) described this species from the Senonian of Sweden and the Speeton forms appear to fall within the width of variation which he described, though the sutures seem to be more elevated than those illustrated by Brotzen. No identical specimens have been seen in the extensive collections of Lower Cretaceous foraminifera housed at Frankfurt, Hannover or Celle though Bettenstaedt (personal discussion) has suggested that it may be an ancestral form of the Barremian species Lenticulina forticostata Bettenstaedt. The chambers in the uncoiled portion of this latter species are arranged in a linear series rather than a gently curving one. Lenticulina italica (Defrance) described from the Italian Pliocene is morphologically very close to this species but is not so well coiled and the chambers do not reach down towards the axis of coiling. Cristellaria navicula d'Orbigny is closer coiled and has not the thick, elevated sutures. Cristellaria triangularis d'Orbigny also from the Cretaceous of France is similar in side view but has a smaller initial coil and a more triangular cross-section.

There are many species that could be compared with the form described here but this only reflects the common tendency for various species of

Lenticulina to become uncoiled and assume a triangular cross-section at various stratigraphical levels.

Occurrence: D6, D5A, D4, D2, D1, C10, C9, C8, C7, C5, C4, C3, C2, LB4.

Lenticulina (Saracenaria) valanginiana Bartenstein & Brand

Plate 7, figures 23 - 28.

Lenticulina (Saracenaria) valanginiana BARTENSTEIN & BRAND, 1951, Valendis, p. 291, pl. 13, figs. 364-365.

Material: Forty-four specimens.

Dimensions of figured specimens:

		Length
Figure 23	HU.24.C.6	0.450 mm
Figure 26	HU.24.C.7	0.630 mm

Description: Test free, elongate and subtriangular in cross-section. The initial part is coiled but soon becomes uncoiled. The smooth globular proloculus is followed by two or three close coiled chambers and then by three to five chambers in a rectilinear series. The chambers, which are triangular in section, are slightly inflated, broader than high and increase rapidly in breadth as added. The face and two sides of the individual chambers are all approximately equal in breadth; the two side faces of the test may be slightly concave. The angles of the test are sharp and keeled. Sutures are distinct, depressed, inclined and gently curving on the uncoiled portion of the test but tend to be indistinct on the initial coiled portion. The ornament consists of three well defined keels at the angles and distinct fine ribs crossing the chambers and sutures. On the side faces two ribs originate near the proloculum and continue to the apertual margin. They may converge towards the aperture as in the figured specimen (fig. 23). The apertual face has two to three ribs extending the whole length of the test. The aperture is radiate at the peripheral angle and on a small neck.

Remarks: It differs from Saracenaria spinosa Eichenberg in having fine ribs and less prominent keels; from Lenticulina (S.) bononiensis (Berthelin) in its smaller planispirally coiled initial portion. Bartenstein & Brand recorded this species in the Mittel Valendis 1 and 2 of north-west Germany.

Occurrence: D7, D6, D4.

Lenticulina (*Vaginulinopsis*) *humilis* *praecursoria* Bartenstein & Brand

Plate 7, figures 12 - 14.

Lenticulina (*Vaginulinopsis*) *humilis* *praecursoria* BARTENSTEIN & BRAND, 1951, Valendis, p. 287, pl. 5, figs. 126-127.

Material: Seventeen specimens.

Dimensions of figured specimen:

Figure 12.	HU.24.C.2	Length 1.040 mm

Description: Test free, robust, elongate, arcuate, and oval in cross-section. Early portion coiled becoming uncoiled later with four to six chambers in a gently curving series; chambers broader than high. Sutures in coiled portion radial but in the uncoiled portion are distinct, curved, limbate, raised slightly above the surface of the test. Wall calcareous with a smooth surface. Aperture radiate, at the peripheral angle.

Remarks: Bartenstein and Brand described this subspecies from the Middle and Upper Valanginian of North-west Germany. It differs from *Lenticulina humilis* (REUSS) in having less prominent sutures, a less compressed test, and a rounder not so tapering proximal portion. The specimen figured here is from the Lower Barremian (LB4).

Occurrence: D5, D4, D2, D1, C5, C4, C1, LB5, LB4, LB3.

Genus CITHARINA d'Orbigny, 1839

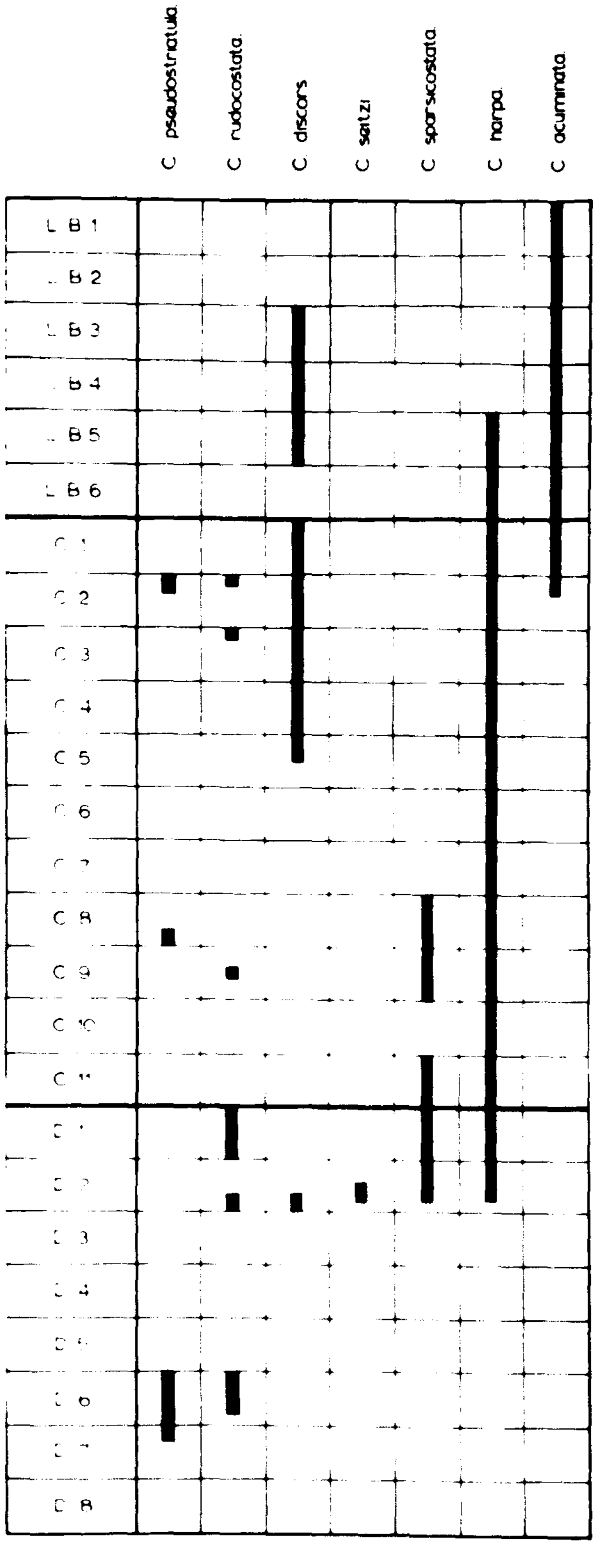
Type species _Vaginulina_ (_citharina_) _strigillata_ Reuss 1846

D'Orbigny's original description of the genus (1839) is (transl.) "Test free, regular, equilateral, elongate to triangular, strongly compressed, straight or arched. Chambers narrow, superimposed without overlapping, always very oblique after the initial globular proloculus; last chamber truncate. Aperture rounded, marginal, at the angle of the test."

Marie (1938) emended d'Orbigny's original description emphasising that _Citharina_ never has an initial coiled portion.

Though the genus was described by d'Orbigny in 1839, he did not name or illustrate any species. Marie (1938) designated _Vaginulina_ _striatula_ Roemer, 1842 as the type species of the genus but this could not be accepted under the Rules of International Zoological Nomenclature as _V._ _striatula_ was not published in connection with _Citharina_. Loeblich and Tappan (1949) designated _Citharina_ _strigillata_ Reuss as the type of the genus stating that "this was the first species so referred". Ellis and Messina point out that this is not true as it is preceded (Reuss p. 106) by _Vaginulina_ (_Citharina_) _costulata_ (Roemer); however, the designation by Loeblich and Tappan now stands.

The genus is a difficult one to deal with as it so closely resembles _Vaginulina_ and the ornament of both is very variable. _Citharina_ can usually be distinguished by its more oblique chambers and sutures, the degree of compression and often its stronger ornamentation. Its range



Distribution of the Genus Citharina in the D, C and Lower B beds at Speeton.

is Lower Jurassic to Lower Eocene though is often regarded as a typical Cretaceous genus.

Citharina acuminata (REUSS)

Plate 12, figures 3-4

Vaginulina acuminata REUSS, 1863, Hils und Gault, p. 49, fig. 1.

Vaginulina acuminata REUSS - EICHENBERG, 1933, Barreme, p. 187, pl. 23, fig. 11.

Vaginulina acuminata REUSS - EICHENBERG, 1935, Unterkreide, pl. 8, fig. 7,

Vaginulina D9 HECHT, 1938, Unterkreide, pl. 11b, fig. 96-97; pl. 9a, fig. 48; pl. 10b, fig. 95-98; pl. 12a, figs. 50-51; pl. 12b, figs. 96-98; pl. 13a, figs. 50-52.

Vaginulina D 19 - HECHT, 1938, Unterkreide, pl. 14b, figs. 46-47; pl. 15a, figs. 94-95; pl. 15b, figs. 62-64.

Citharina acuminata (REUSS) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 39, pl. 7, figs. 159a, b.

Citharina acuminata (REUSS) - BARTENSTEIN, 1959, Hauterive, p. 464, pl. 23, fig. 2.

Citharina acuminata (REUSS) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 271, pl. 38, fig. 13.

Material: One hundred and eighty-seven specimens.

Dimensions of figured specimens:

		Length
Figure 3	HU.26.C.5	0.990 mm
Figure 4	HU.26.C.6	1.950 mm

Description: Test free, triangular in outline, compressed, elongate, slender, delicate. Dorsal edge is straight whilst the ventral margin is convex. The test tapers both proximally and distally with the greatest width at about the mid-point of the test. The angle of divergence of the margins from the proloculus is rather variable though generally is about 15 degrees. The chambers are broad but very low, oblique and in a straight series. Sutures strongly oblique, straight, flush with the surface and usually obscured by the ornament. The wall is ornamented by six to nine closely spaced longitudinal ribs which diverge from the proloculus and extend without interruption over the entire length of the test. The aperture is radiate, on a sub-cylindrical neck at the dorsal angle.

Variation: This species, apart from the rib pattern, exhibits little variation.

Remarks: Citharina acuminata was first described from the Upper Hils clay of Germany and has since been recorded from Holland, Trinidad and Alaska. In north-west Germany it ranges from the Upper Hauterivian to Lower Albian but is found most frequently in the Barremian. At Speeton it occurs in the Upper C and Lower B beds. It differs from <u>Vaginulina strigillata</u> Reuss in having a more slender delicate test and ribs which are continuous over a large proportion of the test.

<u>Occurrence</u>: C3, C2, C1, LB6, LB5, LB4, LB3, LB2, LB1.

<u>Citharina</u> cf. <u>discors</u> (Koch)

Plate 10, figures 5-7.

Plate 11, figures 1-2.

<u>Vaginulina</u> <u>discors</u> KOCH, 1851, Hilsthon, p. 172, pl. 24, figs. 1-2.

<u>Vaginulina</u> <u>discors</u> KOCH - REUSS, 1863, Hils und Gault, p. 50, pl. 3, figs. 10-12.

<u>Vaginulina</u> <u>harpa</u> EICHENBERG (non Reuss) - EICHENBERG, 1932, Unterkreide, pl. 3, fig. 8.

<u>Vaginulina</u> sp. EICHENBERG, 1935, Unterkreide, pl. 9, fig. 6.

<u>Citharina</u> cf. <u>discors</u> (KOCH) - MARIE, 1938, Cretace, p. 96, pl. 8, fig. 10.

<u>Vaginulina</u> D32 HECHT, 1938, Unterkreide, pl. 16b, fig. 89.

<u>Citharina</u> <u>discors</u> (KOCH) - BARTENSTEIN & BRAND, 1951, Valendis, p. 297, pl. 7, fig. 176.

<u>Citharina</u> <u>discors</u> (KOCH) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 254, pl. 36, fig. 1.

Material: Seventy-nine specimens.

Dimensions of figured specimens:

		Length	Maximum width
Figure 5	HU.25.C.13	2.340 mm	0.900 mm
Figure 6	HU.25.C.14	1.560 mm	0.594 mm
Figure 7	HU.25.C.15	1.950 mm	0.702 mm
Figure 1	HU.25.C.19	1.900 mm	0.910 mm

Description: Test free, large, elongate, much compressed, parallel sided. The outline of the test is subtriangular. The chambers are low and broad, gently curving and extending nearly to the base proximally. The chambers increase rapidly in breadth but only very slightly in height; they number between twelve and fifteen. The elliptical proloculus may sometimes be drawn out into a short spine. Periphery may be lobate where the chambers fail to extend to the base. Sutures distinct, oblique, slightly curved with the convex side towards the aperture. They are flush with the surface or depressed and may be obscured by longitudinal costae. The main ornament consists of two to four strong costae which stand up well from the surface of the test and cross the sutures without interruption. They are concentrated close to the apertual margin and rum from the proloculus to the final chamber. A second, minor set of costae, ten to seventeen in number, consists of short, rather weak, costae which may cross a couple of chambers, but more usually are interrupted at the sutures. These weaker costae are best developed near the inner margin. Aperture radiate, terminal, and on a short neck. Wall calcareous.

Variation: Minor variation occur in both ornament and outline of the test. The outline may vary from subtriangular to subrectangular. Two generations have not been recognised.

Remarks: This species with its two sets of strong and weak costae is quite distinct from any other members of this genus at Speeton. German workers confidently regard this form as Citharina discors Koch though the type figure shows a differing ornament. The present author has designated this form as C. cf. discors due to the fact that in C. discors sensu stricto, though the costae running parallel to the dorsal margin are the same, the secondary set of costae are strongly arcuate. The species differs from Citharina cf. discors (Koch) var. gracilis Marie in that the proloculus is not so elongated and drawn out. Citharina d'orbigny differs from Citharina discors in its greater number of costae and their strong divergence. The form illustrated as fig. 6 shows similarities to C. d'orbigny in the divergent nature of the costae from the proloculus. The range of C. discors in N.W. Germany is from Valanginian to Lower Barremian but it only occurs in any number in the Upper Hauterivian.

Occurrence: D6I(?), D2E, C5, C4, C3, C2, C1, LB5, LB4, LB3.

Citharina harpa (Roemer)

Plate 10, figures 1-3

Vaginulina harpa - ROEMER, 1841, Kreidegeb., p. 96, pl. 15, fig. 12.

Vaginulina dunkeri KOCHI, 1851, Hilsthon, p. 172, pl. 24, fig. 3-4.

Vaginulina harpa ROEMER - REUSS, 1863, Hils und Gault, p. 51, pl. 4, figs. 5-7.

Vaginulina paucicostata - REUSS, 1863, Hils und Gault, p. 52, pl. 4, fig. 8.

Vaginulina incrassata - REUSS, 1863, Hils und Gault, p. 52-53, pl. 4, fig. 9.

Vaginulina harpa ROEMER - EICHENBERG, 1934, Hauterive, p. 177, pl. 14, fig. 7.

Vaginulina harpa ROEMER - EICHENBERG, 1935, Unterkreide, pl. 9, fig. 4; pl. 12, fig. 7.

Vaginulina D 24 - HECHT, 1938, Unterkreide, pl. 18a, figs. 93-96; pl. 18b, figs. 125-127.

Vaginulina D 32 - HECHT, 1938, Unterkreide, pl. 15a, fig. 97; pl. 15b, fig. 61; pl. 16b, figs. 87-90; pl. 17b, figs. 49-53.

Citharina pausicosta (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 299, pl. 8, figs. 184-185.

Citharina harpa (ROEMER) - BARTENSTEIN, 1956, Hauterive, p. 518, pl. 2, figs. 27, 29-30.

Citharina harpa (ROEMER) - ZEDLER, 1961, Hauterive, p. 43, pl. 8, figs. 15-16.

Citharina harpa (ROEMER) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 259, pl. 38, fig. 7.

Material: Three hundred and sixty-two specimens.

Dimensions of figured material:

		Length	Maximum width
Figure 1	HU.25.C.9	2.080 mm	0.910 mm
Figure 2	HU.25.C.10	2.600 mm	1.040 mm
Figure 3	HU.25.C.11	2.080 mm	0.910 mm

Description: Test free, robust, subtriangular in outline, much compressed. Dorsal margin gently convex, ventral margin strongly convex and may be slightly lobulate. Widest part of the test at, or slightly above, the mid-point though occasionally just below the mid-point. The dorsal margin has a prominent thin keel. Chambers numerous, broad, narrow, parallel sided, curved, varying in breadth but the height remaining constant. Chambers curve gently from the ventral margin to a much higher position on the dorsal margin. Proloculus spherical or elliptical, sometimes with a short spine. Sutures limbate, flush with the surface and oblique, usually obscured by ornament which consists of ten to sixteen strong, thin ribs which run parallel to the dorsal margin, are equidistant and extend the whole length of the test. Occasionally short costa may be intercalated between the main ribs distally. Aperture terminal, marginal, radiate and on a short neck.

Variation: Shows variation in shape and in the ornamentation. The costae vary in number and in overall pattern due to the intercalation of additional costae in some individuals.

Remarks: In N. W. Germany this species ranges from Upper Valanginian to the Hauterivian/Barremian boundary, and has a similar distribution at Speeton.

Occurrence: D2D, D2C, D1, C11, C10, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB6, LB5.

Citharina pseudostriatula Bartenstein & Brand.

Plate 11, figures 8-10, 14-15.

Vaginulina harpa BARTENSTEIN & BRAND (non ROEMER), 1936, Lias und Dogger, p. 163, pl. 14B, fig. 7.

Citharina pseudostriatula BARTENSTEIN & BRAND, 1951, Valendis, p. 298, pl. 7, fig. 182; pl. 12A, fig. 339; pl. 15D, figs. 18, 20.

Citharina pseudostriatula BARTENSTEIN & BRAND - SZTEJN, 1958, Middle Poland, p. 33, figs. 70a, 70b.

Material: Eighty-nine specimens.

Dimensions of figured specimens:

		Length	Maximum width
Figure 8	HU.25.C.22	1.560 mm	0.540 mm
Figure 9	HU.25.C.23	0.810 mm	0.432 mm
Figure 10	HU.30.C.1	0.828 mm	0.432 mm
Figure 14	HU.25.C.27	0.936 mm	0.414 mm
Figure 15	HU.26.C.1	1.040 mm	0.396 mm

Description: Test free, small, triangular in outline, compressed with straight or gently curved, dorsal margin and convex ventral margin. The globular proloculus is followed by six to twelve curving chambers, with limbate, flush, inclined sutures. Both the chambers and the sutures are usually obscured by the ornament which consists of longitudinal costae. These are parallel to the ventral and dorsal margins and bifurcate distally; up to 18 costae cross the last chamber. The angle of divergence of the margins from the proloculus is between thirty and forty degrees and the test is broadest nearer the apertual end. Aperture radiate, marginal at the dorsal angle and may be on a small tubular extension.

Variation: The outline of the test is variable from triangular to curving triangular. The specimen illustrated as figure 15 has a curved initial portion and is more elongate than typical members of the species. Dimorphism has not been recognised.

Remarks: This species is morphologically very close to Citharina rudocostata but differs from it in having bifurcating ribs. The stratigraphic range is similar to Citharina rudocostata.

Occurrence: D7A3, D6, C8, C2, The majority of the specimens occur in D6.

Citharina rudocostata Bartenstein & Brand

Plate 11, figures 11-13.

Vaginulina harpa MACFADYEN (non ROEMER) - MACFADYEN, 1935, Jurassic, p. 12, pl. 1, fig. 8.

Citharina rudocostata BARTENSTEIN & BRAND, 1951, Valendis, p. 299, pl. 7, fig. 183; pl. 12a, fig. 340; pl. 14c, figs. 13-15.

Citharina rudicostata BARTENSTEIN & BRAND - SZTEJN, 1958, Middle Poland, p. 32, fig. 69a, 69b.

Material: Thirty-three specimens.

Dimensions of figured specimens:

		Length	Maximum width
Figure 11	HU.25.C.24	0.864 mm	0.324 mm
Figure 12	HU.25.C.25	0.846 mm	0.252 mm

		Length	Maximum width
Figure 13	HU.25.C.26	0.882 mm	0.414 mm

Description: Test free, small, compressed, elongate, triangular in outline with widest part near the apertual end. Angle of divergence of the margins from the proloculus is very small; in some specimens they are parallel. The globular proloculus is followed by five to seven, low, broad, inclined chambers with flush, oblique sutures. The chambers and sutures are normally obscured by the ornament which consists of about six or seven longitudinal ribs extending from the proloculus to the apertual margin. The dorsal and ventral margin also has one longitudinal rib. The aperture is radiate, marginal, at the dorsal angle.

Remarks: This species is very similar to Citharina pseudostriatula Bartenstein & Brand which differs in being slightly more elongate and having dichotomising costae. With more specimens a study of the variation might reveal that these two species are synonymous. In N.W. Germany this species ranges from upper Dogger to Upper Valanginian.

Occurrence: D6I, D6, D2, D1, isolated specimens in C9, C2.

Citharina seitzi Bartenstein & Brand.

Plate 10, figure 4.

Vaginulina D27 - HECHT, 1938, Unterkreide, pl. 19a, figs. 87-90.

Vaginulina D 35 - HECHT, 1938, Unterkreide, pl. 24, fig. 131.

Citharina seitzi BARTENSTEIN & BRAND, 1951, Valendis, p. 296, pl. 7, figs. 171-172.

Citharina seitzi BARTENSTEIN & BRAND - SZTEJN, 1958, p. 31, fig. 66.

Citharina seitzi BARTENSTEIN & BRAND - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 261, pl. 35, fig. 15.

Material: Three specimens.

Dimensions of figured specimen:

		Length (broken)	Maximum width
Figure 4	HU.25.C.12	1.560 mm	0.594 mm

Description: Test free, elongate, triangular in outline, much compressed. The proloculus is oval, with numerous costae, and is followed by nine broader than high chambers which are obscured by the dominant ornament. The ornament consists of eleven, longitudinal rather irregular costae on each side which cross the entire length of the test. These longitudinal costae diverge slightly from the proloculus. A second set of costae parallel to the sutures join the main costae giving an irregular reticulate pattern of ornament. This reticulation encloses rectangular areas which are about twice as long as wide. The ventral margin is convex and the dorsal margin straight or weakly convex. Longitudinal costae are continuous along the peripheral margins. The aperture is terminal at the dorsal angle.

Remarks: The figured specimen has been compared with the holotype in the Senckenberg Museum (SMF 3451) and compares very closely. In Germany it is regarded as a good zone fossil occurring in the Upper Valanginian and Lower Hauterivian. It has been recorded from N. W. Germany, Switzerland, Poland and Western Russia. This is the first record from Britain.

Occurrence: D2D.

Citharina sparsicostata (Reuss)

Plate 10, figures 8-14.

Vaginulina sparsicostata REUSS, 1863, Hils und Gault, p. 50, pl. 4, fig. 4.

Vaginulina sparsicostata REUSS - CHAPMAN, 1894, Folkestone, p. 426, pl. 8, fig. 12.

Vaginulina wageri EICHENBERG, 1934, Hauterive, p. 178, pl. 15, fig. 11.

Vaginulina cf. cristellarioides REUSS - EICHENBERG, 1935, Unterkreide, pl. 9, fig. 5.

Vaginulina wageri EICHENBERG - EICHENBERG, 1935, Unterkreide, pl. 9, fig. 7.

Vaginulina D26, 28, 25 HECHT, 1938, Unterkreide, pl. 21, fig. 1-6.

Citharina sparsicostata (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 297, pl. 7, figs. 173-175; pl. 19B, figs. 45-46, 57.

Citharina sparsicostata (REUSS) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 263, pl. 35, fig. 16.

Material: Fifty-five specimens.

Dimensions of figured specimens:

		Length	Maximum width
Figure 8	HU.25.C.16	1.820 mm	0.612 mm
Figure 10	HU.25.C.17	2.730 mm	1.170 mm
Figure 11	HU.25.C.18	1.950 mm	0.910 mm

Description: Test free, large, much compressed, triangular in outline, generally broadest towards the initial end. Dorsal margin typically with a strong keel usually extending from the proloculus to the aperture but better developed proximally. Dorsal edge nearly straight, ventral margin strongly convex; divergence of margins from the proloculus is between 40 to 60 degrees. Proloculus oval, followed by up to sixteen chambers which are low and broad, and curve downwards towards the ventral margin. Sutures limbate, flush with the surface and sometimes obscured by the ornament. Ornament consists of numerous costae which may be short and confined to one or two chambers or may sometimes be continuous over a number of chambers. Costae are weak or absent on the last chamber and often weaker nearer the ventral margin. Aperture protruding at the dorsal angle.

Variation: The species appears to have a wide range of variation in shape and ornament. The specimen figured as no's. 11-14 is very typical of this species and compares very closely with forms from the German Cretaceous. The form illustrated as fig. 10 is not so typical, as in this specimen the ribs are becoming more continuous.

Remarks: *Citharina cristellaroides* (Reuss) differs from this species in having slightly inflated chambers, and much weaker, more regularly spaced, ornament which tends to be confined to the chambers.

Occurrence: D2D, D2C, D1, C11, C9, C8, C5(?).

Citharina strigillata (Reuss)

Plate 12, figures 5-8

Vaginulina (*Citharina*) *strigillata* REUSS, 1846, Böhmischen Kreide, p. 106, pl. 24, fig. 9.

non Vaginulina strigillata REUSS - CUSHMAN, 1930, Upper Cretaceous, p. 26, pl. 4, figs. 1, 9, 10.

Material: Three specimens.

Dimensions of figured specimens:

		Length	Maximum width
Figure 5	HU.26.C.7	1.560 mm	0.360 mm
Figure 7	HU.26.C.8	2.730 mm	0.566 mm
Figure 8	HU.26.C.9	1.690 mm	0.396 mm

Description: Test elongate, slender, triangular in outline, compressed. Dorsal margin straight, ventral margin convex, periphery rounded. Test tapers both proximally and distally with the greatest width at or above the mid-point. The angle of divergence of the margins from the proloculus is between 15-20 degrees. Proloculus ovoid, drawn out, tapering. Chambers six to ten in number, are broad and low, oblique, straight, slightly inflated, and increasing gradually in breadth and height as added. Sutures fairly distinct, straight or slightly curved, strongly oblique, flush with the surface or slightly depressed. Wall ornamented by numerous short costae parallel to the margins of the test. Aperture, radiate, produced at the dorsal angle.

Remarks: This form is very close to Vaginulina suturalis Cushman but this latter species differs in having the ornament confined to the sutures. From Citharina acumenata (Reuss) it differs in having a greater number of costae which are not so continuous, and in being larger and conspicuously broader.

Occurrence: D6C only.

Citharina sp. A.

Plate 11, figures 3-5.

Material: Two specimens.

Dimensions of figured specimen:

		Length	Maximum width
Figure 3	HU.25.C.20	2.080 mm	0.846 mm

Remarks: This form is similar in shape to Citharina laffittei Marie but differs in its sparcity of ornamentation. Its strong dorsal ribs, with only a very few fine secondary costae, place it close to Citharina discors Koch but the dorsal keel is reminiscent of Citharina sparsicostata (Reuss); clearly the form is transitional between these two species.

Occurrence: D2E.

Citharina sp. B.

Plate 11, figures 6-7.

Material: One specimen.

Dimensions of figured specimen:

		Length	Maximum width
Figure 6	HU.25.C.21	1.950 mm	0.990 mm

Remarks: This specimen also falls between *Citharina discors* Koch and *Citharina sparsicostata* (Reuss) though appears closer to *C. sparsicostata*. It differs from *C. discors* in ornamentation and in having a dorsal keel. It is also close to *C. pseudodiscors* Khan but has fewer costae and lacks the slightly grooved ventral side.

Occurrence: D2E.

Genus VAGINULINA d'Orbigny 1826

Type species Nautilus legumen Linne 1758

Vaginulina arguta Reuss

Plate 12, figures 9-12.

Plate 13, figures 6-11.

Vaginulina arguta REUSS, 1860, Westfälischen Kreide, p. 202, pl. 8, fig. 4.

Vaginulina arguta REUSS - REUSS, 1863, Hils und Gault, p. 47, pl. 3, fig. 13.

Vaginulina eurynota REUSS - BURROWS, SHERBORN & BAILEY, 1890, Red Chalk, p. 559, pl. 10, fig. 9.

Vaginulina arguta REUSS - BURROWS, SHERBORN & BAILEY, 1890, Red Chalk, p. 559, pl. 10, figs. 14-15.

Vaginulina kochii ROEMER - CUSHMAN & ALEXANDER, 1930, (non Roemer), Texas, p. 1, pl. 1, figs. 1-9.

Vaginulina arguta REUSS - EICHENBERG, 1933, Unterkreide, p. 10, pl. 8, fig. 5.

Vaginulina truncata REUSS - EICHENBERG, 1933, Barreme, p. 187, pl. 20, fig. 6.

Vaginulina truncata REUSS - EICHENBERG, 1935, Hauterive, p. 179, pl. 16, fig. 5.

Vaginulina truncata REUSS - EICHENBERG, 1935, Apt, p. 28, pl. 5, fig. 9.

Vaginulina D37 HECHT, 1938, Unterkreide, pl. 13a, figs. 55-56.

Vaginulina kochii ROEMER - TAPPAN, 1943, Duck Creek, p. 500, pl. 80, figs. 17-18.

Vaginulina arguta REUSS - ALBERS, 1952, p. 85, pl. 5, figs. 1, 4, 6; text-figs. 12-15.

Material: Two hundred and ninety-five specimens.

Dimensions of figured specimens:

		Length	Maximum Width
Figure 9	HU.26.C.10	0.702 mm	0.486 mm
Figure 11	HU.26.C.11	1.560 mm	0.486 mm
Figure 12	HU.26.C.12	1.560 mm	0.720 mm
Figure 6	HU.26.C.18	3.250 mm	0.720 mm
Figure 8	HU.26.C.19	2.730 mm	0.630 mm

Description: Test free, medium sized, compressed, robust, triangular in outline with the widest part at, or above, the mid-point. Dorsal margin straight or gently convex; ventral margin may be slightly lobulate. Peripheral margin flat and raised above the surface of the test. The spherical proloculus is followed by up to fourteen straight or gently curved, parallel sided chambers. The chambers are broad and low and increase rapidly in breadth as added but remain almost constant in height. They are oblique, high on the dorsal margin but extending low on the ventral margin. The sutures are limbate, raised above the surface of the test, straight for the greater part of their length but curving proximally where they meet the ventral periphery. Wall smooth.

Aperture simple, terminal, at dorsal angle, on a small neck.

Alternation of generations: The microspheric form has a small proloculus followed by up to fourteen chambers; the dorsal margin may be strongly curved. The megalospheric proloculus is large, spherical and raised well above the surface of the test; it is followed by three to seven chambers.

Remarks: This species has caused much confusion in the past; many workers regard these forms as being *Vaginulina kochii* Roemer. Albers (1952) has shown that only smooth forms belong to this species and those with raised sutural ribs belong to *Vaginulina arguta* Reuss.

Occurrence: D2D, D2, D1, C11, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB5, LB4, LB3, LB2.

Vaginulina complanata (Reuss) var. *perstriata* Tappan

Plate 11, figure 16.

Plate 12, figures 1-2

Vaginulina complanata (REUSS) var. *perstriata* TAPPAN, 1940, Grayson, p. 108, pl. 16, fig. 25.

Vaginulina complanata (REUSS) var. *perstriata* TAPPAN - TAPPAN, 1943, Duck Creek, p. 499, pl. 80, fig. 14.

Citharina complanata (REUSS) var. *perstriata* (TAPPAN) - FRIZZELL, 1954, Texas, p. 94, pl. 11, fig. 3.

Material: Thirty-four specimens.

Dimensions of figured specimens:

		Length	Maximum Width
Figure 16	HU.26.C.2	1.026 mm	0.396 mm
Figure 1	HU.26.C.3	0.396 mm	0.198 mm
Figure 2	HU.26.C.4	0.612 mm	0.306 mm

Description: Test small, compressed; dorsal margin curved, convex; ventral margin also convex but stronger than the dorsal margin. The extremely small proloculus, which has a small basal spine, is followed by up to eight gently curved chambers. They are slightly inflated and curve strongly downwards to the proloculus on the ventral side; their height remains almost constant. The sutures are distinct, depressed and meet the ventral margin tangentially. The surface is ornamented with numerous fine, oblique striations which cross both sutures and chambers. Aperture radiate, terminal, at the dorsal angle. Wall calcareous.

Remarks: This subspecies was first described by Tappan from the Lower Cretaceous, Grayson Formation of Texas. It differs from *Vaginulina* complanata var. complanata (Reuss) in having the small, but conspicuous, oblique and longitudinal striations. Zedler (1961) records the subspecies in the Upper Hauterivian of N.W. Germany.

Occurrence: D6C, D6A, D2, D1, C10, C7, C6, C5, C4, C3, C2, LB5, LB4.

Vaginulina kochii Roemer

Plate 13, figures 10-11

Vaginulina kochii ROEMER, 1841, Kreidegebirges, p. 96, pl. 15, fig. 10.

non Vaginulina kochii ROEMER - CUSHMAN & ALEXANDER, 1930, Texas, pl. 1, p. 1, figs. 1-9.

Vaginulina kochii ROEMER - BARTENSTEIN & BRAND, 1951, Valendis, p. 293, pl. 6, figs. 158-159; pl. 17B, figs. 13-14.

Vaginulina kochii ROEMER - ALBERS, 1952, Barreme, p. 89, pl. 5, fig. 2; text-figs. 16-19.

Vaginulina kochii ROEMER - ROMER - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 38, pl. 5, fig. 105; pl. 6, fig. 124.

Vaginulina kochii ROEMER - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 261, pl. 36, fig. 5.

Material: Two hundred and forty-seven specimens.

Dimensions of figured specimen:

		Length	Maximum Width
Figure 10	HU.26.C.20	1.820 mm	0.594 mm

Description: Test elongate, triangular, very compressed with the widest part at, or above, the mid-point. Dorsal margin straight or gently curved, ventral margin strongly convex and may be lobulate. Peripheral margin flat, raised above the surface of the test forming a rim or border. The spherical proloculus is followed by up to fifteen, strongly oblique, chambers; they are broad and low, and increase rapidly in breadth though their height remains almost constant. The chambers are straight or gently curved and not inflated. The sutures are distinct, oblique, flush with the surface, straight for the greater part of their length but curving where they meet the ventral margin. The walls are smooth, generally without ornamentation though one or two specimens have been observed to have faint longitudinal striations crossing some of the chambers. Aperture simple, at the dorsal angle on a very slight elongation.

Alternation of generations: The specimen figured is a microspheric individual with a small spherical proloculus followed by up to fifteen chambers. The initial three or four chambers are more strongly curved and weakly coiled. The megalospheric form has a large spherical proloculus, fewer chambers and a rather robust test; the initial chambers are straight and the proximal portion not so curved.

Remarks: This form is close morphologically to *Vaginulina arguta* Reuss but lacks the prominent ribs of this species. From Roemer's very small illustration of the type, it is not possible to determine the presence or absence of ribs and this has led to the confusion of this species with *Vaginulina arguta*. His description, however, says "without lines standing out".

Occurrence: D2D, D1, C10, C9, C8, C7, C6, C5, C4, C3, C2, C1.

Vaginulina riedeli Bartenstein & Brand.

Plate 13, figures 14-15.

Vaginulina riedeli BRAND, 1949 (nomen nudum) Dogger und Valendis, p. 345, text-fig. 4-5.

Vaginulina riedeli riedeli BARTENSTEIN & BRAND, 1951, Valendis, p. 295, pl. 7, fig. 165; pl. 19a, fig. 31-32.

Vaginulina riedeli BARTENSTEIN & BRAND - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 262, pl. 35, fig. 21; pl. 38, fig. 4.

Material: Twenty-five specimens.

Dimensions of figured specimen:

		Length	Maximum width
Figure 14	HU.26.C.22	1.080 mm	0.288 mm

Description: Test elongate, small, robust, narrow, rectangular in cross-section. Large spherical proloculus is followed by four to seven, broader than high, oblique, slightly inflated, parallel-sided chambers arranged in a rectilinear series. The peripheral angles of the test are acute and keeled. In cross-section the dorsal margin is straight and the ventral margin convex; the side faces are slightly concave. Sutures straight, oblique, slightly depressed. Proloculus may have some faint striations. Aperture at the dorsal margin on a very small neck. Wall smooth.

Remarks: This species has only been recorded from N.W. Germany where it is found in the Upper Valanginian. Bartenstein & Bettenstaedt (1962) in describing the closely related form *Vaginulina weigelti* Bettenstaedt, suggested that it perhaps evolved from the Valanginian species *Vaginulina riedeli* Bartenstein & Brand but that no forms had been found in the Hauterivian of Germany. This first record from the Hauterivian is therefore important. At Speeton it is mainly confined to the Hauterivian and does not occur in the Valanginian.

Occurrence: C9, C8, C7, C4, C2, C1, LB3.

Vaginulina striolata Reuss

Plate 12, figures 13-16

Plate 13, figures 1-5.

Vaginulina striolata REUSS, 1863, Hils und Gault, p. 46, pl. 3, fig. 7.

Vaginulina striolata REUSS - CHAPMAN, 1894, Folkestone, p. 425, pl. 8, fig. 10.

Vaginulina gaultina BERTHELIN - CHAPMAN, 1894, Folkestone, p. 425, pl. 8, fig. 8.

Vaginulina kochii ROEMER var. striolata REUSS - CUSHMAN & ALEXANDER, 1930, p. 4, pl. 1, fig. 10-16.

Vaginulina kochii ROEMER var. striolata REUSS - TAPPAN, 1940, Grayson, p. 110, pl. 17, fig. 5.

Vaginulina kochii striolata REUSS - TAPPAN, 1943, Duck Creek, p. 501, pl. 80, figs. 19-21.

Vaginulina striolata REUSS - BARTENSTEIN & BRAND, 1951, p. 294, pl. 6, figs. 161-164.

Vaginulina striolata REUSS - SZTEJN, 1958, Middle Poland, p. 29, figs. 59 a-b.

Material: One hundred and sixty-five specimens.

Dimensions of figured specimens:

		Length	Maximum width
Figure 13	HU.26.C.13	1.950 mm	0.720 mm

		Length	Maximum width
Figure 15	HU.26.C.14	1.950 mm	0.630 mm
Figure 1	HU.26.C.15	1.820 mm	0.486 mm
Figure 2	HU.26.C.16	1.560 mm	0.378 mm
Figure 4	HU.26.C.17	1.820 mm	0.540 mm

Description: Test elongate, subtriangular in outline, compressed, sides parallel. Dorsal margin nearly straight, ventral convex. Peripheral margin raised above the level of the wall. The spherical proloculus is followed by up to twelve, oblique, parallel-sided chambers which may be straight or gently curved, and often give rise to a lobulate ventral periphery. The sutures are distinct, limbate, raised, running obliquely from the dorsal margin down towards the ventral side. The angle between the dorsal margin and the suture is between thirty and fifty degrees. Ornamentation consists of longitudinal or oblique striations or costae which may be confined to the chambers or cross both chamber and sutures. The aperture is terminal at the dorsal angle. Wall calcareous.

Alternation of generations: Two generations are recognised each with a spherical proloculus but one much larger than the other. The dorsal margin of the megalospheric form always appears to be straight and its proloculus frequently has oblique ribs.

Variation: A very variable species in size, outline and ornamentation.

The striations may be scarcely visible or very strong; they may be confined to the chambers or cross the sutures, breaking up the suture.

Remarks: The species is very similar to Vaginulina arguta Reuss but differs in having the test ornamented with numerous costae. The specimen illustrated as figure 4 is very close to Vaginulina flexa Zedler; here the sutural ribs are broken dorsally by longitudinal striae. This new species of Zedler's is probably only a variety of V. striolata. In N. W. Europe the species is found from the Upper Valanginian to Albian.

Occurrence: D6A, D2, D1, C11, C10, C9, C8, C7, C6, C5, C4, C2, C1, LB6, LB5, LB4.

Vaginulina cf. angustissima Reuss

Plate 13, figures 12-13

Vaginulina angustissima REUSS, 1863, Hils und Gault, p. 45, pl. 3, fig. 3.

Vaginulina angustissima REUSS - EICHENBERG, 1933, Albien, p. 10, pl. 3, fig. 4.

Vaginulina angustissima REUSS - EICHENBERG, 1935, Unterkreide, pl. 4, fig. 11.

Material: Two specimens.

Dimensions of figured specimen:

		Length
Figure 12	HU.26.C.21	1.300 mm

Description: Test free, compressed, subtriangular in outline, parallel-sided. Dorsal margin initially curved but later becoming straight, keeled; ventral margin convex. The small globular proloculus is followed by eight oblique, parallel-sided chambers, which are straight or only very slightly curved. Later chambers are distinct and slightly inflated, but the earlier ones are obscured by ornament. Sutures depressed, distinct when not obscured by costae. Ornament consists of longitudinal ribs which run parallel to the peripheral margins of the test and initially cross a number of chambers without interruption but later tend to be confined to the chambers; they are strongest in the early portion where they mask both chambers and sutures. Aperture terminal, at the dorsal angle.

Remarks: Bartenstein and Brand (1951) record V. cf. angustissima from the Mittel and Ober Valendis but their figured specimen has not the compressed parallel sides of the form illustrated here. The type figured by Reuss is a broken specimen, with the initial end missing; it is close to the Speeton specimens but the dorsal and ventral margins do not diverge so greatly. Reuss records it rarely from the middle Gault of Hildesheim.

Occurrence: D6D, D6C.

Genus FRONDICULARIA Defrance, 1826.

Type species *Renulina complanata* Defrance.

Frondicularia concinna Koch

Plate 14, figures 1-4.

Text-figures

Frondicularia concinna KOCH, 1851, Hilsthon, p. 172, pl. 24, fig. 5.

Frondicularia concinna KOCH, REUSS, 1863, Hils und Gault, p. 54, pl. 4, fig. 13.

Frondicularia quadrata CHAPMAN, 1894, Folkestone, p. 158, pl. 4, fig. 4.

Frondicularia concinna KOCH - EICHENBERG, 1933, Unterkreide, p. 78, pl. 4, fig. 1.

Frondicularia concinna KOCH - EICHENBERG, 1934, Hauterive, p. 181.

Frondicularia concinna KOCH - EICHENBERG, 1935, Unterkreide, p. 181, pl. 9, fig. 1; pl. 10, fig. 2; pl. 11, fig. 14; pl. 12, fig. 12.

Frondicularia D6 - HECHT, 1938, Unterkreide, pl. 18b, figs. 116-119.

Frondicularia D7 - HECHT, 1938, Unterkreide, pl. 17b, figs. 41-45.

Frondicularia D9 - HECHT, 1938, Unterkreide, pl. 13a, fig. 36.

Frondicularia D20 - HECHT, 1938, Unterkreide, pl. 10b, figs. 99-100.

Frondicularia D22 - HECHT, 1938, Unterkreide, pl. 12b, fig. 95.

Frondicularia concinna KOCH - DAM, 1950, Albien, p. 31, pl. 2, fig. 22.

Frondicularia concinna KOCH - BARTENSTEIN & BRAND, 1951, Valendis, p. 305, pl. 8, fig. 209-210.

Frondicularia sp. 1. - BARTENSTEIN & BRAND, 1951, Valendis, p. 307, pl. 9, fig. 217.

Frondicularia sp. 2. - BARTENSTEIN & BRAND, 1951, Valendis, p. 307, pl. 9, fig. 218.

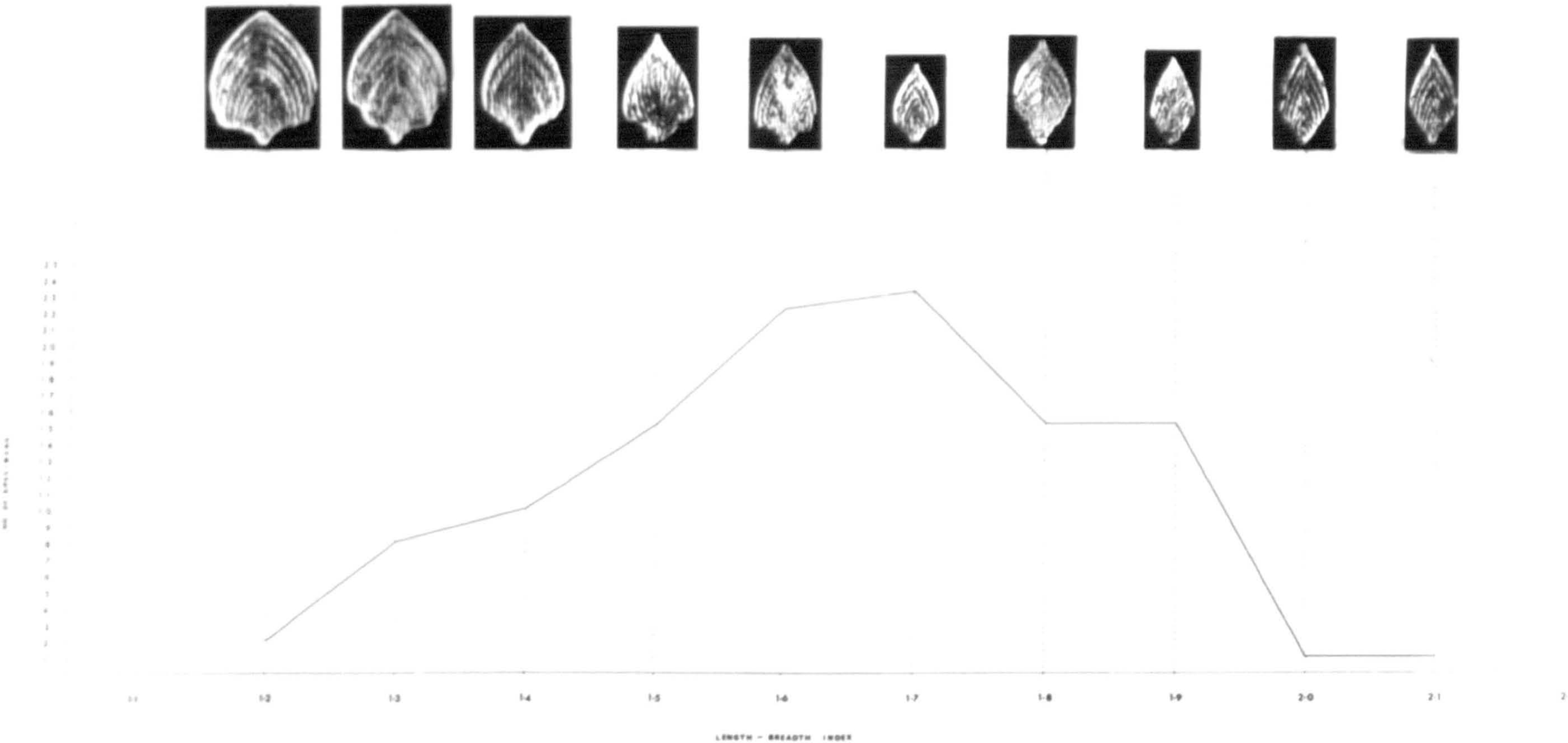
Frondicularia concinna KOCH - BARTENSTEIN, 1956, Hauterive, p. 519, pl. 2, figs. 40, 47.

Material: One hundred and ninety-eight specimens.

Dimensions of figured specimens (plate 14 only)

		Length	Maximum breadth
Figure 1	HU.26.C.24	1.950 mm	1.560 mm
Figure 2	HU.26.C.25	2.730 mm	1.820 mm
Figure 3	HU.26.C.26	1.430 mm	0.810 mm
Figure 4	HU.26.C.27	0.990 mm	0.648 mm

Description: Test free, much compressed, heart shaped, diamond shaped or palmate. Proloculus spherical or ovate, usually with one or more ribs, often inflated above the surface of the test. Three to fourteen strongly equitant chambers of nearly equal height but increasing rapidly in breadth. Chambers often slightly inflated; sutures distinct, depressed. The surface of the test is characteristically ornamented by numerous low longitudinal ribs which are usually interrupted at the suture. The spacing of these ribs tends to become much more uniform on the last two chambers. The aperture is terminal, radiate and produced on a short neck. Wall calcareous, finely perforate.



Frondicularia concinna Koch, 1851

Alternation of Generations: The length of the test against the length x diameter of the proloculus has been plotted but no clear dimorphism or trimorphism stands out. It is perhaps possible to say that three groups of proloculus size are shown, .0038 - .0080 mm, .0110 - .0240 mm, and .0250 - .0430 mm, but these grade into one another and it appears that the size of the proloculus does not give any clear indication of megalospheric or microspheric individuals. In some rare forms, perhaps the microspheric generation, the proloculus is followed by an initial one or two chambers arranged in a planularian series.

Variation: A considerable width of variation is seen in *Frondicularia concinna* though it is mainly confined to differences in shape and ornamentation.

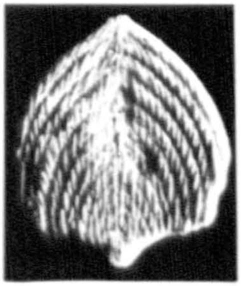
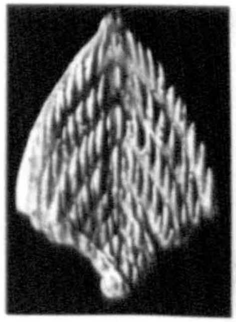
(a) Shape - this is extremely variable ranging from heart shaped to palmate. The length - breadth index of 113 specimens has been plotted graphically in the accompanying text-figure and shows a range from 1.2 to 2.1 with the optimum between 1.6 and 1.7.

(b) Ornament - this is the most variable character of *Frondicularia concinna*. Koch's figure of the type specimen shows numerous small, straight ribs or striae which are confined to each chamber and do not cross the sutures. If a large number of specimens are studied the ribs are frequently seen to be arcuate rather than straight over very short distances and to cross the sutures. When ribs cross a suture they are usually very weak at this point and are better developed and more elevated at the mid point of the chamber. Sometimes the ribs cross a

Text - figure

Frondicularia concinna Koch - main types of variation in ornament


1

2

3

4

Short ribs mainly confined to individual chambers.


5

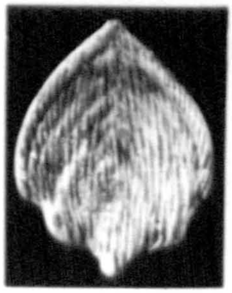
6

7

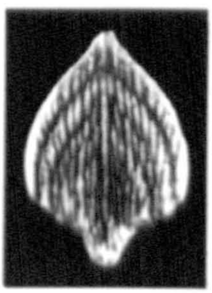
8

9

Ribs diverging.


10

11

Ribs tending to converge.


12

13

14

Ribs becoming stronger and continuous over earlier chambers.

number of the earlier chambers but in the distal portion they are generally confined to a single chamber. In individuals where the ribs extend continuously over a large part of the test the rib number increases by the intercalation of other costae; it is extremely rare for ribs to branch. The ribs vary a lot in their strength; there is a tendency for those on the early chambers to be stronger than those on later ones, but in some individuals they may be very weak and scarcely visible over the whole of the test. There is also a tendency for the ribs on the last two chambers to be more uniformly spaced than on the earlier ones. In some forms there is a central zone of parallel ribs extending from the proloculus to the apertual margin and this zone may be slightly depressed with the ribs not so prominent or even absent. In this zone the ribs, though finer, may extend over a greater number of chambers. When the ribs extend continuously over most of the test the chambers are obscured by the costae, or alternatively, the fact that the chambers are not inflated allows the ribs to continue unbroken across them. In Koch's original figure of this species the ribbing is seen to diverge from the proloculus; this has been observed in a number of the specimens from Speeton and is shown in the accompanying text-figure. Less commonly, specimens occur with a converging rib pattern. Ribs which originate on the proloculus commonly continue uninterrupted across a number of chambers.

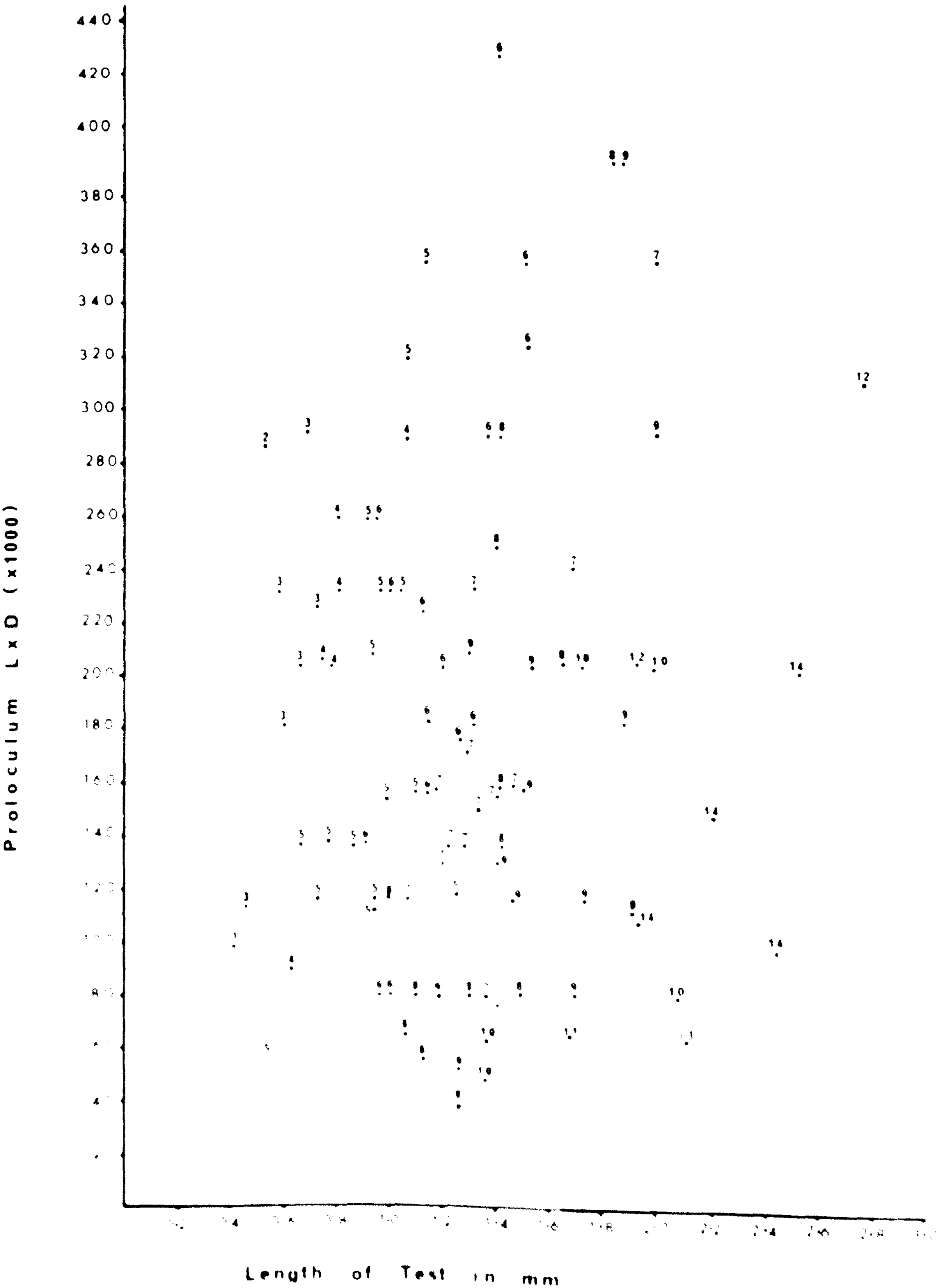
Remarks: *Frondicularia strigillata* Reuss differs from *Frondicularia concinna* in having a greater number of chambers which are smaller and more delicate, very fine ribbing and a proloculus that is drawn out into a long spine. It will be seen from the accompanying histogram that in _F. concinna_ the most frequent number of chambers is between five and nine. Chapman's holotype of _Frondicularia quadrata_ (Br. Mus. P.4823) is slightly crushed in the centre and is regarded here as a juvenile form of _Frondicularia concinna_. Another species which Chapman described from the Gault of Folkestone, _Frondicularia perovata_, is also very similar to _Frondicularia concinna_ but the edge is grooved and the outline more ovate. _Frondicularia cushmani_ Loeblich and Tappan from the Lower Cretaceous Washita group appears to differ only in having a faint rib along each peripheral margin and in having a single, strong rib on the proloculus. _F. concinna_ is also strikingly similar to _Frondicularia nikitini_ Uhlig from the Callovian of Europe and might have evolved from it.

The distribution of _F. concinna_ has been plotted for the C and Lower B beds according to their length/breadth ratio. The frequency of length/breadth ratios can not, in this case, be used as a stratigraphic tool as the distribution is seen to be a random one.

Occurrence: D4A2, D1, C11, C10, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB6, LB5, LB4, LB2.

Text - figure

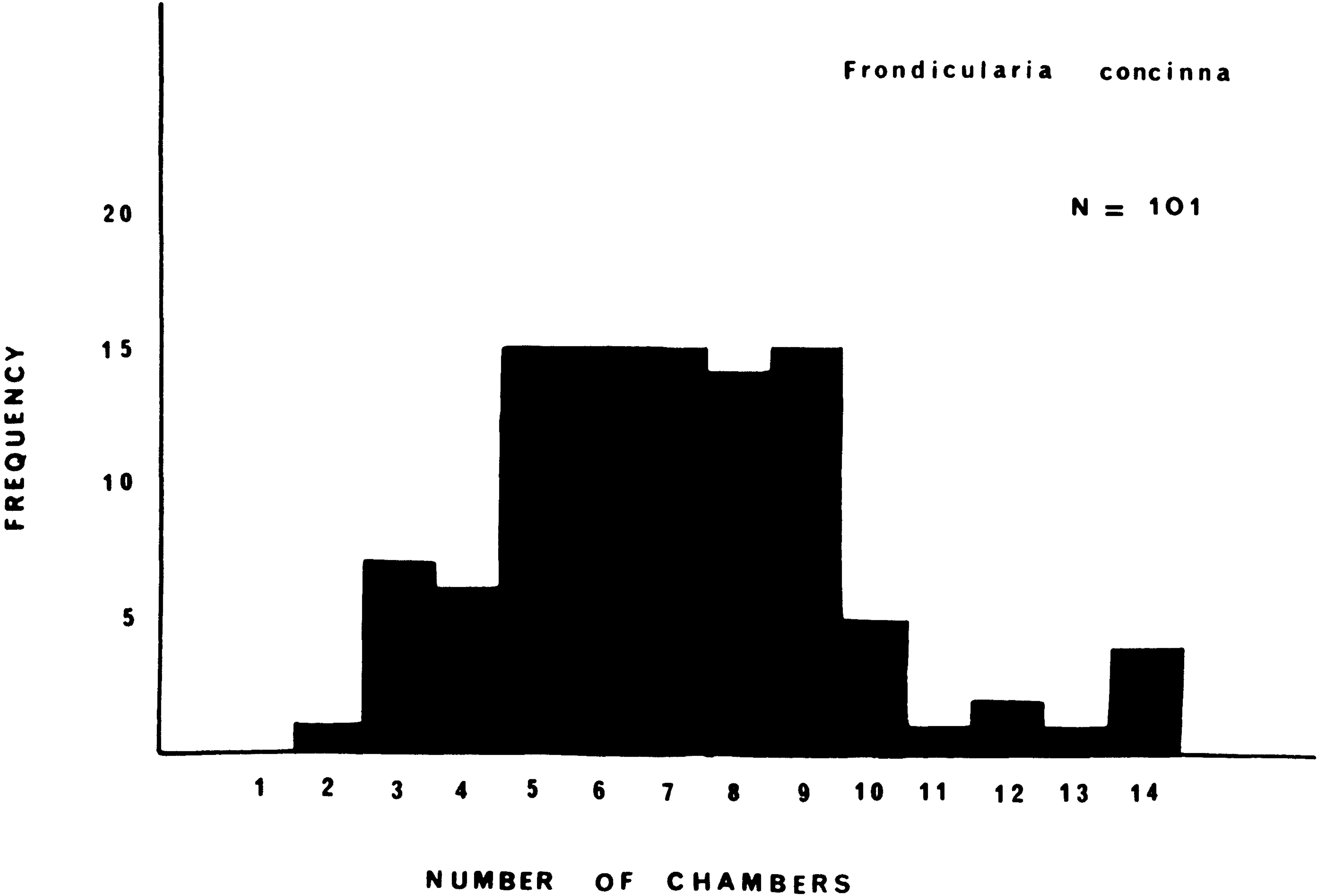
<u>Frondicularia</u> <u>concinna</u> Koch - the length of the test is plotted against the horizontal scale, the product of the length X breadth (X 1000) against the vertical scale. The number of chambers is indicated beside each point.



Frondicularia concinna

Text - figure

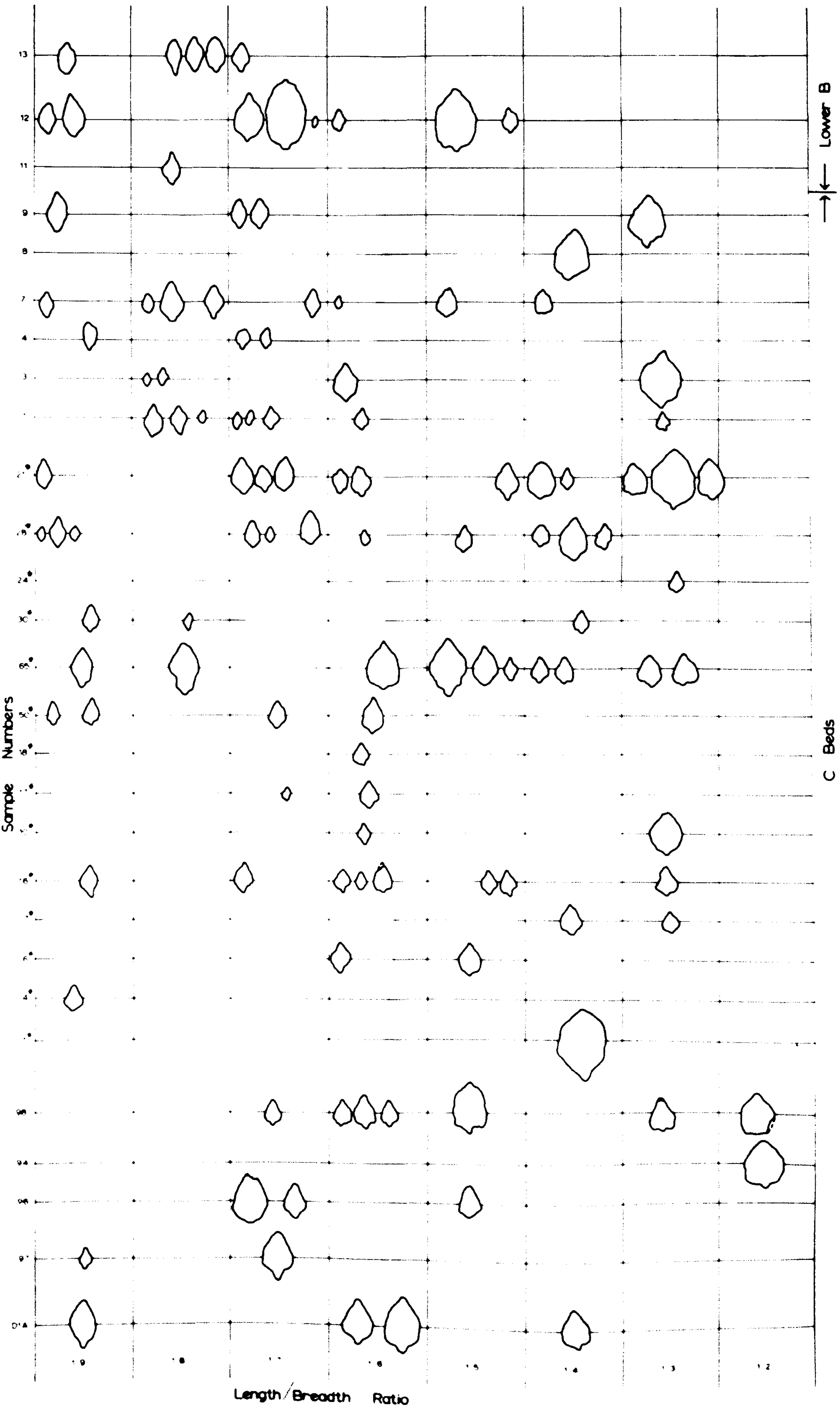
Frondicularia concinna Koch - the number of chambers is plotted against the horizontal scale and their frequency against the vertical scale.



Frondicularia concinna
N = 101
FREQUENCY
20
15
10
5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
NUMBER OF CHAMBERS

Text - figure

The distribution of Frondicularia concinna Koch in the C and Lower B beds. The specimens in each sample are plotted according to their length/breadth ratio.



Sample Numbers
Length/Breadth Ratio
Lower B
C Beds
13
12
11
9
8
7
4
3

Frondicularia hastata ROEMER

Plate 14, figures 11-12

Frondicularia hastata ROEMER, 1842, Kreide Foram., p. 272, pl. 7B, fig. 5.

Frondicularia hastata ROEMER - REUSS, 1863, Hils und Gault, p. 53, pl. 4, fig. 10.

Frondicularia gaultina(?) REUSS - SHERLOCK, 1914, Speeton Clay, p. 258, pl. 19, fig. 11.

Frondicularia inversa EICHENBERG (non REUSS) - Eichenberg, 1934, Unterkreide, Hauterive, p. 180, pl. 15, fig. 10.

Frondicularia inversa EICHENBERG (non REUSS) - EICHENBERG, 1935, Unterkreide, pl. 9, fig. 2,; pl. 10, fig. 1.

Frondicularia D26 - HECHT, 1938, Unterkreide, pl. 21, fig. 18.

Frondicularia hastata hastata ROEMER - BARTENSTEIN & BRAND, 1951, Valendis, p. 304, pl. 8, figs. 207, 208; pl. 14B, fig. 16; pl. 16, figs. 38, 39; pl. 18, fig. 41; pl. 19, figs. 38, 39.

Material: Ninety-two specimens.

Dimensions of figured specimens:

		Length	Maximum Width
Figure 11	HU.27.C.7	3.640 mm	0.810 mm
Figure 12	HU.27.C.8	3.900 mm	1.040 mm

Description: Test free, large, very compressed, elongate and tapering.

Chambers are equitant, numerous, eight to sixteen in number, of uniform shape, increasing slowly in size as added and sometimes very slightly inflated. Widest part of the test is at the proximal end of the last equitant chamber. Periphery is smooth, rounded and may have a slightly lobulate outline. Sutures distinct, strongly angled at the centre of the test, depressed, though may be flush with the surface, particularly in the early portion. Wall smooth, calcareous. Large proloculus may be ornamented with one or two costae. Aperture terminal, radiate on a long apertual neck.

Alternation of generations: Two sizes of proloculus are recognised, the microspheric form having a small globular one and the megalospheric form having a large proloculus, which may be subglobular but is often elongate, cylindrical and raised above the general level of the test.

Remarks: The great length and unornamented surface makes this species of *Frondicularia* distinctive. It is very similar to *Frondicularia midwayensis* Cushman but the latter differs in having slightly raised sutures and a finely papillate surface. As a result of being very long and thin the test is often found broken in residues. The broken specimen which Sherlock (1914) figured as *Frondicularia gaultina*(?) Reuss from the Speeton clay would appear to be *Frondicularia hastata*.

Occurrence: D2D, C9, C8, C7, C6, C5, C3, C2, LB6, LB5, LB4, LB3.

Frondicularia inversa Reuss

Plate 14, figures 5, 7.

Frondicularia inversa REUSS, 1845, böhm Kreide, p. 31, pl. 8, figs. 15-19; pl. 13, fig. 42.

Frondicularia inversa REUSS - CHAPMAN, 1894, Folkestone, p. 155, pl. 3, fig. 8.

Frondicularia inversa REUSS - FRANKE, 1928, Oberkreide, p. 60, pl. 5, fig. 1.

Frondicularia inversa REUSS - BROTZEN, 1936, Senon, p. 96, pl. 6, fig. 12.

Frondicularia inversa REUSS - CUSHMAN, 1946, Gulf Coast, p. 86, pl. 33, figs. 11-18.

Frondicularia inversa REUSS - BARTENSTEIN & BRAND, 1951, Valendis, p. 304, pl. 8, figs. 205-206.

Material: Eighty-eight specimens.

Dimensions of figured specimens:

		Length	Maximum Width
Figure 5	HU.27.C.1	1.690 mm	0.702 mm
Figure 7	HU.27.C.3	1.560 mm	0.648 mm

Description: Test elongate, much compressed, palmate to elliptical in outline. Proloculus narrow elongate, followed by five to nine acutely angled equitant chambers. They are low and broad and all nearly equal in height; later chambers fail to reach the base giving a test tapering towards the proloculum. The chambers are distinct, slightly inflated; sutures distinct, depressed, though sometimes flush with the surface. Chambers frequently ornamented with a longitudinal rib which runs parallel to the chamber; the proloculus may also have a longitudinal rib produced to form a spine. The ribs are stronger proximally and are generally at the base of the chambers giving the appearance of an elevated, limbate suture. Aperture terminal, radiate, slightly produced.

Remarks: The specimen illustrated as figure 7 is very typical of the Speeton material, though the specimen seen in figure 5 falls within the range of variation of Reuss's original illustrations. Bartenstein & Brand record the species from the Upper Valanginian of N.W. Germany.

Occurrence: D6I, D6, D5, D4, D3, D2, D1, C7, C3, C2.

Frondicularia cf. microdisca Reuss

Plate 14, figure 8.

Frondicularia microdisca REUSS, 1860, Westphalien Kreide, p. 195, pl. 5, fig. 4.

Frondicularia microdisca REUSS - REUSS, 1863, Hils und Gault, p. 91.

Frondicularia microdiscus REUSS - CHAPMAN, 1894, Folkestone, p. 158, pl. 4, fig. 3.

Frondicularia sp. 2. - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 40, pl. 5, fig. 109; pl. b, figure 138.

Material: Seven specimens.

Dimensions of figured specimen:

		Length	Maximum Width
Figure 8	HU.27.C.4	1.300 mm	0.684 mm

Description: Test broad, palmate, very compressed, periphery very slightly lobulate. Chambers distinct, flat, equitant, six to nine in number. The spherical or ovate proloculus has a small, median, longitudinal ridge. Peripheral margin flattened. Narrow sutures are flush with the surface. The surface of the test is smooth and generally without any ornamentation. Aperture terminal, produced on a cylindrical neck.

Remarks: The specimens agree in every respect with Frondicularia microdisca Reuss except that they lack the median rib which runs from the proloculus to the apertual neck. For this reason they are here referred to as F. cf. microdisca. It differs from Frondicularia cushmani Loeblich & Tappan in not having its chambers extending to the base. One of the specimens has faint vertical striae crossing the chambers.

Occurrence: D6H, C7, C3, C2, LB4.

Frondicularia simplicissima Dam

Plate 14, figure 6.

Frondicularia loryi BERTHELIN - EICHENBERG, 1934, Hauterive, p. 179, pl. 11, fig. 1.

Frondicularia D11 - HECHT, 1938, Unterkreide, pl. 16a, fig. 32-33.

Frondicularia simplicissima DAM, 1946, Netherlands, p. 576, pl. 88, fig. 11.

Frondicularia simplicissima DAM - BARTENSTEIN, 1956, Hauterive, p. 519, pl. 2, fig. 39.

Frondicularia simplicissima DAM - ZEDLER, 1961, Hauterive, p. 45, pl. 8, figs. 23-27.

Material: Twenty-one specimens.

Dimensions of figured specimen:

		Length	Maximum width
Figure 6	HU.27.C.2	0.594 mm	0.180 mm

Description: Test small, strongly compressed, elongate, with a spherical or oval proloculus which is followed by four to six, chevron or arch-shaped, embracing chambers. The chambers are slightly inflated, very low, broader than high and increasing in breadth more rapidly than height as added, giving a test tapering towards the proloculus. The peripheral outline is weakly lobulate. The sutures are distinct, depressed and arched upwards. Aperture terminal, oval. Wall calcareous, smooth.

Variation: There is considerable variation in the shape of the chambers, some forms having more acutely arched chambers than others. The length/breadth index is also variable, some forms being more elongate than others.

Remarks: This species is very close to *Frondicularia bettenstaedti* Zedler but differs in having a more elongate test, more strongly arched chambers and a smaller proloculus.

Occurrence: C4, C3, C2.

Frondicularia sp. A.

Plate 14, figures 9-10

Material: Three specimens.

Dimensions of figured specimens:

		Length	Maximum width
Figure 9	HU.27.C.5	2.210 mm	0.594 mm
Figure 10	HU.27.C.6	1.430 mm	0.612 mm

Description: Test free, much compressed, elongate or palmate. Proloculus tubular shaped, inflated and extremely elongate. It is followed by five inflated, strongly equitant chambers. The periphery is smooth; sutures distinct, depressed. The surface of the test is smooth and unornamented; aperture terminal, radiate and produced on a long neck.

Remarks: Both forms probably megalospheric individuals, the specimen illustrated as figure 9 shows affinities with *Frondicularia hastata* Roemer but that of figure 10 with its characteristic proloculus is, as far as the writer is aware, different from any other known form.

Occurrence: C6, C5.

Frondicularia sp. B

Plate 22, figure 9.

Material: A single specimen.

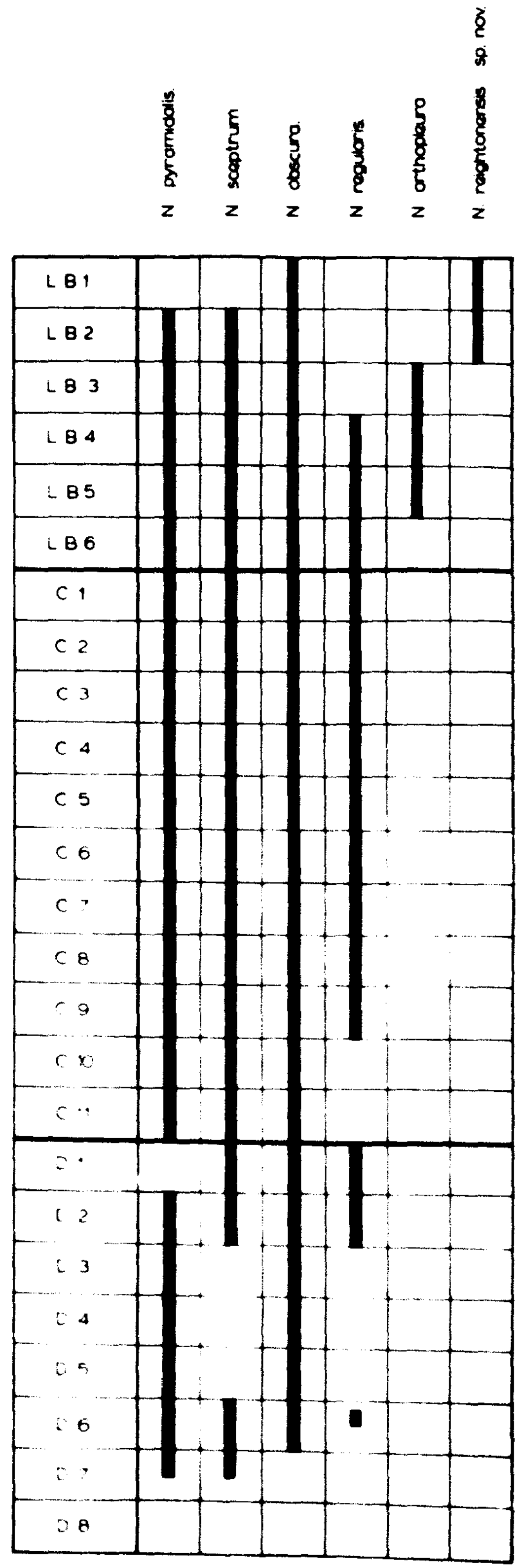
Dimensions of figured specimen:

		Length	Maximum Width
Figure 9	HU.32.C.3	1.300 mm	0.450 mm

Description: Test free, palmate, elongate, tapering, and strongly compressed. The globular proloculus is followed by eight, slightly inflated, equitant chambers which are low, broad and all of nearly equal height. They do not reach back to the base, resulting in a test tapering to the proloculus. Sutures are narrow and slightly depressed. The surface of the test is ornamented with longitudinal costae which cross all, or a large number, of the chambers. The costae tend to be slightly curved, paralleling the margin of the test. Aperture terminal, radiate, produced on a small neck.

Remarks: Frondicularia octocostata Burbach is similar in outline but has eight very regular straight continuous costae which diverge strongly from the proloculus. This specimen appears unlike any other form, but as only a single specimen has been found, it may be an aberrant form.

Occurrence: Sample7*, C8.



Distribution of the genus Nodosaria in the D, C and Lower B beds at Speeton.

Genus NODOSARIA Lamarck, 1812.

Type species Nautilus radicula Linne

Nodosaria obscura Reuss

Plate 15, figures 4-6, 16

Nodosaria obscura - REUSS, 1845-46, böhm. Kreideform.,p. 26, pl. 13, figs. 7-9.

Nodosaria obscura REUSS-REUSS, 1863, Hils und Gault,p.38

Nodosaria obscura REUSS-CHAPMAN, 1891, Folkestone,p.11,pl.9., fig. 16.

Nodosaria (Dentaline) fontannesi BERTHELIN-SHERLOCK, 1914, Speeton, p. 257, pl. 18, fig. 7.

Nodosasia raphanus LINNE- EICHENBERG, 1933, Albien, p. 5, pl. 4, fig.3.

Nodosaria n. sp. 3 - EICHENBERG, 1935, Apt, p.23, pl.2, fig. 3.

Nodosaria fontannesi BERTHELIN - EICHENBERG, 1935,Apt., p.23, pl. 2, fig. 3.

Nodosaria obscura REUSS - BARTENSTEIN & BRAND, 1937, Lias und Dogger, p.147, pl.8, fig. 15.

Nodosaria D53 - HECHT, 1938, Unterkreide, pl. 8a, fig.17-18

Nodosaria obscura REUSS-BARTENSTEIN & BRAND, 1951, Valendis, p.312, pl. 10, fig. 247,248.

Nodosaria obscura REUSS - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad,p. 36, pl.5, fig. 101; pl.6, fig. 129.

Material: Seven hundred and seventeen specimens.

Dimensions of figured specimens:

		Length
Figure 4	HU.27.C.12	1.040 mm
Figure 5	HU.27.C.13	1.300 mm
Figure 6	HU.27.C.14	1.430 mm
Figure 16	HU.27.C.24	1.820 mm

Description: Test free, elongate, rectilinear, circular in cross-section. The chambers are inflated, subglobular, three to nine in number. They are broader than high with a progressive increase in diameter towards the apertual end, giving a tapering test. Sutures horizontal, narrow, constricted, usually distinct but may be obscured by costae. The test is strongly ornamented by eight to twelve costae which stand up well above the surface of the test and continue across all the chambers and sutures without any break. The ribs are thin and often broken giving a ragged edge to the costae. Very occasionally the last two chambers have a rib intercalated between some of the main costae. The globular proloculus is usually obscured by costae and a small apical spine may be developed. The aperture is terminal, central, at the end of a tubular neck.

Alternation of generations: In the microspheric form the proloculus is small, and drawn out to a point, and is followed by up to nine chambers.

The megalospheric generation has a large subglobular proloculus and is followed by fewer chambers.

Remarks: The shape, dominant costae and the central tubular apertual neck makes this species quite distinctive. The single specimen of Nodosaria (Dentalina) fontannesi which Sherlock (1914) recorded from Upper C2 at Speeton is included here in the synonymy. Nodosaria obscura is very similar to Nodosaria pyramidalis Koch which differs only in the lateral displacement of the aperture. The species was first described by Reuss from the Cretaceous of Bohemia. It occurs in both the Lower and Upper Cretaceous beds of Navarro and Taylor age.

Occurrence: D7A, D6, D5, D4, D3, D2, D1, C11, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB6, LB5, LB4, LB3, LB2, LB1.

Nodosaria orthopleura Reuss

Plate 15, figures 17-18.

Plate 16, figure 1.

Nodosaria orthopleura REUSS, 1863, Hils und Gault, p. 89, pl. 12, fig. 5.

Nodosaria orthopleura REUSS - CHAPMAN, 1891, Folkestone, p. 595, pl. 9, figs. 22-23.

Nodosaria orthopleura REUSS - BARTENSTEIN, 1956, Hauterive, p. 521, pl. 1, fig. 19.

Material: Twenty-one specimens.

Dimensions of figured specimens:

		Length
Figure 17	HU.27.C.25	1.690 mm.
Figure 18	HU.27.C.26	2.600 mm
Figure 1	HU.28.C.1	1.040 mm.

Description: Test free, elongate, slender, five sided, side faces parallel or nearly so, tapering at either end. Chambers arranged in a rectilinear series, up to twelve in number, slightly inflated, twice as high as broad. Sutures distinct, horizontal. The ornamentation consists of five, prominent longitudinal ribs which run from the base to the apertual end without interruption forming the straight sides of the test. The proloculus has a well developed basal spine. Aperture terminal, radiate, central and on a long neck.

Remarks: This species was originally described by Reuss from the Gault of Folkestone and was also recorded from the same locality by Chapman (1891) who thought it was a species restricted to the Gault. Bartenstein (1956) found it in the Tealby clay and his specimens in the Senckenberg Museum are identical to those from Speeton. The species differs from Nodosaria tetragona Reuss in having five instead of four sides, and from Nodosaria prismatica Reuss in having straight sides and thinner costae. Some variation occurs in the number of ribs; forms with six ribs have been observed.

Occurrence: LB5, LB4, LB3.

Nodosaria pyramidalis Koch

Plate 15, figures 7-9.

Nodosaria pyramidalis KOCH, 1851, Hilsthon, p. 173, pl. 24, fig. 8.

Dentalina inepta REUSS, 1863, Hils und Gault, p. 40, pl. 2, fig. 13.

Dentalina inepta REUSS - EICHENBERG, 1935, Unterkreide, p. 174, pl. 10, fig. 11.

Nodosaria D64 - HECHT, Unterkreide, pl. 17b, figs. 1-9.

Marginulina dispar REUSS - DAM, 1950, Albien, p. 23, pl. 2, fig. 7.

Marginulina pyramidalis (KOCH) - BARTENSTEIN & BRAND, 1951, Valendis, p. 37, pl. 9, figs. 221-223; pl. 15a, fig. 4; pl. 15D, fig. 21; pl. 16, fig. 35; pl. 18, figs. 43, 47, 49; pl. 19A, figs. 40-42; pl. 19B, fig. 47.

Marginulina pyramidalis (KOCH) - BARTENSTEIN, 1956, Hauterive, pl. 1, figs. 20-21.

Marginulina pyramidalis (KOCH) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 34, pl. 5, fig. 100; pl. 6, fig. 132.

Marginulina pyramidalis (KOCH) - SZTEJN, 1958, Middle Poland, p. 27, fig. 55b.

Material: Four hundred and forty-four specimens.

Dimensions of figured specimens:

		Length
Figure 7	HU.27.C.15	1.170 mm
Figure 8	HU.27.C.16	1.560 mm
Figure 9	HU.27.C.17	1.430 mm

Description: Test free, elongate, rectilinear, circular in cross-section. There are up to twelve, chambers which are slightly inflated, particularly the later chambers. They are subglobular, broader than high with the breadth about twice the height and increase gradually in size in a distal direction. The sutures are horizontal, narrow, contricted and often obscured by the ornament. The ornament consists of nine to twelve very prominent thin costae which are continuous over the whole length of the test. The costae extend a considerable distance from the chamber walls but are thin and easily damaged. The aperture is terminal at the end of a tubular neck which is not central but displaced to one side of the test.

Alternation of generations: Two generations are distinguishable with the megalospheric form having a long proloculus with well developed costae.

Remarks: This species only differs from Nodosaria obscura in the lateral shifting of the aperture. As there is a variation in the position of the apertual neck it becomes impossible to distinguish the two forms if the aperture approaches the central position. This species has been assigned to the genus Marginulina by recent Lower Cretaceous workers in Europe but this genus is characterised by an early coiled portion. The writer has sectioned a number of specimens but has never observed an initial coil in Nodosaria pyramidalis and the species has therefore been placed in the genus Nodosaria. It is possible that this species falls within the range of variation of Nodosaria obscura.

Occurrence: D7C, D6, D5, D4, D3, D2, D1, C11, C10, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB6, LB5, LB4, LB2.

Nodosaria cf. regularis Terquem

Plate 16, figures 3-4.

Nodosaria regularis TERQUEM, 1862, Lias, p. 436, pl. 5, fig. 12.

Nodosaria sp. EICHENBERG, 1934, Hauterive, p. 172, pl. 12, fig. 4.

Nodosaria regularis TERQUEM - BARTENSTEIN & BRAND, 1937, Lias und Dogger, p. 144, pl. 11a, fig. 6.

Nodosaria D 62 HECHT, 1938, Unterkreide, pl. 17b, fig. 35; pl. 11a, figs. 78-80; pl. 18b, figs. 63-64; pl. 20b, figs. 74-75; pl. 21, fig. 28.

Nodosaria cf. regularis TERQUEM - BARTENSTEIN & BRAND, 1951, Valendis, p. 311, pl. 10, figs. 244-245.

Material: Eighty-two specimens.

Dimensions of figured specimens:

		Length	Maximum diameter
Figure 3	HU.28.C.3	0.540 mm	0.162 mm
Figure 4	HU.28.C.4	0.954 mm	0.162 mm

Description: Test small, elongate, circular in cross-section, initial end with a distinct spine. Chambers inflated, commonly two in number but may be more, in a rectilinear series. Initial chamber large and spherical, subsequent chambers may be smaller, ovoid and separated by distinct necks. Sutures straight, horizontal, narrow and deeply constricted. Wall smooth; aperture terminal, radiate, at the end of a slender neck.

Remarks: The form illustrated as figure 3 is identical in shape to Nodosaria loeblichae Dam but lacks the rugose surface of this latter species. Nodosaria rudis d'Orbigny is similar to the specimen figured as No. 4 having isolated chambers separated by long, thin tubular necks but d'Orbigny's species has a hispid surface. It is morphologically close to Nodosaria regularis from the Lias but has fewer chambers and has a tendency for the chambers to change from spherical to ovoid.

Occurrence: D6E, D2, D1, C9, C7, C5, C4, C3, C2, C1, LB6, LB5, LB4.

Nodosaria reightonensis sp. Nov.

Plate 15, figures 10-15

Plate 16, figure 2.

Derivation of name: After Reighton, the nearest village to the Speeton section.

Material: Three hundred and twenty specimens.

Dimensions of figured specimens:

		Length
Figure 10	HU.27.C.18	1.690 mm
Figure 11	HU.27.C.19	1.300 mm
Figure 12	HU.27.C.20	1.430 mm
Figure 13	HU.27.C.21	1.560 mm
Figure 14	HU.27.C.22	1.560 mm
Figure 15	HU.27.C.23	1.300 mm
Figure 2	HU.28.C.2	1.820 mm

Diagnosis: Test elongate, slender, straight or slightly curved, circular in cross-section. The chambers are in a rectilinear series, subglobular, inflated, usually, but not always, higher than broad, increasing in size gradually as added and up to ten in number. Sutures very slightly oblique, distinct, narrow and constricted. Test strongly ornamented with longitudinal costae which are continuous over the whole length of the test. In some specimens intercalated between these main costae are very fine longitudinal ribs which are confined to the chambers and do not cross the sutures. The aperture is terminal, at the end of a slender tubular neck which is displaced to one side of the test.

Alternation of generations: The microspheric form has a small, but distinct, globular proloculus and it is often only after the first two chambers that the test increases gradually in size; the initial chambers being small in relation to the rest of the test. The megalospheric forms are very rare, having fewer chambers, up to five in number, and a larger proloculus.

Remarks: The species is very similar to Nodosaria pyramidalis Koch but is slimmer, more elongate and has a greater number of chambers. In contrast to N. pyramidalis the chambers are generally higher than broad, the sutures distinct and oblique and the ribs more numerous. The fine rib intercalated between the larger ones and confined to the chamber (fig. 11) is similar to Nodosaria sceptrum Reuss but the chambers in this latter species are more inflated, the periphery lobulate and the terminal aperture central. This species is confined to the Upper B beds where it is numerically the dominant foraminifer.

Occurrence: LB2, LB1.

Nodosaria sceptrum Reuss

Plate 15, figures 1 - 3.

Nodosaria sceptrum REUSS, 1863, Hils und Gault, p. 37, pl. 2, fig. 3.
Nodosaria internota CHAPMAN, 1893, Folkestone, p. 592, pl. 9, fig. 10.
Nodosaria D55 HECHT, 1938, Unterkreide, pl. 12a, figs. 36, 37; pl. 11b, figs. 33-35; pl. 16b, fig. 81.

Nodosaria D63 HECHT, 1938, Unterkreide, pl. 17b, figs. 39-40; pl. 18, fig. 49.

Nodosaria sceptrum sceptrum REUSS - BARTENSTEIN & BRAND, 1951, Valendis, p. 313, pl. 10, figs. 252-253; pl. 16, fig. 33; pl. 18, fig. 40; pl. 19A, fig. 35.

Nodosaria sceptrum REUSS - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, p. 35, pl. 7, fig. 150.

Nodosaria sceptrum REUSS - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 255, pl. 36, fig. 2; pl. 38, fig. 1.

Material: Three hundred and six specimens.

Dimensions of figured specimens:

		Length
Figure 1	HU.27.C.9	0.990 mm
Figure 2	HU.27.C.10	0.684 mm
Figure 3	HU.27.C.11	0.828 mm

Description: Test elongate, slender, tapering; circular in cross-section. The spherical or oval proloculus is followed by three to five distinct, narrow, inflated chambers in a straight linear series. The chambers are of greater height than breadth and increase gradually in size as added. The sutures are narrow, straight and constricted. The wall is ornamented by ten to sixteen longitudinal costae which are continuous over the whole length of the test. They may be thin, sharp and fragile and consequently easily broken. On individual chambers a fine short rib may be intercalated between the main ribs (fig. 2). The aperture is terminal, central, radiate and may have a short phialine neck. The round or oval proloculus has well developed costae.

Variation: This is seen in the shape of the chambers which in some specimens are more elongate and less inflated, and also in the strength and number of the costae.

Remarks: Is almost identical to *Nodosaria tubifera* Reuss which Bartenstein (1951) regards as a subspecies of *Nodosaria sceptrum*; it differs in having slightly different shaped chambers which lack the fine intercalated rib that is frequently found in *Nodosaria sceptrum*.

Occurrence: D7C, D6, D2, D1, C11, C10, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB6, LB5, LB4, LB3, LB2.

Genus DENTALINA Risso, 1826

Type species *Nodosaria* (*Dentaline*) *cuvieri* d'Orbigny, 1826.

The Treatise described this genus as "Test elongate, arcuate, uniserial; sutures commonly oblique; aperture radiate, terminal, may be eccentric or nearly central". The genus differs from *Nodosaria* Lamarck in being asymmetrical.

Dentalina *communis* d'Orbigny

Plate 16, figures 16 - 21.

Nodosaria (*Dentalina*) *communis* ORBIGNY, 1826, Tabl. method, p. 258, No. 35.

Nodosaria (*Dentalina*) *communis* ORBIGNY - SHERLOCK, 1914, Speeton Clay, p. 258, pl. 18, fig. 24.

Dentalina *communis* ORBIGNY - EICHENBERG, 1933, Albien, p. 6, pl. 2, fig.12.

Dentalina *communis* ORBIGNY - BARTENSTEIN & BRAND, 1937, Lias & Dogger, p. 136, pl. 1A, fig. 6.

Dentalina D12 HECHT, 1938, Unterkreide, pl. 11b, fig. 22-26.

Dentalina *communis* ORBIGNY - TAPPAN, 1943, Duck Creek, p. 495, pl. 79, figs. 28, 29.

Dentalina *communis* ORBIGNY - BARTENSTEIN & BRAND, 1951, Valendis, p. 308, pl. 9, figs. 228-231.

Dentalina communis ORBIGNY - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, p. 34, pl. 7, figs. 144a, b, 145.

Dentalina communis ORBIGNY - SZTEJN, 1958, Poland, p. 37, figs. 82a, b.

Material: Four hundred and four specimens.

Dimensions of figured specimens:

		Length
Figure 16	HU.28.C.14	0.780 mm
Figure 19	HU.28.C.15	0.700 mm
Figure 20	HU.28.C.16	0.650 mm
Figure 21	HU.28.C.17	1.040 mm

Description: Test elongate, tapering, gently arcuate, slightly compressed in cross-section. The chambers are oblique, very slightly inflated, particularly near the apertual end, up to nine in number and arranged in a linear series. Initially they are wider than high but soon become higher than wide. The early chambers are usually indistinct unless they are examined in a clarifying agent. The sutures are narrow, inclined, slightly at first but strongly later, flush with the surface in the early portion but later depressed. The proloculus is elliptical, frequently with a basal spine. The last chamber is produced to form a slender apertual neck; aperture terminal, radiate. Wall smooth without ornamentation.

Remarks: Variation in the size, distinctness and shape of the proloculus has been observed but dimorphism is not readily apparent. The species shows a wide range of variation and similar forms in the Mesozoic have been given a number of different specific names. From Dentalina siliqua (Reuss) it differs in having a compressed cross-section.

Occurrence: D7D, D6, D2, D1, C11, C10, C9, C7, C5, C4, C3, C2, C1, LB6, LB5, LB4, LB3, Lb2.

Dentalina danfordi sp. nov.

Plate 13, figures 16-18

Plate 22, figures 1-5.

Derivation of name: In honour of the late C. [illegible]. Danford who studied the Speeton clay Ammonoidea and Belemnoidea.

Types: Holotype in authorscollection and not figured here.

Paratypes HU.26.C.23, and HU.26.C.26.

Material: Seven specimens.

Dimensions of figured specimens:

		Length
Figure 16, 1	HU.26.C.23	0.780 mm
Figure 2	HU.26.C.26	1.170 mm

Diagnosis: Test free, tapering, subtriangular in cross-section. Large spherical proloculus is followed by up to five chambers in a linear series. They are inflated and distinct and increase gradually in height as added; their width may remain almost constant (pl. 22, fig. 1) or increase progressively as added (pl. 22, fig. 2-3). Sutures narrow, constricted, strongly oblique. Dorsal margin straight or weakly lobulate, ventral margin distinctly lobulate. Test distinctly ornamented with ribs which are widely spaced and cross the whole length of the test without interruption. Proloculus large with ribs and a small basal spine. Aperture terminal, radiate, at the dorsal margin on a long tubular extension of the test.

Remarks: The ornamentation of this species of Dentalina makes it distinctive. It is close to D. debilis (Berthelin) but differs in having the strong ornament and a more robust test. Vaginulina riedeli Bartenstein & Brand differs from this species in having a rectilinear cross-section, less inflated chambers and no ornament. It can be distinguished from Vaginulina mediocarinata Ten Dam by its lobulate periphery, striations crossing the whole length of the test, and its inflated chambers.

Occurrence: C11, C3, C2, C1.

Dentalina debilis (Berthelin)

Plate 16, figures 8-14.

Marginulina debilis BERTHELIN, 1880, Montcley, p. 35, pl. 3, fig. 28.

Marginulina debilis BERTHELIN, - CHAPMAN, 1894, Folkestone, p. 161, pl. 4, fig. 15.

Dentalina debilis BERTHELIN - EICHENBERG, 1933, Barreme, p. 183, pl. 23, fig. 10.

Dentalina debilis BERTHELIN - EICHENBERG, 1934, Hauterive, p. 167, pl. 12, fig. 9.

Dentalina debilis BERTHELIN - EICHENBERG, 1935, Unterkreide, pl. 11, fig. 17.

Dentalina D 13 HECHT, 1938, Unterkreide, pl. 18a, fig. 53-55.

Vaginulina debilis (BERTHELIN) - TAPPAN, 1943, Grayson, p. 108, pl. 16, fig. 26

Vaginulina debilis (BERTHELIN) - TAPPAN, 1943, Duck Creek, p. 500, pl. 80 fig. 15.

Vaginulina debilis (BERTHELIN) - TAPPAN, 1950, Albian, p. 37, pl. 3, fig. 5.

Dentalina debilis (BERTHELIN) - BARTENSTEIN & BRAND, 1951, Valendis, p. 310, pl. 10, figs. 239, 240.

Dentalina debilis (BERTHELIN) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 35, pl. 7, figs. 149a, b.

Material: One hundred and thirty-one specimens

Dimensions of figured specimens:

		Length
Figure 8	HU.28.C.7	1.300 mm
Figure 9	HU.28.C.8	0.864 mm
Figure 10	HU.28.C.9	0.910 mm
Figure 11	HU.28.C.10	0.780 mm
Figure 13	HU.28.C.11	1.040 mm
Figure 14	HU.28.C.12	1.430 mm

Description: Test small, delicate, elongate, tapering, usually slightly curved, subtriangular in cross-section. Chambers up to seven in number in a linear series, may be indistinct initially but later chambers inflated and distinct. They increase in height gradually as added but their width remains fairly constant. The last one or two chambers are tear shaped in outline. Sutures distinct, narrow, strongly oblique, may be flush with the surface initially but becoming more depressed with a basal spine. Surface of the wall, smooth; aperture terminal, radiate on a long narrow, tubular neck.

Variation: Mainly in size and number of chambers. Occasionally straight forms occur and one of the specimens illustrated here (fig. 14) has in addition some extremely fine striae on the face of the chambers. Generally the tests are gently curving and without ornamentation.

Remarks: Its delicate, elongate form, with strongly oblique sutures makes this species distinctive.

Occurrence: D6I, D6, D3, D2, D1, C11, C10, C9, C8, C7, C5, C4, C3, C2, LB6, LB5, LB4.

Dentalina linearis (Roemer)

Plate 16, figures 5-6

Nodosaria linearis ROEMER, 1841, Kreidegebirge, p. 95, pl. 15, fig. 5.

Nodosaria (Dentalina) lorneiana SHERLOCK (non d'ORBIGNY) 1914, Speeton, p. 257, pl. 18, fig. 13.

Nodosaria linearis ROEMER - EICHENBERG, 1934, Hauterive, p. 164, pl. 10, fig. 13.

Nodosaria D65 HECHT, 1938, Unterkreide, pl. 23, fig. 95.

Dentalina linearis (ROEMER) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, p. 35, pl. 7, figs. 148a, b.

Material: Forty-six specimens.

Dimensions of figured specimen:

		Length
Figure 5	HU.28.C.5	0.910 mm

Description: Test elongate, tapering, arcuate, circular in cross-section with up to ten chambers arranged in a rectilinear series. The spherical proloculus is followed by one or two chambers which are broader than high but these are followed by ones that are nearly twice as high as broad. The chambers are distinct and increase gradually in size as added; except for the initial few they are barrel shaped and inflated, giving a lobulate, peripheral outline. The sutures are distinct, horizontal, depressed. Aperture terminal, radiate; wall smooth without any ornamentation.

Remarks: There is a variation in the degree of arcuateness of the test in this species, and a morphological series of specimens can be arranged which at one extreme clearly belong to the genus *Dentalina* and at the other *Nodosaria*.

Occurrence: D6, D1, C11, C10, C9, C7, C4, C2, C1, LB6, LB4.

Dentalina terquemi d'Orbigny

Plate 16, figure 15.

Dentalina terquemi d'ORBIGNY, 1849, Prodrone, p. 241, no. 257.

Dentalina sp. EICHENBERG, 1933, Barreme, p. 184, pl. 18, fig. 4.

Dentalina terquemi d'ORBIGNY - BARTENSTEIN & BRAND, 1937, Lias und Dogger, p. 138, pl. 2A, fig. 8.

Dentalina terquemi d'ORBIGNY - BARTENSTEIN & BRAND, 1951, Valendis, p. 308, pl. 9, figs. 225-227; pl. 17B, fig. 27.

Dentalina terquemi d'ORBIGNY - BARTENSTEIN & BRAND, 1962, Marine Unterkrei p. 256, pl. 38, fig. 5.

Material: Thirty-six specimens.

Dimensions of figured specimen:

		Length
Figure 15	HU.28.C.13	1.300 mm

Description: Test robust, elongate, tapering, circular in cross-section, with up to eight chambers in a linear series. The proloculus is ovoid with, in some specimens, a basal spine. It is followed at first by indistinct chambers which are as wide as high but these give way to ones which are higher than wide, the last two of which are distinctly inflated The sutures are narrow, horizontal or slightly oblique in the early portion but later are constricted and strongly oblique. The last chamber is produced to form a very small apertual neck; aperture terminal, radiate, at the dorsal margin.

Remarks: This species has been recorded from north-west Germany, France and Switzerland where it ranges from middle Valanginian to Lower Aptian.

Occurrence: D6, D2, D1, C9, C4, C2, LB6, LB5, LB4.

Dentalina sp. A

Plate 16, figure 7.

Material: A single specimen.

Dimensions of figured specimen:

		Length
Figure 7	HU.28.C.6	0.910 mm

Description: Test is robust, elongate, very slightly arcuate, circular in cross-section with a large proloculus followed by five chambers. The first two of these are higher than wide but later chambers are as wide as high; all are slightly inflated, giving a lobulate outline to the ventral margin. Sutures distinct, depressed, initially horizontal but later oblique. Wall smooth. Aperture radiate, terminal, marginal.

Remarks: This single specimen is different from any other forms from the Speeton clay. It is close to Dentalina terquemi d'Orbigny and might be a megalospheric form of this species. It is also very similar to Dentalina distincta Reuss but differs in having the later sutures oblique and the chambers less inflated. Dentalina distincta is found from the Lower Barremian to Upper Aptian in Europe.

Occurrence: C7.

Genus *PSEUDONODOSARIA* Boomgaart, 1949.

In 1839 d'Orbigny described *Glandulina* as a subgenus of *Nodosaria* but in 1929 Cushman proposed the generic name *Pseudoglandulina* for completely uniserial glanduline Nodosariidae and left the name *Glandulina* for those species with early biserial chambers. These two generic names have been used very loosely and uniserial forms have often been called *Glandulina*. The type species which Cushman designated for the genus *Pseudoglandulina* was *Nautilus comatus* Batsch, 1791 but this has since been shown by Loeblich & Tappan (1955) to be a *Nodosaria*. Loeblich and Tappan (1955) proposed the name *Rectoglandulina* for those forms lacking a biserial stage and having all chambers closely appressed with the later chambers unseparated by constricted sutures. For forms with a test like *Rectoglandulina* but with a slightly arcuate axis they gave the name *Pandaglandulina*. Boomgaart (1949) gave the generic name *Pseudonodosaria* for forms similar to the genus which later Loeblich and Tappan called *Rectoglandulina*. *Pseudonodosaria* differed in having less embracing chambers in the later portion which were separated by constricted sutures, i.e. becoming like *Nodosaria* in the adult. Boomgaart designated *Glanduline discreta* Reuss 1850 as the type species of *Pseudonodosaria*. In the Treatise *Rectoglandulina* is regarded as synonymous with *Pseudonodosaria*, with the latter having priority. Lutze (1960) studying Jurassic and Cretaceous forms demonstrated how very variable the genus is. He regards all forms as variants of three species, *Pseudonodosaria vulgata* (Bornemann), *P. tenuis* (Bornemann) and

P. humilis (Roemer) and all these are recorded from Speeton.

Pseudonodosaria humilis (ROEMER)

Plate 17, figures 7 - 8.

Nodosaria humilis ROEMER, 1841, Kreidegebirge, p. 95, pl. 15, fig. 6.

Nodosaria (*Gl.*) *humilis* ROEMER - CHAPMAN, 1893, Folkestone, p. 585, pl. 8, figs. 9-11.

Glandulina humilis ROEMER - EICHENBERG, 1934, Hauterive, p. 174, pl. 16, fig. 9; pl. 11, fig. 15.

Glandulina humilis ROEMER - EICHENBERG, 1935, Unterkreide, pl. 9, fig. 16.

Pseudoglandulina humilis (ROEMER) - BARTENSTEIN & BRAND, 1937, Lias, p. 150, pl. 8, fig. 18.

Glandulina D11 HECHT, 1938, Unterkreide, pl. 14a, fig. 16; pl. 15a, figs. 71-74.

Pseudoglandulina humilis (ROEMER) - BARTENSTEIN & BRAND, 1951, Valendis, p. 315, pl. 10, figs. 266-271.

Pseudoglandulina humilis (ROEMER) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 37, pl. 7, figs. 153-155.

Material: Twenty specimens.

Dimensions of figured specimens:

		Length	Maximum diameter
Figure 7	HU.28.C.20	0.558 mm	0.306 mm
Figure 8	HU.28.C.21	0.378 mm	0.270 mm

Description: Test free, subfusiform, rectilinear, chambers closely appressed, increasing rapidly in diameter as added. Initial chamber subglobular followed by three to five more of which the last chamber may be very large and inflated; chambers are twice as wide as high. The sutures are generally distinct, horisontal and may be either slightly depressed or flush with the surface. Wall calcareous, smooth. Aperture terminal, radiate and slightly projecting.

Remarks: This species differs from Pseudonodosaria vulgata (Bornemann) in its more ovoid shape and its flush or only very gently depressed sutures. The species ranges from Lias to Upper Cretaceous.

Occurrence: Beds D3, C10, C4, C3, C2, LB5, LB4, LB3, (Valanginian to Lower Barremian).

Pseudonodosaria tenuis (Bornemann)

Plate 17, figures 9 - 10.

Glandulina tenuis BORNEMANN, 1854, Göttingen, p. 31, pl. 2, fig. 3a, b.

Glandulina tenuis BORNEMANN - EICHENBERG, 1933, Barreme, p. 187, pl. 23, fig. 3.

Glandulina tenuis BORNEMANN - EICHENBERG, 1934, Hauterive, p. 175, pl. 16 fig. 10.

Glandulina tenuis BORNEMANN - EICHENBERG, 1935, Apt, p. 25, pl. 7, fig. 10.

Glandulina tenuis BORNEMANN - EICHENBERG, 1935, Unterkreide, pl. 9, fig. 17.

Glandulina tenuis BORNEMANN - FRANKE, 1936, Lias, p. 55, pl. 5, fig. 13.

Pseudoglandulina tenuis (BORNEMANN) - BARTENSTEIN & BRAND, 1937, Lias und Dogger, p. 150, pl. 4, fig. 41.

Pseudoglandulina tenuis (BORNEMANN) - BARTENSTEIN & BRAND, 1951, Valendis, p. 315, pl. 13, fig. 349.

Pseudoglandulina tenuis (BORNEMANN) - SZTEJN, 1958, Middle Poland, p. 40, fig. 93.

Material: Two specimens.

Dimensions of figured specimen:

		Length	Maximum diameter
Figure 9	HU.28.C.22	0.594 mm	0.198 mm

Description: Test free, elongate, subcylindrical with a rounded base followed by a series of rectilinear chambers. Chambers twice as broad as high, up to eight in number. Early chambers are closely appressed and strongly overlapping. Later ones are inflated with not as much overlap. The sutures, except on the early chambers, are distinct, horizontal and constricted giving a lobulate outline. The wall is calcareous, smooth, hyaline; the aperture terminal and radiate.

Remarks: This species can be distinguished from Pseudonodosaria vulgata (Bornemann) and P. humilis (Roemer) by its more elongate, parallel sided test and greater number of chambers. The sutures are distinctly constricted and in this respect differs from P. humilis (Roemer). P. tenuis (Bornemann) appears to be very similar to P. larva (Carsey) from the basal Navaro strata (Upper Senonian) of Texas.

Occurrence: Beds C3 and LB4.

Pseudonodosaria vulgata (Bornemann)

Plate 17, figures 11-18.

Glandulina vulgata BORNEMANN, 1854, Lias, p. 31, pl. 2, figs. 1-2.

Glandulina mutablis REUSS, 1863, Hils und Gault, p. 58, pl. 5, figs. 7, 9-11.

Nodosaria (Glandulina) mutablis REUSS - CHAPMAN, 1893, Folkestone, p. 585, pl. 8, fig. 19, 20.

Glandulina vulgata BORNEMANN - FRANKE, 1936, Lias, p. 54, pl. 5, fig. 9.

Pseudoglandulina cf. mutablis (REUSS) - TAPPAN, 1940, Grayson, p. 105, pl. 16, fig. 15.

Pseudoglandulina cf. mutablis (REUSS) - LOEBLICH & TAPPAN, 1949, Walnut, p. 258, pl. 49, figs. 9-10.

Pseudoglandulina mutablis (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 315, pl. 14c, fig. 36; pl. 15c, fig. 10.

Pseudoglandulina mutablis (REUSS) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 37, pl. 7, fig. 156.

Pseudoglandulina mutablis (REUSS) - SZTEJN, 1958, p. 40, fig. 92.

Rectoglandulina vulgata (BORNEMANN) - LUTZE, 1960, Callovian & Oxfordian, p. 480, pl. 29, figs. 4-7.

Pseudonodosaria mutablis (REUSS) - TAKAYANAGI, 1960, Japan, p. 99, pl. 5, fig. 22.

Material: Thirty-four specimens.

Dimensions of figured specimens:

		Length	Maximum diameter
Figure 11	HU.28.C.23	0.594 mm	0.396 mm
Figure 12	HU.28.C.24	0.378 mm	0.216 mm
Figure 13	HU.28.C.25	0.558 mm	0.252 mm
Figure 14	HU.28.C.26	0.378 mm	0.180 mm
Figure 15	HU.28.C.27	0.242 mm	0.198 mm

		Length	Maximum diameter
Figure 16	HU.29.C.1	0.702 mm	0.378 mm
Figure 18	HU.29.C.2	0.774 mm	0.414 mm

Description: Test free, elongate, rectilinear, circular in cross-section. The chambers are inflated, about twice as broad as high, and increase gradually in size as added. The proloculus is subglobular and is followed by four to six chambers which are often inflated. The last chamber may be smaller than its predecessor and adjacent ones may show marked differences in dimensions. The sutures are distinct, horizontal, constricted. Surface of the test smooth with a calcareous wall. Aperture terminal and radiate.

Alternation of generations: The microspheric form (fig. 13) with a small proloculus, pointed initial end and tapering test can readily be distinguished from the megalospheric form (fig. 16) which has a large rounded proloculus and a more cylindrical test.

Remarks: The shape of the test is highly variable. In Europe it ranges from the Lias to Barremian.

OCCURRENCE: Beds C10, C8, C4, C3, C2, C1, LB5, LB4, LB3.

Pseudonodosaria sp.

Plate 22, figures 7-8

Material: Five specimens, all crushed.

Dimensions of figured specimens:

		Length
Figure 7	HU.32.C.1	0.594 mm
Figure 8	HU.32.C.2	0.630 mm

Description: Test free, subfusiform, with the chambers arranged in a rectilinear series increasing in diameter as added. The subglobular proloculus, which has a basal spine, is followed by three or four chambers which are twice as wide as high. The last chamber may be much larger and more inflated than the preceeding ones. Sutures horizontal, slightly depressed, indistinct. Test strongly ornamented with longitudinal costae. Aperture terminal, central, on a short neck.

Remarks: This species is similar to *Lingulina costata* d'Orbigny from the Tertiary but lacks the round apertual neck. It is also similar to *Lingulina multicostata* Costa but differs in having a basal spine and the ornament extending over the final chamber. From *Lingulina paucicostata* Chang it differs in being more elongate. The species has not the characteristic slit-like aperture of the genus *Lingulina* and it is here assigned to *Pseudonodosaria*. It is probably a new species but as only five specimens are available for study, and all of these are crushed, it is not proposed to give the species a name until more material is available.

Occurrence: D6E, D6C, C3.

Genus LAGENA Walker & Jacob, 1798

Type species *Serpula* (*Lagena*) *sulcata* Walker & Jacob

Lagena *apiculata* (Reuss)

Plate 18, figure 11.

Oolina *apiculata* REUSS, 1851, Lemberg, p. 22, pl. 1, fig. 1.

Lagena *apiculata* REUSS - CHAPMAN, 1893, Folkestone, p. 581, pl. 8, fig. 2-3.

Lagena *apiculata* REUSS - SHERLOCK, 1914, Speeton, p. 255, pl. 18, fig. 12

Lagena *apiculata* REUSS - EICHENBERG, 1934, Hauterive, p. 182, pl. 12, fig. 12.

Lagena D5 HECHT, 1938, Unterkreide, pl. 23, fig. 74.

Lagena D13 HECHT, 1938, Unterkreide, pl. 23, fig. 77.

Lagena D 14 HECHT, 1938, Unterkreide, pl. 17b, fig. 36; 38; pl. 19b, fig. 83

Lagena *apiculata* (REUSS) - TAPPAN, 1943, Duck Creek, p. 503, pl. 80, fig. 31.

Lagena *apiculata* (REUSS) - SZTEJN, 1958, Middle Poland, p. 41, fig. 96.

Material: Thirty-four specimens.

Dimensions of figured specimen:

Figure 11	HU.29.C.15	Diameter 0.234 mm

Description: Test small, unilocular, pyriform. Centrally placed basal spine. Wall calcareous, smooth. Aperture terminal, central, simple on a well developed neck.

Remarks: This species is distinguished from Lagena hauteriviana hauteriviana Bartenstein & Brand by its pyriform shape. The apertual neck is produced very gradually from the chamber in Lagena apiculata in contrast to the sharp angle in Lagena hauteriviana hauteriviana.

Occurrence: D6C, D2, C10, C7, C3, C2, C1.

Lagena hauteriviana hauteriviana Bartenstein & Brand

Plate 18, figures 6-10.

Lagena sp. EICHENBERG, 1934, Hauterive, p. 182, pl. 12, fig. 13.

Nodosaria rudis d'ORBIGNY - EICHENBERG, 1935, Unterkreide, pl. 11, fig.19

Lagena D14 HECHT, 1938, Unterkreide, pl. 17b, figs. 36-38; pl. 18a, figs. 20-35; pl. 18b, figs. 5-12; pl. 19a, figs. 41-44; pl. 19b, figs. 82-85; pl. 20b, figs. 61-70; pl. 21, figs. 30-33.

Lagena hauteriviana hauteriviana - BARTENSTEIN & BRAND, 1951, p. 317, pl. 10, figs. 277-278.

Lagena hauteriviana hauteriviana BARTENSTEIN & BRAND - ZEDLER, 1961, Hauterive, p. 48, text-fig. 7.

Lagena hauteriviana hauteriviana BARTENSTEIN & BRAND - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 265, pl. 35, fig. 18.

Material: Five hundred and sixteen specimens.

Dimensions of figured specimens:

		Diameter
Figure 6	HU.29.C.10	0.378 mm
Figure 7	HU.29.C.11	0.396 mm
Figure 8	HU.29.C.12	0.280 mm
Figure 9	HU.29.C.13	0.384 mm
Figure 10	HU.29.C.14	0.144 mm

Description: Test small, oval to spherical, circular in transverse section, unilocular. Greatest width at the middle. Centrally placed, tapering, initial spine. Wall calcareous, thin with a smooth surface. Aperture simple, round, at the end of a short tubular neck.

Variation: Zedler (1961) has plotted the length-breadth index showing a continuous variation between 1.0 and 3.4 with Lagena hauteriviana hauteriviana at one extreme and Lagena hauteriviana cylindracea Bartenstein & Brand, at the other. The Speeton forms have a low length/breadth ratio (1.0 - 1.6).

Remarks: This species is common in the Hauterivian of both Germany and Speeton. The cylindrical variety Lagena hauteriviana cylindracea is absent from Speeton, though abundant in the German Hauterivian especially from the *capricornu* to *hildesiense* zone. An examination of the Hauterivian Tealby clay of Lincolnshire, however, has shown it to be present there.

Occurrence: D7, D6, D5, D4, D2, D1, C11, C10, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB6, LB5, LB4, LB3, LB2.

Lagena cf. *hispida* Reuss

Plate 18, figures 13-14

Lagena hispida REUSS, 1863, Lageniden, p. 335, pl. 6, fig. 77.

Lagena hispida REUSS - CHAPMAN, 1896, Folkestone, p. 582, pl. viii, figs. 9a-b.

Lagena hispida REUSS - CUSHMAN, 1946, Gulf Coast, p. 93, pl. 39, fig. 13.

Lagena hispida REUSS - FRIZZELL, 1954, Texas, p. 103, pl. 14, fig. 18.

Material: One hundred and thirty-eight specimens.

Dimensions of figured specimens:

		Diameter
Figure 13	HU.29.C.17	0.280 mm
Figure 14	HU.29.C.18	0.252 mm

Description: Test small, with a spherical inflated chamber and a long basal spine. The surface is fine to coarsely hispid. Aperture central, simple and on a long tubular neck.

Remarks: This form differs from *Lagena hispida* in having a basal spine but agrees in all other respects with the species which Reuss described from the Oligocene. Similar forms from N.W. Germany have been described as *Lagena* cf. *oxystoma* Reuss though this species has a much finer hispid surface than *Lagena hispida*. The basal spine makes this form distinctive but in view of the variability of this group no new name is proposed here to add to the already very large number of specific names belonging to this genus. In the case of specimens of *Lagena* having basal spines of this type, the possibility of them being detached chambers of *Nodosaria hispida* d'Orbigny or *Nodosaria aspera* Reuss must be borne in mind.

Occurrence: C9, C8, C4, C3, C2, C1, LB6, LB5, LB4.

Lagena cf. *sulcata* (Walker & Jacob)

Plate 18, figure 12.

Serpula (*Lagena*) *sulcata* WALKER & JACOB, 1798, p. 634, pl. 14, fig. 5.

Lagena sulcata WALKER & JACOB - CHAPMAN, 1893, Folkestone, p. 583, pl. 8,

fig. 11.

Lagena _sulcata_ (WALKER & JACOB) - TAPPAN, 1943, Duck Creek, p. 504, pl. 80, figs. 33-34.

Lagena cf. _sulcata_ (WALKER & JACOB) - BARTENSTEIN & BRAND, 1951, Valendis, p. 319, pl. 10, fig. 281.

Material: Eight specimens

Dimensions of figured specimen:

Figure 12	MU.29.C.16	Diameter 0.180 mm

Description: Test free, small, ovate to spherical, unilocular. Wall ornamented by eight, equally spaced, longitudinal ribs which extend the whole length of the test. Aperture central, terminal, simple on a small neck.

Remarks: This differs from the type specimen of Walker & Jacob in having fewer ribs, their specimen having twenty-one. It agrees closely with the single specimen described by Bartenstein and Brand (1951) from the upper Valanginian of N.W. Germany.

Occurrence: D6, D5, C3, C2.

Subfamily LINGULININAE Loeblich & Tappan, 1961

Genus LINGULINA d'Orbigny, 1826

Type species Lingulina carinata Cushman, 1913

Cushman (1948) in describing the genus Lingulina states "Test in the early stages, at least in the microspheric form, planispiral, later chambers in a rectilinear series". Barnard (1956) was unable to find a coiled stage in either the megalospheric or the microspheric generations of this genus in the Lias, and d'Orbigny (1826) in his original description did not mention any coiled portion. The present writer has also never observed an initial coiled portion in Lower Cretaceous material and it is presumed that Cushman's description is in error on this point.

Lingulina hauteriviana sp. nov.

Plate 17, figures 21-24

Plate 18, figures 2-3.

Derivation of name: Referring to the stage Hauterivian in which this species occurs.

Holotype: HU.29.C.5

Paratypes: HU.29.C.4

HU.29.C.7

Dimensions of figured specimens:

		Length	Maximum width
Figure 21	HU.29.C.4	0.594 mm	0.216 mm
Figure 24	HU.29.C.5	0.720 mm	0.234 mm
Figure 2	HU.29.C.7	0.594 mm	0.210 mm

Diagnosis: Test elongate, laterally compressed, tapering towards the proloculus and composed of five or six chambers in a rectilinear series. The chambers are distinct, slightly inflated and, except for the final one, are always broader than high. They increase very slowly in width as added and the test consequently tapers very gradually to the proloculus, or may be almost parallel sided. The sutures are distinct, depressed, constricted and markedly limbate. The peripheral outline is gently lobulate. Wall calcareous, smooth; aperture central, terminal slit-like.

Alternation of generations: The specimen illustrated as figures 21-22 appears to be the megalospheric form with a large, spherical proloculus and fewer chambers than the microspheric individual. This latter form has a very small spherical proloculus, a more elongate test and a greater number of chambers.

Remarks: This species is distinguished from L. nodosaria (Reuss) by its more compressed test, its less inflated and more overlapping chambers, the rather weak lobulate outline, and the thickened sutures. This species would appear very similar to the form figured by Bartenstein & Brand (1951, pl. 8, fig. 186) as Lingulina sp. 4 from the Upper Valanginian but the latter species has sutures which are not constricted and has a smooth peripheral outline.

Occurrence: C6, C5, C3, LB5, LB4.

Lingulina sp. A

Plate 18, figure 5

Material: Six specimens

Dimensions of figured specimen:

		Length
Figure 5	HU.29.C.9	0.630 mm

Description: Test elongate, laterally compressed tapering very gradually towards the large spherical proloculus. Five inflated chambers arranged in a rectilinear series. They are broader than high, weakly chevron shaped, arched along the median line. The test is slightly depressed along the median line, with the chambers having a lobular appearance on either side. Sutures distinct, narrow, depressed. Aperture central, terminal, oval shaped. Wall calcareous, smooth.

Remarks: The specimen is probably a megalospheric individual and is unlike any described form. It shows similarities to _Lingulina_ sp. 1 described by Lütze (1960) from the Middle Callovian of N.W. Germany but the median line is not so depressed nor do the sutures arch up so strongly at this point. From _Lingulina_ _semiornata_ Reuss it differs in lacking the ornamentation and in having more chevron-shaped chambers.

Occurrence: D2D, C3, LB3.

Genus LINGULONODOSARIA Silvestri, 1903.

Type species _Lingulina_ _nodosaria_ Reuss, 1863.

The genus _Lingulonodosaria_ Silvestri only differs from _Lingulina_ d'Orbigny in having chambers which have very little overlap. Variation often makes it difficult in practice to separate these two genera.

Lingulonodosaria _nodosaria_ (Reuss)

Plate 17, figures 19-20

Plate 18, figures 1, 4.

Lingulina _nodosaria_ REUSS, 1863, Hils und Gault, p. 59, pl. 5, fig. 12.

Lingulina _nodosaria_ REUSS - CHAPMAN, 1894, Folkestone, p. 153, pl. 3, fig. 1.

Lingulina _nodosaria_ REUSS - EICHENBERG, 1934, Hauterive, p. 175, pl. 11

fig. 9.

Lingulina nodosaria REUSS - EICHENBERG, 1935, Apt, p. 24, pl. 2, fig. 12.

Lingulina D1 HECHT, 1938, Unterkreide, pl. 23, fig. 78.

Lingulina nodosaria REUSS - TAPPAN, 1943, Duck Creek, p. 499, pl. 80, figs. 12-13.

Material: Thirty-four specimens.

Dimensions of figured specimens:

		Length
Figure 19	HU.29.C.3	0.540 mm
Figure 1	HU.29.C.6	0.738 mm
Figure 4	HU.29.C.8	0.486 mm

Description: Test elongate, laterally compressed, tapering gradually towards the proloculus. Chambers distinct, numerous, slightly inflated, five to eight in number, in a rectilinear series. The chambers increase in height rapidly but only gradually in width. Periphery lobulate. Sutures distinct, depressed horizontal. Proloculus spherical; wall calcareous, smooth. Aperture central, terminal, elliptical or slit-like, flush with the surface.

Alternation of generations: Dimorphism is easily recognised in this species. The megalospheric form has a large spherical, slightly compressed proloculus followed by four or five chambers. The sutures are horizontal. In the microspheric form (pl. 18, fig. 1) the proloculus is smaller, spherical and distinct, and is followed by eight chambers. The first two sutures after the proloculus are curved but all the remaining ones are horizontal. The test in the microspheric form is not so strongly compressed and the chambers do not overlap so much.

Remarks: The species differs from *Lingulina rotundata* d'Orbigny, from the Tertiary, in having a compressed cross-section. In north-west Germany the species was recorded by Bartenstein & Brand (1951) from the Ober Valendis.

Occurrence: $D6A_2$, C4, C3, C2, LB6, LB5, LB4.

Subfamily RAMULININAE Brady, 1884

Genus RAMULINA Jones, 1875

Type species Ramulina laevis Jones

Jones & Chapman (1897) give the generic characters of Ramulina as "Test free or attached; branching; consisting of a calcareous tube, swollen at intervals, so as to form more or less definite, often irregular segments, from which lateral stolons or branches are sometimes given off. -------- the one or more apertures in the forms that are free are circular, being formed by the open end of the calcareous stolon-tube".

The genus is a very variable one both in size and shape and many of the species pass imperceptibly into one another. Jones & Chapman (1897) after studying all the known species at that time came to the conclusion that all the free forms really belonged to only three species:-

1. Ramulina laevis Jones, 1875 - straight or branching; pyriform or subglobular chambers; wall thick and smooth.
2. Ramulina globulifera Brady, 1879 - branching; segments of different sizes, globular or subglobular, connected by stoloniferous tubes of different length. Wall thin and hispid.
3. Ramulina aculeata Wright, 1886 - subangular, inflated segments connected by stout, curved or rarely straight stolon tubes. Walls thicker than R. globulifera with numerous strong tubercles on the surface.

There is much to be said for this classification as all the species described since 1897 could be regarded as varieties of these three species. In this thesis, however, the forms are assigned to the individually described species and not to the threefold classification of Jones and Chapman.

Ramulina fusiformis Khan

Plate 18, figures 18, 20-21

Marginulina cf. *Dentalina aculeata* d'ORBIGNY - BERTHELIN, 1880, Montcley, p. 35, pl. 2, figs. 10-13.

Ramulina globulifera BRADY - CHAPMAN, 1876, Folkestone, p. 582, pl. 12, figs. 3-4.

Ramulina sp. TAPPAN, 1940, Grayson, p. 114, pl. 18, fig. 4.

Ramulina fusiformis KHAN, 1950, p. 272, pl. 2, figs. 1-2.

Material: Thirty-seven specimens.

Dimensions of figured specimens:

		Diameter
Figure 18	MU.29.C.22	0.324 mm
Figure 20	MU.29.C.24	0.324 mm
Figure 21	MU.29.C.25	0.330 mm

Description: Test free, consisting of elongate fusiform chambers arranged in a linear series and joined by a narrow neck. The chambers are inflated with the widest part at the mid-point. The wall is calcareous and distinctly hispid. Aperture at end of open tube.

<u>Remarks</u>: The broken specimens with one chamber are identical to Khan's figured types from the Albian of Kent. The material from Speeton is significant in that forms with two chambers have been found and it is clear that these broken isolated chambers originally formed a linear series. Khan (1950) states "The possibility of these specimens being broken nodosarian chambers is remote; there is no species of <u>Nodosaria</u> in the Gault which has such chambers, and indeed the shape of these chambers does not lend any support to this theory". The Speeton forms belong to Khan's species but he does not appear to have found any examples with more than one chamber. They are close to <u>Nodosaria hispida</u> d'Orbigny but this latter species has spherical chambers. <u>Ramulina</u> <u>fusiformis</u> Khan differs from <u>Ramulina</u> <u>globulifera</u> in the elongate fusiform chambers and the absence of peripheral stolon tubes.

<u>Occurrence</u>: D6C, D2D, C10, C3, C2, IB4.

__Ramulina muricatina__ Loeblich & Tappan

Plate 19, figure 2.

__Ramulina aculeata__ WRIGHT - CHAPMAN, 1896, Folkestone, p. 583, pl. 11, fig. 9.

__Ramulina aculeata__ WRIGHT - BROTZEN, 1936, Senon, p. 116, fig. 38.

__Ramulina muricatina__ LOEBLICH & TAPPAN, 1949, Walnut, p. 261, pl. 50, figs. 5-6.

__Ramulina muricatina__ LOEBLICH & TAPPAN - BARTENSTEIN & BRAND, 1951, Valendis, p. 321, pl. 11, fig. 308.

__Ramulina spandeli__ BARTENSTEIN, BETTENSTAEDT & BOLLI (non PAALZOW), 1957, Trinidad, p. 42, pl. 5, fig. 106.

__Ramulina muricatina__ LOEBLICH & TAPPAN - SZTEJN, 1958, Middle Poland, p.43, fig. 104.

__Material:__ One hundred and eighteen broken specimens.

__Dimensions of figured specimen:__

		Maximum length
Figure 2	HU.30.C.2	0.756 mm

__Description:__ Test free, composed of elongate irregular, cylindrical branching tubes, which may diverge at irregular angles from a slightly inflated subglobular chamber (figure 2). The wall is thin, calcareous and very fragile; the surface is covered with fine spines. Aperture at the ends of the open tubes.

Remarks: Usually found fragmentary. Differs from Ramulina spandeli in its greater number of cylindrical branching tubes and from Ramulina laevis in its hispid surface. The forms illustrated by Bartenstein & Brand (1951, pl. 11, fig. 308) and by Bartenstein, Bettenstaedt & Bolli (1957, pl. 5, fig. 106) appear identical to the specimen figured here.

Occurrence: C10, C8, C4, C3, C2, C1, LB6, LB5, LB4, LB3.

Ramulina spandeli Paalzow

Plate 18, figures 15, 17, 19, 22 and 23

Plate 19, figure 1

Nodosaria hispida SHERLOCK (non d'ORBIGNY), 1914, Speeton, p. 256, pl. 18 fig. 18.

Ramulina spandeli PAALZOW, 1917, Jura Sueddeutschland, p. 46, pl. 47, fig. 15

Material: One hundred and sixty specimens.

Dimensions of figured specimens:

		Diameter
Figure 15	HU.29.C.19	0.414 mm
Figure 16	HU.29.C.20	0.378 mm
Figure 17	HU.29.C.21	0.396 mm
Figure 19	HU.29.C.23	0.540 mm
Figure 22	HU.29.C.26	0.594 mm
Figure 23	HU.32.C.4	0.612 mm
Figure 1	HU.29.C.27	0.450 mm

Description: Test free, elongate, consisting of a single oviform chamber with a long stoloniferous tube at either end. The tubes are commonly not on the same axis. The surface of both chamber and tubes is coarsely hispid. Test hyaline, delicate, easily broken. Aperture simple, rounded at the end of the tube.

Remarks: Considerable variation occurs both in shape and size, and there is a possibility that with perfect unbroken specimens the species may have a series of chamber like swellings connected by the stoloniferous tubes. The specimen illustrated as figure 22 is identical with the drawing of Paalzow's holotype. The forms illustrated here as figures 17, 19 have very long tubes and more symmetrical chambers than the typical members of this species.

Occurrence: D2, D1, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB6, LB5, LB4.

Family POLYMORPHINIDAE d'Orbigny, 1839

Subfamily POLYMORPHININAE d'Orbigny, 1839

'fistulose' Polymorphinidae

Plate 19, figures 5-6

Material: Twenty-two specimens

Dimensions of figured specimens:

		Length
Figure 5	HU.29.C.5	0.390 mm
Figure 6	HU.29.C.6	0.520 mm

Remarks: A number of fistulose forms occur at various horizons in the Speeton clay and two are figured here. The writer agrees with Barnard (1963) that fistulose forms are abnormal variants of smooth forms and are not distinct fistulose species. Terquem (1864) recorded fistulose Polymorphinidae from the Lias but it is only in the Cretaceous that they are found in any number. The fistulose variants at Speeton have a finely hispid test with the last part coarsely fistulose with numerous widely spaced apertures on long tubular necks. They may represent variants of *Globulina prisca* and *G. obtusa*.

Occurrence: Irregularly distributed in beds C3, C2, C1, LB6, LB5, LB4.

Genus GLOBULINA d'Orbigny, 1839

Type species *Polymorphina* (*Globuline*) *gibba* d'Orbigny, 1826

Globulina *prisca* Reuss

Plate 19, figures 3-4

Globulina *prisca* (non d'Orbigny) - REUSS, 1863, Hils und Gault, p. 79, pl. 9, fig. 8.

Globulina *prisca* REUSS - BERTHELIN, 1880, Montcley, p. 57, pl. 4, figs. 20-21.

Polymorphina *fusiformis* CHAPMAN (non ROEMER), 1896, Folkestone, p. 11, pl. 2, fig. 9.

Polymorphina *fusiformis* SHERLOCK (non ROEMER) 1914, Speeton, p. 263, pl. 19, fig. 12.

Globulina *prisca* REUSS - CUSHMAN & OZAWA, 1930, , p. 73, pl. 12, fig. 6.

Guttulina D7 HECHT, 1938, Unterkreide, pl. 16B, figs. 78-80.

Guttulina D18 HECHT, 1938, Unterkreide, pl. 15B, figs. 65-70.

Globulina *prisca* REUSS - MARIE, 1941, la Craie, pl. 22, figs. 239 a-b.

Globulina *prisca* REUSS - DAM, 1948, Neocomian, p. 185, pl. 32, fig. 15.

Globulina *prisca* REUSS - BARTENSTEIN & BRAND, 1951, Valendis, p. 320, pl. 10, fig. 286; pl. 14C, fig. 29; pl. 16, figs. 48, 50, 52.

Globulina cf. *prisca* REUSS - BARTENSTEIN, BETTENSTAEDT &BOLLI, 1951, p. 41, pl. 7, figs. 166 a-b.

Material: One hundred and seventy-two specimens.

Dimensions of figured specimens:

		Length
Figure 3	HU.29.C.3	0.414 mm
Figure 4	HU.29.C.4	0.450 mm

Description: Test elongate, elliptical or ovoid in shape, circular in cross-section. Three elongate chambers arranged alternately with the last two chambers strongly overlapping the first. The initial chamber is only partially visible. The sutures are distinct, depressed and narrow. Aperture terminal, central, radiate. Wall smooth; a basal spine is sometimes developed.

Remarks: The species is very close to *Globulina obtusa* (Reuss) but it is more elongate and tapering, and has not the broadly rounded base of *Globulina obtusa*.

Occurrence: D7C, D6, D2, D1, C10, C9, C8, C7, C6, C5, C4, C3, C2, C1, LB2, LB4, LB5.

Family GLANDULINIDAE Reuss, 1860

Subfamily GLANDULININAE Reuss, 1860

Genus TRISTIX Macfadyen, 1941.

Type species Rhabdogonium liasinum BERTHELIN

Tristix acutangula (Reuss)

Plate 17, figures 1-3

Rhabdogonium acutangulum REUSS, 1863, Hils und Gault, p. 55, pl. 4, fig. 14.

Rhabdogonium tricarinatum ORBIGNY var. acutangulum REUSS - CHAPMAN, 1893, Folkestone, p. 159, pl. 4, fig. 8.

Rhabdogonium D1 - HECHT, 1938, Unterkreide, pl. 17b, figs. 15-19.

Rhabdogonium D2 - HECHT, 1938, Unterkreide, pl. 18a, figs. 3-4.

Dentalinopsis tricarinatum var. acutangulum REUSS - TAPPAN, 1940, Grayson, p. 119, pl. 18, fig. 13.

Tristix acutangulum (REUSS) - DAM, 1950, Albian, p.46, pl. 2, fig.21.

Tristix acutangulus (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p.314, pl. 10, figs. 257-261; pl. 16, fig. 60; pl.19a, figs. 36-37

Tristix acutangula (REUSS) - BARTENSTEIN & BURRI, 1954, pl. 28, 1 fig.

Tristix acutangula Reuss - BARTENSTEIN, 1956, Hauterive, p.520, pl.2, fig.50.

Tristix acutangula REUSS - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, p. 37, pl. 5, fig. 111; pl. 6, fig. 139.

Tristix acutangulus (REUSS) - SZTEJN, 1958, Middle Poland, p. 38, fig. 86.

Material: Forty-five specimens.

Dimensions of figured specimen:

		Length	Maximum width
Figure 1	HU.28.C.18	0.810 mm	0.288 mm.

Description: Test free, rectilinear, uniserial, triangular in transverse section. Tapers towards the proloculus though the last few chambers often tend to be parallel sided. The sides of the test are flat or slightly concave whilst the angles of the test are sharp and carinate. The keels cross the proloculus and meet to form a small point. The subglobular proloculus is followed by six to ten, subtriangular, inflated chambers which are broader than high and increase very gradually as added. The last chamber is a rounded pyramid in shape and is sometimes smaller than the preceding one. Sutures are distinct, depressed and arch upwards on each face. The surface of the test is smooth, hyaline. Aperture terminal, radiate and either flush with the surface or produced on a small neck.

Remarks: This form differs from *Tristix insignis* (Reuss) in the sharp angles of the test which are produced into thin fragile keels which extend the length of the test and cross the proloculus. The test of this species is generally more elongate than that of *Tristix insignis* (Reuss).

Occurrence: D6I, D6, D4, D2, D1, C9, C8, C5, C3, C2, C1, LB5, LB4, LB2.

<u>Tristix</u> <u>insignis</u> (Reuss)

Plate 17, figures 4-6.

<u>Rhabdogonium</u> <u>insigne</u> REUSS, 1863, Hils und Gault, p. 56, pl. 5, fig. 2.

<u>Rhabdogonium</u> <u>insigne</u> REUSS - SHERLOCK, 1914, Speeton, p. 258, pl. 18, fig. 21.

<u>Rhabdogonium</u> <u>insigne</u> REUSS - EICHENBERG, 1934, Hauterive, p. 181, pl. 14, fig. 4.

<u>Rhabdogonium</u> D3 HECHT, 1938, Unterkreide, pl. 24, fig. 105.

<u>Tristix</u> <u>insigne</u> (REUSS) - DAM, 1948, Neocomian, p. 182, pl. 32, figs. 11-12.

<u>Tristix</u> <u>insignis</u> (REUSS) - BARTENSTEIN & BRAND, 1951, Valendis, p. 314, pl. 10, figs. 262-263.

<u>Tristix</u> <u>insigne</u> (REUSS) - SZTEJN, 1958, Middle Poland, p. 38, fig. 85.

<u>Material</u>: Sixty-nine specimens.

<u>Dimensions of figured specimen</u>:

		Length	Maximum width
Figure 4	HU.28.C.19	0.486 mm	0.162 mm

<u>Description</u>: Test free, rectilinear, uniserial, triangular in cross-section and tapering gradually towards the proloculus. The proloculus is followed by three to five slightly inflated, subtriangular chambers which are broader than high and increase very gradually in height as added. The sutures are generally distinct, depressed and on each face

strongly arched upwards towards the apertual margin. Both generations have been observed; the microspheric form having a very small proloculus which is produced to a blunt point whilst the megalospheric form has a large, smooth, spherical proloculus. The wall is smooth, hyaline, perforate. Aperture terminal, on a very low neck, radiate.

Remarks: Differs from Tristix acutangula (Reuss) in its more rounded angles, together with a rounded base.

Occurrence: D6I, D6, D1, C10, C3, C2, C1, LB4.

Superfamily CASSIDULINACEA d'Orbigny

Family OSANGULARIIDAE Loeblich & Tappan

Genus GONOROTALITES Kaever

Type species Conorotalites bartensteini aptiensis (BETTENSTAEDT)

Conorotalites sigmoicosta (Dam)

Plate 19, figures 7-18

Anomolina sigmoicosta DAM, 1948, Netherlands, p. 189, pl. 32, figs. 23-24.

Conoratalites sigmoicosta (DAM) - ZEDLER, 1961, Hauterive, p. 51, pl. 8, fig. 13.

Gavelinella? sigmoicosta (DAM) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 271, pl. 37, fig. 6; pl. 38, fig. 12.

Material: One hundred and thirty-one specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 7	HU.30.C.7	0.450 mm.
Figure 10	HU.30.C.8	0.504 mm.
Figure 13	HU.30.C.9	0.432 mm.
Figure 16	HU.30.C.10	0.414 mm.

Description: Test free, circular, plano-convex. Periphery rounded, sub-acute. Dorsal side flat showing only one coil clearly, earlier coils obscured. Ventral side convex, much elevated with a deep umbilicus. Last coil composed of seven to nine, narrow, sigmoidal shaped, depressed chambers. The sutures on the dorsal side are strongly curved, sigmoidal, raised, thickened. Sutures on the ventral side are not so distinct and can be either raised or depressed; they are slightly curved. The last chamber is higher than any of the preceding chambers. The aperture is a narrow slit at the base of the apertual face extending from the umbilicus to about halfway towards the periphery. Wall calcareous, perforate.

Remarks: The Speeton forms coil both dextrally and sinistrally with a larger number coiling sinistrally. Dextrally coiled forms have not previously been figured. The genus is distinguished from *Globorotalites* Brotzen by its coarsely perforate wall. The species is a very good zone fossil and in Europe is found from the highest part of the Upper Hauterivian (*tenuis* Zone) to the Lower Barremian. This is the first record from the Cretaceous of Britain though the species is known from N.W. Germany and Holland.

Occurrence: C3, C2, C1, LB6, LB5, LB4.

Superfamily	ROBERTINACEA	Reuss, 1850
Family	CERATOBULIMINIDAE	Cushman, 1927
Subfamily	CERATOBULIMININAE	Cushman, 1927
Genus	CONORBOIDES	Hofker, 1952
Type species	*Conorboides mitra*	(Hofker)

Conorboides acuta sp. nov.

Plate 21, figures 9-12

Derivation of name: acuta - referring to the pointed spire with an acute apical angle.

Holotype: HU.30.C.23 from bed C3 at Speeton illustrated here as figures 11-12.

Material: Fifty eight specimens

Dimensions of figured specimens:

		Length	Greatest diameter
Figure 9	HU.30.C.22	0.270 mm	0.252 mm
Figure 11	HU.30.C.23	0.234 mm	0.198 mm

Diagnosis: Test free, trochoid, planoconvex, with a high rather pointed spire of about three volutions, periphery rounded. Chambers semilunate in shape, increasing rapidly in size as added with only two in the last whorl. The umbilical side may be flat or slightly concave with the last chamber occupying two thirds of this area. Sutures flush on the spiral side, depressed on the umbilical side. Aperture a low arch extending along most of the length of the umbilical margin of the final chamber. Wall smooth, very thin, calcareous.

Remarks: The species shows little variation though in some forms the final two chambers may be inflated. It has a much higher spire, a more acute apical angle, and fewer chambers in the last whorl than either C. mitra (Hofker) or C. umiatensis (Tappan). The author has not yet been able to obtain an X-ray determination of the wall composition but Loeblich, who has examined some of the specimens from Speeton, has stated (personal communication) that the wall is aragonite.

Occurrence: LB5, LB4, LB3.

Conorboides valendisensis Bartenstein & Brand

Plate 19, figures 19-21.

Conorbis valendisensis BARTENSTEIN & BRAND, 1951, Valendis, p. 326, pl. 11, figs. 321-322, 342-343.

Conorboides valendisensis (BARTENSTEIN & BRAND) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 253, pl. 35, fig. 5.

Material: Two hundred and six specimens

Dimensions of figured specimen:

		Maximum diameter
Figure 19	HU.30.C.11	0.360 mm

Description: Test small, trochoid, with two to three whorls, circular in cross-section, planoconvex or concavoconvex. Periphery acute, smooth. Up to thirteen chambers, with about five in the last whorl. The dorsal side is convex and the ventral side either flat or concave. The initial chambers are indistinct dorsally but later ones are distinct, narrow, gently curving and increasing gradually in size as added. The sutures on the dorsal side are narrow, gently curved, flush or very slightly raised above the surface; ventrally they are indistinct but appear to be straight. Wall calcareous; aperture a low intermarginal umbilical arch with a short flap.

Remarks: All the specimens are rather poorly preserved particularly on the ventral side; most are infilled with pyrite. In N.W. Germany and Poland the species is only found in Mittel Valendis particularly at the junction of Mittel Valendis I and 2.

Occurrence: D7, D6, D4, D3.

Genus PSEUDOLAMARCKINA Myatlyuk, 1959

Type species PSEUDOLAMARCKINA RJASANENSIS (Uhlig), 1883

Lamarckina Berthelin differs from this genus in being deeply umbilicate and having a final chamber which occupies nearly half the area of the umbilical side.

Pseudolamarckina lamplughi (Sherlock)

Plate 20, figures 1-9.

Pulvinulina lamplughi SHERLOCK - 1914, Speeton, p. 290, pl. 19, fig. 16.

Discorbis turbo EICHENBERG (non d'ORBIGNY) 1933, Hauterive, p. 20, pl. 1, fig. 11.

Discorbis D1 HECHT, 1938, Unterkreide, pl. 9a, figs. 52-53, pl. 9b, figs. 49-54.

Discorbis D6 HECHT, 1938, Unterkreide, pl. 8a, figs. 23-25.

Discorbis D8 HECHT, 1938, Unterkreide, pl. 3b, 1-5, 23.

Lamarckina lamplughi (SHERLOCK) - DAM, 1946, Lamarckina p. 14, figs. 6a-c.

Lamarckina lamplughi (SHERLOCK) - DAM, 1948, Netherlands, p. 187, fig. 3.

Lamarckina lamplughi (SHERLOCK) - DAM, 1950, Albien, p. 49, fig. 5.

Lamarckina lamplughi (SHERLOCK) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 289, pl. 36, fig. 15.

Material: Four hundred and sixty-six specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 1	HU.30.C.12	0.486 mm
Figure 4	HU.30.C.13	0.450 mm
Figure 7	HU.30.C.14	0.450 mm

Description: Test free, biconvex or planoconvex, trochoid, consisting of two or three whorls with five or six chambers in the last whorl. The periphery is acute, limbate, smooth and slightly lobulate. Dorsal side strongly convex; ventral side weakly convex or flat. There are up to twelve chambers visible dorsally which increase gradually in size as added, they are usually distinct, narrow, curved, subtriangular in shape. The sutures on the dorsal surface are distinct, limbate, flush or slightly raised, curved, and meet the peripheral margin tangentially. The thickened sutures of the initial chambers are so close together that they tend to fuse forming an umbonal boss. On the ventral side the sutures are depressed and radial. Wall smooth, probably aragonitic; aperture interiomarginal extending up the face of the final chamber.

Remarks: This species is usually placed in the genus *Lamarckina* but it lacks the deep umbilicus and enlarged final chamber of that genus. *Lamarckina hemiglobosa* Dam differs from this species in having a low, very broadly rounded dorsal surface. In north-west Germany and France

P. lamplughi ranges from the Upper Hauterivian to lower Albian, and at Speeton it is numerically strongest in the Upper Hauterivian beds, C4 and C3. Some variation in the height of the spire has been noted, some forms having a more acute apical angle than others. The species was originally described from Speeton by Sherlock (1914) from C3, C2 and lower B.

Occurrence: C4, C3, C2, C1, LB6, LB5, LB4, LB3, LB2.

Subfamily EPISTOMININAE Wedekind, 1957.

The classification of the Epistomininae used here is that of the Treatise. In 1954 Hofker proposed a complete reclassification of the subfamily based largely upon dental plates and, to a lesser extent, on the nature of the apertures. He considered the type species Epistomina regularis Terquem to be invalid as it did not show many of the features regarded as characteristic of this group, in particular the absence of protoforaminal and deuteroforaminal apertures and dental plates. He suggested that Terquem's specimens may have belonged to Conorboides Hofker. For forms previously assigned to the genus Epistomina, Hofker erected three new genera - Brotzenia, Voorthuysenia and Hiltermannia and also included Höglundina Brotzen, all of which are distinguished from one another on the nature of the tooth-plates. Loeblich and Tappan (Treatise 1964) state that the type Epistomina regularis Terquem appears to be lost but they regard E. mosquensis Uhlig as identical to it and as this species was placed in the genus Brotzenia by Hofker (1954), Brotzenia becomes a synonym of Epistomina. Cordey (1963), after examining then sections of Brotzenia mosquensis Uhlig and B. parastelligera Hofker from the Oxford clay, found that although Hofker referred both species to Brotzenia they had dental plates which corresponded "exactly to the type described by Hofker (1954) for the genus Voorthuysenia". Cordey therefore regarded Voorthuysenia and Brotzenia as synonymous and emended the genus Brotzenia accordingly. Hofker's genus Voorthuysenia was erected by him

CORDEY (1963)	HOFKER (1954)	TREATISE (1964)
<u>BROTZENIA</u>	<u>BROTZENIA</u>	<u>EPISTOMINA</u>
	<u>VOORTHUYSENIA</u>	
<u>HILTERMANNIA</u> ?	<u>HILTERMANNIA</u>	<u>HÖGLUNDINA</u>
<u>HÖGLUNDINA</u>	<u>HÖGLUNDINA</u>	

Some recent classifications of "<u>EPISTOMINA</u>"

on the relative size of the tooth-plates and this, in any case, is regarded in the Treatise as of specific value only. Similarly the characters which he used to separate Hiltermannia are also regarded as of only specific importance. By definition in Hofker's classification Höglundina has plates only in the last chamber. Cordey (1963) reports observing, in some Lower Cretaceous specimens of H. caracolla (Roemer), plates in other than the final chamber suggesting that the species belongs to Brotzenia. A number of sections were made by the writer of this species but plates were observed only in the final chamber. The majority of the specimens of 'Epistomina' from the Speeton clay are either infilled by pyrite, fragile and difficult to section satisfactorily or have the final chamber damaged and eroded. The author has found the classification by Hofker, which groups forms having similar external morphology into different genera, virtually impossible to apply in practice and much is to be said for retaining the pre-1954 usage of the genus Epistomina.

Genus EPISTOMINA Terquem, 1883

Type species Epistomina mosquensis Uhlig, 1883

Epistomina hechti Bartenstein, Bettenstaedt & Bolli

Plate 20, figures 16-21

Epistomina D7 HECHT, 1938, Unterkreide, pl. 12B, figs 1-29.

Epistomina (Brotzenia) hechti BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 46, pl. 7, fig. 170.

Epistomina (Brotzenia) hechti BARTENSTEIN, BETTENSTAEDT & BOLLI - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 279, pl. 36, fig. 10.

Material: Several thousand specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 16	HU.30.C.17	0.378 mm
Figure 19	HU.30.C.18	0.450 mm

Description: Test free, small, trochoid, biconvex, composed of two and a half to three whorls, the last of which has nine to ten chambers. Periphery acute, very slightly lobulate. Test either equally biconvex or with the dorsal side more strongly convex than the ventral side. On the dorsal side about twenty-one depressed chambers are visible; the ventral chambers are generally slightly inflated. Sutures distinct, limbate, raised above the surface of the test. Ventral sutures straight, radiating from a central umbilical boss; dorsal sutures curved, meeting periphery and spiral suture tangentially. Apertures of two types - a small oval, areal one on the terminal face and long slit-like, lateromarginal apertures running parallel, and close to, the periphery on the ventral surface. The earlier lateromarginal apertures are infilled with secondary wall material. Wall smooth, thin, calcareous.

Remarks: The Speeton forms have been compared with the holotype and paratypes in the Senckenberg Museum and agree closely with them and the type descriptions by Bartenstein, Bettenstaedt & Bolli (1957). The paratype which they figured from Trinidad differs in having the ventral, radial sutures slightly curved and not straight. The species is very close to E. chapmani Dam from the Albian but differs in not having the raised sutures and depressed chambers of the early whorls. In Trinidad E. hechti is found in the middle Barremian, and in north-west Germany from the upper part of the lower Barremian (denckmanni zone). The specimens from Speeton are usually infilled with pyrite and occur in large numbers in the dark, highly pyritic, clays of the upper B beds.

Occurrence: The upper part of the lower Barremian beds LB2, LB1.

Epistomina ornata (Roemer)

Plate 21, figure 1-8

Planulina ornata ROEMER, 1841, Kreidegebirge, p. 98, pl. 15, fig. 25.

Epistomina ornata (ROEMER) - DAM, Neocomien, p. 188, pl. 32, figs. 16, 18, 19.

Epistomina ornata (ROEMER) - BARTENSTEIN & BRAND, 1951, Valendis, p. 327, pl. 12A, fig. 327; pl. 19, figs. 58-60.

Brotzenia ornata ROEMER - HOFKER, 1954, Epistomanidae, p. 181, figs. 7-8.

Epistomina (Brotzenia) ornata (ROEMER) - BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Trinidad, p. 46, pl. 15, fig. 110, 115; pl. 6, fig. 143.
Epistomina (Brotzenia) ornata (ROEMER) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 264, pl. 35, fig. 17; pl. 38, fig. 6.

Material: Several hundred specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 1	HU.30.C.19	1.690 mm
Figure 4	HU.30.C.20	0.864 mm
Figure 7	HU.30.C.21	1.040 mm

Description: Test free, lenticular, equally biconvex, trochoid, with one and a half or two whorls and ten chambers in the last whorl. On the dorsal side all the chambers are visible; they are curved, depressed and up to nineteen in number. On the ventral surface only those of the last whorl are seen; they are triangular, subtriangular or pentagonal in outline and their surface is depressed; they join to a central umbilical pit. Sutures very limbate and tuberculate, raised well above the surface of the test. The ventral sutures are straight or gently curved, radiating from the central umbilical pit, whilst the dorsal ones are strongly curved, meeting the periphery tangentially, forming a lobulate acute, tuberculate periphery. The terminal face of the last chamber usually not preserved and the areal aperture therefore not observed. Lateromarginal apertures occur on the ventral surface near the periphery; the earlier ones can be seen though are often obscured by the sutures and secondary wall material. Chamber walls usually smooth but occasionally finely punctate.

Remarks: Both dextral and sinistrally coiled forms occur though the sinistral ones are the more common. The species is similar to E. spinulifera (Reuss), but lacks the strongly lobulate outline formed by the limbate, arched, dorsal sutures of this latter species. At Speeton E. ornata (Roemer) is numerically strongest in the upper Hauterivian between beds C5A and C1; this is similar to its distribution in north-west Germany where Zedler (1961) records its abundance in the hildesiense, seeleyi and tenuis zones.

Occurrence: D2, D1, C11, C10, C6, C5, C4, C3, C2, LB6.

Genus HÖGLUNDINA Brotzen, 1948

Type species Rotalia elegans d'Orbigny, 1826

Höglundina caracolla (Roemer)

Plate 20, figures 10-15

Gyroidina caracolla ROEMER, 1841, Kreidegebirge, p. 97, pl. 15, fig. 22.

Rotalia caracolla ROEMER - REUSS, 1863, Hils und Gault, p. 84, pl. 10, fig. 6.

Pulvinulina caracolla (ROEMER) - SHERLOCK, 1914, Speeton, p. 289, pl. 19, fig. 15.

Epistomina caracolla ROEMER - EICHENBERG, 1934, Hauterive, p. 185, pl. 13, fig. 8.

Epistomina caracolla ROEMER - EICHENBERG, 1935, Unterkreide, pl. 10, figs. 15-17; pl. 13, figs. 15-18.

Epistomina D5 HECHT, 1938, Unterkreide, pl. 14a, figs. 40-50;

Epistomina caracolla (ROEMER) - DAM, 1948, Neocomian, p. 187, pl. 32, figs. 17, 20, 21.

Epistomina caracolla caracolla (ROEMER) - BARTENSTEIN & BRAND, 1951, Valendis, p. 326, pl. 11, fig. 323; pl. 12A, fig. 300, pl. 16, figs. 53-57; pl. 17B, figs. 28-30; pl. 18, figs. 73-81, 89-99; pl. 19A, figs. 48-52.

Höglundina caracolla (ROEMER) - HOFKER, 1954, Epistomaridae, p. 193, figs. 33-35.

Epistomina (Höglundina) caracolla caracolla (ROEMER) - BARTENSTEIN & BETTENSTAEDT, 1962, Marine Unterkreide, p. 260, pl. 35, fig. 13.

Epistomina caracolla (ROEMER) - SORGENFREI & BUCH, 1964, Denmark, p. 113, pl. 1, fig. 7.

Material: Several thousand specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 10	HU.30.C.15	0.900 mm
Figure 13	HU.30.C.16	0.540 mm

Description: Test free, lenticular, biconvex, trochoid, with one and a half to two whorls; the last formed whorl has six to ten chambers. Periphery acute, slightly keeled. The ventral side is markedly convex, the dorsal side less so. All the chambers are visible dorsally and are up to eighteen in number. On the ventral side only the chambers of the last whorl are visible. The chambers are depressed, triangular in shape dorsally, gently curved ventrally. Sutures strongly limbate, flush with the surface or slightly raised. Ventral sutures straight, radiating from a central boss; sutures on dorsal side are gently curved and meet the periphery tangentially. Oval areal aperture and also a more conspicuous, slit-like, lateromarginal aperture on the ventral side, very close to the peripheral border and parallel to the plane of coiling. The earlier lateromarginal apertures are visible along the ventral periphery but are usually closed by secondary wall material. Wall smooth, thick, calcareous.

Variation: Occurs mainly in the size of the test and its degree of convexity. Dextrally coiled forms occur in all populations but are always less in number than those coiling in a sinistral manner.

Remarks: This species often occurs in vast quantities forming the bulk of the residue; this is particularly so in the upper Hauterivian and is paralleled in north-west Germany. Frequently the tests are eroded, especially the thinner chamber walls between the sutures (fig. 10); in some cases little remains apart from the periphery and central boss.

It is not thought that this necessarily indicates transportation and sorting by bottom currents after deposition.

In the cliff sections of the C beds, specimens can often be seen by the naked eye, weathering out on the surface of the clay.

A number of specimens were dissolved in dilute acetic acid and in every case a brown 'chitinous' lining to the chambers remained.

Externally Höglundina caracolla (Roemer) and Epistomina parastelligera (Hofker) appear identical (see Cordey 1963, p. 656).

Occurrence: D6, D5, D4, D3, D2, D1, C11, to C1, LB6, LB5, LB4, LB3, LB2.

Family NONIONIDAE Schultze, 1854

Subfamily CHILOSTOMELLINAE Brady, 1881.

Genus ALLOMORPHINA Reuss, 1849.

Type species Allomorphina trigona Reuss, 1850.

Allomorphina sp. A

Plate 21, figures 13-16.

Material: Eighteen specimens.

Dimensions of figured specimens:

		Maximum diameter
Figure 13	HU.30.C.24	0.216 mm
Figure 15	HU.30.C.25	0.234 mm

Description: Test small, trochospiral, subcircular to subtriangular in shape, involute with only the chambers of the last whorl distinctly visible. The last whorl is composed of three, inflated chambers which form the bulk of the test. Sutures distinct, depressed. Aperture a small elongate slit at the ventral edge of the last chamber. Wall thin, smooth.

Remarks: This is the first record of this genus from the Speeton clay. The majority of the specimens are unfortunately rather poorly preserved, and due to their small size are difficult to determine; whilst the form is almost certainly a new species no name is given here until further material has been obtained and studied. It is similar to *Allomorphina aliai* Colom from the Maestrichtian of the Spanish Sahara but is much smaller and has a less distinctive aperture.

Occurrence: C3, LB5, LB3.

The Upper D beds - note the differing beach levels against the same pillbox on two occasions.

CHAPTER 7

DISTRIBUTION OF THE FORAMINIFERA.

It is clear from the distribution chart that on the basis of the foraminifera, the D beds can be subdivided into four faunal units:-

1. Beds D4C1 to D1 — (b) D2D-D1; (a) D4C1-D2E
2. Beds D5E to D4C2.
3. Beds D7D to the top of D6.
4. Beds D8 to D7E.

Fauna 4 D8-D7E. Immediately overlying the Coprolite Bed (E), these lowest beds contain a sparse but distinctive fauna of arenaceous foraminifera which are recorded here for the first time. All the forms have been assigned to the genus *Haplophragmoides*, but because of their crushed and distorted preservation they have been left under *Nomenclatura aperta*. They show strong affinities with *Haplophragmoides neocomiensis* (Chapman), *H. concavus* (Chapman) and *H. fontinensis* (Terquem).

The black shaly clays of D8 with their pieces of phosphatic material and occasional grains of glauconite, probably accumulated in brackish water conditions, perhaps in an estuary, which allowed the belemnites *Acroteuthis sublateralis* and *A. lateralis* to drift in. The glauconite gains may have been derived and do not necessarily indicate true marine conditions. No ammonites have been found in D8 or the lower D7 beds, and unfortunately the microfauna is probably more indicative of poor ecological conditions than age of strata. Similar forms of Haplophragmoides have been recorded from the Tithonian and Berriasian of north-west Bulgaria (Jovcheva & Trifonova 1961), the Infra-Valanginian of Poland (Sztejn 1960, 1964), and the Wealden 6 to Mittel Valendis of Germany (Bartenstein & Brand 1951).

Fauna 3 D7D to the top of D6. Here a marked improvement in ecological conditions is reflected in the increased number of both calcareous and arenaceous foraminifera. Whilst only three species occur in bed D7D, twenty-two are present in D6A1. The genera Glomospirella, Ammobaculites, Trochammina, Verneuilinoides, Nodosaria, Citharina, Frondicularia, Lagena, Lenticulina, Dentalina, Vaginulina, Lingulonodosaria, Globulina, Ramulina, Tristix, Conorboides and Höglundina all occur for the first time at Speeton. Restricted to these beds are Haplophragmoides nonioninoides (Reuss), Lenticulina (M.) striatacostata (Reuss), Vaginulina cf. angustissima Reuss, and Citharina strigillata (Reuss).

All the foraminifera in these beds are also found in the Mittel Valendis of Germany. In contrast, the ostracoda are restricted to these beds and are not comparable with any other known fauna (Neale 1962b). Neale (1962b) suggests the ostracoda have affinities with the Volgian of the Emba region in Russia rather than the Lower Cretaceous, although the ammonites (Neale 1962a) point to a Subcraspeditan (Upper Berriasian) age. With foraminiferal assemblages it is difficult to distinguish between Berriasian and Valanginian, although strata of Valanginian age tend to have a greater variety and number of species.

STOLLEY'S GERMAN ZONES	SPEETON	LINCS.
ALBIAN UPPER GAULT :— 12 Zone of *Schloenbachia inflata* and *Puzosia planulata*; with *Bel.* (*Neohib.*) cf. *ultimus*. 11 .. .. *Hoplites interruptus*; with *Bel.* (*Neohib.*) *minimus*. MIDDLE GAULT :— 10 Zone of *Hoplites regularis* d'Orb., with *Bel.* (*Neohib.*) *minor*. 9 .. .. *Leymeriella tardefurcata* and *Acanthoplites milletianus*; with *Bel.* (*Neohib.*) *strombecki*; (without Parahoplitids in upper part; perhaps two zones) 8. .. .. *Leymeriella schrammeni* and *Phylloceras velledae*; with *Bel.* (*Neohib.*) aff. *strombecki*. 7. .. .. *Acanthoplites jacobi*; with *Bel.* (*Neohib.*) *wollemanni*. 6. .. .. *Acanthoplites nolani*; with *Bel.* (*Neohib.*) aff. *wollemanni*.	Red Chalk - - - - - Minimus Marls	Red Chalk Carstone
APTIAN LOWER GAULT :— 5. Zone of *Parahoplites schmidti* and *Oppelia* (*Adolphia*) aff. *trautscholdi*; with *Bel.* (*Neohib.*) *inflexus* and Bel. (*Duval.*) *grasiana*. 4. .. .. *Bel.* (*Neohib.*) *clava* and *Bel.* (*Neohib.*) *duvaliaeformis*, ammonites wanting. 3. .. .. *Hoplites deshayesi*, with *Bel.* (*Neohib.*) *ewaldi* and *Bel.* (*Duvalia*) *grasiana* 2. .. .. *Douvilleiceras albrechti-austriae* and *Hoplites weissi*; with *Bel.* (*Neohib.*) *ewaldi* and *Bel.* (*Duvalia*) *grasiana* 1. .. .. *Hoplitides bodei*, with *Bel.* (*Neohib.*) cf. *ewaldi* and *Bel.* (*Duvalia*) *grasiana*	Ewaldi Marl Upper B	Sutterby Marl - - - - - - Fulletby Beds
BARREMIAN UPPER NEOCOMIAN 11. Zone of *Ancyloceras scalare* and *Crioceras bidentatum*; 10. .. .. *Crioceras* aff. *rude* and *Oppelia haugi*; with *Bel.* cf. *brunsvicensis* in zones 10 and 11. 9. .. .. *Crioceras sparsicosta* and *Oppelia nisus*; 8. .. .. *Ancyloceras innexum* (and *Anc. castellatum*); c Zone of *Crioceras pingue*. b .. .. *Crioceras robustum*. 7. .. .. a *Crioceras denckmanni*; 6 .. .. *Crioceras roemeri*. 5 .. .. *Crioceras elegans*. with *Bel.* *brunsvicensis* in zones 5 to 9. 4 .. .. *Crioceras fissicostatum*, and *Bel.* aff. *absolutiformis* 3 .. .. *Bel.* *absolutiformis*, *Bel.* *speetonensis* 2 .. .. *Crioceras rarocinctum* with *Bel.* [illegible] in zones 2 and 3 1 .. .. *Crioceras strombecki* and *Bel.* *jasikowi*	- - - - - Cement Beds Lower B	Upper Tealby Clay - - - - - - Tealby Limestone
HAUTERIVIAN MIDDLE NEOCOMIAN 6 Zone of *Simbirskites phillipsi* 5 .. .. perisphinctoid Simbirskitids and *Bel.* aff. *pseudo-panderi* 4 .. .. *Crioceras seeleyi* and numerous Simbirskitids 3 .. .. *Crioceras capricornu* and numerous Simbirskitids 2 .. .. *Hoplites* aff. *neocomiensis* and *Hopl.* *brevigatus*. 1 .. .. *Hoplites noricus*, *Hopl.* *radiatus* and *Bel.* *subquadratus* .. *B* [illegible] in zones 1 to 4	C Beds - - - - - - D1 D2	Lower Tealby Clay - - - - - - Claxby Ironstone
VALANGINIAN LOWER NEOCOMIAN 10 Zone of *Astieria astieri*, *Ast.* *psilostoma* and others, and *Bel.* aff. *subquadratus* 9 .. .. *Hoplitides arnoldi* and aff. *arnoldi* and ? *Saynoceras verrucosum* Dichotomid beds 8 .. .. *Polyptychites bidichotomus*, *P.* *obsoletecostatus*, *Craspedites* div. sp. and *Bel.* sp. n. No 5 7 .. .. *Polyptychites brancoi*, *P.* *terscissus*, *Crioceras curvicosta* and *Bel.* sp. n. No 4 Polyptychitid beds ? 6 Intermediate zone of Haslage 5 Zone of *Polyptychites clarkei*, *P.* *ascendens*. 4 .. .. *Polyptychites* [illegible], *P.* *keyserlingi*. 3 .. .. *Polyptychites bullatus*, *P.* aff. *diplotomus*. with *Belemnites* sp. n. Nos. 2 and 3 in zones 3 to 6 2 .. .. *Polyptychites diplotomus*, and *Bel.* sp. n. No 1 Oxynoticeratid beds ? 1a .. .. *Oxynoticeras marcoui* 1 .. .. *Oxynoticeras gevrili* and *O.* *heteropleurum*.	Lower D Beds	Spilsby Sandstone

FIG. STOLLEY'S GERMAN ZONES ADAPTED FROM LAMPLUGH 1924 P.23-5.

In north-west Bulgaria the Berriasian microfauna includes <u>Haplophragmoides</u> aff. <u>neocomiensis</u> (Chapman), <u>Verneuilinoides neocomiensis</u> (Mjatliuk) and <u>Glomospirella gaultina</u> (Berthelin) all of which occur in this Speeton fauna. The evidence of both ammonoidea and foraminifera suggests a Berriasian age for these beds and the absence of <u>Ammovertella cellensis</u> Bartenstein & Brand, a zone fossil for the Mittel Valendis, adds weight to this view.

<u>Fauna 2</u> D5E-D4C2. These beds are characterised by their paucity of foraminifera, both as regards numerical abundance and number of species, and the total absence of ostracoda. Lithologically they are grey to greyish brown pyritic clays and mudstones in which <u>Lingula</u> occurs quite commonly, together with various species of <u>Acroteuthis</u>. Shallow water is suggested by the presence of <u>Lingula</u> though the belemnites indicate connection with the open sea. It is probable that these deposits were laid down in the littoral zone under reducing conditions; an environment in which only the more tolerant foraminifera could live and even these in small numbers. <u>Ammovertella cellensis</u> Bartenstein & Brand occurs in D5A though is rather rare, and <u>Ammobaculites subcretaceus</u> Cushman & Alexander, in D4C6. In Bulgaria this latter species is found in the Valanginian but is absent from the Berriasian.

<u>Fauna 1</u> D4C1 up to and including D1. The return of good marine conditions in bed D4C1 is reflected in the rich benthonic fauna which persists to the top of the D beds and up into the C beds. On faunal grounds these beds can be divided into two at the D2D-D2E boundary:-

(a) beds D4C1 up to and including D2E. Here Ammodiscus tenuisimus (Gümbel), Glomospira gordialis (Jones & Parker), Nodobacularia nodulosa (Chapman), Frondicularia concinna Koch, Citharina cf. discors (Koch), Lenticulina (L.) saxonica Bartenstein & Brand, L. (L.) guttata var. intermedia var. nov., L. (A.) cf. pachynota (Dam), L. (A.) schreiteri (Eichenberg), L. (P.) crepidularis (Roemer) and Pseudonodosaria humilis (Roemer) appear for the first time. It is in these beds that Ammovertella cellensis Bartenstein & Brand and Conorboides valendisensis Bartenstein & Brand, good zone fossils in Germany for Mittel Valendis 1b and 2, reach their acme. In north-west Germany however Ammodiscus tenuisimus (Gümbel), Frondicularia concinna Koch and Lenticulina (L.) saxonica Bartenstein & Brand do not occur below Ober Valendis 1-3. The ostracods Protocythere hannoverana Bartenstein & Brand, Schuleridea praethorenensis Bartenstein & Brand, and Dolocytheridea wolburgi Bartenstein & Brand, which occur in these beds, suggests a correlation ranging from Mittel Valendis 1 to the top of Ober Valendis 1 of Germany. The foraminifera Lenticulina (A.) schreiteri (Eichenberg); L. (L.) guttata (Dam) and L. (P.) crepidularis (Roemer) all range upwards from the German Ober Valendis 2 and 3. From this it would appear that the beds between D4C1 and D2E have an age equivalence ranging from Mittel Valendis 1 and 2 to Ober Valendis 3 in terms of the north-west German succession.

(b) beds D2D up to and including D1. A true Hauterivian fauna occurs in D2D with the appearance of Citharina harpa (Roemer), C. seitzi Bartenstein & Brand, C. sparsicostata (Reuss), Vaginulina arguta Reuss,

Cenoman		*Schloenbachia* sp. sp.
Ober-Alb		*Mortoniceras* sp. sp.
Mittel-Alb		*Euhoplites lautus* (SOWERBY) *Anahoplites intermedius* SPATH *Hoplites dentatus* (SOWERBY) *Douvilleiceras mammillatum* (SCHLOTHEIM)
Unter-Alb		*Leymeriella regularis* (ORBIGNY) *Leymeriella tardefurcata* (LEYMERIE) *Leymeriella schrammeni* (JACOB) *Acanthohoplites jacobi* (COLLET) *Acanthohoplites nolani* (SEUNES)
Ober-Apt		*Parahoplites schmidti* JACOB & TOBLER *Neohibolites clava* STOLLEY
Unter-Apt		*Deshayesites deshayesi* (LEYMERIE) *Deshayesites bodei* (KOENEN)
Ober-Barrême		*Crioceras bidentatum* KOENEN *Crioceras rude* KOENEN
Mittel-Barrême		*Crioceras sparsicosta* KOENEN *Crioceras denckmanni* KOENEN *Crioceras elegans* KOENEN
Unter-Barrême		*Crioceras fissicostatum* NEUMAYR & UHLIG *Crioceras rarocinctum* KOENEN *Crioceras strombecki* KOENEN
Ober-Hauterive	4	*Neocraspedites tenuis* (KOENEN)
	3	*Crioceras seeleyi* NEUMAYR & UHLIG
	2	*Crioceras hildesiense* KOENEN
	1b 1a	*Crioceras capricornu* (F. A. ROEMER)
Unter-Hauterive	2	*Acanthodiscus bivirgatus* (WEERTH)
	1	*Lyticoceras noricum* (F. A. ROEMER)
Ober-Valendis	4	*Astieria* sp. *Arnoldia* sp.
	3 2 1	*Dichotomites* sp. sp.
Mittel-Valendis	2	*Polyptychites* sp. sp.
	1	*Platylenticeras* sp. sp.

Zones currently used in Germany.

(after Bartenstein & Bettenstaedt 1962)

V. kochii Roemer, Frondicularia hastata Roemer, Lenticulina (L.) guttata (Dam) var. eichenbergi Bartenstein & Brand, L. (L.) ouachensis (Sigal), wisselmanni (Bettenstaedt), Ramulina spandeli Paalzow and Epistomina ornata (Roemer). The ostracods Cythereis senckenbergi Triebel and Protocythere triplicata (Roemer) which also occur in these upper D beds are well known species in the Lower Hauterivian noricum and bivirgatus zones of Germany. On the other hand Dorothia oxycona Reuss which is common in the upper Valendis and bivirgatus zone of Germany is absent from the D beds. The distinctive species Triplasia emslandensis Bartenstein & Brand which is absent from the Lower Cretaceous of Britain, is regarded in north-west Germany and Denmark, where it commonly occurs, as a facies fossil confined to littoral conditions.

The C beds

These beds, in contrast to the D beds, do not show distinct micro-faunal units separated by relatively barren strata, but have a very rich fauna with many long ranging forms. The occurrence of Höglundina caracolla (Roemer), Haplophragmium aequale (Roemer), Citharina harpa (Roemer) and Epistomina ornata (Roemer) clearly indicate their Hauterivian age. Höglundina caracolla (Roemer) is very common, often occurring in vast numbers and forming the bulk of the washed residue. Similarly Lenticulina münsteri (Roemer) is common throughout most of the C beds although never occurring in 'floods' as does Höglundina caracolla (Roemer). In C11, the basal member of the C beds, Haplophragmium aequale (Roemer), Bigenerina clavellata Loeblich & Tappan and Tritaxia pyramidata Reuss occur for the first time. In Germany this latter species appears in the zone of Crioceras hildesiense Koenen as does Lagena cf. hispida Reuss a form which first appears in and ranges upwards from bed C9.

The zone Crioceras capricornu Roemer is divided in Germany into an upper and a lower part, with the ammonite Simbirskites first appearing in the upper capricornu zone and ranging upwards. At Speeton this genus first appears at the base of the C6 beds. Frondicularia simplicissima Dam, which occurs in bed C6 at Speeton, is a distinctive species which in north-west Germany is first seen in the upper capricornu zone. Citharina sparsicostata (Reuss) which dies out in the capricornu zone in Germany is not found above mid-C5 at Speeton. In C5 Lenticulina (L.) heiermanni Bettenstaedt is recorded and in Germany this occurs first at the top of the seeleyi zone. In C4 the two useful species Pseudolamarckina lamplughi (Sherlock) and Wellmanella antiqua (Reuss) occur. Although a boreal form, the latter species is regarded as indicative of a rather warm, oxygen rich biotope in the same way as Citharina harpa (Roemer). Wellmanella antiqua Reuss, though found in the upper capricornu zone, is most abundant in the seeleyi and tenuis zones of north-west Germany. The occurrence of Conorotalites sigmoicosta (Dam) and Citharina acuminata Reuss in C3 suggests a correlation with the tenuis and seeleyi zones of Germany.

Correlation with north-west Germany is thus good and easily made in general terms of a Hauterivian age, but is less satisfactory in the finer subdivisions where it depends on only a few 'index' species.

The Lower B beds

A marked diminution in the number of genera and species of foraminifera is seen as successively higher beds are sampled. The base of these beds contains a rich and varied fauna whereas in the uppermost beds only four species occur. This gradual reduction in the rich Hauterivian fauna is seen in Germany as well as in England and is a reflection of a deterioration in the environment. In the field this is seen in the very black clays which are frequently finely laminated and contain abundant pyrite - characteristics associated with reducing conditions. Spath (1924) on the basis of the ammonites, recognised that the lower part of the Lower B beds was of Hauterivian age but did not indicate the position of the Hauterivian/Barremian boundary in the field. Foraminifera such as *Haplophragmium aequale* (Roemer), *Epistomina ornata* (Roemer) and *Citharina harpa* (Roemer) in these lowest beds also indicate a Hauterivian age. In Germany *Haplophragmium aequale* (Roemer) is not found above the zone of *Neocraspedites tenuis* (Koenen), at the top of the Hauterivian, and at Speeton it has not been recorded above the highly glauconitic LB4C bed. *Citharina harpa* (Roemer) is last seen in bed LB5B and in north-west Germany ranges up to the base of the *Crioceras strombecki* Koenen zone at the base of the Barremian. *Epistomina ornata* (Roemer) again an essentially Hauterivian form, ranges up to bed LB6. *Lenticulina münsteri* (Roemer) and *Höglundina caracolla* (Roemer) occur abundantly in all samples up to and including LB2D. *Conorotalites sigmoicosta* (Dam), which first occurs in bed C3 and dies out in LB4D, is a valuable and easily recognised index fossil. In north-west Germany and in the Netherlands it ranges from the highest part of the upper Hauterivian (<u>tenuis</u> zone) to the lower Barremian.

In bed LB1 at the top of the Lower B beds <u>Epistomina</u> <u>hechti</u> Bartenstein, Bettenstaedt & Bolli and <u>Nodosaria</u> <u>reightonensis</u> sp. nov., are the dominant foraminifera with <u>Lenticulina</u> <u>münsteri</u> (Roemer) and <u>Nodosaria</u> <u>obscura</u> Reuss occurring in smaller numbers. <u>Epistomina</u> <u>hechti</u> is a form which ranges in Europe from the highest Lower Barremian (<u>fissicostatum</u> zone) to the Middle Barremian (<u>denckmanni</u> zone). It is the characteristic species of Hecht's (1938) 'Epistomina D7' zone of north-west Germany and is also found in the Barremian of Trinidad. <u>Lenticulina</u> (<u>L.</u>) <u>heiermanni</u> Bettenstaedt, though present in the C beds, is numerically strongest in the Lower B beds, and is also found in the Barremian of the Vocontian trough (Flandrin, Moullade & Porthault 1962).

The distribution of the foraminifera in these beds is very similar to that in equivalent strata in north-west Germany and suggests that the Hauterivian/Barremian boundary may be placed as high as bed LB4C, some 19 feet above the base of the B beds. The beds above LB4C are of Lower Barremian age (<u>strombecki</u> to <u>fissicostatum</u> zones), possibly ranging up into the lower part of the Middle Barremian (<u>elegans</u> and <u>Denckmanni</u> zones) in bed LB1. Although <u>Conorotalites</u> <u>intercedens</u> (Bettenstaedt), a well known Barremian form in north-west Germany and Trinidad, is absent at Speeton (Khan 1962) it has been found in core samples from the Fordon G1 borehole (see Appendix 1).

Ideally the distribution of microfauna should be related to ammonite zones but at Speeton we have no modern zonal scheme on which to do this. Spath (1924) gives eleven zones in the Valanginian and fifteen in the Hauterivian but this is an artificial zonal or subzonal scheme as many of the species have not been recorded from Britain. In contrast, the Germans recognise five Valanginian ammonite zones and six in the Hauterivian. The value of Spath's (1924) list of ammonites from Speeton is much limited by his failure to give the precise location of his specimens.

The Lower Cretaceous microfauna at Speeton is strikingly similar to that of the boreal province of north-west Germany, Holland, Denmark and Poland. In Germany all the ammonite zones can be distinguished on their microfauna and the present study has shown that it is possible to correlate much of the Speeton succession on the basis of the foraminifera. The author cannot agree, however, with the almost identical range of index foraminifera in both Germany and Speeton which Khan (1962) has suggested. No correlation with the Lower Barremian Snettisham clay from Heacham, Norfolk could be made, samples supplied by Mr. A.R. Lord proving, after sieving, to be composed almost entirely of limonite ooliths and devoid of microfauna. An examination of borehole material from Fordon (Appendix 1) shows a similar microfaunal sequence to that at the coast but indicates that the beds of Hauterivian age are almost twice as thick.

The number of species of Lower Cretaceous benthonic foraminifera which occur at Speeton as well as in other widely separated parts of the world is impressive. Bartenstein, Bettenstaedt & Bolli (1957) described the Barremian foraminifera from two formations in Trinidad, those of the Cuche Formation of the Central Range, whose tectonic complexity is reflected in its formidable topography, and the Toco Formation in the easterly part of the Northern Range. Whilst they drew attention to the similarity with north-west Germany, the comparison with the Lower Barremian of Speeton is equally striking. Of some ninety species described from Trinidad forty also occur at Speeton. The stratigraphical value of the Lower Cretaceous benthonic foraminifera from widely different parts of the world is further emphasised by the fact that though some of the areas have ammonites which are restricted to tethyal (e.g. Trinidad) or boreal (e.g. Germany) environments, certain benthonic foraminifera are common to both.

CHAPTER 8

CONCLUSIONS

The D, C and lower B beds all have a distinctive microfauna. In the D beds, four faunal units based upon the foraminifera can be recognised.

Fauna 1a - D4C1 to D2E which is equivalent to Mittel Valendis 1 and 2 to Ober Valendis 3 of North-west Germany.

Fauna 1b - D2D to D1 of Lower Hauterivian age.

Fauna 2 - D5E to D4C2 with only a few foraminifera, but of Valanginian age.

Fauna 3 - D7D to D6 with a rich microfauna indicative of a Berriasian age.

Fauna 4 - D8 to D7E having only *Haplophragmoides* spp.

Beds equivalent to Ober Valendis 4 have not been recognised at Speeton and would appear to be missing. In this respect the condensed bed at the base of D2D, with its eroded and broken belemnites together with phosphatised ammonites, is significant. The C beds, which are generally more varied in colour than the D beds and contain a number of sideritic bands, are characterised by their rich microfauna with 'floods' of *Höglundina caracolla.* Bed C6 and perhaps the lowest part of C5 are equivalent to the upper *capricornu* zone of North-west Germany, whilst the upper part of C5 and C4, with *Lenticulina* (*L.*) *heiermanni* Bettenstaedt and *Wellmanella antiqua* (Reuss) can be equated with the *seeleyi* zone. *Conorotalites sigmoicosta* (Dam) and

Citharina acuminata Reuss from C3 suggest correlation with both the seeleyi and the tenuis zones. The basal B beds with Haplophragmium aequale (Roemer), Epistomina ornata (Roemer) and Citharina harpa (Roemer) are Hauterivian and it is suggested, on the basis of the foraminifera, that the Hauterivian/Barremian boundary can be placed about 19 feet above the base of these beds.

The size of the samples used in this research (4 lb) resulted in a large quantity of specimens being available for study, and showed the wide morphological variation which exists within some species. Many of the specimens, if studied in isolation, could be regarded as new species but the examination of large numbers often revealed a complete gradation in morphological characters between widely different end members, clearly emphasising the importance of establishing the width of variation in species.

Whilst the foraminifera from the Speeton clay provide a host of future research problems, much still remains to be done on the stratigraphy of these clays. Exposures are continually varying, tantalising glimpses of the clays beneath the beach sand are occasionally seen, and there still remain parts of the succession which have never been seen. It is the difficulty of the section, combined with the chance of discovering something new, that makes every visit to Speeton either so rewarding or so frustrating - in this lies its fascination.

Beach exposure in the upper C beds showing a brown weathering sideritic band standing up above the adjacent clays.

A good exposure of Lower B beds after tides had swept the beach clear of shingle.

APPENDIX 1

NORTH FORDON G1. BOREHOLE

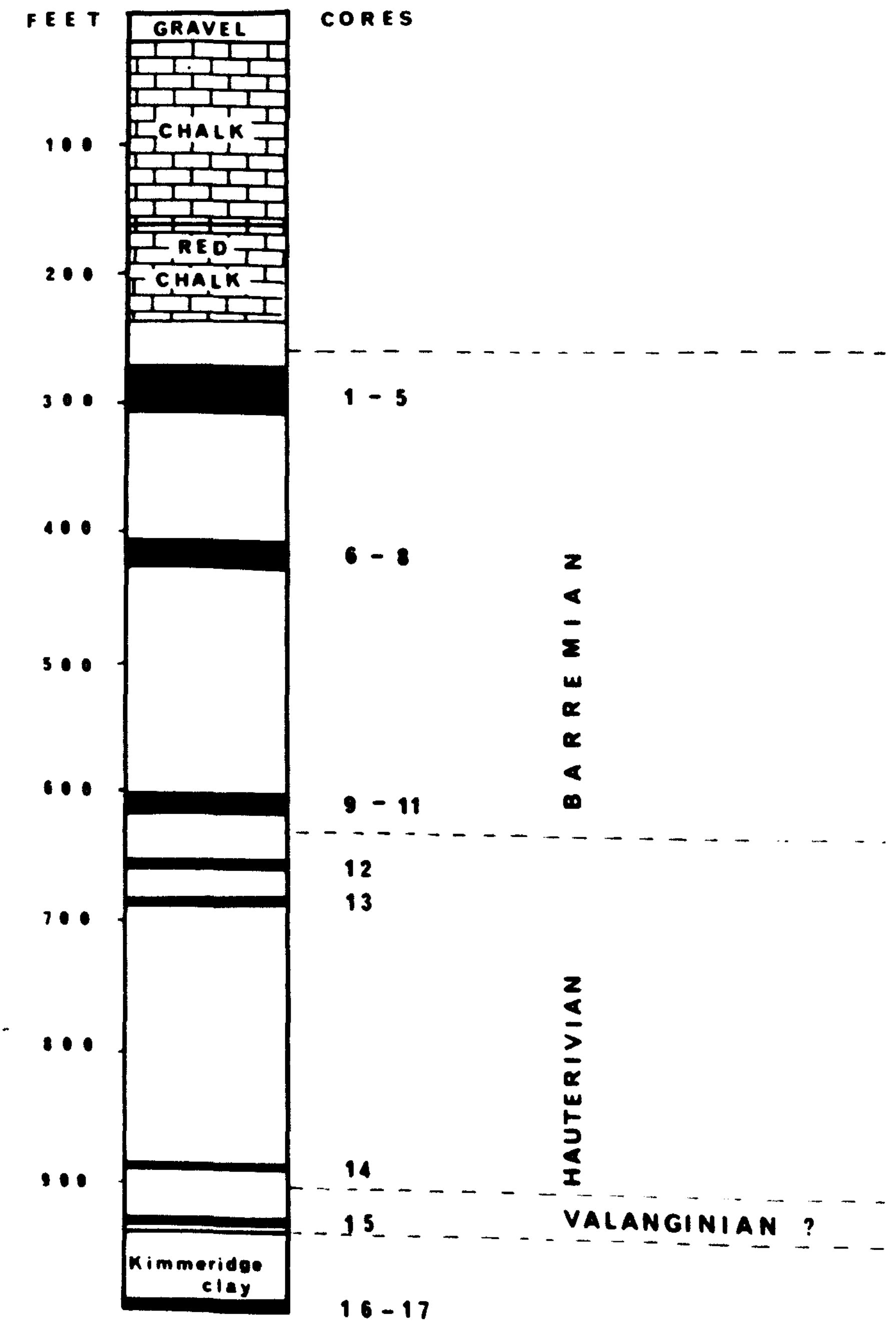
NORTH FORDON G 1. BOREHOLE.

This borehole (Lat. 45° 10' 36.7", Long. 0° 24' 15.6") was put down by the British Petroleum Company Limited, in 1955 as part of their exploration programme for oil and natural gas in Great Britain. It lies eight miles WNW of Speeton and is three and a half miles west of the Hunmanby fault, which has a downthrow of two hundred feet to the west.

The Fordon Gl. borehole is of considerable interest in that, whereas the Speeton clay is just under 300 feet thick at the coast, it was found to be 695 feet thick in the borehole, the greatest thickness of Speeton Clay so far recorded.

Fifteen cores were made available to Hull University and the ostracoda from these were described by Neale (1960); the foraminifera are given below:-

Depth in feet	
270	Glomospirella gaultina Ammodiscus tenuissimus Glomospira gordialis Hedbergella infracretacea
274	Haplophragmoides sp. Glomospirella gaultina Ammodiscus tenuissimus Glomospira gordialis
284	Textularia foeda Glomospirella gaultina Ammodiscus tenuissimus Glomospira gordialis
285	Textularia foeda Glomospira gordialis Ammodiscus gaultina



NORTH FORDON G.1 BOREHOLE

SHOWING POSITION OF CORES

290	Verneuilinoides neocomiensis Textularia foeda Glomospirella gaultina Ammodiscus tenuissimus
293	As above
294	As above. Large amount of chlorite in residue
300	Haplophragmoides sp. Glomospira gordialis Glomospirella gaultina Ammodiscus tenuissimus
302	Glomospira gordialis Glomospirella gaultina Ammodiscus tenuissimus Globulina prisca
303	Ammobaculites irregularis Glomospirella gaultina Ammodiscus tenuissimus
304	Glomospira gordialis Ammodiscus tenuissimus Spiroplectammina sp. Lenticulina subangulata
406	Lenticulina (L.) münsteri Conorotalites intercedens
409	Epistomina ornata (abundant) Lenticulina (L.) münsteri numerous echinoid spines
410	Pseudolamarckina lamplughi Spiroplectammina sp. Textularia foeda Trochammina depressa Verneuilinoides neocomiensis Lenticulina (L.) münsteri L. (P.) crepidularis echinoid spines in residue
414	Textularia foeda Verneuilinoides neocomiensis residue very pyritic

416 Spiroplectammina sp.
Verneuilinoides neocomiensis
Glomospirella gaultina
Haplophragmoides spp.
Lenticulina robusta

417 as above
Lituotuba?

419 Ammobaculites subcretaceus
Verneuilinoides neocomiensis
V. cf. subfiliformis
Haplophragmoides spp.

420 Ammodiscus sp.
Ammobaculites subcretaceus
Dorothia kummi/oxycona
Lenticulina (L.) münsteri
L. (L.) heiermanni
L. (S.) bronni
L. (M.) gracilissima
Frondicularia conncinna
Nodosaria obscura
Citharina acuminata
Höglundina caracolla
Epistomona ornata
Pseudolamarckina lamplughi
Conorboides?
pyrite and glauconite in residue

421 Epistomina ornata
E. spinulifera?
Lenticulina crepidularis
Lituotuba?

422 Epistomina hechti
Pseudolamarckina lamplughi
Citharina acuminata
glauconite in residue

423 Trochammina sp.
Conorotalites sigmoicosta
Pseudolamarckina lamplughi

424 Lenticulina (L.)münsteri
Höglundina caracolla
Pseudolamarckina lamplughi
pyrite spheres in residue

426 Lenticulina (L.) münsteri
L. (L.) subangulata
L. (M.) gracilissima
Höglundina caracolla
Nodosaria sp.

601 Nodosaria obscura
Trochammina depressa
Gastropods in the residue

608 Epistomina hechti - abundant
Gaudryinella sherlocki
numerous gastropods in residue

610 Epistomina hechti
Nodosaria obscura
N. pyramidalis
Lenticulina (L.) münsteri

614 Lenticulina (L.) münsteri
L. (M.) gracilissima
Trochammina sp.
very poor microfauna

652 Nodosaria obscura
Lenticulina (L.) münsteri

656 Lenticulina (L.) münsteri
L. (M.) gracilissima
L. (M.) robusta
L. (P.) crepidularis
Pseudolamarckina lamplughi
Höglundina caracolla
Lagena hauteriviana cylindracea
Citharina acuminata

680 Lenticulina (L.) münsteri
Höglundina caracolla

682 Lenticulina (L.) münsteri
L. (M.) robusta
L. (P.) crepidularis
Nodosaria sceptrum
N. obscura
Dentalina communis
Citharina acuminata
Verneuilinoides neocomiensis
Haplophragmium aequale
Globulina sp.
Vaginulina arguta
Höglundina caracolla - abundant
Epistomina ornata
Pseudolamarckina lamplughi
residue iron stained

683 Lenticulina (L.) münsteri
Nodosaria sceptrum
Frondicularia concinna
Höglundina caracolla
Epistomina ornata

880' 6" Verneuilinoides neocomiensis
Ammobaculites subcretaceous
Lenticulina (L.) münsteri
L. (L.) subangulata
L. (A.) schreiteri - not typical
L. (L.) cf. heiermanni
L. (M.) robusta
L. (P.) crepidularis
Frondicularia concinna
F. microdisca
F. hastata
Dentalina debilis
Dentalina sp.
Nodosaria sceptrum
Höglundina caracolla
Epistomina ornata
Pseudonodosaria humilis
Citharina pseudostriatula
Nodobacularia nodulosa
crinoid ossicles

881	Ammobaculites subcretaceus Lenticulina (L.) subangulata L. (L.) münsteri L. (M.) striatacosta Höglundina caracolla Pseudonodosaria humilis
917	no microfauna pyrite spheres
918	Trochammina sp. unidentifiable fragments of arenaceous foraminifera fish remains
920	fragments of Lingula
921 & 923	no microfauna fragments of Lingula, residue very pyritic, pyrite spheres, framboidal and pyrite rods, fish remains.

Discussion

Kimmeridge clay was encountered in the borehole at a depth of 930 feet (Neale 1960) and the lowest cores between 917 and 923 feet are virtually barren of microfauna. The residues from these cores are very rich in pyrite and also have fish remains and fragments of Lingula. No microfauna indicative of strata older than the Hauterivian has been obtained from this borehole, but lithologically, the residues from 917' - 923' are typical of the Valanginian D4 and D5 beds. These cores are clearly higher than the D6 - upper D7 beds which have a rich microfauna and do not show Lingula fragments in the residue; nor do they belong to D8 which has a distinctive Haplophragmoides spp. fauna. At the outcrop at Speeton, D5 is 13 feet above the Coprolite bed at the base of the Speeton clay, but in the borehole there appears to be only half this thickness.

The residue from core 14 at 880' 6" has a flood of Hoglundina caracolla together with Epistomina ornata, Dentalina debilis etc., and is clearly Hauterivian. If the thickness of strata above D4-D5 is the same as that at the coast this core should represent C11 or C10 at the base of the C beds, Lenticulina (L.) cf. heiermanni however suggests mid-C beds.

Cores 12 and 13 (652' - 683') are again clearly Hauterivian with Epistomina ornata at 683'. It is interesting that Pseudolamarckina lamplughi occurs at a depth of 682' as this species is only known from the base of C4 upwards, whilst Citharina acuminata from 656' only from C3 or above.

The fauna from 652' is very poor and not diagnostic of horizon. Core 11 (614') is probably the Lower B beds and the residue from 610' with Epistomina hechti is clearly Lower Barremian. The boundary between the B and C beds, which is generally taken as that between the Hauterivian and the Barremian, can be placed between 656' and 610'. This is about 100' lower than Neale (1960) tentatively placed the boundary, though he does state that he only provisionally referred cores 9 and 11 to the upper Hauterivian as no ostracods were obtained from them.

Both the ostracoda and foraminifera from cores 1-5, 6-8 (270' - 426') show that the strata here is of Barremian age. The occurrence of Conorotalites intercedens (Bettenstaedt) at 406' is of particular interest as in Germany this species is a valuable zone fossil for the upper Mittel Barreme and lower Ober Barreme. This is the first record in Britain, though the closely related species C. aptiensis (Bettenstaedt) and C. bartensteini (Bettenstaedt) have not yet been recognised in this country.

CONCLUSIONS - Compared with the strata at the coastal outcrop the Fordon G1. borehole shows that:-

1. The Hauterivian is twice as thick.
2. There is no microfaunal evidence of any of the D beds being present; D4-D5 beds are suggested by lithology only.
3. The lower D beds, D5 to the Coprolite bed are much thinner.
4. There appears to be a reduction in the thickness of strata between the mid-C beds and D4-D5.
5. The foraminifera from 880' - 881' suggest that here we may have mid-C beds.

APPENDIX 2

SAMPLE DATA.

SAMPLE DATA

Sample 1:- BED C2F
Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	= 2097.9 gms.
Wt. of residue held 100	= 17.44 gms.
Wt. through 100 held 200	= 9.775 gms.
% held 100	= 0.8
% held 200	= 0.4

Granular and framboidal pyrite together with pyrite tubes, Shell fragments.

Sample 2:- Bed C2E
Colour Light grey (N7)

Wt. of sample	= 2210.65 gms.
Wt. of residue held 100	= 38.01 gms.
Wt. through 100 held 200	= 9.05 gms.
% held 100	= 1.7
% held 200	= 0.4

Almost entirely foraminifera, mainly 'Epistomina'. Quartz absent, orange brown flattened arenaceous tubes, sometimes branching common. Granular and rod-like pyrite.

Sample 3:- Bed C2D
Colour (wet) Olive grey (5Y4/1)

Wt. of sample	= 1048.95 gms.
Wt. of residue held 100	= 70.40 gms.
Wt. through 100 held 200	= 22.02 gms.
% held 100	= 6.7
% held 200	= 2.1
% passing through 200	= 91.2
wt. of glauconite held 100	= 58.875 gms.

Residue mainly glauconite.

Sample 4:- Bed C2C base.
Colour Light olive grey - medium grey (5Y5/2-N6)

Wt. of sample	= 1970.32 gms.
Wt. of residue held 100	= 15.56 gms.
Wt. through 100 held 200	= 11.27 gms.
% held 100	= 0.7
% held 200	= 0.5

Sample 5:- Bed C2C top.
Colour Medium greenish grey (5GY5/1)

Wt. of sample	= 2041.2 gms.
Wt. of residue held 100	= 16.03 gms.
Wt. through 100 held 200	= 4.51 gms.
% held 100	= 0.7
% held 200	= 0.2

Mainly pyrite and foraminifera. 50% of residue is 'Epistomina'. Gastropods also in this residue.

<u>Sample 6</u>:- Bed C2B
Colour Medium light grey/greenish grey (N6-5GY6/1)

Wt. of sample	= 1502.55 gms.
Wt. of residue held 100	= 7.68 gms.
Wt. through 100 held 200	= 7.03 gms.
% held 100	= 0.5
% held 200	= 0.4

<u>Sample 7</u>:- Bed C2A
Colour Medium dark grey/medium grey (N4-N5)

Wt. of sample	= 2041.2 gms.
Wt. of residue held 100	= 240.97 gms.
Wt. through 100 held 200	= 30.189 gms.
% held 100	= 11.8
% held 200	= 1.4

Residue almost all glauconite.

<u>Sample 8</u>:- Bed C1B
Colour Medium light grey (N6)

Wt. of sample	= 1814.4 gms.
wt. of residue held 100	= 184.27 gms.
Wt. through 100 held 200	= 21.117 gms.
% held 100	= 10.1
% held 200	= 1.1

Residue almost entirely glauconite.

<u>Sample 9</u>:- Bed C1A
Colour Medium grey (N5)

Wt. of sample	= 1530.9 gms.
Wt. of residue held 100	= 240.13 gms.
Wt. through 100 held 200	= 33.90 gms.
% held 100	= 15.6
% held 200	= 2.2

Residue almost entirely glauconite.

<u>Sample 10</u>:- Bed LB6 Base
Colour Light grey/greenish grey (N7-5 GY 6/1)

Wt. of sample	= 2069.55 gms.
Wt. of residue held 100	= 56.64 gms.
Wt. through 100 held 200	= 31.04 gms.
% held 100	= 2.7
% held 200	= 1.4

Large quantity of brown calcareous material, shell fragments, glauconite and pyrite occurs.

Sample 11:- Bed LB6 top.
Colour Light grey (N7)

Wt. of sample	= 1800.22 gms.
Wt. of residue held 100	= 11.55 gms.
Wt. through 100 held 200	= 7.30 gms.
% held 100	= 0.64
% held 200	= 0.4

Mainly microfossils, some glauconite, shell debris and small amount pyrite.

Sample 12:- Bed LB5E
Colour Medium grey - medium dark grey (N4-N5)

Wt. of sample	= 1934.8 gms.
Wt. of residue held 100	= 340.20 gms.
Wt. through 100 held 200	= 25.59 gms.
% held 100	= 17.5
% held 200	= 1.2

Largely glauconite.

Sample 13:- Bed LB5D 1' above base.
Colour Medium grey (N5)

Wt. of sample	= 1842.7 gms.
Wt. of residue held 100	= 19.83 gms.
Wt. through 100 held 200	= 6.07 gms.
% held 100	= 1.0
% held 200	= 0.3

Much pyrite with forams, and small amount glauconite.

Sample 14:- Bed LB5D 3' above base.
Colour Medium dark grey - medium grey (N4-N5)

Wt. of sample	= 1219.0 gms.
Wt. of residue held 100	= 15.14 gms.
Wt. through 100 held 200	= 13.15 gms.
% held 100	= 1.2
% held 200	= 1.0

Much pyrite with shell debris, forams, and small quantity of glauconite.

Sample 15:- Bed C11 Base.
Colour Medium light grey (N6)

Wt. of sample	= 1148.2 gms.
Wt. of residue held 100	= 170.1 gms.
Wt. through 100 held 200	= 34.25 gms.
% held 100	= 14.8
% held 200	= 2.9

Largely glauconite.

Sample 16:- Bed C11 just below green mottled seam
Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 9.78 gms.
Wt. through 100 held 200	= 5.04 gms.
% held 100	=
% held 200	=

Shelly with much microfauna.

Sample 17:- Bed LB5D Top.

Wt. of sample	= 2182 gms.
Wt. of residue held 100	= 20.92 gms.
Wt. through 100 held 200	= 6.69 gms.
% held 100	= 0.9
% held 200	= 0.3

A large quantity of pyrite, often in large pieces with abundant shell debris and microfossils. Fragments of Echinoderms and immature mollusca are abundant.

Sample 18:- Bed LB5B 1' above base.
Colour Medium grey (N5)

Wt. of sample	= 3145 gms.
Wt. of residue held 100	= 11.30 gms.
Wt. through 100 held 200	= 6.50 gms.
% held 100	= 0.3
% held 200	= 0.1

Large pyrite with abundant shell debris and macrofossils.

Sample 19:- Bed LB5B 3' above base
Colour Medium grey with olive tinge (N5)

Wt. of sample	= 2720 gms.
Wt. of residue held 100	= 15.55 gms.
Wt. through 100 held 200	= 1.54 gms.
% held 100	= 0.5
% held 200	= 0.05

Much granular pyrite and shell fragments. A little glauconite. Ostracods and holothurian sclerites.

Sample 20:- Bed LB5B 5' above base.
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 12.15 gms.
Wt. through 100 held 200	= 2.32 gms.
% held 100	= 0.6
% held 200	= 0.1

Much pyrite, abundant shell debris and a little quartz.

Sample 21:- Bed LB4D 1' above base
Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 11.95 gms.
Wt. through 100 held 200	= 3.86 gms.
% held 100	= 6.5
% held 200	= 2.1

Abundant pyrite, shell debris and microfossils.

Sample 22:- Bed LB4D 3' above base
Colour Olive grey (5Y 4/1)

Wt. of sample	=	1530 gms.
Wt. of residue held 100	=	11.51 gms.
Wt. through 100 held 200	=	7.00 gms.
% held 100	=	0.7
% held 200	=	0.4

Abundant shell debris, microfossils and pyrite with a little glauconite, micaceous material and fish remains.

Sample 23:- Bed LB4D 5' above base
Colour Medium dark grey (N4)

Wt. of sample	=	2501 gms.
Wt. of residue held 100	=	26.69 gms.
Wt. through 100 held 200	=	21.50 gms.
% held 100	=	1.06
% held 200	=	0.86

Abundant pyrite, shell debris and microfossils. Glauconite fairly common.

Sample 24:- Bed LB4C
Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	=	1091 gms.
Wt. of residue held 100	=	410.4 gms.
Wt. through 100 held 200	=	38.21 gms.
% held 100	=	37.6
% held 200	=	3.5

Abundant glauconite with a little shell debris and ostracods.

Sample 25:- Bed LB4B
Colour Light grey - Very light grey (N7-N8)

Wt. of sample	=	1588 gms.
Wt. of residue held 100	=	11.70 gms.
Wt. through 100 held 200	=	2.93 gms.
% held 100	=	7.3
% held 200	=	1.8

Large quantity of twig-like pyrite with subordinate shell debris and microfossils.

Sample 29:- Bed LB3
Colour Medium grey (N5)

Wt. of sample	=	1729 gms.
Wt. of residue held 100	=	12.43 gms.
Wt. through 100 held 200	=	1.86 gms.
% held 100	=	0.7
% held 200	=	0.1

Much large pyrite with abundant shell debris and microfossils.

Sample 30:- Bed LB4B

Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 2.86 gms.
Wt. through 100 held 200	= 0.40 gms.
% held 100	= 0.5
% held 200	= 0.07

Much twig-like pyrite, a little shell debris, fish remains and gastropods.

Sample 31:- Bed LB4C

Colour Medium grey - medium light grey (N5-N6)

Wt. of sample	= 1814.0 gms.
Wt. of residue held 100	= 77.00 gms.
Wt. through 100 held 200	= 22.84 gms.
% held 100	= 4.24
% held 200	= 1.26

Flood of glauconite, a little shell debris.

Sample 32:- Bed LB4D

Colour Medium grey (N5)

Wt. of sample	= 709 gms.
Wt. of residue held 100	= 5.51 gms.
Wt. through 100 held 200	= 3.10 gms.
% held 100	= 0.7
% held 200	= 0.4

Bulk of residue shell debris and microfossils, pyrite subordinate.

Sample 33:- Bed LB4D

Colour Medium light grey (N6)

Wt. of sample	= 879 gms.
Wt. of residue held 100	= 4.41 gms.
Wt. through 100 held 200	= 2.35 gms.
% held 100	= 0.5
% held 200	= 0.3

Residue composed of shell debris, microfossils, siderite and some pyrites. Quartz common but may be contaminated.

Sample 35:- Lower B beds, 6' horiz. above 'platy' stone band.

Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 9.52 gms.
Wt. through 100 held 200	= 9.68 gms.
% held 100	= 0.5
% held 200	= 0.5

Dominantly shell fragments, large number of 'Epistomina' ostracods, some pyrite.

Sample 36:- Lower B beds, 12' horiz. above 'platy' stone band
Colour Olive grey (5Y 4/1)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 4.96 gms.
Wt. through 100 held 200	= 9.56 gms.
% held 100	= 0.3
% held 200	= 0.5

Abundant fish remains and white calcareous material. Nodosaria dominant.

Sample 37:- Bed LB2C just below platy stone band.
Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 15.04 gms.
Wt. through 100 held 200	= 9.71 gms.
% held 100	= 0.8
% held 200	= 0.5

Fine grained, pyrite, fish remains.

Sample 38:- Bed LB2C 1'4" below platy stone band (5' horiz.)
Colour Medium grey - olive grey (N5-5Y 4/1)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 13.41 gms.
Wt. through 100 held 200	= 17.15 gms.
% held 100	= 0.7
% held 200	= 0.9

Abundant pyrite and fish remains. White granular calcitic material common.

Sample 39:- Bed LB2C 3'8" below platy stone band (10' horiz.)
Colour Medium dark grey (N4)

Wt. of sample	= 1842 gms.
Wt. of residue held 100	= 40.43 gms.
Wt. through 100 held 200	= 31.27 gms.
% held 100	= 2.1
% held 200	= 1.7

Abundant pyrite and fish remains, shell and belemnite fragments. Quartz less than 1%. Some pyrite spheres.

Sample 40:- Lower B beds - 17' horiz. below 'cement' stone G.
Colour Medium dark grey (N4)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 36.99 gms.
Wt. through 100 held 200	= 5.19 gms.
% held 100	= 2.0
% held 200	= 0.3

Very shelly, pyritic.

Sample 41:- Lower B - 30' horiz. below cementstone G.
Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 5.09 gms.
Wt. through 100 held 200	= 11.05 gms.
% held 100	= 0.3
% held 200	= 0.6

Pyritic. Residue dominantly fish remains, gastropods. Barren of microfauna.

Sample 42:- Lower B - 24' horiz. below cement bed G.
Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 10.19 gms.
Wt. through 100 held 200	= 10.48 gms.
% held 100	= 0.5
% held 200	= 0.5

Very pyritic, gastropods.

Sample 43:- Lower B - 15' horiz. below cement bed G.
Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 23.97 gms.
Wt. through 100 held 200	= 12.00 gms.
% held 100	= 1.3
% held 200	= 0.6

Very pyritic, microfauna poor, gastropods, lamellibranchs, fish remains.

Sample 44:- Lower B - 10' horiz. below cement bed G.
Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	= 1658 gms.
Wt. of residue held 100	= 13.49 gms.
Wt. through 100 held 200	= 5.99 gms.
% held 100	= 0.8
% held 200	= 0.3

Very shelly, rich in gastropods.

Sample 45:- Lower B - 5' horiz. below 'cement' bed G.
Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 36.87 gms.
Wt. through 100 held 200	= 6.64 gms.
% held 100	= 2.0
% held 200	= 0.4

Very pyritic, plenty of gastropods.

Sample 46:- Lower B - 1' horiz. below cement bed G.
Colour Medium grey - medium light grey (N5-N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 27.14 gms.
Wt. through 100 held 200	= 35.22 gms.
% held 100	= 1.4
% held 200	= 1.9

Virtually barren except for Nodosaria and Epistomina, rich in fish remains, pyrite, gastropods and lamellibranchs.

Sample 47:- 10' horiz. above 'cement' bed G.
Colour Medium grey - Medium light grey

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 31.75 gms.
Wt. through 100 held 200	= 8.57 gms.
% held 100	= 1.7
% held 200	= 0.5

Residue similar to sample 46.

Sample 48:- Basal Bed LB3 (1' horiz. above)
Colour Medium grey - olive grey (N5-5Y 4/1)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 19.73 gms.
Wt. through 100 held 200	= 11.55 gms.
% held 100	= 1.08
% held 200	= 0.6

Abundant pyrite and siderite. Few ostracoda.

Sample 49:- Bed LB3 1' above base (4' horiz. above)
Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 10.40 gms.
Wt. through 100 held 200	= 1.84 gms.
% held 100	= 0.6
% held 200	= 0.1

Abundant granular pyrite, foraminifera common, shell debris.

Sample 50:- Bed LB3 1'6" above base (6' horiz.)
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 10.12 gms.
Wt. through 100 held 200	= 1.37 gms.
% held 100	= 0.5
% held 200	= 0.07

Abundant granular and twig-like pyrite, ostracods rare.

Sample 51:- Bed LB3 2' above base (8' horiz.)
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 10.24 gms.
Wt. through 100 held 200	= 0.99 gms.
% held 100	= 0.5
% held 200	= 0.05

Abundant granular and twig-like pyrite, some foraminifera but ostracoda absent.

Sample 52:- Bed LB3 2'6" above base (10' horiz.)
Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 10.62 gms.
Wt. through 100 held 200	= 1.12 gms.
% held 100	= 0.6
% held 200	= 0.06

Abundant granular and twig-like pyrite.

Sample 53:- Bed LB3 3' above base (12' horiz.)
Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 17.66 gms.
Wt. through 100 held 200	= 1.46 gms.
% held 100	= 0.9
% held 200	= 0.08

Abundant granular and twig-like pyrite. Few foraminifera, ostracoda rare.

Sample 54:- Bed LB3 3'6" above base (14' horiz.)
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 7.17 gms.
Wt. through 100 held 200	= 1.66 gms.
% held 100	= 0.4
% held 200	= 0.09

Some ostracoda, granular pyrite, much shell debris.

Sample 55:- Bed LB3 4' above base (16' horiz.)
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 11.04 gms.
Wt. through 100 held 200	= 4.81 gms.
% held 100	= 0.6
% held 200	= 0.3

Brown siderite material, pyrite and ostracoda.

Sample 56:- Bed LB3 4'6" above base (18' horiz.)
Colour Medium light grey - Light olive grey (N6-5Y 6/1)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 3.38 gms.
Wt. through 100 held 200	= 2.33 gms.
% held 100	= 0.2
% held 200	= 0.1

Abundant shell debris and foraminifera, some ostracoda. Pyrite common.

Sample 57:- Bed LB3 5' above base (20' horiz.)
Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 13.61 gms.
Wt. through 100 held 200	= 1.43 gms.
% held 100	= 0.7
% held 200	= 0.07

Abundant granular pyrite, shell debris and ostracoda rare.

Sample 58:- Bed LB3 5'6" above base (22' horiz.)
Colour Light grey (N7)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 13.34 gms.
Wt. through 100 held 200	= 1.75 gms.
% held 100	= 0.7
% held 200	= 0.09

Abundant granular and twig-like pyrite.

Sample 59:- Bed LB3 6' above base (24' horiz.)
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 12.72 gms.
Wt. through 100 held 200	= 1.57 gms.
% held 100	= 0.7
% held 200	= 0.09

Abundant granular and twig-like pyrite. Ostracods rare.

Sample 60:- Bed LB3 6'6" above base (26' horiz.)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 8.03 gms.
Wt. through 100 held 200	= 1.73 gms.
% held 100	= 0.4
% held 200	= 0.09

Abundant granular and twig-like pyrite, shell fragments, foraminifera and ostracods.

Sample 61:- Bed LB3 7' above base (28' horiz.)
Colour Medium grey - medium light grey (N5-N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 15.5 gms.
Wt. through 100 held 200	= 2.94 gms.
% held 100	= 0.8
% held 200	= 0.1

Abundant pyrite with shell debris and microfauna.

Sample 62:- Bed LB3 11'8" above base (45' horiz.)
Colour Dark greenish grey (5GY 4/1)

Wt. of sample	= 1644 gms.
Wt. of residue held 100	= 9.27 gms.
Wt. through 100 held 200	= 3.09 gms.
% held 100	= 0.5
% held 200	= 0.2

Much pyrite and shell debris, many ostracods.

Sample 63:- Bed LB3 1' above base
Colour Light olive grey - light grey (5Y 5/2 - N7)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 23.27 gms.
Wt. through 100 held 200	= 6.30 gms.
% held 100	= 1.3
% held 200	= 0.3

Twig-like pyrite, iron carbonate, microfossils fairly common.

Sample 64:- Bed LB3 3' above base
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 23.64 gms.
Wt. through 100 held 200	= 1.21 gms.
% held 100	= 1.3
% held 200	= 0.06

Almost all twig-like pyrite with relatively few foraminifera and little shell debris.

Sample 65:- Bed LB3 5'9" above base
Colour Light grey - very light grey (N7-N8)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 10.53 gms.
Wt. through 100 held 200	= 1.89 gms.
% held 100	= 0.6
% held 200	= 0.1

Much pyrite, shell debris and foraminifera.

Sample 66:- Bed LB3 8'6" above base
Colour Medium light grey - light grey (N6-N7)

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	15.43 gms.
Wt. through 100 held 200	=	1.85 gms.
% held 100	=	0.8
% held 200	=	0.1

Much granular pyrite some pieces very large. Crystalline pyrite also common. A little shell debris and white granular calcitic material. One species of ostracoda Dolocytheridea intermedia.

Sample 67:- Bed LB3 11'6" above the base
Colour Medium dark grey - Medium grey (N4-N5)

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	10.70 gms.
Wt. through 100 held 200	=	3.20 gms.
% held 100	=	0.6
% held 200	=	0.2

Much pyrite, shell debris and ostracoda.

Sample 68:- Bed LB3 14'3" above base

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	9.79 gms.
Wt. through 100 held 200	=	2.65 gms.
% held 100	=	0.5
% held 200	=	0.1

Much pyrite, shell fragments and microfossils.

Sample 69:- Bed LB3 17'3" above base
Colour Medium light grey (N6)

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	7.38 gms.
Wt. through 100 held 200	=	1.68 gms.
% held 100	=	0.4
% held 200	=	0.09

Much pyrite, shell debris and microfossils.

Sample 70:- Bed LB3 19'6" above base
Colour Medium light grey (N6)

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	5.17 gms.
Wt. through 100 held 200	=	4.94 gms.
% held 100	=	0.3
% held 200	=	0.3

Large amounts of shell debris and microfauna. Abundant ostracoda, mainly Dolocytheridea intermedia, Acrocythere sp., Schuleridea rhomboidalis and Protocythere triplicata. Pyrite a very minor constituent.

Sample 71:- Bed LB2D
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 8.24 gms.
Wt. through 100 held 200	= 2.70 gms.
% held 100	= 0.4
% held 200	= 0.1

Much pyrite, shell and microfossils.

Sample 72:- Bed LB2C 1' above base.
Colour Olive grey (5Y 4/1)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 15.86 gms.
Wt. through 100 held 200	= 2.87 gms.
% held 100	= 0.8
% held 200	= 0.1

Twig-like pyrite common, shell debris, Ostracods represented by one species Dolocytheridea intermedia. A few fish remains.

Sample 73:- Bed LB2C 4' above base
Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 33.53 gms.
Wt. through 100 held 200	= 20.75 gms.
% held 100	= 1.8
% held 200	= 1.14

Microfauna poor, pyrite and fish remains.

Sample 74:- Bed LB2A, 7'6" above bed LB2D
Colour Medium grey (N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 12.79 gms.
Wt. through 100 held 200	= 7.38 gms.
% held 100	= 0.7
% held 200	= 0.4

Almost all gypsum with subordinate pyrite and shell debris.

Sample 75:- Bed LB2A 12' above bed LB2D
Colour Medium grey (N5)

Wt. of sample	= 1276 gms.
Wt. of residue held 100	= 22.38 gms.
Wt. through 100 held 200	= 3.80 gms.
% held 100	= 1.7
% held 200	= 0.3

Much pyrite with a few pyritised gastropods and lamellibranchs. Quite a lot of small white granular calcite and fish remains, with a little rounded quartz.

Sample 94:- Bed C11A
Colour Medium light grey
Wt. of sample = 1587 gms.
Wt. of residue held 100 = 6.45 gms.
Wt. through 100 held 200 = -
% held 100 = 0.5
% held 200 = -

Abundant 'Epistomina', glauconite and pyrite.

Sample 95:- C11B top
Colour Medium grey - olive grey (N5 - 5Y 4/1)
Wt. of sample = 1360 gms.
Wt. of residue held 100 = 10.48 gms.
Wt. through 100 held 200 = 4.31 gms.
% held 100 = 0.7
% held 200 = 0.3

Dominantly glauconite, some pyrite, well preserved microfauna.

Sample 96:- C11B (Middle)
Colour Medium grey (N5)
Wt. of sample = 1814 gms.
Wt. of residue held 100 = 40.41 gms.
Wt. through 100 held 200 = 12.44 gms.
% held 100 = 2.3
% held 200 = 0.7

Flood of glauconite.

Sample 97:- C11B (base)
Colour Medium light grey
Wt. of sample = 1658 gms.
Wt. of residue held 100 = 208.7 gms.
Wt. through 100 held 200 = 31.3 gms.
% held 100 = 12.58
% held 200 = 1.88

Flood of glauconite.

Sample 98:- Bed C10 1' above base
Colour Light grey - medium light grey (N7-N6)
Wt. of sample = 1814 gms.
Wt. of residue held 100 = 10.7 gms.
Wt. through 100 held 200 = 4.36 gms.
% held 100 = 0.58
% held 200 = 0.24

Very rich residue almost entirely microfauna. Some pyrite and brown siderite rods.

Sample 99:- Bed C9D just above top of C10
Colour Medium light grey - light olive grey (N6-5Y 6/1)
Wt. of sample = 1814 gms.
Shelly and rich in ostracoda and foraminifera.

Sample 100:- Bed C9D 1' above previous sample
Colour Medium grey (N5)
Wt. of sample = 1502 gms.

Sample 1*:- Bed C9D
Colour Medium light grey (N6)
Wt. of sample = 1587 gms.
Wt. of residue held 100 = 54.67 gms.
Wt. through 100 held 200 = 27.3 gms.
% held 100 = 3.44
% held 200 = 1.72
Flood of glauconite with conspicuous brick red coloured fragments (siderite?)

Sample 2*:- Bed C9D
Colour Medium grey (N5)
Wt. of sample = 1729 gms.
Wt. of residue held 100 = 6.80 gms.
Wt. through 100 held 200 = 7.33 gms.
% held 100 = 0.39
% held 200 = 0.42
A little glauconite, shell debris, gastropods, ostracods.

Sample 3*:- Bed C9D 1' below top
Colour Medium grey (N5)
Wt. of sample = 1502 gms.
Wt. of residue held 100 = 4.74 gms.
Wt. through 100 held 200 = 2.44 gms.
% held 100 = 0.31
% held 200 = 0.16
Residue mainly pyrite, rich in gastropods.

Sample 4*:- Bed C9C
Colour Light grey (N7)
Wt. of sample = 1814 gms.
Wt. of residue held 100 = 4.76 gms.
Wt. through 100 held 200 = 2.60 gms.
% held 100 = 0.26
% held 200 = 0.14
Shelly, micaceous, fish remains.

<u>Sample 5*</u>:- Bed C9B

Colour Medium dark grey - medium grey (N4-N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 30.78 gms.
Wt. through 100 held 200	= 7.25 gms.
% held 100	= 1.69
% held 200	= 0.39

Residue entirely pyrite, tubes and branching type.

<u>Sample 6*</u>:- Bed C9A base

Colour Medium light grey - Olive grey (N6-5Y 4/1)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 23.32 gms.
Wt. through 100 held 200	= 6.81 gms.
% held 100	= 1.28
% held 200	= 0.37

Very pyritic, 'Epistomina', gastropods, lamellibranchs.

<u>Sample 7*</u>:- Bed C8 base

Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	= 1469 gms.
Wt. of residue Held 100	= 10.04 gms.
Wt. through 100 held 200	= 3.70 gms.
% held 100	= 0.68
% held 200	= 0.25

Small granular pyrite and abundant microfauna, shelly.

<u>Sample 8*</u>:- Bed C7A

Colour Medium light grey

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 134.2 gms.
Wt. through 100 held 200	= 343.0 gms.
% held 100	= 7.39
% held 200	= 18.90

Large proportion of siderite forming bulk of sample

<u>Sample 9*</u>:- Bed C7C

Colour Medium grey (N5)

Wt. of sample	= 1417 gms.
Wt. of residue held 100	= 8.68 gms.
Wt. through 100 held 200	= 4.33 gms.
% held 100	= 0.61
% held 200	= 0.30

Rich in pyrite; shelly, a little glauconite.

Sample 10*:- Bed C7D
Colour Medium grey (N5) with paler mottling (N6)

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	56.55 gms.
Wt. through 100 held 200	=	21.94 gms.
% held 100	=	3.11
% held 200	=	1.20

Abundant glauconite, shelly, microfauna very poor.

Sample 11*:- Bed C7E
Colour Medium dark grey - medium grey (N4-N5)

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	143.7 gms.
Wt. through 100 held 200	=	-
% held 100	=	7.92
% held 200	=	-

Residue almost entirely glauconite, some pyrite, ostracods and foraminifera.

Sample 12*:- Bed C7F
Colour Light grey (N7)

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	2.55 gms.
Wt. through 100 held 200	=	2.06 gms.
% held 100	=	0.14
% held 200	=	0.11

Rich in aggregates of siderite, foraminifera, ostracods and ophiuroids.

Sample 13*:- Bed C7G
Colour Medium grey (N5) with lighter mottling (N6)

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	8.41 gms.
Wt. through 100 held 200	=	4.89 gms.
% held 100	=	0.46
% held 200	=	0.27

Large amount of shell fragments and granular pyrite. 'Epistomina' dominant.

Sample 14*:- Bed C7H - base
Colour Medium grey - olive grey (N5-5Y 4/1)

Wt. of sample	=	1814 gms.
Wt. of residue held 100	=	13.70 gms.
Wt. through 100 held 200	=	18.06 gms.
% held 100	=	0.75
% held 200	=	0.99

Large amount of shell and calcareous material, good microfauna, fish remains, belemnites.

Sample 15*:- 1' below top of C8
Colour Medium grey - Medium light grey (N5-N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 11.05 gms.
Wt. through 100 held 200	= 3.73 gms.
% held 100	= 0.61
% held 200	= 0.20

Pyrite, shell fragments.

Sample 16*:- Mid C8
Colour Medium grey (N5)

Wt. of sample	= 1587 gms.
Wt. of residue held 100	= 21.47 gms.
Wt. through 100 held 200	= 8.59 gms.
% held 100	= 1.35
% held 200	= 0.54

Shelly, much calcitic material, pyrite 'cylinders', fish vertebrae, foraminifera.

Sample 17*:- Bed C6 1' above base
Colour Medium grey (N5)

Wt. of sample	= 1530 gms.
Wt. of residue held 100	= 226.5 gms.
Wt. through 100 held 200	= 42.21 gms.
% held 100	= 14.80
% held 200	= 2.75

Residue rich in glauconite, shelly, fish remains, belemnite fragments.

Sample 18*:- Bed C6 Middle
Colour Medium dark grey (N4)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 3.24 gms.
Wt. through 100 held 200	= 2.62 gms.
% held 100	= 0.17
% held 200	= 0.14

Shelly, pyrite, some quartz. Contains H. jaculoides var. depressirostris

Sample 19*:- Bed C6 top
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 13.64 gms.
Wt. through 100 held 200	= 97.95 gms.
% held 100	= 0.75
% held 200	= 5.39

Rich in siderite.

Sample 20*:- Bed C2F
Colour Medium light grey - light grey (N6-N7)

Wt. of sample	= 1332.4 gms.
Wt. of residue held 100	= 11.16 gms.
Wt. through 100 held 200	= 8.35 gms.
% held 100	= 0.83
% held 200	= 0.62

Large lumps of granular pyrite, bulk of residue microfauna particularly '*Epistomina*'.

Sample 21*:- Bed C3 1' below top
Colour Greenish grey - medium light grey (5GY 6/1 - N6)

Wt. of sample	= 1672.6 gms.
Wt. of residue held 100	= 19.64 gms.
Wt. through 100 held 200	= 7.07 gms.
% held 100	= 1.17
% held 200	= 0.42

Flood of 'Epistomina', some granular pyrite, gastropods and lamellibranchs.

Sample 22*:- Bed C3 2' below top
Colour Medium light grey - light grey (N6-N7)

Wt. of sample	= 1587 gms.
Wt. of residue held 100	= 20.82 gms.
Wt. through 100 held 200	= 11.32 gms.
% held 100	= 1.31
% held 200	= 0.71

Residue almost entirely 'Epistomina'.

Sample 23*:- Bed C3 3' below top.
Colour Greenish grey (5GY 6/1)

Wt. of sample	= 1474 gms.
Wt. of residue held 100	= 17.57 gms.
Wt. through 100 held 200	= 7.21 gms.
% held 100	= 1.19
% held 200	= 0.49

Sample 24*:- Bed C3 just below nodule band
Colour Light olive grey - olive grey (5Y 6/1-5Y 4/1)

Wt. of sample	= 1701 gms.
Wt. of residue held 100	= 16.15 gms.
Wt. through 100 held 200	= 4.62 gms.
% held 100	= 0.94
% held 200	= 0.27

Large lumps of pyrite, 'Epistomina' dominant.

Sample 26*:- Pale clay just below brown nodule at base of D2D.

Sample 27*:- Bed C3 - base

Colour Light grey (N7)	
Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 22.73 gms.
Wt. through 100 held 200	= 6.12 gms.
% held 100	= 1.25
% held 200	= 0.34

Flood of 'Epistomina', large amount of shell debris, some gastropods, ostracods and a little pyrite.

Sample 28*:- Bed C3 - mid-way between base and nodular band.

Colour Light grey (N7)	
Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 17.00 gms.
Wt. through 100 held 200	= 6.44 gms.
% held 100	= 0.93
% held 200	= 0.35

Residue almost entirely microfauna, flood of 'Epistomina'.

Sample 29*:- Bed C4B - top

Colour Medium grey (N5)	
Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 23.88 gms.
Wt. through 100 held 200	= 7.47 gms.
% held 100	=
% held 200	=

Pyrite, rich microfauna dominated by 'Epistomina'.

Sample 30*:- Bed C4B - base

Colour Medium grey - medium light grey (N5-N6)	
Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 15.71 gms.
Wt. through 100 held 200	= 4.16 gms.
% held 100	= 1.32
% held 200	= 0.23

Pyrite, shelly, calcitic material, microfauna plentiful.

Sample 31*:- Bed C4C - top

Colour Light grey - medium light grey (N7-N6)	
Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 21.44 gms.
Wt. through 100 held 200	= 9.41 gms.
% held 100	= 1.18
% held 200	= 0.52

Rich microfauna, shelly, some siderite.

Sample 34*:- Bed C4G
Colour Medium light grey - medium grey (N5-N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 185.0 gms.
Wt. through 100 held 200	= 28.70 gms.
% held 100	= 10.19
% held 200	= 1.58

Pyrite, a little glauconite, microfauna dominated by 'Epistomina'.

Sample 36*:- Bed D2D
Colour Medium dark grey - medium grey (N4-N5)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 89.16 gms.
Wt. through 100 held 200	= 85.0 gms.
% held 100	= 4.91
% held 200	= 4.68

Almost all glauconite.

Sample 37*:- Bed D2E top
Colour Brownish grey - olive grey (5YR 4/1 - 5Y 4/1)

Wt. of sample	= 1701 gms.
Wt. of residue held 100	= 38.68 gms.
Wt. through 100 held 200	= 7.20 gms.
% held 100	= 2.27
% held 200	= 0.42

Sample 38*:- Just above coprolite bed.
Colour Dark grey (N3)
Residue mainly shale fragments, some fish remains, white calcitic material, occasional grains of glauconite.

Sample 39*:- Coprolite bed.

Sample 41*:- Bed C7F

Sample 42*:- Bed C11B - 4' above Compound Nodular bed.
Colour Medium light grey (N6)

Wt. of sample	= 1814 gms.
Wt. of residue held 100	= 310.5 gms.
Wt. through 100 held 200	= -
% held 100	= 17.11
% held 200	= -

Very glauconitic, abundant crinoid ossicles and fish vertebrae.

Sample 44*:- 12' horiz. below cementstone exposed on beach.
Colour Medium grey - olive grey (N5-5Y 4/1)

Wt. of sample	= 1445 gms.
Wt. of residue held 100	= 31.36 gms.
Wt. through 100 held 200	= 20.46 gms.
% held 100	= 2.17
% held 200	= 1.14

Lumps of granular pyrite, belemnite fragments, shelly, good microfauna.

Sample 46*:- LB3 10' horiz. above sample 45*
Colour Medium grey (N5)

Wt. of sample	= 1474 gms.
Wt. of residue held 100	= 4.70 gms.
Wt. through 100 held 200	= 4.05 gms.
% held 100	= 0.32
% held 200	= 0.27

Sample 47*:- Bed LB3 11' above sample 45*
Colour Light grey (N7)

Wt. of sample	= 1389 gms.
Wt. of residue held 100	= 3.68 gms.
Wt. through 100 held 200	= 3.57 gms.
% held 100	= 0.26
% held 200	= 0.25

Rich in ostracoda and foraminifera, pyrite 'cylinders', fish remains, belemnite and shell fragments.

Sample 48*:- 25' horiz. above bed LB4A
Colour Medium grey - olive grey (N5-5Y 4/1)

Wt. of sample	= 1219 gms.
Wt. of residue held 100	= 49.12 gms.
Wt. through 100 held 200	= 5.23 gms.
% held 100	= 4.02
% held 200	= 0.43

Residue almost entirely pyrite.

Sample 49*:- 39' horiz. above bed LB4A
Colour Medium grey

Wt. of sample	= 1701 gms.
Wt. of residue held 100	= 23.05 gms.
Wt. through 100 held 200	= 4.09 gms.
% held 100	= 1.35
% held 200	= 0.24

Residue mainly granular pyrite and pyrite tubes, lamellibranchs, gastropods, fish remains, faecal pellets. No ostracods, very few foraminifera.

Sample 50*:- Bed C5I
Colour Light olive grey (5Y 6/1)

Wt. of sample	= 1445 gms.
Wt. of residue held 100	= 5.08 gms.
Wt. through 100 held 200	= 3.16 gms.
% held 100	= 0.35
% held 200	= 0.22

Pyrite, much shell debris and broken 'Epistomina', fish vertebrae, echinoid spines. Plenty of foraminifera and ostracoda.

<u>Sample 51</u>*:- C7C
Mainly granular pyrite, belemnite fragments. 'Epistomina' dominant.

<u>Sample 52</u>*:- Bed C7D

Colour Medium grey (N5)	
Wt. of sample	= 907 gms.
Wt. of residue held 100	= 22.15 gms.
Wt. through 100 held 200	= 10.36 gms.
% held 100	= 2.44
% held 200	= 1.14

Predominantly glauconite with a little pyrite.

<u>Sample 53</u>*:- Bed C5A

Colour Medium grey (N5)	
Wt. of sample	= 1389 gms.
Wt. of residue held 100	= 15.14
Wt. through 100 held 200	= 3.35 gms.
% held 100	= 1.09
% held 200	= 0.24

Abundant pyrite, a little glauconite.

<u>Sample 54</u>*:- C4B top

Colour Medium grey (N5)	
Wt. of sample	= 453.0 gms.
Wt. of residue held 100	= 108.0 gms.
Wt. through 100 held 200	= 18.44 gms.
% held 100	= 23.8
% held 200	= 4.07

Very rich in glauconite.

<u>Sample 55</u>*:- C3 base

Colour Medium light grey (N6)	
Wt. of sample	= 453.0 gms.
Wt. of residue held 100	= 7.93 gms.
Wt. through 100 held 200	= 3.98 gms.
% held 100	= 1.75
% held 200	= 0.87

Large amount of calcareous material, with pyrite and glauconite. Good microfauna.

<u>Sample 56</u>*:- Bed C4H

Colour Medium light grey (N6)	
Wt. of sample	= 1303 gms.
Wt. of residue held 100	= 73.78 gms.
Wt. through 100 held 200	= 87.50 gms.
% held 100	= 5.66
% held 200	= 6.72

Brown sandy residue composed almost entirely of siderite.

Sample 57*:- Bed LB2A - dark finely laminated clay
Colour Medium light grey - light grey (N6-N7)
Wt. of sample = 1757 gms.
Wt. of residue held 100 = 48.78 gms.
Wt. through 100 held 200 = 44.38 gms.
% held 100 = 2.77
% held 200 = 2.52

A very distinctive residue - almost entirely white faecal pellets. Some fish vertebrae but virtually barren of microfauna.

Sample 58*:- Top of Bed C4K
Colour Medium light grey - light grey (N6-N7)
Wt. of sample = 1275 gms.
Wt. of residue held 100 = 23.22 gms.
Wt. through 100 held 200 = 3.69 gms.
% held 100 = 1.82
% held 200 = 0.29

Residue mainly pyrite, siderite and quartz. Microfauna only a minor constituent.

Sample 59*:- C5E
Colour - Medium grey (N5)
Wt. of sample = 1587 gms.
Wt. of residue held 100 = 28.60 gms.
Wt. through 100 held 200 = 36.64 gms.
% held 100 = 1.80
% held 200 = 2.30

Residue mainly glauconite, rich well preserved microfauna.

Sample 60*:- Bed C5G
Colour Medium light grey - light olive grey (N6-5Y 6/1) weathering to Moderate yellowish brown (10YR 5/4 on the surface).
Wt. of sample = 2041 gms.
Wt. of residue held 100 = 214 gms.
Wt. through 100 held 200 = 253 gms.
% held 100 = 10.48
% held 200 = 12.39

Residue almost all siderite.

Sample 61*:- Bed C5K
Colour Medium grey (N5)
Wt. of sample = 1785 gms.
Wt. of residue held 100 = 6.99 gms.
Wt. through 100 held 200 = 6.15 gms.
% held 100 = 0.39
% held 200 = 0.34

Pyrite, shelly material and 'Epistomina'.

Sample 62*:- Bed C5L

Colour Olive grey - brownish grey (5Y 4/1-5YR 4/1)

Wt. of sample	=	1303 gms.
Wt. of residue held 100	=	121 gms.
Wt. through 100 held 200	=	401 gms.
% held 100	=	9.28
% held 200	=	30.8

Very 'sandy' brown sideritic residue.

Sample 63*:- Bed C5 A

Colour Medium grey (N5)

Wt. of sample	=	1105 gms.
Wt. of residue held 100	=	3.69 gms.
Wt. through 100 held 200	=	2.71 gms.
% held 100	=	0.33
% held 200	=	0.24

Shelly, granular pyrite, dominant microfauna 'Epistomina'.

Sample 64*:- Bed C4K - top

Colour Medium grey - medium light grey (N5-N6)

Wt. of sample	=	1474 gms.
Wt. of residue held 100	=	26.67 gms.
Wt. through 100 held 200	=	7.68 gms.
% held 100	=	1.81
% held 200	=	0.52

Abundant 'Epistomina', some pyrite and otolith.

Sample 65*:- Bed C4E

Colour Medium light grey - light grey (N6-N7)

Wt. of sample	=	1545 gms.
Wt. of residue held 100	=	360.0 gms.
Wt. through 100 held 200	=	32.0 gms.
% held 100	=	23.30
% held 200	=	2.07

Abundant glauconite, pyrite, shell fragments and 'Epistomina' caracolla.

Sample 66*:- Bed C4C base just above stoneband.

Colour Medium light grey (N6)

Wt. of sample	=	1049 gms.
Wt. of residue held 100	=	19.08 gms.
Wt. through 100 held 200	=	6.53 gms.
% held 100	=	1.82
% held 200	=	0.62

Shell fragments, pyrite, glauconite. 'Epistomina' dominant.

Sample 67*:- 1' below basal Cement Bed.
Colour Medium grey - olive grey (N5-5Y 4/1)

Wt. of sample	= 1417 gms.
Wt. of residue held 100	= 28.80 gms.
Wt. through 100 held 200	= 8.09 gms.
% held 100	= 2.03
% held 200	= 0.57

Very shelly residue, with pyrite and gastropods.

Sample 68*:- Bed D5 top
Colour Olive grey

Wt. of sample	= 1502 gms.
Wt. of residue held 100	= 26.55 gms.
Wt. through 100 held 200	= 7.88 gms.
% held 100	= 1.76
% held 200	= 0.52

Abundant granular pyrite and pyrite rods, fragments of Lingula common.

Sample 69*:- Bed D4B
Colour Medium light grey

Wt. of sample	= 1021 gms.
Wt. of residue held 100	= 19.84 gms.
Wt. through 100 held 200	= 1.86 gms.
% held 100	= 1.94
% held 200	= 0.18

Abundant shell debris, granular and 'rod' pyrite. Crinoid ossicles, fish teeth, black phosphatic material. Microfauna poor.

Sample 70*:- Kimmeridge clay - just below the Coprolite bed. Sample barren, residue entirely calcitic material.

APPENDIX 3

LITHOLOGICAL SECTIONS.

SECTION THROUGH THE CEMENT BEDS AND UPPER B BEDS

(SECTION DRAWN TO SCALE IN CHAPTER 3)

6' +	Very dark grey clays
6"	Brown indurated clay band which in parts forms a good stone band, though an impersistent one. On the surface many infilled worm tubes are weathered out.
13'	Dark grey clays with Parancyloceras bidentatum indicating a Lower Aptian age.
6"	Pale grey bed with phosphatic nodules and pyrite on bedding planes.
11'	Dark grey shelly clays with Nucula. Near the base the clays are not so pyritic and are lighter in colour.
4"	Band of clay with small brown phosphatic nodules.
30'	Dark grey rather blocky clay, shelly and pyritic. Near the base close to the stoneband the clay is brown in colour, fossil wood and Serpula occur.
1'	Stoneband. Large grey 'cementstone' nodules veined by calcite. This stone band which marks the top of the 'Cement Beds' is set in a brown gritty clay.
3'	Brown clay.
5' 4"	Hard, blocky black clay with pyrite. At the top of this clay division is a thin mottled bed of large markings of brown clay penetrating into the black clay. Near the bottom of this division a small amount of glauconite occurs.
3' 8"	Pale grey clay
1'	Brown silty clay becoming indurated and forming an intermittent stone band.
1' 8"	Brownish black clay with, at the top, a band of small mottling of brown in black clay.

6"	Pale bluish grey soft clay.
8"	Dark black clay with a little glauconite. At the top there is large mottling of light clay in dark whilst generally throughout this division small mottling of light in dark clay occurs.
3'	Brownish black clay with a mottled bed at the top of large dark markings in lighter coloured clay.
1'	Cementstone band. Grey nodules are veined by calcite.
8'	Brownish grey clay, blocky and pyritic. The beds at this point are dipping at 30° towards the south south west.
5'	Much browner clay
1'	Line of grey calcareous 'cementstone' nodules.
1' 9"	Pale grey clay
7'	A very dark black clay in which large granular pyrite occurs near the top of this lithological division. The junction with the bed above is marked by a mottled zone of large and small light coloured markings in dark clay.
	Occasional very weathered brown nodules.
12' +	Black clay
about 3'	OBSCURED
1'	'Cementstone' band with the nodules spaced fairly widely apart. The clays immediately overlying this stone band are black in colour.

2' 3"	Brown clay
8'	Black pyritic clay with a mottled band at the top (both large and small brown mottling in the black clay)
5'	Brown clay with a thin paler bed at the junction with the bed above.
2'	Dark grey to black clay, becoming paler near the base. At the top there is a mottled layer of small brown markings in the black clay.
6"	Black glauconitic clay, mottled at the top, with both large and small light coloured mottling in the dark clay.
1' 6"	Brown clay
1'	Thin 'cementstone' in Brown clay.
	ABOUT 6 FEET OBSCURED.
1'	Pale and dark clays. The dark clays contain abundant impressions of a small lamellibranch. Fossil wood occurs in these clays.
2'	Dark grey clays, mottled at the top with large mottling of light clay in dark.
4'	Grey clays
1' 6"	Large grey calcareous 'cement' nodules forming a double layer in pale clay.
1' 9"	Black very shelly clays, mottled at the top with large and small light markings in the dark clay.
6"	Pale grey clay which penetrates into the dark pyritic clays

beneath, giving a zone of large mottling.

1'   Black clay with large pieces of pyrite.

ABOUT 10' OBSCURED BY SAND

2'   Large grey nodules - 'cementstone'

6'   Well laminated black clay with paler pyritic laminations. These clays are quite distinctive.

2'   Widely spaced large circular 'cement' nodules dipping at 20° to the south south-west.

2' 8"   Very well laminated clays with pyrite along the bedding planes. The clays become paler at the base with occasional elongated brown nodules.

2' 4"   Dark well laminated clay.

1'   Pale grey, soft clay with a band of crushed ammonites at the base.

6'   Dark black clay with numerous small pieces of pyrite. The clay is shelly and contains gasteropods. Near the centre of this division is a band of small brown nodules.

1'   Widely spaced apart rather elongated grey nodules.

2'   Dark grey/black pyritic clays

8"   Pale grey pyritic clay with occasional large 'cementstone' nodules.

5'   Very dark grey/black pyritic clay with very slight mottling at the top of light coloured clay in dark.

1'	Occasional grey nodules.

Dark clays of Lower B.

Beach exposure near pillbox in Upper B beds 3.5.62.

Seen to 6' Very dark clays

Indurated brown band; has a very rough surface due to infilling of worm tubes, some quite large. Stoneband seems impersistent.

13' Dark clays. *Parancyloceras bidentatum* near base

Pale clay band with small phosphatic nodules. Pyrite associated with this band.

11' Dark, shelly clays; almost black.

Very small phosphatic nodules

30' Dark pyritic clay, shelly. Passes downwards into lighter grey blocky clay.

Stoneband (A), large grey nodules with calcite veining. The stoneband is in a brown rather gritty clay.

4' Light blue grey clay weathering brown on the surface.

6" Mottled clay-light brown in darker.

Seen to 8' Dark black rather hard clay.

Exposure on shore near upper B Pillbox 22.12.62.

Brown band of clay

6' Black pyritic clays

3' Chocolate brown clay

2' Pale grey, non glauconitic clay.

9" Dark black glauconitic clay.

2' Band of brown clay with occasional nodules.

2' Brown clay

'Cement' nodules with mottled clay beneath

2' Dark clay.

Large 'Cement' nodules with

Exposed on shore near upper B Pillbox 22.12.62.

Brown clay

2' Paler clay

Dark grey clay mottled at the top L in D[1]

6" Glauconitic clay

1'6" Paler grey clay with occasional brown nodules near the top.

1'0" Dark glauconitic clays, shelly; belemnites.

2'6" Paler grey clays

6" Brown clay band

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1. L in D = mottled clays, light coloured clay penetrating into dark. L in D,S = small mottling; L in D,L = large mottling.

6" Paler clay

1'0" Dark clays mottled at the top (L in D,L)

1'0" Pale grey clays

9" Dark clay with some glauconite. Large mottling at the top (L in D).

2'0" Grey clays

Stoneband in a brown clay

11' Clays

Band of 'cement' stones.

Section measured in Black Cliff 17.10.62.

Grey clay

3' Rather black, olive grey clay, breaks conchoidally. The clay has some wood fragments with yellow weathering rims.

1' Pale grey clay with some mottling at the top

10" Dark grey/black pyritic clay with some glauconite.

9" Pale grey clay with large dark mottling.

2' 0" Brown clay becoming a darker brown at the base. Clays are shelly and have belemnites. Some woody material at the junction with the underlying bed.

7" Pale grey clay

7" Mottled bed L in D,S has some pyrite.

Seen to 1' Grey clay.

Measured behind the most southerly pillbox in the cliff face 23.10.62

Seen to 4' Brownish black clays

Silty brown clay becoming indurated in places. Cement bed nodules with brown calcite veining

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2'10" Brown Clay

3' 7" Dark black/brown clay. Mottled at the top L in D,L. Shelly, pyritic and glauconitic at the base.

Slightly lighter coloured bed, mottled at the top.

Section on shore near the 'cement beds Pillbox' 11.12.63.

Seen to 2' Dark clays

Band of elongated brown nodules.

2' Dark clays though paler than ones above.

6' Dark clays, much massive pyrite on the surface.

4' Olive grey clays, with a line of occasional small white or 'potato' nodules.

6" Paler clay band

3' Olive grey clay. Occasional rotten brown nodules at the base.

1' Pale grey clay in which are large 'cementstone' nodules.

9' Well laminated dark clays.

7' Dark grey clays which are striped near the base.

15' Dark black pyritic clays

'Cementstone' nodules.

Section on shore at Black Cliff Nab 6.1.64.

'Cementstone' band. Large grey nodules appear to form a double line.

31' Clays

1' Dark grey clay

1' Pale grey clay

10' Dark pyritic clay

3" Soft pale clay with pyrite.

6' 7" Grey clays

Seam of pyrite (Probably a very local feature).

5' 9" Very dark grey/black clay.

Pale stripe

10' 3" Pale grey shaly clay.

Brown stone band. The large nodules being widely spaced apart.

8' 3" Dark grey clay

1' 9" Pale grey clay with occasional small brown nodules.

2' Slightly darker clay

2' Pale grey clay

1' Large brown nodules. LB4A

1' 5" Pale grey clay

1' 9" Dark grey clay, mottled at the top L in D, LCS

6'10" Dark grey clay.

2' Pale grey clay weathering to a brown colour. It has widely spaced grey nodules (about 1' apart).

Section in the Lower 'B' beds immediately east of Black Cliff Nab measured in the cliff and on the shore 8.11.1961

1' Band of large brown nodules (LB4A)

1' Pale bluish grey clay (Sample No. 25)

1' Dark glauconitic clay mottled at the junction of the overlying bed (L in D, L & S) (Sample No. 24)

5' Dark clay rather pyritic (Sample No. 21, 1' above base; No. 22, 3' above base; No. 23, 5' above base)

1' A pale brown clay band with nodules

5' Dark pyritic clays (3 samples 1', 3', 4' above base, Nos. 18, 19, 20).

1' Brown weathering band with small rounded brown nodules.

4' Dark brownish black, pyritic clays mottled near the top. Near the base it contains a little glauconite and a few nodules. (3 samples 1', 3', 4', above the base, Nos. 13, 14, 17.)

1' 2" Black highly glauconitic and pyritic clay. The glauconite decreases upwards (Sample No. 12)

10" Soft pale grey clay mottled at top (D in L,L) (Sample No. 11)

8" Hard brownish weathering band of clay becoming glauconitic and softer at the base. (Sample No. 10)

5" Dark, highly glauconitic clays. Mottled especially near the top. This is bed C1A (Hauterivian) (Sample No. 9).

4" Pale grey clay with dark highly glauconitic streaks. (Sample No. 8)

1' Dark grey highly glauconitic clay with abundant large pyrite. (Sample No. 7).

1' Pale grey clay with brownish nodular band at the base. (Sample No. 6).

2' 6" Dark grey clay (2 samples 1' & 2' above base Nos. 4, 5.)

4" Dark glauconitic clay with paler streaks. (Sample No. 3).

1' 8" Pale clay with occasional brown nodules. Weathers brown. (Sample No. 2)

2' Dark grey clay with paler mottlings at the top (Sample No. 1)

2' + Pale grey clays with brown nodules.

Section in Lower 'B' beds measured on shore at Speeton Beck 16.11.1961

Pale grey clay

1' Brown stone band (LB4A) dipping at 40° to the south south-west (Sample No. 29)

1' 6" Pale grey clay (Sample No. 30)

1' 0" Dark glauconitic clay mottled at top (L in D, L) (Sample No. 31)

Darker clay (Sample No. 32)

Pale clay (Sample No. 33)

Section in Lower B and Cement beds measured on shore S.E. of Speeton Beck 21.11.1961

2' 8" Pale grey shelly clay seen to 10' horizontal.

1' Band of large grey concretions. Cementstone band of Kaye.

10' Pale grey clays with a lighter mottled band. Seen 38' horizontal.

8' 6" Very dark highly pyritic clays with large pieces of granular pyrite on the surface. 32' horizontal.

6" Band of large flat (platy) nodules. Bed LB2A.

4' Dark highly pyritic clays. Pyrite often in large crystalline pieces. 15' horizontal (3 samples 37, 38, 39)

1' Band of nodules in pale grey clay. Bed LB2D.

23' Dark clays passing down into a pale blue clay. Seen to 89' horizontal.

1' Brown calcareous stone band.

<u>Section in Lower 'B' on shore near Speeton Beck.</u>

6" Band of large flat (platy) nodules.

2' Dark clays

6" Mottled bed L in D,L

Dark clays with granular pyrite weathering out on the surface.

Section in Lower 'B' beds at Mouth of Speeton Beck 7.12.61

Dip 15°. Seen to 45' horizontally.

8' Grey clays

6" Small very rounded brown nodules

3' Grey clay

1' Brown stone band LB4A

Samples 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62.

Section in Lower 'B' at Black Cliff Nab on shore 7.17.61

11' 4" Dark highly pyritic clay. Seen to 13' horizontal.

Large pale nodules widely spaced dip 65 degrees

Grey clays

Occasional rotten brown phosphatic nodules.

Line of nodules

Dark grey clay

4" Line of pale grey nodules

1' 7" Dark grey clay

1' Brown stone band, LB4A, dip 60 degrees to south south-west

Section measured in Lower B in good beach exposure S.E. of Black Cliff Nab. 13.12.63.

1' Brown band which is indurated in places, very shelly. A very occasional light grey nodule.

4' Grey clay

1' Large cementstone nodules in parts appears to be a double line. Basal cementstone bed?

4" Pale grey clay

5" Mottled clay (L in D,S)

7" Dark clay very pyritic

4' Dark pyritic clay

¼" Seam of bright pyrite

6' Dark clays

2" Pale stripe

10' Dark clays very well laminated. Laminations are very thin, often a light green-grey colour. (Sample No. 57)

6" Pale grey nodule

11' Darker clay, laminated near the top, with pyrite along the bedding planes. Brown small phosphatic nodules near the top. Nearer the base of this division the black clays are not laminated.

4" One flat septarian nodule ('platy'?)

6" Dark black clay

6' Dark clays becoming paler below. Within this division was one large grey nodule in a paler grey band.

1' Brown band which is indurated, giving a brownstone.

4' 5" Grey clays with a line of small grey nodules at the base.

4'7" Grey clays with the conspicuous brown band at the base (LB4A). Just above this brown stone band are a line of small grey nodules.

3' Pale grey clay.

2' Dark black clay

2' 7" Brown weathering band

5" Dark clay which is mottled at the top (L in D,S)

6' 5" Grey clay

6" Widely spaced grey nodules

1' Pale grey clay

Dark grey/black clay.

N.B. This section is rather contorted in the upper part and appears to be part of a slipped mass.

Section measured on the shore 9.5.63.

Small 'cementstone' nodules.

9' Dark clay becoming paler near the stone band at the base.

1' Large grey 'cementstone' nodules. This is the basal nodule band of the 'cement' beds.

4" Pale grey clay.

8" Darker clays. Mottled L in D, L & S passing downwards into L in D,S. (Sample No. 67)

4' Dark black clay, very pyritic with well formed pyritic crystals. Shelly and ammonite nuclei

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4" Seam of massive pyrite on the clay surface.

5' Dark pyritic shaly clays.

7' 9" Well laminated clays, pyrite often marking the lighter coloured laminations.

6" Very occasional indurated fine grey clay which gives nodules elongated along the bedding planes.

10' + Dark clays

Section exposed on beach immediately to the south of 'Lower B' Pillbox. 9.5.63.

Line of large double 'cementstones'. Strike 298° dip 70 - 80° to the south west.

5' Obscured by shingle

3' Dark pyritic shelly clay.

7' Paler beds which become the characteristic striped ones, well laminated with pyrite along bedding planes.

6" Thin paler bed?

13' Dark pyritic beds not so well laminated.

4' Clays which are not quite as black. Pyrite crystals and tubes.

6" Paler bed.

6" Mottled clay L in D,S which passes down into dark grey clay with no pyrite.

1' Brown gritty stone band (LB3)

3' 6" Grey clays with small grey nodules and occasional brown rotten phosphatic nodules at the base.

<u>Section in 'Cement beds' and Lower 'B' beds measured on the shore 24.9.64.</u>

Dark black to olive grey clays.

Large 'cementstone nodules (about 2' long).

2' Darker clays.

1' Pale grey band sometimes weathering brown and with occasional grey nodules.

3' 3" Dark black clays, mottled at the top L in D,S.

\- Thin, flat, weathered, brown phosphatic nodules.

2' 6" Grey clays

\- Rather rounded grey nodules

7' Grey clay which is generally lighter in colour than the clay below the cementstone at the base of this division.

1' Large grey nodules forming the basal 'cement' bed. The nodules are about 2' long, veined by brown calcite, and has a rusty weathering stone beneath. Pale clay associated with the cementstone.

9' Black very pyritic clays, large pieces of pyrite on surface.

1' Pale grey clay

5' Paler grey clays

9' Well laminated clays, granular pyrite on the surface. A general alternation of pale and darker laminated clays.

1' Pale grey clay very shelly

8' Grey/black laminated clays

Small grey nodules in a pale grey clay. Nodules are about 2' apart along the strike. A Crioceratid is associated with these nodules

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11' Dark black rather blocky clays

\- Grey nodules widely spaced apart.

12' Grey clays

\- Brown stone band with occasional grey stone

8' Grey clays

\- Small, flat?, grey nodules widely spaced apart. Also some brown, rotten phosphatic nodules.

3' Clays

Small flat grey nodules

2' Clays

6" Brown gritty stone band (IB4A)

2' Pale grey clay

8' Black clays glauconitic near the top. Mottling occurs at the junction with the overlying bed L in D, L & S.

Brown weathering clay with occasional small brown nodules.

<u>Section in Lower 'B' and Upper 'C' beds measured on shore immediately S.E. of Black Cliff Nab. 20.9.62.</u>

1' Large nodules widely spaced apart.

4' Greyish black clay

6" Shattered stone band (?) and band of pyrites.

4' Grey clay with pyrites

2' Pale grey clay with brown 'potato' nodules.

5' Darker grey clay with weathered brown nodules near the base

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1' Brown silty stone band in a light grey clay (LB4A)

4" Pale grey clay

1' 3" Black glauconitic clay mottled at top (L in D)

5' 9" Dark clay

1' 6" Brown lenticular stones, widely spaced apart in a pale brownish grey clay.

5' 5" Dark clay

1' 6" Paler brown/grey clay with scattered nodules.

2'10" Darker clay

1' 7" Lighter grey clay

4' 0" Dark black clay becoming glauconitic at the base.

2' 8" Pale grey clay with occasional brown nodules. Mottled near the top (D in L)

6" Dark glauconitic clays mottled at top (L in D)

6" Light grey clay with dark mottling of glauconite from the upper bed.

2' Dark glauconitic clay with pyrites.

2' 8" Light grey clay, small mottling near base.

6' Dark grey clay becoming lighter near the base.

6' Darker glauconitic clay becoming paler near the base. Mottling (L in D)

Section exposed on shore and in part of low cliff immediately to the S.E. of the slipped mass of Lower 'B' in Black Cliff Nab. 25.10.62.

1' Stone band, large brown nodules with grey unweathered lower portion.

4' 4" Grey clays

4" Band of occasional small grey nodules.

3' 3" Grey clays

2" Small grey 'potato' nodules.

1' 3" Brown stone band (LB4A)

Section exposed on shore immediately to the S.E. of Black Cliff Nab. 17.12.62.

Occasional nodule in a brown weathering clay.

1' Pale grey clay

11' 7" Very dark grey or black clay.

1' Large cementstone nodules. Strike 105° mag.

18' Grey Clay (Sample No. 44)

1' Pale clay with a large nodule.

4' Pale clay

2' Darker grey clay

2' Pale grey clay (Sample No. 49)

5' Grey clay with a band of small brown nodules at the top.

6" Widely spaced grey nodules

6" - 2' Black blocky clay

1" Soft pale grey clay

9' Dark, hard, pyritic clay. Lumps of pyrite on the surface, (Sample Nos. 47, 48)

1' Pale clay with occasional large grey nodules.

1' Mottled bed (L in D,S) with pale stripe at base.

10' Pale grey clay (Sample No. 46)

1' Widely spaced apart brown stone

10' Clays with two lines of small nodules 1' and 3' above the base.

1' Brown stone band (LB4A)

<u>Section measured in cliff & shore immediately N.W. of Speeton Beck. February 1965.</u>

'Cementstone' band G?

8' Dark black highly pyritic clays much pyrite on the surface.

24' Striped laminated clays paler than beds above.

6" Line of widely spaced grey nodules.

6' Black clay.

6" Pale grey clay with widely spaced grey nodules

10' Pale grey clays

Brown stoneband of LB4A

In Cliff at Speeton Beck January 1965

1'   Cement nodules

3'   Dark grey clay

1'   Large circular grey 'cement' nodules.

10'   Grey clays

6" White and brown nodules in a pale clay

9'   Grey clays

Brown stoneband - LB4A

Section in upper part of C4 measured on shore 10.5.62

Greenish coloured stone band.

3' 0" Dark black glauconitic clay. The glauconitic content of the clay decreases towards the base. Near the stone band the glauconite is absent. (Sample No. 30)

2'   Pale clay with brown rounded nodules (Sample No. 31)

Dark glauconitic clay mottled near the top (L in D) (Sample No. 34).

Section in 'D' beds measured in the cliff and shore 6.7.62.

Dark black clay.

2' Black mudstone, mottled at the top, L in D, becomes lighter at the base.

1" - 2" Bright blue seam with light coloured markings (D6D)

3" Dark grey clay

3" Pale grey clay

4" Dark grey clay with small white mottling

1' Blocky mudstone, pale grey with dark streaks. This bed develops a lenticular stone band (D6H)

2' Blocky mudstone, pale grey, similar to bed above but has light coloured streaks in it.

4" Bright blue, soft clay with white markings cutting across the bedding.

1' Brown shaly bed.

7" Bluish mottled bed.

5" Brown-black clay.

5" Bright blue clay (D7D)

3½" Dark, streaky shaly clay.

2½" Blue clay

Dark black blocky clay. Seen to 2"

Section measured in the upper 'D' beds 11.10.62.

Compound nodular bed.

6" Green glauconitic clays with large mottling

6" Dark black clay with small prominent white mottling.

1' 0" Greenish clay. Mottled (L in D,L)

Line of nodules, eroded belemnites and pyrite.

7' 0" Brown clay

4" Pale brown stone band.

Pale clay with Exogyra sinuata

Section in Lower D beds measured in cliff 25.10.62.

Brown shale

Band of blue soft clay weathering yellow.

1' Brown weathering clays or shale.

6" Stone band

1' 8" Brown shaly beds.

4" Blue clay mottled yellow

9" Shaly, looks like a stone band. Yellow weathering.

1' 5" Harder, blocky and shaly. Some mottling (L in D).

7" Paler bed weathering grey

4" Dark grey bed.

3" Pale blue mottled clay.

2' 4" Brown/black shaly clays

Coprolite bed.

Section in Lower 'D' beds measured in cliff 25.10.62

Dark brown/black shaly clays.

3" Light grey mottled at base.

6" Dark grey clay with occasional light mottling from the bed above.

5" Blocky clay-mudstone with some mottling

¼" Thin soft clay.

6" Mudstone

3" Mottled mustone (L in D,L)

1¾" Dark clay with vivid pale mottling (blue band)

2¼" Dark grey clays

3½" Pale grey clay with occasional black streaks.

5" Dark mottled clay (L in D,L & S)

5" Grey streaky clay

Stoneband D6

<u>Basal part of the 'D' beds measured in the cliff 6.7.62.</u>

Brown shales.

3" Blue, mottled clays weathering yellow and blue D7F

1' 4" Black shale

2" Soft black clay

7" Black shaly clays

4" Coprolite bed

1" Black shale

Pale buff nodules

<u>Beach exposure by old shipwreck, September 1964</u>

Compound Nodular bed D1

42' 3" Clays

2" Bright blue and white mottled clay band.

1' 9" Clays

Stone band

3'

Thin band of clay with white markings.

3' Black clay

Coprolite bed

<u>Beach exposure at foot of cliff in lower D beds 5.12.63.</u>

6' + Dark black clays

8" Dark mottled clays lighter coloured near the top.
Mottling L in D,L

1' 1" Pale grey blocky mudstone, streaky D in L,L occasional *Exogyra*.

2" Bright vlue, clay band mottled white in blue.

7" Light coloured clay mottled with dark streaks. The clay is darker at the top.

4" Dark grey clay characteristically mottled L in D,L & S.

9" Light grey mudstone giving a stone band. Mottling L in D,L. (D6)

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1'3" + Pale grey blocky streaky mudstone, L in D,L.

Section measured on shore near shipwreck in the Lower C beds 1965.

1' Brown band

6' Grey clay

1' Gritty brown band

6" Mottled beds L in D, L & S.

12' Grey to dark black clays with a line of small brown nodules

---

2' 5" Black clay with brown nodules and widely spaced grey nodules

---

1' 7" Darker grey clay

1' Pale grey clay (C9C)

5' Dark non glauconitic clay

1' Glauconitic clay

1' Mottled beds L in D,L

5' Medium grey clays

2" Brown stone band

1' Pale grey clay

9" Strongly mottled bed

6' 3" Dark grey/black glauconitic clays with 'clots' of glauconite (C11B)

Compound nodular bed (D1)

APPENDIX 4

OTHER MICROFAUNA

<u>OTHER MICROFAUNA</u>

Though foraminifera formed the bulk of the microfauna, other microfossils occurred and these are listed here:-

Phylum BRYOZOA

Bryozoa have been found in one sample (No. 3) from bed C9. In this sample they occurred abundantly.

Phylum MOLLUSCA: Class GASTROPODA

Small gastropods are common in some of the residues though their distribution is very sporadic. They are common in the Lower D beds, especially D6, and also in the Lower B beds. Their preservation is usually poor.

Phylum ARTHROPODA: Class CRUSTACEA Subclass OSTRACODA

Ostracoda are generally common in the Speeton Clays though their distribution and abundance is variable. The C beds and Lower B beds are rich in ostracoda, but in parts of the D beds, the lower part of the Lower B, and in the Cement beds they may be absent or very rare. Nowhere in the Speeton succession are they numerically stronger than foraminifera, nor are they so tolerant of strongly reducing conditions. The ostracoda of the Berriasian and Valanginian have been dealt with by Neale (1960, 1962), whilst the Barremian to Albian fauna has been described by Kaye 1963 A-E, 1964 A,C). The forms from the Hauterivian clays still remain to be described.

Phylum ECHINODERMATA Sub-phylum ELEUTHEROZOA: Class HOLOTHURIIDAE

During the examination of the foraminifera from the Speeton Clay a number of samples were found to contain holothurian sclerites. This was an unexpected occurrence as Frizzel and Exline (1955) have pointed out that virtually no work has been published on sclerites from strata of Cretaceous age. The only previous records of Cretaceous holothurian sclerites are Calcligula (?) huckei Frizzel from the Gault of Pomerania, Theelia rotula (Egger) from Germany and Hemisphaeranthos frankei (Müller) from the Tusonian of Germany. "Chisodota" from the Hauterivian of France were noted by Deprat (1900), and Wetzel (1953) obtained sclerites from a Baltic flint which Deflandre - Rigaud (1953) identified as Myriotrochites elegans (Schlumberger), Chiridotites atavus (Waagen) and Chiridotites cf. ingens (Joshua). More recently Kemper (1963) recorded 'Holothurienreste' from the Hauterivian of Germany though he did not describe them.

A systematic search for holothurian spicules in over two hundred micropalaeontological residues of the Speeton Clay, mainly from the type locality but also from borehole material, revealed several horizons which contained a large number of holothurian remains. All were obtained from strata of Hauterivian and Barremian age.

The sclerites from Speeton belong to four families; Achistridae, Theeliidae, Stichopitidae and Priscopedatidae. All are well preserved and free from matrix and secondary growth. Of particular interest in the Barremian clays is the occurrence of the Family Achistridae which is represented by the species Achistrum (Cancellrum) monochordata Hodson, Harris and Lawson. This is a sclerite in the form of a hook, with a terminal loop which is crossed by a single cross bar. Forty one examples of this species have so far been found. With this record of Achistrum (Cancellrum) monochordata the range of the Family Achistridae, previously regarded as being from the Devonian (?) to the Jurassic, can now be extended to include the Lower Cretaceous.

It is interesting to note that A. monochordata is a common form species in the Oxfordian (Fletcher 1962; Hodson, Harris and Lawson 1956), though the specimens from the Barremian are generally smaller than the Jurassic ones. The width of the terminal loop in the specimens from Speeton ranges from 0.090 mm. to 0.144 mm. whilst those from the Oxfordian are from 0.162 mm. to 0.324 mm.

Holothurian sclerites have not previously been recorded from the Cretaceous of Britain.

Classification of Holothurian sclerites

Fragmental microfossils present problems of classification and nomenclature to the palaeontologist, for they represent parts of animals which are now dissociated and may have been scattered widely before being incorporated in the sediments. These fossil fragments, though distinctive, are inadequate for the identification of the whole animal.

Croneis (1938) proposed an artificial classification outside the International Rules of Zoological Nomenclature, the "ordo militaris". This scheme is used by Deflandre-Rigaud in her holothurian papers, although recognition of the "ordo militaris" was rejected at the Paris International Congress of 1948. Holothurian workers of the present time, with but a few exceptions, use Linnaean binominal nomenclature but realise that the sclerites are inadequate for the identification of the complete animal and are thus parataxa. Many different 'species' of sclerite may in fact originate from one true biological species. Giving form species' names to dissociated sclerites leads to a very large number of fossil names, but this is the only way in which the stratigraphical value of holothurian sclerites can be determined.

SYSTEMATIC DESCRIPTIONS

Phylum - ECHINODERMATA

Sub-phylum - ELEUTHEROZOA

Class - HOLOTHURIIDAE

Family - ACHISTRIDAE, Frizzel and Exline, 1955.

Genus - ACHISTRUM, Etheridge, 1881, amend. Frizzel and Exline 1955.

Hampton (1958) subdivided the genus *Achistrum* into the following four subgenera based upon the form of the terminal loop:-

- *Achistrum* sensu stricto - terminal loop empty.
- *Spinrum* - terminal loop occupied by two thorn-like processes.
- *Aduncrum* - terminal loop replaced by two incurved hook like projections.
- *Cancellrum* - terminal loop with a cross-bar.

All the *Achistrum* from Speeton fall within the subgenera *Cancellrum*.

Achistrum (*Cancellrum*) *monochordata* Hodson, Harris, and Lawson.

Plate 22, figures 17-19.

Achistrum monochordata Hodson, Harris and Lawson, 1956, p. 340, figs. 10-11.

Achistrum (*Cancellrum*) *monochordata* Fletcher, 1962, p. 325, figs. 6-7.

Material: 41 specimens from the Barremian clays.

Dimensions: Width of terminal loop varies between 0.090 mm and 0.144 mm. the average width is 0.126 mm.

Description: Sclerite in the form of a hook with a terminal loop which is crossed by a single cross-bar.

Remarks: With this record of *A. monochordata* the range of the family Achistridae, previously regarded as being from the Devonian (?) to the Jurassic, can now be extended to include the Lower Cretaceous.

Occurrence: D4, C8 and upper Barremian (90).

Family - THEELIIDAE Frizzel and Exline 1955.

Genus - THEELIA Schlumberger 1890.

Theelia annulata sp. Nov.

Plate 22, figures 15, 16

Theelia wessemensis var. Hodson, Harris and Lawson, 1956 p. 348 text-fig. 3.

Material: 109 specimens from the Valanginian, Hauterivian and Barremian clays.

Holotype: HU. 32. C. 7 from sample 90 - 16'6" above the base of 'Upper B'.

Diagnosis: Sclerite in the form of a wheel with six symmetrically placed spokes. The outline is circular with the interspoke spaces of spherical triangle shape. Rim inclined to the plane of the wheel curving upward and inward.

Description: Sclerite in the form of a wheel with six spokes. The outline is circular, though viewed from the lower side there is a tendency towards flattening opposite the spokes, giving a very slight subcircular outline. The rim is inclined to the plane of the wheel curving upward and inward. The inner margin of the rim is finely dentate with approximately 32-34 teeth per quadrant.

The spokes are strongly arched downwards and taper slightly towards the centre and the rim, giving a petalloid shape. The central portion has a raised, smooth boss which is elevated above the plane of the lower surface of the rim but does not project above the rim on the upper surface. The greatest peripheral diameter of the sclerite varies between 0.162 mm and 0.270 mm, with an average diameter of 0.225 mm.

Remarks: The single specimen from the Oxford clay referred to as T. wessexensis var. Hodson, Harris and Lawson is here regarded as synonymous with T. annulata sp. Nov. It differs from T. wessexensis in having six spokes instead of seven and is generally larger in size, and from T. ingens (Joshua) in the distinctly petalloid shape of the spokes. It is almost twice as large as T. lanceolata (Schlumberger), has a rounded periphery and narrower spokes.

Occurrence: D4, C8, C2B, Lower B, Upper B. Sample NO's. 6, 9, 19, 21, 27, 90, 69.

Family - PRISCOPEDATIDAE Frizzel and Exline 1955.

Genus - PRISCOPEDATUS Schlumberger, emend. Frizzel and Exline.

Priscopedatus sp. A.

Plate 22, figs. 13, 14.

Material: 43 specimens.

Dimensions of figured specimens:

fig. 13 - maximum width 0.234 mm.

fig. 14 - maximum width 0.180 mm.

Description: Sclerite in the form of a table with spire and stirrup. Outline subcircular, periphery irregular lobate. Has a single large central perforation surrounded by seven or eight circular or elliptical perforations and occasionally with smaller holes at the periphery, either between the main perforations or on lobate extensions.
The spire is large, spinose and frequently broken. Stirrup with four feet which slope from the disc to the spire.

Remarks: The genus at Speeton is characterised by a very irregular lobate outline. The form and number of the perforations appear extremely variable and until a study of this variation is completed a holotype is not being designated. It does not appear to have any close affinities with any other forms of this genus. The stratigraphic range of this genus is Jurassic to Pleistocene, though nearly all the records are from the Jurassic and Eocene of France.

Occurrence: Samples 40, 90 (Hauterivian and Barremian).

Family - STICHOPITIDAE Frizzel and Exline 1955

Genus - CALCLIGULA Frizzel and Exline 1955.

Calcligula speetonensis sp. Nov.

Plate 22, figures 11-12.

Material: 19 specimens.

Holotype: HU. 32. C. 5 from 16'6" above the base of 'Upper B' - sample No. 90.

Diagnosis: Sclerite in the form of a racquet, consisting of a straight or slightly curved rod ending in a perforated, excavated disc. The perforations are numerous.

Description: Sclerite racquet shaped, consisting of a rod ending in a very slightly excavated disc which is subcircular or subelliptical with a large number of perforations. The perforations are generally round or elliptical and are largest in size near the centre of the disc. A number of irregularly placed smaller perforations occur with a tendency for these to be found more frequently nearer the periphery. The rod, which is usually found broken, is circular or elliptical in cross section.

Remarks: Only three species are known in this genus; *Calcligula* ? *huckei* Frizzel and Exline, *C* ? *jurassica* Frizzel and Exline, and *C. perforata* Frizzel and Exline. The form described here differs from

C. ? huckei and C. perforata in the greater number of perforations and from C. ? jurassica in lacking the very large perforations in the disc and the numerous pits on the rod.

This genus has not been previously recorded from Britain.

Measurements of Holotype:

Fig. 11, MU. 32. C. 5 — Length 0.684 mm.

Maximum width 0.144 mm

Occurrence: Sample No's. 18, 20, 21, 90, 40 (Lower - Upper B beds).

Class ECHINOIDEA

This class is represented in the residues by spines and occasionally by thecal plates. They occur mainly in the Hauterivian clays.

Class OPHIUROIDEA

Plates, or more commonly arm ossicles, are common in most of the samples from Speeton.

Sub phylum PELMATOZOA Class CRINOIDEA

Crinoid ossicles occur frequently in the samples from the upper part of the D beds, particularly between D2D and D1. They appear to be absent from all other parts of the Speeton section.

Order HYSTRICHOSPHAERALES

Many of the residues contained quite large numbers of hystrichospheres of such a size that they could be picked out with a sable brush. They occurred either as single specimens or as a matted aggregate. Some of the specimens in the author's collection were identified by Dr. W. A. S. Sarjeant as belonging to the genus Hystrichosphaeridium. These hystrichospheres of unusually large size were only found in the Hauterivian clays.

Phylum PISCES

Fish remains are found throughout the clays though are never very common. They include teeth, bone fragments, vertebrae, scales and otoliths. The latter, which have been found in C7, have not been recorded before in the Speeton clay.

APPENDIX 5

LIST OF FORAMINIFERA

LIST OF FORAMINIFERA

Allomorphina sp. A

Ammobaculites reophacoides
subcretaceus

Ammodiscus tenuissimus

Ammovertella cellensis

Bigenerina clavellata

Citharina acuminata

cf. discors

harpa

pseudostriatula

rudocostata

seitzi

sparsicostata

strigillata

sp. A

sp. B

Conorboides acuta sp. nov.

valendisensis

Conorotalites sigmoicosta

Dentalina communis

danfordi sp. nov.

debilis

linearis

terquemi

sp. A

Dorothia kummi

Epistomina hechti

ornata

Frondicularia concinna

hastata

inversa

cf. microdisca

simplicissima

sp. A

sp. B

Gaudryinella sherlocki

Globulina prisca

Glomospira gordialis

Glomospirella gaultina

Haplophragmium aequale

Haplophragmoides cushmani

nonioninoides

spp.

Höglundina caracella

Lagena apiculata

hauteriviana hauteriviana

cf. hispida

cf. sulcata

Lenticulina (Astacolus) pachynota

cf. pachynota

schlönbachi

schreiteri

Lenticulina (Lenticulina) guttata

guttata var eichenbergi

guttata var. intermedia var. nov.

guttata var. striata

heiermanni

münsteri

nodosa

ouachensis wisselmanni

saxonica
subalata
subangulata
Lenticulina (Marginulinopsis) foeda
gracilissima
robusta
striatocostata
Lenticulina (Planularia) crepidularis
Lenticulina (Saracenaria) bronnii
cf. jarvisi
valanginiana
Lenticulina (Vaginulinopsis) humilis praecurseria
Lingulina hauteriviana sp. nov.
sp. A
Lingulonodosaria nodosaria
Lituotuba sp.
Nodobacularia nodulosa
Nodosaria obscura
orthopleura
pyramidalis
cf. regularis
reightonensis sp. nov.
sceptrum
Polymorphinidae 'fistulose'
Pseudolamarckina lamplughi
Pseudonodosaria humilis
tenuis
vulgata
sp.

Quinqueloculina speetonensis sp. nov.

Ramulina fusiformis

muricatina

spandeli

Textularia foeda

Thurammina albicans

Tristix acutangula

insignis

Tritaxia pyramidata

Trochammina depressa

Vaginulina cf. angustissima

arguta

complanata var. perstriata

kochii

riedeli

striolata

Verneuilinoides neocomiensis

Wellmanella antiqua

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PLATE 1

PLATE 1

1 Lituotuba sp. HU. 21. C. 1, sample 22, bed LB4D, (x 26)

2 Ammovertella cellensis Bartenstein & Brand, HU.21.C.2, bed D4A2, (x 40)

3 Ammovertella cellensis Bartenstein & Brand, HU.21.C.3, sample 37*, bed D2E, (x 40)

4 Ammovertella cellensis Bartenstein & Brand, HU.21.C.4, bed D2E, (x 26)

5 Thurammina albicans Brady, HU.21.C.5, sample 22, bed LB4D, (x 40)

6 Ammodiscus tenuissimus (Gümbel), HU.21.C.6, sample 41, bed LB1, (x 53)

7 Ammodiscus tenuissimus (Gümbel), HU.21.C.10, sample 41, bed LB1, (x 53)

8 Haplophragmium aequale (Roemer), HU.21.C.7, sample 28*, bed C3, (x 40)

9 Glomospirella gaultina (Berthelin), HU.21.C.11, bed D2E, (x 53)

10 Glomospirella gaultina (Berthelin), HU.21.C.12, bed D2E, (x 53)

11 Glomospirella gaultina (Berthelin), HU.21.C.13, bed D2E, (x 53)

12-13 Glomospira gordialis (Jones & Parker), HU.21.C.14, bed D3A, (x 40)

14 Haplophragmoides nonionoides (Reuss) HU.21.C.15, bed D6D, (x 27)

15-17 Haplophragmoides nonioninoides (Reuss), HU.21.C.16, bed D2E, (x 27). Fig. 17 under glycerine.

18-19 Haplophragmium aequale (Roemer), HU.21.C.8, sample 21, bed LB4D, (x 20)

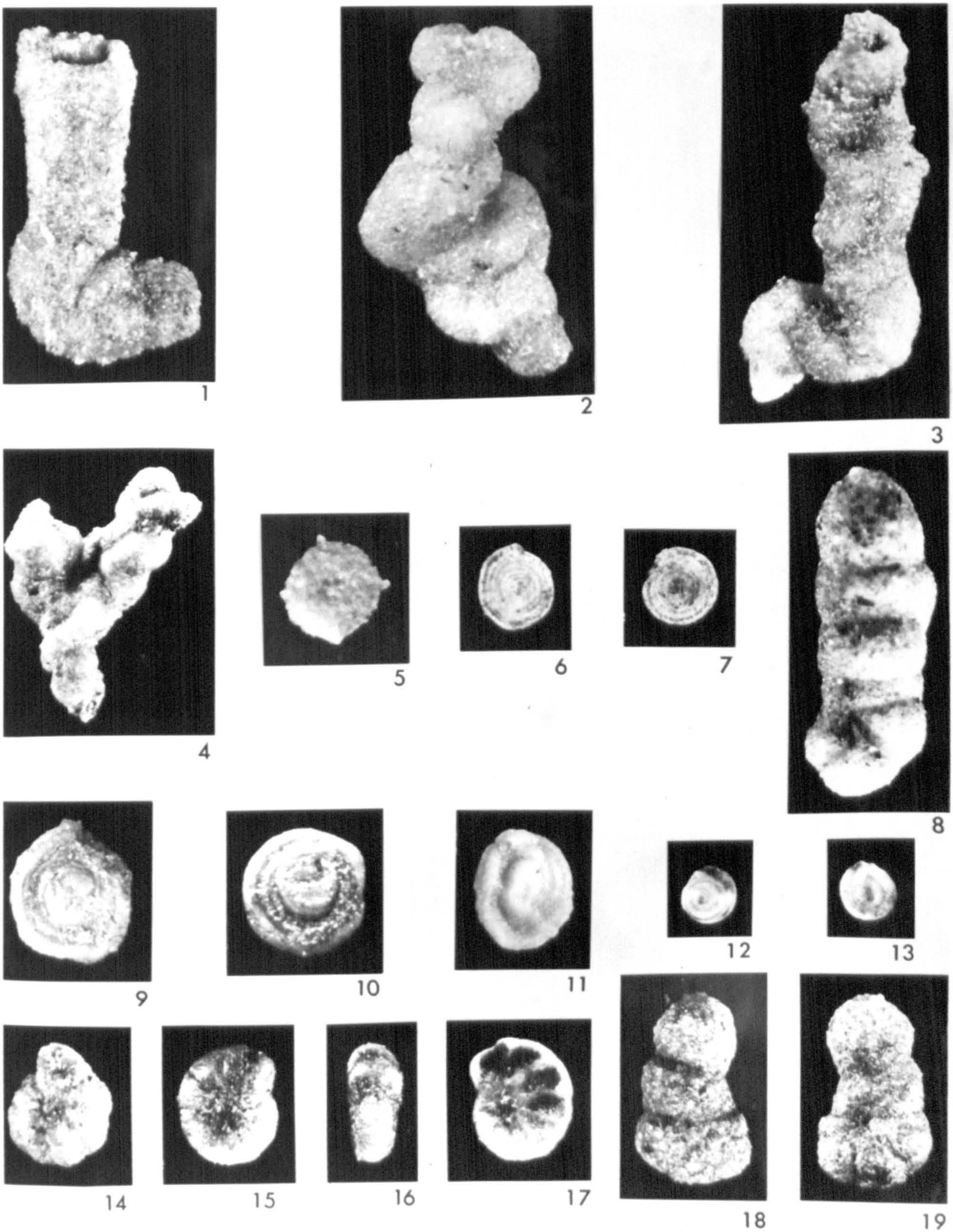
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PLATE 2

PLATE 2

1-2 Haplophragmium aequale (Roemer), HU.21.C.9, sample 22, bed LB4D, (x 26)

3 Ammobaculites subcretaceous Cushman & Alexander, HU.21.C.17, bed D2E, (x 40)

4-5 Ammobaculites subcretaceous Cushman & Alexander, HU.21.C.18, bed D2E, (x 40)

6 Ammobaculites subcretaceous Cushman & Alexander, HU.21.C.19, sample 4*, bed C9, (x40)

7 Ammobaculites reophacoides Bartenstein, HU.21.C.20, sample 20, bed LB5B, (x 42)

8-9 Verneuilinoides neocomiensis (Mjatliuk), HU.21.C.21, bed D2E, (x 55)

10. Verneuilinoides neocomiensis (Mjatluik), HU.21.C.22, bed D2E, (x 55)

11 Verneuilinoides neocomiensis (Mjatluik), HU.21.C.23, bed D2E, (x 55)

12-13 Verneuilinoides neocomiensis (Mjatluik), HU.21.C.24, bed D2E, (x 42). Fig. 13 under glycerine

14 Textularia foeda Reuss, HU.21.C.25, sample 18*, bed C7, (x 42)

15 Bigenerina clavellata Loeblich & Tappan, HU.21.C.26, sample 2*, bed C9, (x 42)

16 Bigenerina clavellata Loeblich & Tappan, HU.21.C.27, sample 18*, bed C7, (x 55)

17-18 Haplophragmoides cushmani Loeblich & Tappan, HU.22.C.1, sample 4*, bed C9, (x 55)

19-20 <u>Trochammina</u> <u>depressa</u> Lozo, HU.22.C.2, bed D6C, (x 35)

21-22 Trochammina depressa Lozo, HU.22.C.3, bed D6C, (x 35)


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PLATE 3

PLATE 3

1 *Gaudryinella sherlocki* Bettenstaedt, HU.22.C.4, sample 20, bed LB5B, (x 50)

2-4 *Tritaxia pyramidata* Reuss, HU.22.C.5, sample 9, bed C1A, (x 40) Figure 3 apertual view

5 *Tritaxia pyramidata* Reuss HU.22.C.6, sample 22*, bed C3, (x 40)

6-9 *Tritaxia pyramidata* Reuss, HU.22.C.7, sample 22*, bed C3, (x 40). Figure 7 apertual view

10 *Tritaxia pyramidata* Reuss, HU.22.C.8, sample 22*, bed C3, (x 40)

11-12 *Dorothia kummi* (Zedler), HU.22.C.9, sample 22*, bed C3, (x 34)

13-15 *Dorothia kummi* (Zedler), HU.22.C.10, sample 4*, bed C9, (x 34). Figure 14 apertual view

16-17 *Dorothia kummi* (Zedler), HU.22.C.11, sample 22*, bed C3, (x 40). Figure 17 apertual view

18 *Nodobacularia nodulosa* (Chapman), HU.22.C.12, sample 22*, bed C3, (x 42)

19 *Nodobacularia nodulosa* (Chapman), HU.22.C.13, sample 1*, bed C9, (x 42)

20 *Nodobacularia nodulosa* (Chapman), HU.22.C.14, sample 22*, bed C3, (x 42)

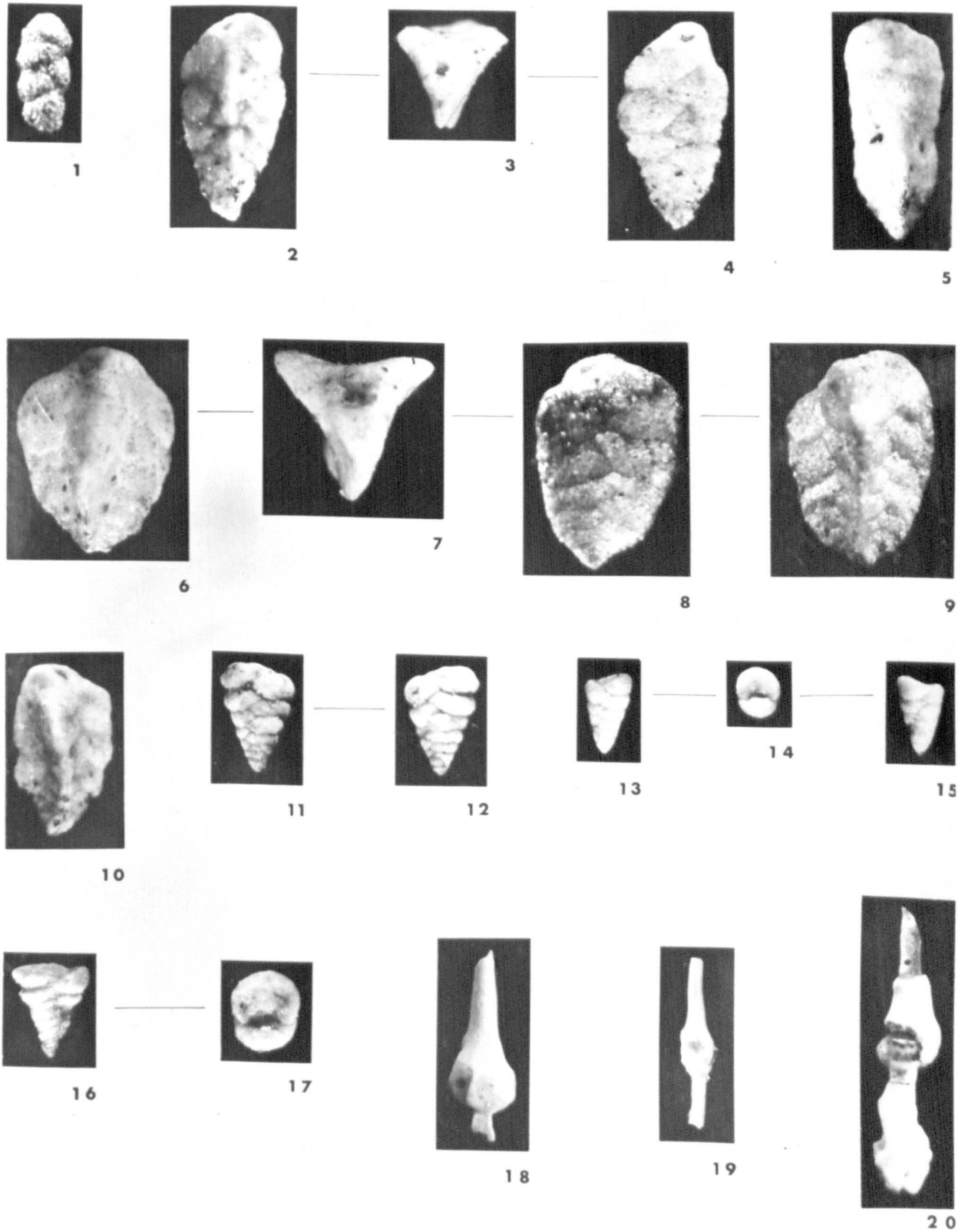
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PLATE 4

PLATE 4

1-4 *Quinqueloculina speetonensis* sp. nov., HU.22.C.15, sample 17, bed LB5D, (x 40), fig. 4 apertual view.

5-7 *Wellmanella antiqua* (Reuss), HU.22.C.16, sample 21, bed LB4D, (x 35), fig. 6, apertual view.

8-9 *Lenticulina* (*Lenticulina*) *subalata* (Reuss), HU.22.C.17, sample 21*, bed C3, (x 27)

10-11 *Lenticulina* (*Lenticulina*) *münsteri* (Roemer) HU.22.C.18, sample 23, bed LB4D, (x 27)

12 *Lenticulina* (*Lenticulina*) *münsteri* (Roemer), HU.22.C.19, sample 9, bed C1A, (x 40)

13 *Lenticulina* (*Lenticulina*) *münsteri* (Roemer), HU.22.C.20, sample 20, bed LB5B, (X 40)

14 *Lenticulina* (*Lenticulina*) *münsteri* (Roemer), HU.22.C.21, sample 1, bed C2F, (x 25)

15 *Lenticulina* (*Lenticulina*) *subangulata* (Reuss), HU.22.C.22, sample 9, bed C1A, (x 40)

16-17 *Lenticulina* (*Lenticulina*) *nodosa* (Reuss), HU.22.C.23, sample 28*, bed C3, (x 27)

18 *Lenticulina* (*Lenticulina*) *heiermanni* Bettenstaedt, HU.22.C.24, bed D2D, (x 26)

19 *Lenticulina* (*Lenticulina*) *heiermanni* Bettenstaedt, HU.22.C.25, sample 71, bed LB2D, (x 27)


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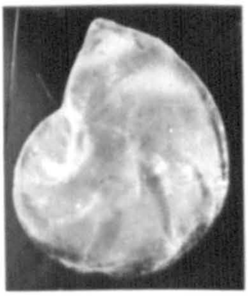
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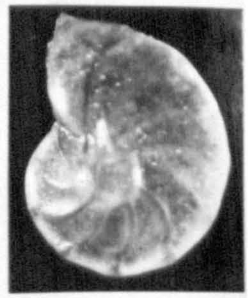
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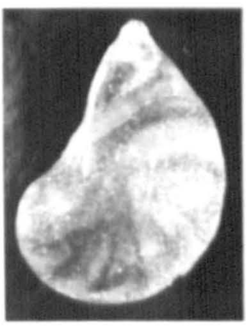
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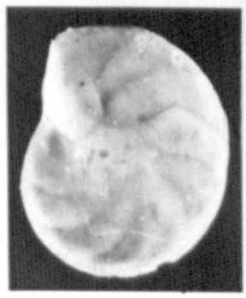
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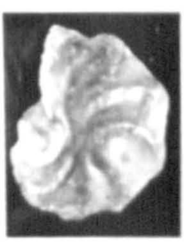
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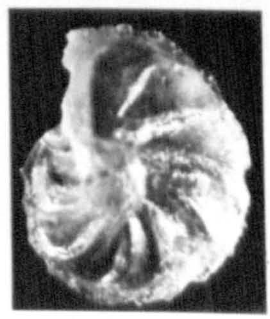
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PLATE 5

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1 *Lenticulina* (*Lenticulina*) *guttata* (Dam) var. *eichenbergi* Bartenstein & Brand, HU.22.C.26, sample 65*, bed C4E, (x 24)

2 *Lenticulina* (*Lenticulina*) *guttata* (Dam) var. *intermedia* n. var. HU.22.C.27, sample 21*, bed C3, (x 24)

3 *Lenticulina* (*Lenticulina*) *guttata* (Dam), HU.23.C.1, sample 21*, bed C3, (x 24)

4 *Lenticulina* (*Lenticulina*) *guttata* (Dam) var. *eichenbergi* Bartenstein & Brand, HU.23.C.2, sample 1, bed C2F (x 24)

5 *Lenticulina* (*Lenticulina*) *guttata* (Dam) HU.23.C.3, sample 64*, bed C4K, (x 24)

6 *Lenticulina* (*Lenticulina*) *guttata* (Dam) HU.23.C.4, sample 98, bed C10, (x 24)

7 *Lenticulina* (*Lenticulina*) *guttata* (Dam) HU.23.C.5, sample 22*, bed C3, (x 24)

8 *Lenticulina* (*Lenticulina*) *guttata* (Dam) HU.23.C.6, sample 22*, bed C3, (x 22)

9 *Lenticulina* (*Lenticulina*) *guttata* (Dam) var. *intermedia* n. var. HU.23.C.7, sample 29*, bed C4B, (x 24)

10 *Lenticulina* (*Lenticulina*) *guttata* (Dam) var. *striata* Bartenstein & Brand, HU.23.C.8, sample 65*, bed C4E, (x 24)

11 *Lenticulina* (*Lenticulina*) *guttata* (Dam) var. *striata* Bartenstein & Brand, HU.23.C.9, sample 1, bed C2F, (x 24)

12 *Lenticulina* (*Lenticulina*) *guttata* (Dam) HU.23.C.10, sample 35*, bed

C7, (x 24)

13 Lenticulina (Lenticulina) guttata (Dam) var. striata Bartenstein & Brand, HU.23.C.11, sample 98, bed C10, (x 24)

14 Lenticulina (Lenticulina) guttata (Dam) HU.23.C.12, sample22*, bed C3, (x 24)

15-16 Lenticulina (Lenticulina) guttata (Dam) var. intermedia n. var. HU.23.C.13, sample 21*, bed C3, (x 24)

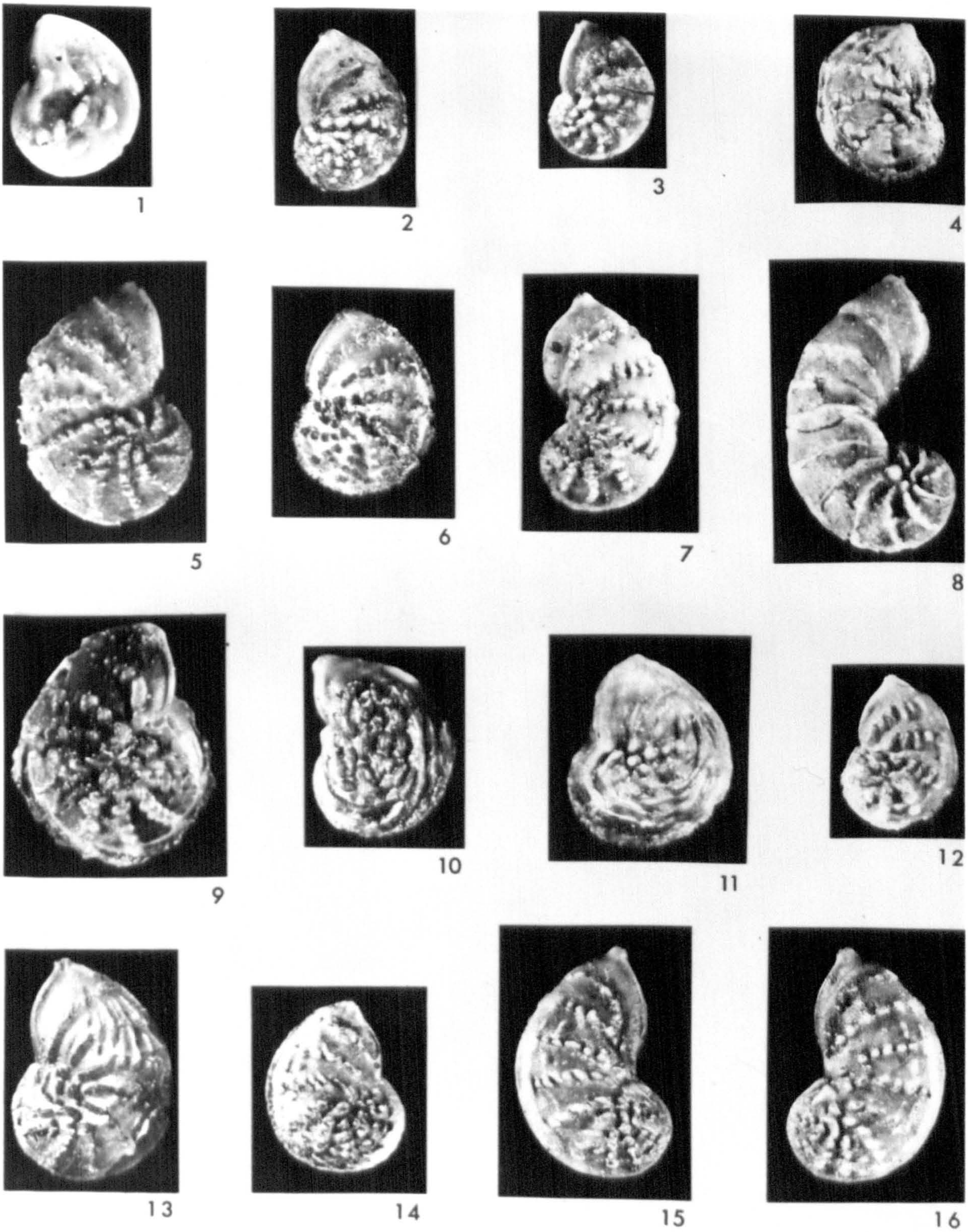
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PLATE 6

PLATE 6

1-2, 12 Lenticulina (Lenticulina) saxonica Bartenstein & Brand, HU.23.C.14, sample 18, bed LB5B, (x 45)

3-4 Lenticulina (Lenticulina) ouachensis (Sigal) wisselmanni (Bettenstaedt) HU.23.C.15, sample 22*, bed C3, (x 26)

5-6 Lenticulina (Lenticulina) ouachensis (Sigal) wisselmanni (Bettenstaedt) HU.23.C.16, bed C4, (x 26)

7-8 Lenticulina (Lanticulina) ouachensis (Sigal) wisselmanni (Bettenstaedt) HU.23.C.17, sample 22*, bed C3, (x 26)

9 Lenticulina (Lenticulina) ouachensis (Sigal) wisselmanni (Bettenstaedt) HU.23.C.18, bed C4, (x 48)

10 Lenticulina (Lenticulina) ouachensis (Sigal) wisselmanni (Bettenstaedt) HU.23.C.19, sample 28*, bed C3, (x 26)

11 Lenticulina (Lenticulina) ouachensis (Sigal) wisselmanni (Bettenstaedt) HU.23.C.20, bed D1A, (x 26)

13-15 Lenticulina (Astacolus) schlönbachi (Reuss) HU.23.C.21, sample 23, bed LB4D, (x 55), fig. 14 apertual view

16-18 Lenticulina (Astacolus) pachynota (Dam) HU.23.C.22, bed D2E, (x 40). Fig. 17 apertual view.

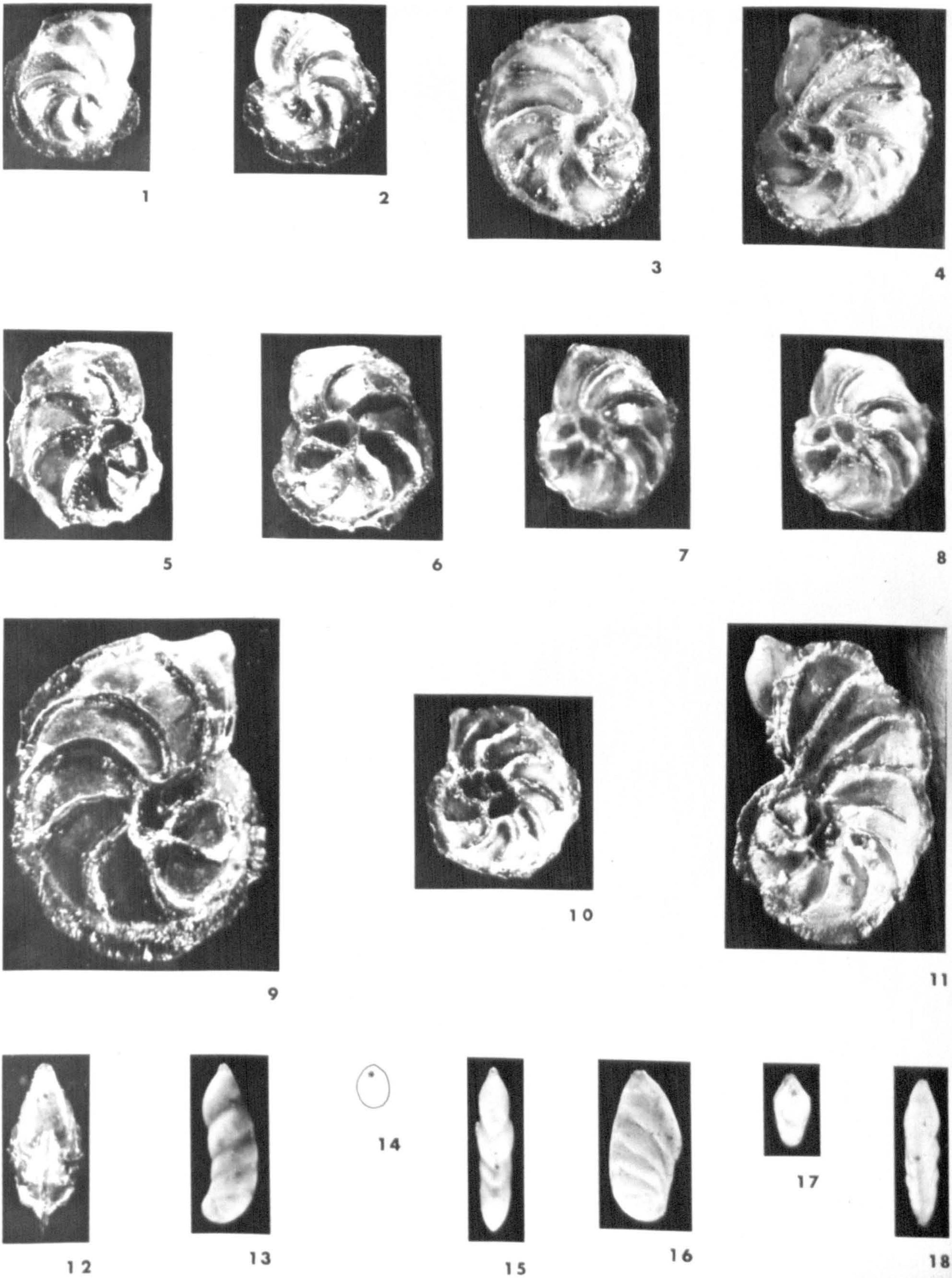
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PLATE 7

PLATE 7

1-2 *Lenticulina* (*Astacolus*) *schlönbachi* (Reuss) HU.23.C.23, sample 18*, bed C6, (x 33)

3-5 *Lenticulina* (*Astacolus*) *pachynota* (Dam) HU.23.C.24, bed D2E, (x 33). Figure 4 apertual view

6-8 *Lenticulina* (*Astacolus*) cf. *pachynota* (Dam) HU.23.C.25, bed D2E, (x 41). Figure 7 apertual view

9 *Lenticulina* (*Astacolus*) *pachynota* (Dam) HU.23.C.27, bed D4A2,(x 31)

10 *Lenticulina* (*Astacolus*) *pachynota* (Dam) HU.23.C.26, bed D3B3,(x 41)

11 *Lenticulina* (*Astacolus*) *pachynota* (Dam) HU.24.C.1, bed D4A2, (x 31)

12-14 *Lenticulina* (Vaginulinopsis) *humilis praecursoria* Bartenstein & Brand, HU.24.C.2, sample 30, bed LB4B, (x 31), fig. 13 apertual view

15-16 *Lenticulina* (*Saracenaria*) cf. *jarvesi* (Brotzen) HU.24.C.3, sample 11*, bed C7E, (x 41)

17-20 *Lenticulina* (*Saracenaria*) cf. *jarvesi* (Brotzen) HU.24.C.4, sample 3, C2D, (x 26). Fig. 19 apertual view

21-22 *Lenticulina* (*Saracenaria*) cf. *jarvesi* (Brotzen) HU.24.C.5 sample 7*, bed C7E, (x 33)

23-25 *Lenticulina* (*Saracenaria*) *valanginiana* Bartenstein & Brand, HU.24.C.6, bed D6E, (x 42). Fig. 24 apertual view

26-28 *Lenticulina* (*Saracenaria*) *valanginiana* Bartenstein & Brand, HU.24.C.7, bed D68, (x 42). Fig. 27 apertual view

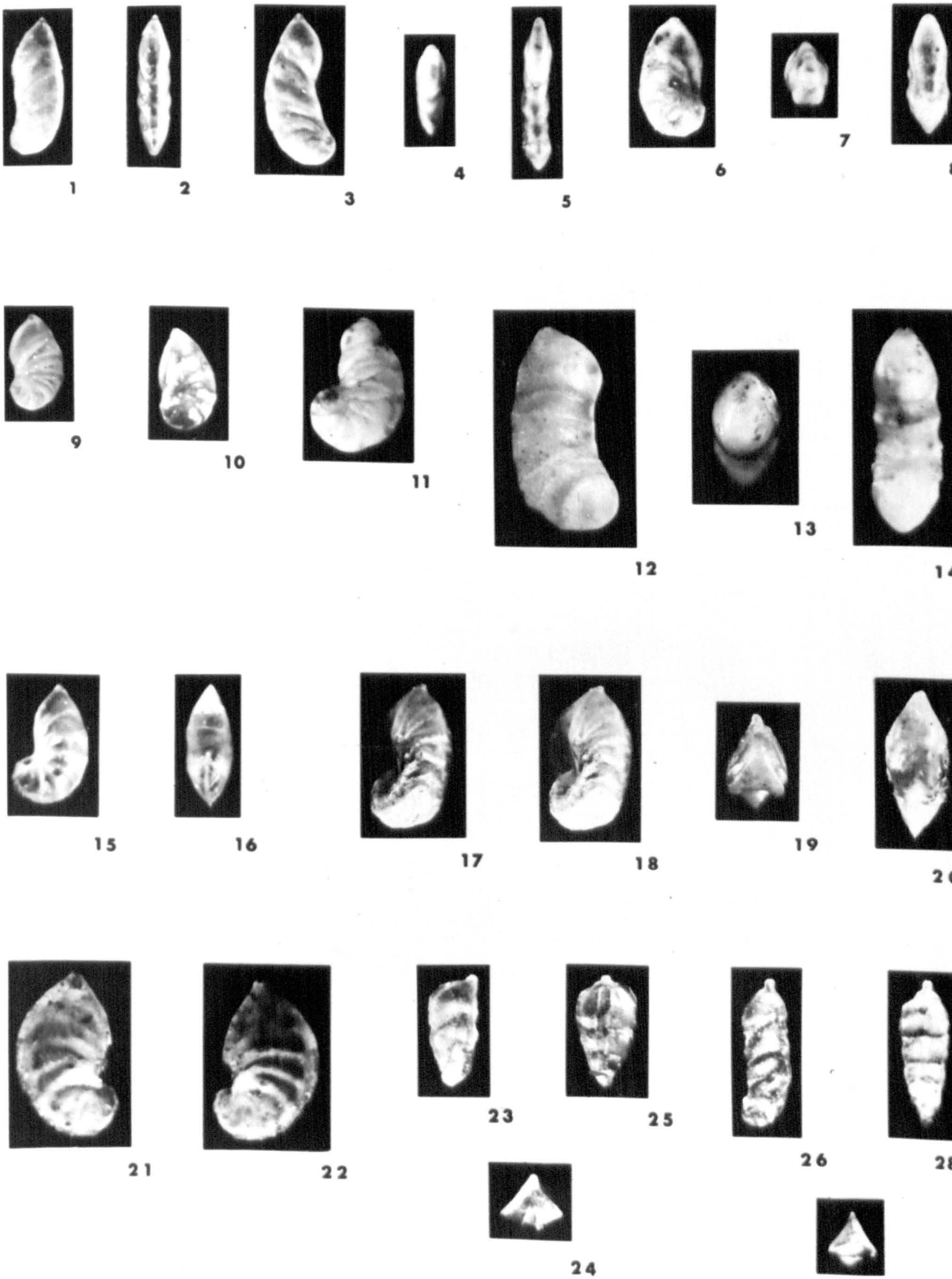
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PLATE 8

PLATE 8

1 Lenticulina (Marginulinopsis) robusta (Reuss) HU.24.C.8, sample 9, bed C1A, (x 41)

2 Lenticulina (Marginulinopsis) robusta (Reuss) HU.24.C.9, sample 28*, bed C3, (x 41)

3-4 Lenticulina (Marginulinopsis) robusta (Reuss) HU.24.C.10, bed D2E, (x 41). Fig. 4 apertual view

5-6 Lenticulina (Marginulinopsis) robusta (Reuss) HU.24.C.11, sample 22*, bed C3, (x 41)

7-9 Lenticulina (Saracenaria) bronnii (Roemer) HU.24.C.12, sample 9, bed C1A, (x 33), Figure 8 apertual view

10-12 Lenticulina (Saracenaria) bronnii (Roemer) HU.24.C.13, bed D7A3 (x 33). Figure 11 apertual view

13-14 Lenticulina (Marginulinopsis) striatocostata (Reuss) HU.24.C.14 bed D6E, (x 33)

15-17 Lenticulina (Marginulinopsis) striatocostata (Reuss) HU.24.C.15 bed D6G, (x 33)


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PLATE 9

PLATE 9

1 Lenticulina (Planularia) crepidularis (Roemer) HU.24.C.16, sample 18*, bed C6, (x 42)

2 Lenticulina (Planularia) crepidularis (Roemer) HU.24.C.17, sample 5, bed C2C, (x 42)

3 Lenticulina (Planularia) crepidularis (Roemer) HU.24.C.18, sample 5, bed C2C (x 33)

4-5 Lenticulina (Planularia) crepidularis (Roemer) HU.24.C.19, sample 5, bed C2C, (x 33)

6 Lenticulina (Planularia) crepidularis (Roemer) HU.24.C.20, sample 5, bed C2C, (x 33)

7 Lenticulina (Planularia) crepidularis (Roemer) HU.24.C.21, sample 5, bed C2C, (x 33)

8 Lenticulina (Planularia) crepidularis (Roemer) HU.24.C.22, sample 5, bed C2C, (x 33)

9 Lenticulina (Astacolus) schreiteri (Eichenberg) HU.24.C.23, sample 5, bed C2C, (x 33)

10 Lenticulina (Astacolus) schreiteri (Eichenberg) HU.24.C.24, sample 9, (x 33)

11 Lenticulina (Astacolus) schreiteri (Eichenberg) HU.24.C.25, sample 2, (x 33)

12 Lenticulina (Astacolus) schreiteri (Eichenberg) HU.24.C.26, sample 1, (x 33)

13 Lenticulina (Astacolus) schreiteri (Eichenberg) HU.24.C.27, Sample 1, (x 33)

14 *Lenticulina* (*Astacolus*) *schreiteri* (Eichenberg) HU.25.C.1, saple 1, (x 33)

15 *Lenticulina* (*Marginulinopsis*) *foeda* (Reuss) HU.25.C.2, sample 3, bed C2D, (x 33)

16 *Lenticulina* (*Marginulinopsis*) *foeda* (Reuss) HU.25.C.3, sample

17 *Lenticulina* (*Marginulinopsis*) *foeda* (Reuss) HU.25.C.4, sample 3, bed C2D, (x33)

18 *Lenticulina*(*Marginulinopsis*) *foeda* (Reuss)HU.25.C.5, sample 25, bed . LB4B, (x 33)

19 *Lenticulina* (*Marginulinopsis*) *gracilissima* (Reuss) HU.25.C.6, bed D6C, (x 33)

20 *Lenticulina* (*Marginulinopsis*) *gracilissima* (Reuss) HU.25.C.7, bed D6C, (x 33)

21 *Lenticulina* (*Marginulinopsis*) *gracilissima* (Reuss) HU.25.C.8, bed D6C, (x 33)

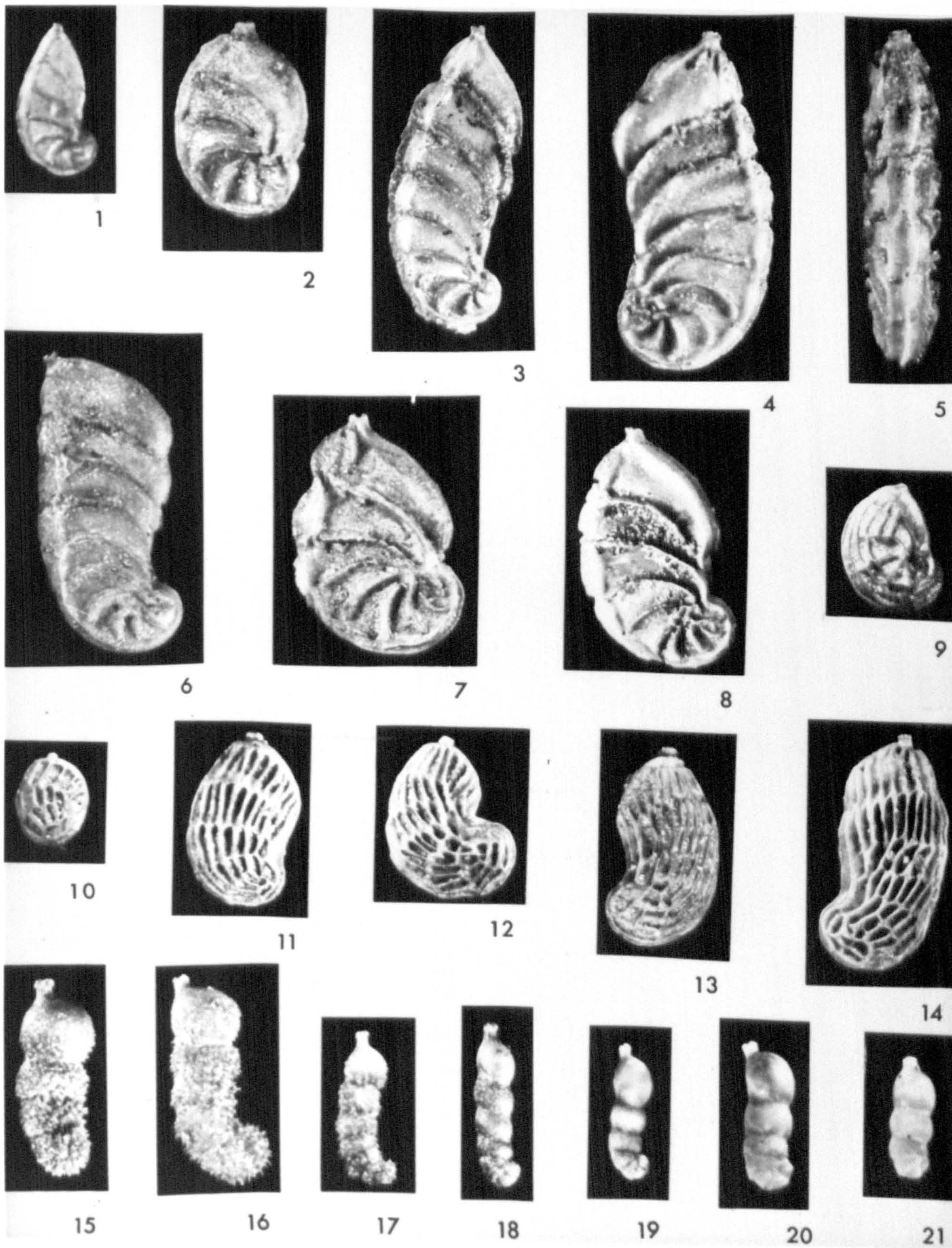
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PLATE 10

PLATE 10

1 *Citharina harpa* (Roemer) HU.25.C.9, sample 14, bed LB5D, (x 23)

2 *Citharina harpa* (Roemer) HU.25.C.10, sample 22*, bed C3, (x 23)

3 *Citharina harpa* (Roemer) HU.25.C.11, sample 9, bed C1A, (x 25)

4 *Citharina seitzi* Bartenstein & Brand, HU.25.C.12, bed D2D, (x 25)

5 *Citharina* cf. *discors* (Koch) HU.25.C.13, sample 63, bed LB3, (x 25)

6 *Citharina* cf. *discors* (Koch) HU.25.C.14, sample 23, bed LB4D, (x 30)

7 *Citharina* cf. *discors* (Koch) HU.25.C.15, sample 22*, bed C3, (x 25)

8-9 *Citharina sparsicostata* (Reuss) HU.25.C.16, bed D1A, (x 25)

10 *Citharina sparsicostata* (Reuss) HU.25.C.17, sample 4*, bed C9C, (x 16)

11-14 *Citharina sparsicostata* (Reuss) HU.25.C.18, sample 36*, bed D2D, (x 25)

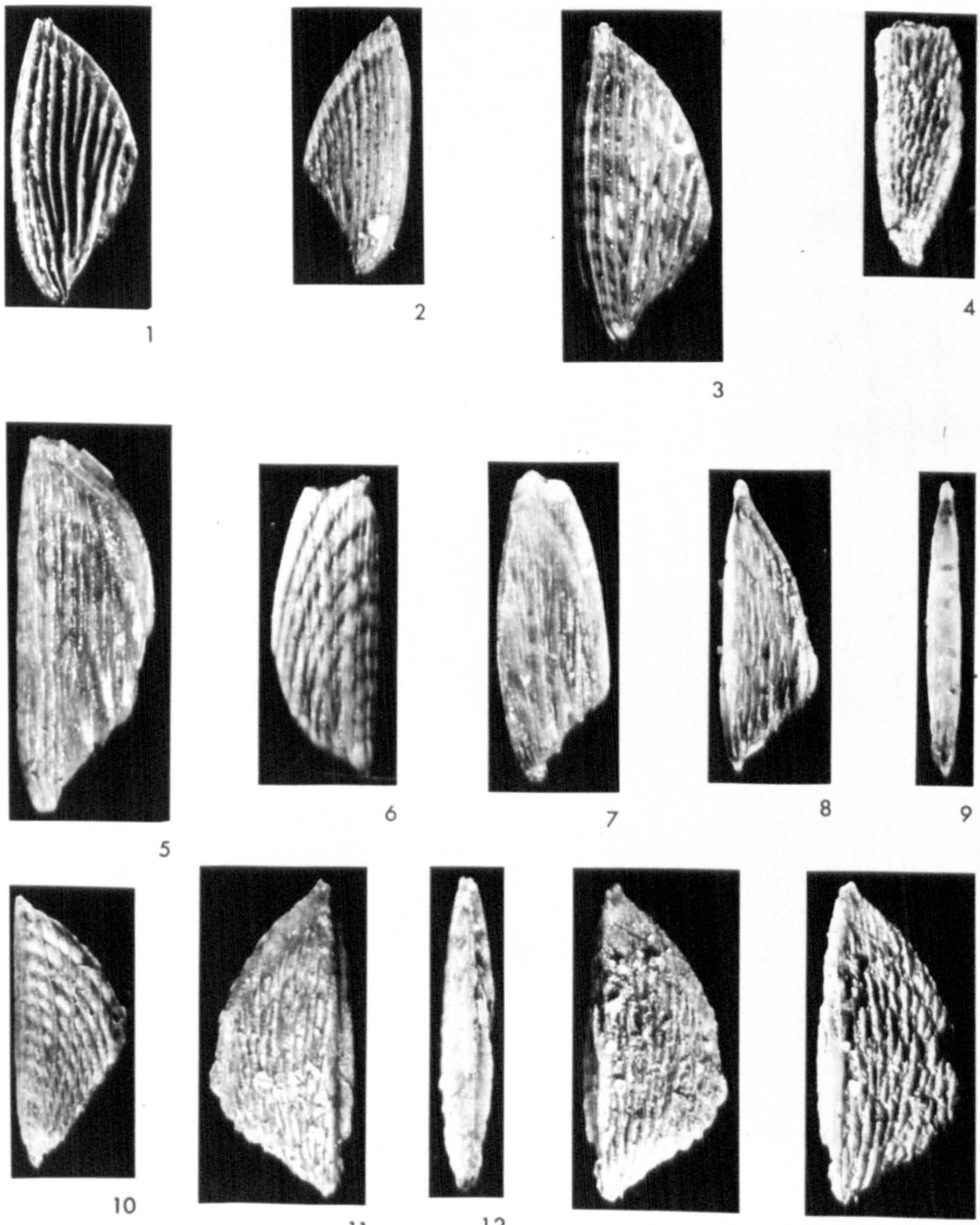
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PLATE 11

PLATE 11

1-2 Citharina cf. discors (Koch) HU.25.C.19, sample 9, bed C1A, (x 27). Fig. 2 dorsal view

3-5 Citharina sp. A, HU.25.C.20, bed D2E, (x 27). Fig. 4 dorsal view

6-7 Citharina sp. B, HU.25.C.21, bed D2E, (x 27)

8 Citharina pseudostriatula Bartenstein & Brand, HU.25.C.22, bed D6I, (x 27)

9 Citharina pseudostriatula Bartenstein & Brand, HU.25.C.23, bed D6I, (x 27)

10 Citharina pseudostriatula Bartenstein & Brand, HU.30.C.1, bed D6I, (x 27)

11 Citharina rudocostata Bartenstein & Brand, HU.25.C.24, bed D6A, (x 27)

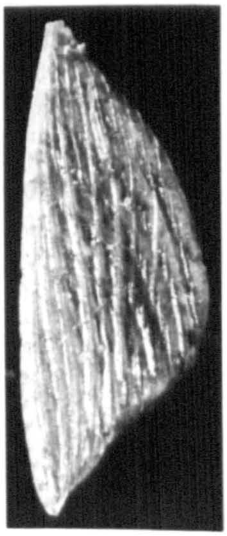
12 Citharina rudocostata Bartenstein & Brand, HU.25.C.25, sample 4*, bed C9C, (x 34)

13 Citharina rudocostata Bartenstein & Brand, HU.25.C.26, sample 4*, bed C9C, (x 34)

14 Citharina pseudostriatula Bartenstein & Brand, HU.25.C.27, bed D6A1, (x 34)

15 Citharina pseudostriatula Bartenstein & Brand, HU.26.C.1, bed D6A1, (x 34)

16 Vaginulina complanata (Reuss) var. perstriata Tappan, HU.26.C.2, bed D2E, (x 27)



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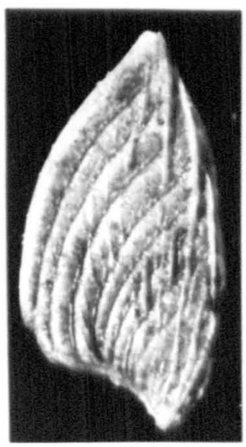

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PLATE 12

PLATE 12

1 *Vaginulina complanata* (Reuss) var. *perstriata* Tappan, HU.26.C.3, bed D2E, (x 42)

2 *Vaginulina complanata* (Reuss) var. *perstriata* Tappan, HU.26.C.4, bed D2E, (x 35)

3 *Citharina acuminata* (Reuss) HU.26.C.5, sample 3, bed C2D, (x 35)

4 *Citharina acuminata* (Reuss) HU.26.C.6, sample 23, bed LB4D, (x 31)

5-6 *Citharina strigillata* (Reuss) HU.26.C.7, bed D6C, (x 35)

7 *Citharina strigillata* (Reuss) HU.26.C.8, bed D6C, (x 27)

8 *Citharina strigillata* (Reuss) HU.26.C.9, bed D6C, (x 27)

9-10 *Vaginulina arguta* (Reuss) HU.26.C.10, sample 22*, bed C3, (x 35). Figure 10 dorsal view

11 *Vaginulina arguta* (Reuss) HU.26.C.11, bed C4C, (x 27). Aberrant form

12 *Vaginulina arguta* (Reuss) HU.26.C.12, sample 35*, bed C7, (x 27)

13-14 *Vaginulina striolata* (Reuss) HU.26.C.13, sample 17*, bed C6, (x 27)

15-16 *Vaginulina striolata* (Reuss) HU.26.C.14, sample 12, bed L35E, (x 27). Figure 16 dorsal view

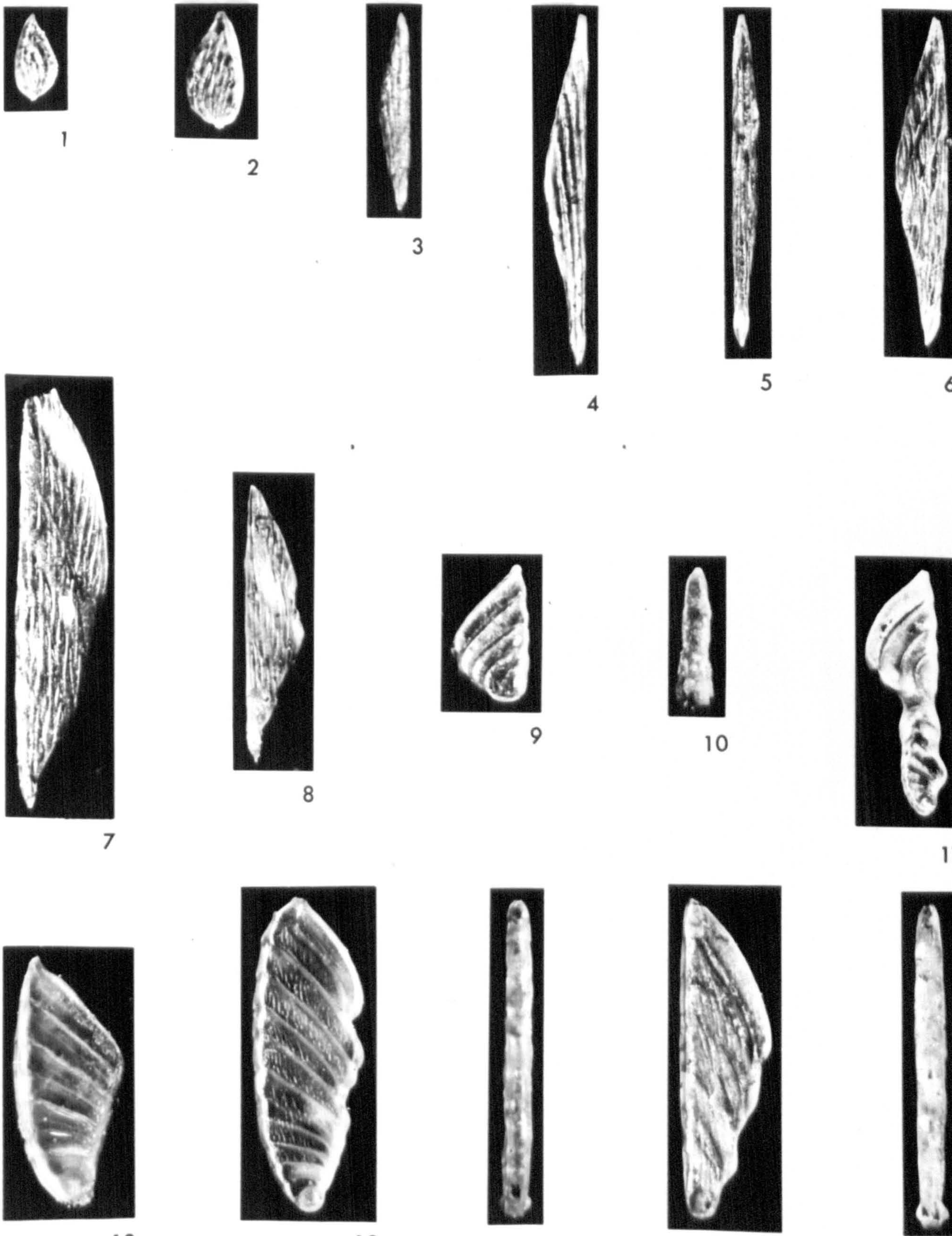
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PLATE 13

PLATE 13

1 *Vaginulina striolata* Reuss, HU.26.C.15, sample 34, basal cement bed, (x 26)

2-3 *Vaginulina striolata* Reuss, HU.26.C.16, sample 3, bed C2D, (x 26). Figure 3 dorsal margin.

4-5 *Vaginulina striolata* Reuss, HU.26.C.17, sample 35*, bed C7, (x 26). Fig. 5 dorsal view

6-7 *Vaginulina arguta* Reuss, HU.26.C.18, sample 22*, bed C3, (x 22) Fig. 7 dorsal view

8-9 *Vaginulina arguta* Reuss, HU.26.C.19, sample 22*, bed C3, (x 20) Fig. 9 dorsal view

10-11 *Vaginulina kochii* Roemer, HU.26.C.20, sample 3*, bed C9C, (x 26) Fig. 11 dorsal view

12-13 *Vaginulina* cf. *angustissima* Reuss, HU.26.C.21, bed D6D, (x 26) Fig. 13 dorsal view

14-15 *Vaginulina riedeli* Bartenstein & Brand, HU.26.C.22, sample 17*, bed C6, (x 26). Fig. 15 ventral view

16-18 *Dentalina danfordi* sp. nov., HU.26.C.23, bed D1A, (x 50). Fig. 16 ventral, fig. 18 dorsal view

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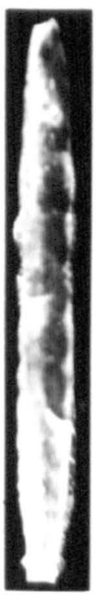

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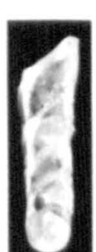

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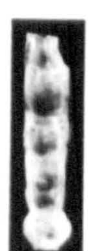

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PLATE 14

PLATE 14

1 Frondicularia concinna Koch, HU.26.C.24, sample 94, bed C11A, (x 26)

2 Frondicularia concinna Koch, HU.26.C.25, sample 12, bed LB5E, (x 16)

3 Frondicularia concinna Koch, HU.26.C.26, sample 50*, bed C5I, (x 32). Under glycerine

4 Frondicularia concinna Koch, HU.26.C.27, sample 18*, bed C6, (x 30). Under glycerine

5 Frondicularia inversa Reuss, HU.27.C.1, bed D6A2, (x 26)

6 Frondicularia simplicissima Dam, HU.27.C.2, sample 22*, bed C3, (x 40)

7 Frondicularia inversa Reuss, HU.27.C.3, bed D2E, (x 26)

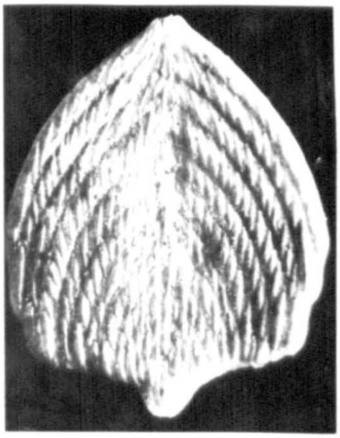
8 Frondicularia cf. microdisca Reuss, HU.27.C.4, sample 7*, bed C8, (x 26)

9 Frondicularia sp. A, HU.27.C.5, sample 61*, bed C7C, (x 26)

10 Frondicularia sp. A, HU.27.C.6, sample 50*, bed C5I, (x 32)

11 Frondicularia hastata Roemer, HU.27.C.7, sample 67, bed LB3, (x 16)

12 Frondicularia hastata Roemer, HU.27.C.8, sample 10*, bed C7D, (x 20)



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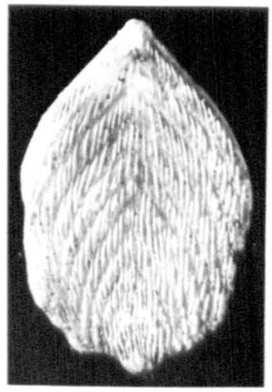

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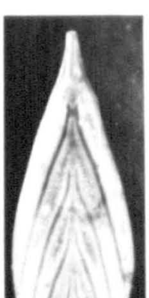

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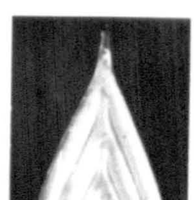

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PLATE 15

PLATE 15

1 Nodosaria sceptrum Reuss, HU.27.C.9, sample 33, bed LB4, (x 27)

2 Nodosaria sceptrum Reuss, HU.27.C.10, sample 9, bed C1, (x 32)

3 Nodosaria sceptrum Reuss, HU.27.C.11, sample 25, bed LB4, (x 41)

4 Nodosaria obscura Reuss, HU.27.C.12, sample 14, bed LB5, (x 41)

5 Nodosaria obscura Reuss, HU.27.C.13, sample 61*, bed C5K, (x 27)

6 Nodosaria obscura Reuss, HU.27.C.14, sample 28*, bed C3, (x 27)

7 Nodosaria pyramidalis Koch, HU.27.C.15, sample 61*, bed C5K, (x 27)

8 Nodosaria pyramidalis Koch, HU.27.C.16, bed D3A, (x 27)

9 Nodosaria pyramidalis Koch, HU.27.C.17, bed D3A, (x 27)

10 Nodosaria reightonensis sp. nov. HU.27.C.18, sample 47, basal cement bed, (x 20)

11 Nodosaria reightonensis sp. nov. HU.27.C.19, sample 44, bed LB1, (x 27)

12 Nodosaria reightonensis sp. nov. HU.27.C.20, sample 47, basal cement bed, (x 27)

13 Nodosaria reightonensis sp. nov. HU.27.C.21, sample 47, basal cement bed, (x 41)

14 Nodosaria reightonensis sp. nov. HU.27.C.22, sample 45, bed LB1, (x 32)

15 Nodosaria reightonensis sp. nov. HU.27.C.23, sample 47, basal cement bed (x 32)

16 Nodosaria obscura Reuss, HU.27.C.24, bed D3B, (x 27)

17 Nodosaria orthopleura Reuss, HU.27.C.25, sample 25, bed LB4B, (x 27)

18 Nodosaria orthopleura Reuss, HU.27.C.26, sample 67, bedLB3, (x 27)


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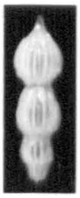
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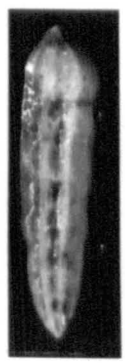
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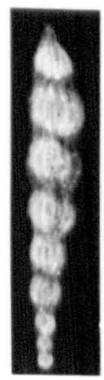
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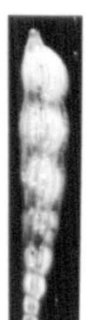
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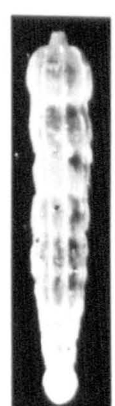
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PLATE 16

PLATE 16

1 *Nodosaria orthopleura* Reuss, HU.28.C.1, sample 25, bed LB4B, (x 40)

2 *Nodosaria reightonensis* sp. nov. HU.28.C.2, sample 45, bed LB1, (x 28)

3 *Nodosaria* cf. *regularis* Terquem, HU.28.C.3, sample 4*, bed C9C, (x 55)

4 *Nodosaria* cf. *regularis* Terquem, HU.28.C.4, sample 4*, bed C9C, (x 40)

5-6 *Dentalina linearis* (Roemer), HU.28.C.5, sample 22*, bed C3, (x 40). Fig. 6 apertual view

7 *Dentalina* sp. A, HU.28.C.6, sample 11*, bed C7, (x 40)

8 *Dentalina debilis* (Berthelin) HU.28.C.7, bed D1A, (x40)

9 *Dentalina debilis* (Berthelin) HU.28.C.8, sample 4, bed C2C, (x 40)

10 *Dentalina debilis* (Berthelin) HU.28.C.9, sample 23*, bed C3,(x 42)

11-12 *Dentalina debilis* (Berthelin) HU.28.C.10, sample 63, bed LB3, (x 40)

13 *Dentalina debilis* (Berthelin) HU.28.C.11, bed D1A, (x 42)

14 *Dentalina debilis* (Berthelin) HU.28.C.12, bed D1A, (x 42)

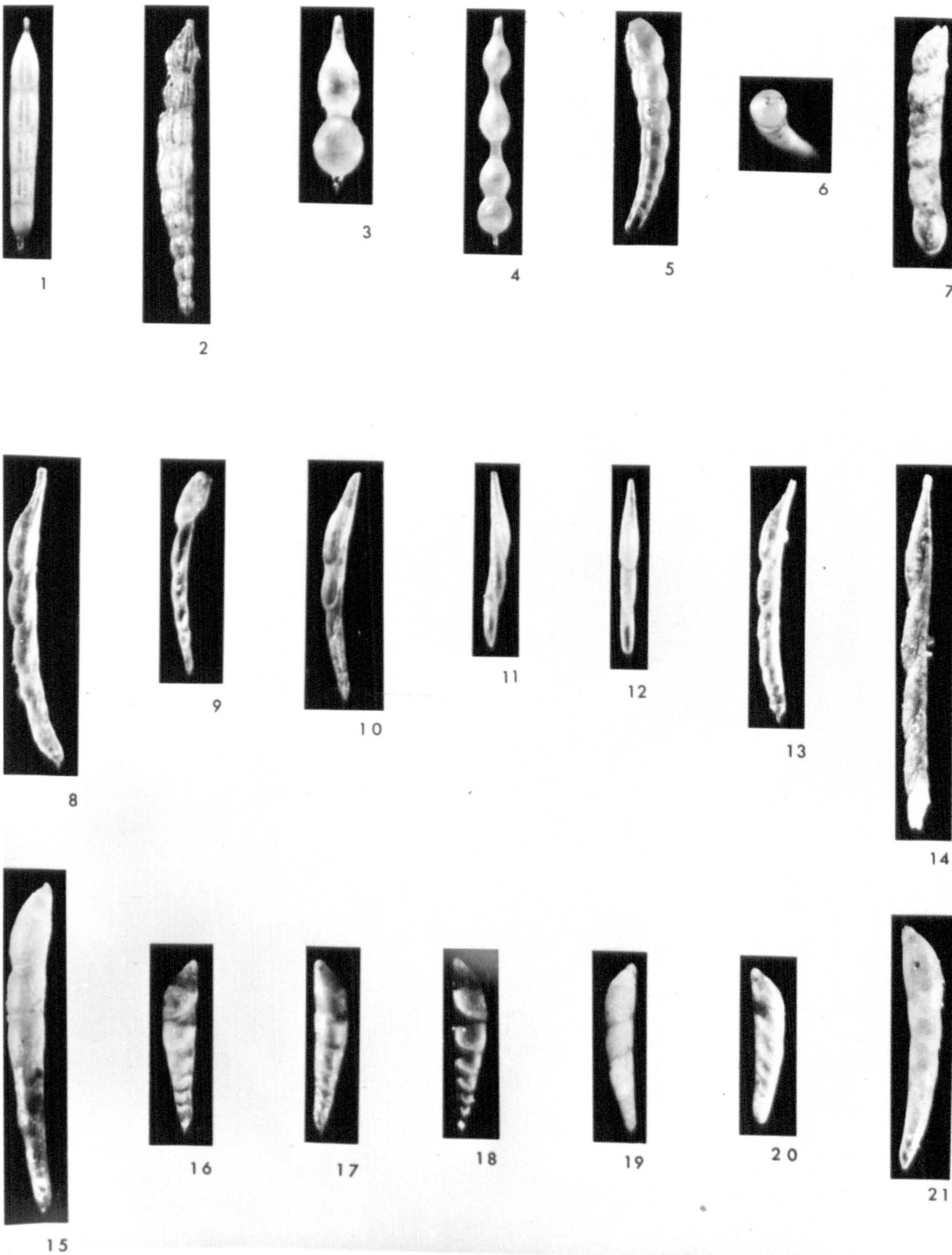
15 *Dentalina terquemi* d'Orbigny, HU.28.C.13, bed D1A, (x 42)

16-18 *Dentalina communis* d'Orbigny, HU.28.C.14, sample 21, bed LB4D, (x 40). Fig. 18 under glycerine

19 *Dentalina communis* d'Orbigny, HU.28.C.15, sample 18, bed LB5B, (x 40)

20 Dentalina communis d'Orbigny, HU.28.C.16, sample21, bed LB4D, (x 40)

21 Dentalina communis d'Orbigny, HU.28.C.17, sample 25, bed LB4B, (x 40)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PIATE 17

PLATE 17

1-3 *Tristix acutangula* (Reuss) HU.28.C.18, sample 7*, bed C8, (x 40). Fig. 2 apertual view

4-6 *Tristix insignis* (Reuss) HU.28.C.19, sample 22*, bed C3, (x 40), Fig. 5 apertual view

7 *Pseudonodosaria humilis* (Roemer) HU.28.C.20, sample 15*, bed C8, (x 40)

8 *Pseudonodosaria humilis* (Roemer) HU.28.C.21, sample 21, bed LB4D, (x 50)

9-10 *Pseudonodosaria tenuis* (Bornemann) HU.28.C.22, sample 22*, bed C3, (x 40). Fig. 10 apertual view

11 *Pseudonodosaria vulgata* (Bornemann) HU.28.C.23, sample 22*, bed C3, (x 50)

12 *Pseudonodosaria vulgata* (Bornemann) HU.28.C.24, sample 21, bed LB4D, (x 50)

13 *Pseudonodosaria vulgata* (Bornemann) HU.28.C.25, sample 67, bed LB3, (x 40)

14 *Pseudonodosaria vulgata* (Bornemann) HU.28.C.26, sample 21, bed LB4D, (x 50)

15 *Pseudonodosaria vulgata* (Bornemann) HU.28.C.27, sample 21, bed LB4D, (x 50)

16-17 *Pseudonodosaria vulgata* (Bornemann) HU.29.C.1, sample 22*, bed C3, (x 40). Fig. 17 apertual view

18 *Pseudonodosaria vulgata* (Bornemann) HU.29.C.2, sample 22*, bed C3, (x 40)

19-20 *Lingulonodosaria nodosaria* Reuss, HU.29.C.3, sample 22*, bed C3, (x 50). Fig. 20 apertual view.

21-22 Lingulina hauteriviana sp. nov. HU.29.C.4, sample 28*, (x 40)

23-24 Lingulina hauteriviana sp. nov. HU.29.C.5, sample 22*, bed C3, (x 40). Fig. 23 apertual view.


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PLATE 18

PLATE 18

1 Lingulonodosaria nodosaria Reuss, HU.29.C.6, sample 17, bed LB5D, (x 40)

2-3 Lingulina hauteriviana sp. nov. HU.29.C.7, sample 28*, bed C3, (x 40)

4 Lingulonodosaria nodosaria Reuss, HU.29.C.8, sample 28*, bed C3, (x 40)

5 Lingulina sp. A. HU.29.C.9, sample 17, bed LB5D, (x 40)

6 Lagena hauteriviana hauteriviana Bartenstein & Brand, HU.29.C.10, sample 8, bed C1B, (x 50)

7 Lagena hauteriviana hauteriviana Bartenstein & Brand, HU.29.C.11, sample 8, bed C1B, (x 50)

8 Lagena hauteriviana hauteriviana Bartenstein & Brand, HU.29.C.12, sample 8, bed C1B, (x 50)

9 Lagena hauteriviana hauteriviana Bartenstein & Brand, HU.29.C.13, sample 8, bed C1B, (x 50)

10 Lagena hauteriviana hauteriviana Bartenstein & Brand, HU.29.C.13, bed D1A, (x 80)

11 Lagena apiculata (Reuss) HU.29.C.15, bed D1A, (x 50)

12 Lagena cf. sulcata (Walker & Jacob) HU.29.C.16, bed D6C, (x 50)

13 Lagena cf. hispida Reuss, HU.29.C.17, sample 9, bed C1A, (x 40)

14 Lagena cf. hispida Reuss, HU.29.C.18, sample 9, bed C1A, (x 40)

15 Ramulina spandeli Paalzow, HU.29.C.19, sample 7*, bed C8, (x 35)

16 Ramulina spandeli Paalzow, HU.29.C.20, sample 7*, bed C8, (x 35)

17 *Ramulina spandeli* Paalzow, HU.29.C.21, sample 7*, bed 68,(x 25)

18 *Ramulina fusiformis* Khan, HU.29.C.22, sample9, bed C1A, (x 35)

19 *Ramulina spandeli* Paalzow, HU.29.C.23,sample C1A, (x 27)

20 *Ramulina fusiformis* Khan, HU.29.C.24, sample 9, bedC1A, (x 35)

2L *Ramulina fusiformis* Khan, HU.29.C.25, sample 11, bed LB6,(x 35)

22 *Ramulina spandeli* Paalzow, HU.29.C.26, sample 3, bed C2D, (x 25)

23 *Ramulina spandeli* Paalzow, HU.32.C.4, sample 7*, bed C8, (x 35)

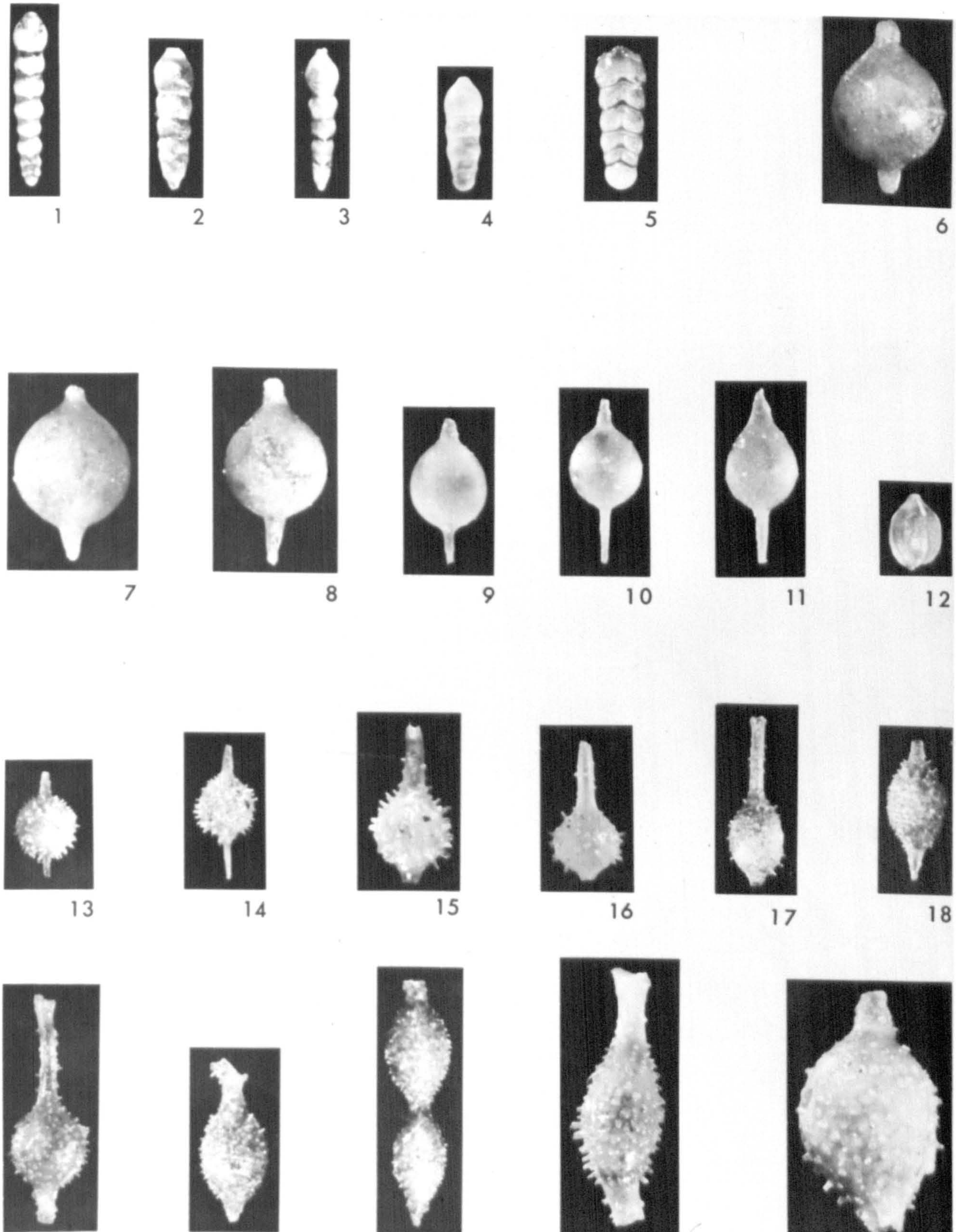
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PLATE 19

PLATE 19

1 Ramulina spandeli Paalzow, HU.29.C.27, sample 7*, bed C8, (x 40)

2 Ramulina muricatina Loeblich & Tappan, HU.30.C.2, sample 22*, bed C3, (x 40)

3 Globulina prisca Reuss, HU.29.C.3, sample 22*, bed C3, (x 40)

4 Globulina prisca Reuss, HU.29.C.4, sample 30*, bed C4, (x 40) under glycerine

5 'Fistulose' Polymorphinidae HU.29.C.5, sample 4, bed C2C, (x 40)

6 'Fistulose' Polymorphinidae HU.29.C.6, sample 8, bed C1A, (x 40)

7-9 Conorotalites sigmoicosta (Dam) HU.30.C.7, sample 30, bed (x 50)

10-12 Conorotalites sigmoicosta (Dam) HU.30.C.8, sample 30, bed LB4B, (x 50)

13-15 Conorotalites sigmoicosta (Dam) HU.30.C.9, sample 30, bed LB4B, (x 50)

16-18 Conorotalites sigmoicosta (Dam) HU.30.C.10, sample 5, bed C2C, (x 50)

19-21 Conorboides valendisensis Bartenstein & Brand, HU.30.C.11, bed D7A2, (x 38)

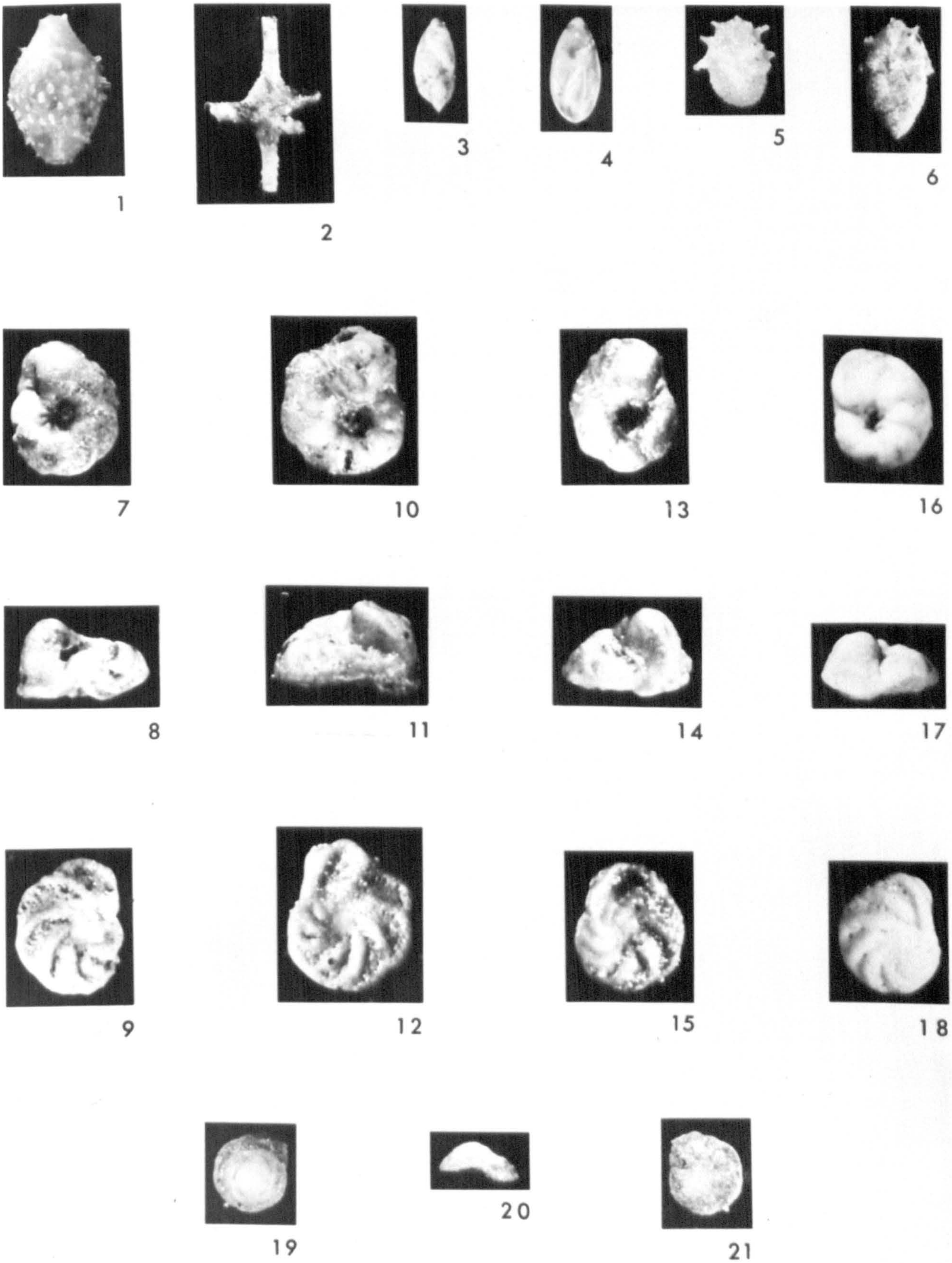
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PLATE 20

PLATE 20

1-3 *Pseudolamarckina lamplughi* (Sherlock) HU.30.C.12, sample 1, bed C2F, (x40)

4-5 *Pseudolamarckina lamplughi* (Sherlock) HU.30.C.13, sample 1, bed C2F, (x 40)

7-9 *Pseudolamarckina lamplughi* (Sherlock) HU.30.C.14, sample 21, bed LB4D, (x 40)

10-12 *Höglundina caracolla* (Roemer) HU.30.C.15, sample 18, bed LB5B, (x 28)

13-15 *Höglundina caracolla* (Roemer) HU.30.C.16, sample 20, bed LB5B, (x 40)

16-18 *Epistomina hechti* Bettenstaedt & Bolli, HU.30.C.17, sample 44*, bed LB1, (x 40)

19-21 *Epistomina hechti* Bartenstein, Bettenstaedt & Bolli, HU.30.C.18, sample 44*, bed LB1, (x 40)

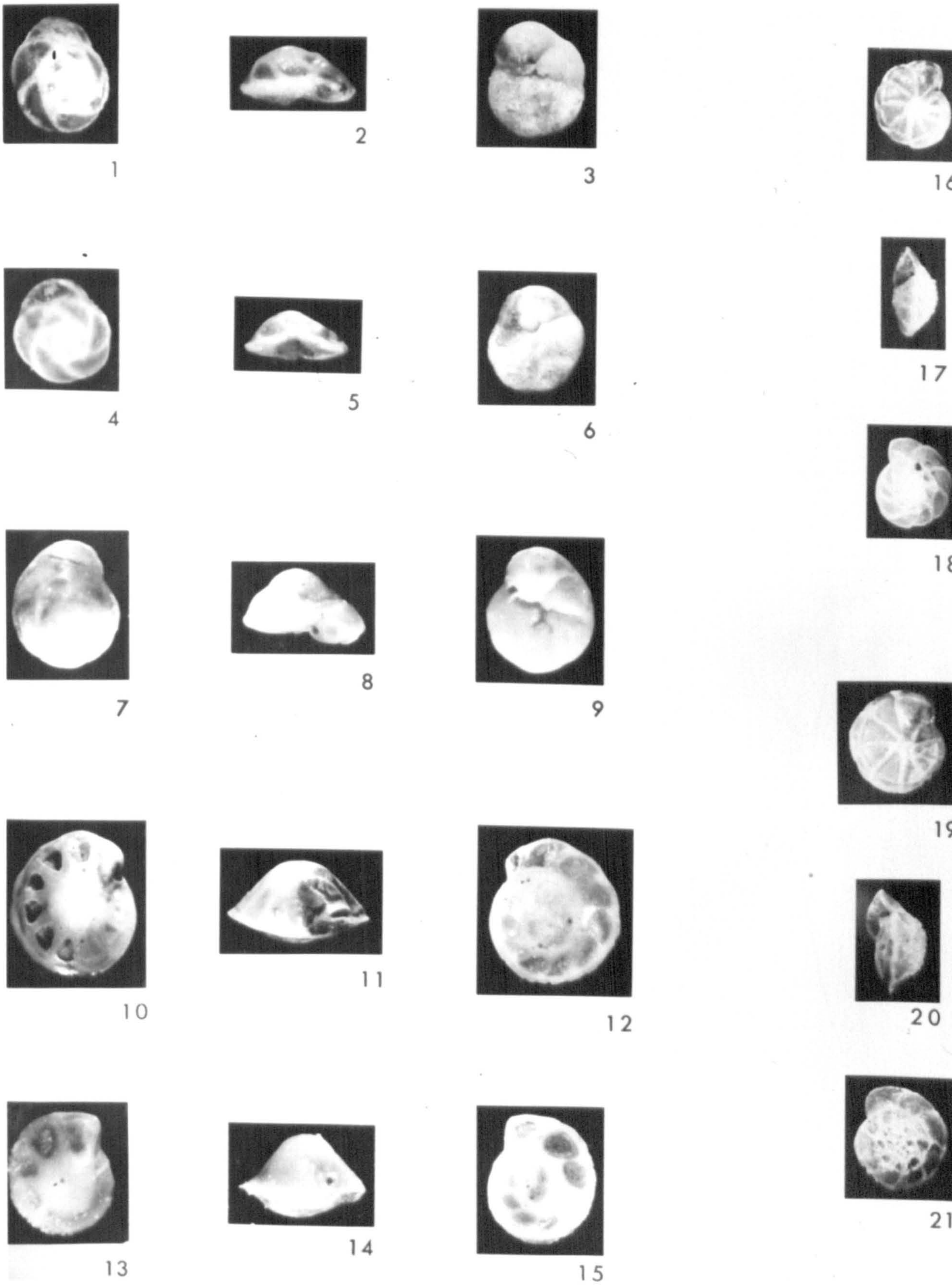
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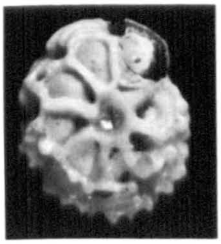
PLATE 21

PLATE 21

1-3	Epistomina ornata (Roemer) (x 15)	HU.30.C.19, sample 21*, bed C3,
4-6	Epistomina ornata (Roemer) (x 25)	HU.30.C.20, sample 21*, bed C3,
7-8	Epistomina ornata (Roemer) (x 25)	HU.30.C.21, sample 21*, bed C3,
9-10	Conorboides acuta sp. nov. (x 37) Fig. 10 apertual view.	HU.30.C.22, sample 20, bed C2,
11-12	Conorboides acuta sp. n ov. (x 37) Fig. 12 apertual view.	HU.30.C.23, sample 24, bed C3,
13-14	Allomorphina sp. A (x 37)	HU.30.C.24, sample 33, bed LB4D,
15-16	Allomorphina sp. A (x 37)	HU.30.C.25, sample 18, bed LB5B,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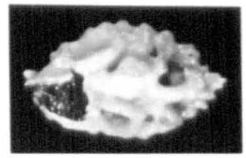
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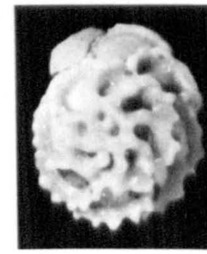
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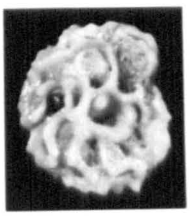
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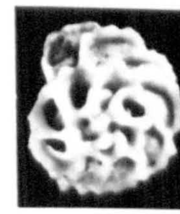
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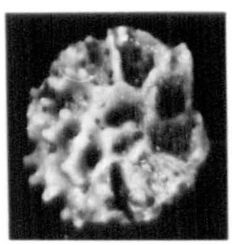
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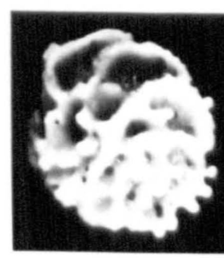
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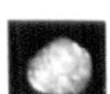
14


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16

PLATE 22

PLATE 22

1 <u>Dentalina</u> <u>danfordi</u> sp. nov. HU.26.C.23, bed D1A, (x 50)

2-5 <u>Dentalina</u> <u>danfordi</u> sp. nov. HU.31.C.26, sample 28*, bed C3, (x 40)

6 <u>Lenticulina</u> (<u>Planularia</u>) <u>crepidularis</u> (Roemer), HU.30.C.27, sample 54*, bed C4B, (x 40)

7 <u>Pseudonodosaria</u> sp. HU.32.C.1, bed D6E, (x 40)

8 <u>Pseudonodosaria</u> sp. HU.32.C.2, bed D6C, (x 40)

9 <u>Frondicularia</u> sp. B. HU.32.C.3, sample 7*, bed C8, (x 30)

10 Otolith, sample 10*, bed C7.

11 <u>Calcligula</u> <u>speetonensis</u> sp. nov. HU.32.C.5, sample 90, Upper B beds (x 40)

12 <u>Calcligula</u> <u>speetonensis</u> sp. nov. HU.32.C.6, sample 21, bed LB4D, (x 40)

13 <u>Priscopedatus</u> sp. A. sample 40*, bed LB5B, (x 45)

14 <u>Priscopedatus</u> sp. A. sample 90, Upper B beds, (x 35)

15 <u>Theelia</u> <u>annulata</u> sp. nov. HU.32.C.7, sample 90, Upper B beds, (x 40)

16 <u>Theelia</u> <u>annulata</u> sp. nov. HU.32.C.8, sample 19, bed LB5B, (x 40)

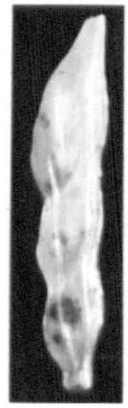
17 <u>Achistrum</u> (<u>Cancellrum</u>) <u>monochordata</u> Hodson, Harris & Lawson, sample 90, upper B beds, (x 40)

18 <u>Achistrum</u> (<u>Cancellrum</u>) <u>monochordata</u> Hodson, Harris & Lawson, sample 90, upper B beds.

19 <u>Achistrum</u> (<u>Cancellrum</u>) <u>monochordata</u> Hodson, Harris & Lawson, sample 90, upper B beds.


1


2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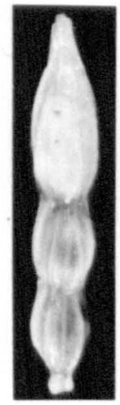
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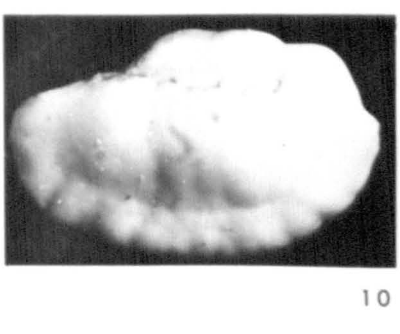
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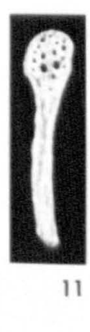
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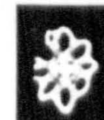
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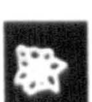
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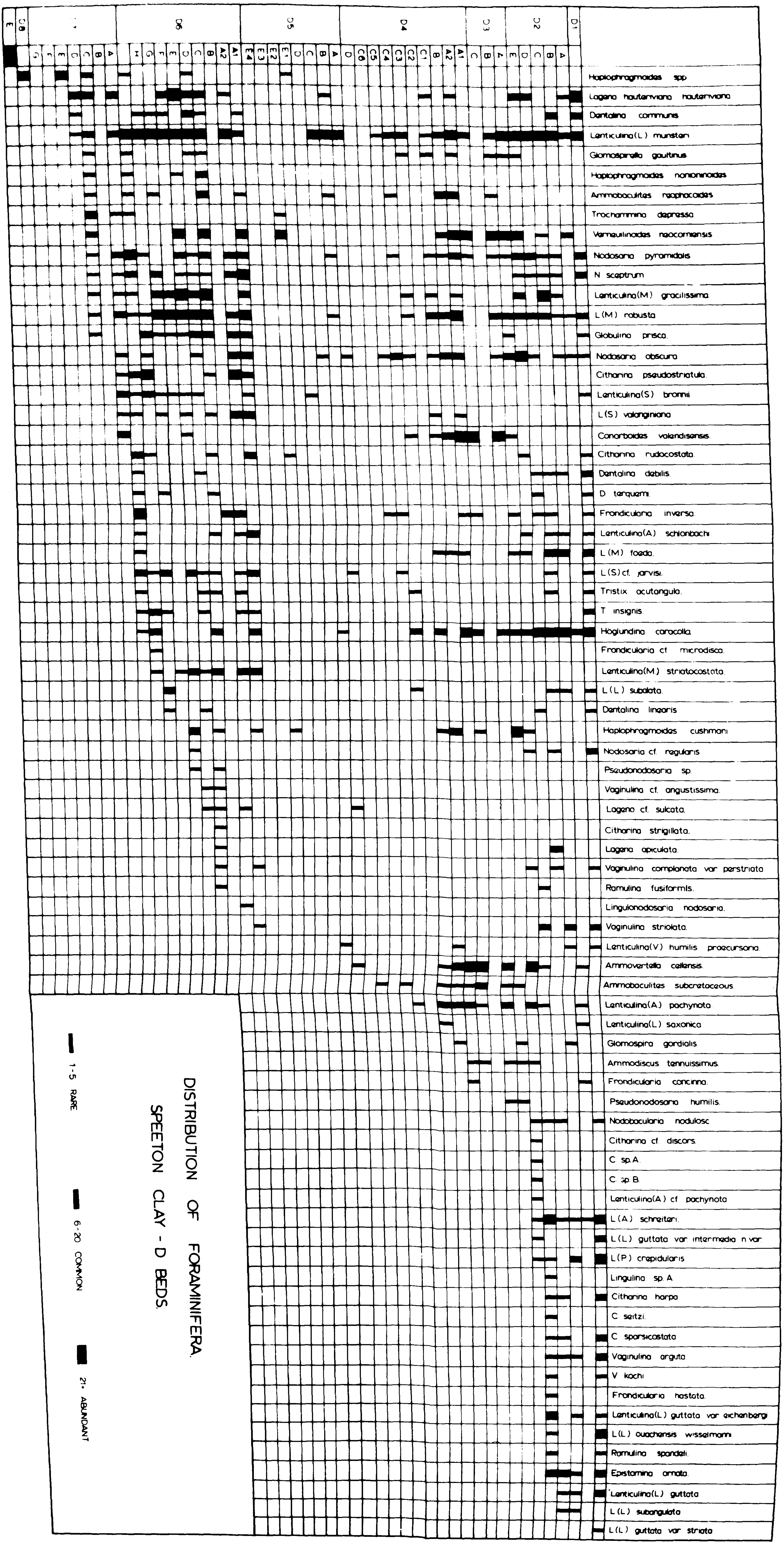
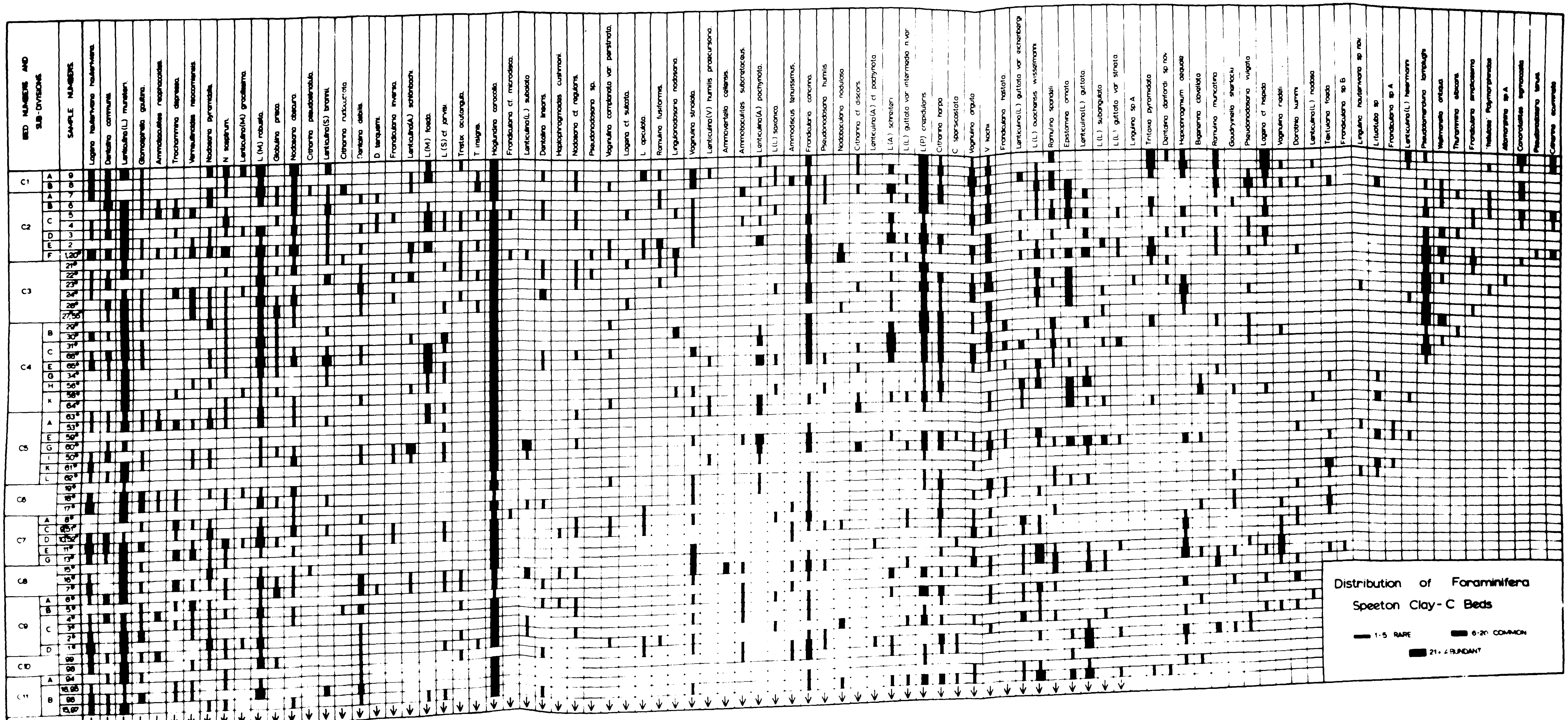
DISTRIBUTION OF FORAMINIFERA

SPEETON CLAY - D BEDS


DISTRIBUTION OF FORAMINIFERA.
SPEETON CLAY - D BEDS.
1-5 RARE
6-20 COMMON
21+ ABUNDANT
E
D8
D6
D5
D4
D3
D2
D1
Haplophragmoides spp
Lagena hauteriviana hauteriviana
Dentalina communis
Lenticulina(L) munsteri
Glomospirella gaultinus
Haplophragmoides nonioninoides
Ammobaculites reophacoides
Trochammina depressa
Verneuilinoides neocomiensis
Nodosaria pyramidalis
N sceptrum
Lenticulina(M) gracilissima
L(M) robusta
Globulina prisca
Nodosaria obscura
Citharina pseudostriatula
Lenticulina(S) bronnii
L(S) valanginiana
Conorboides valendisensis
Citharina rudocostata
Dentalina debilis
D terquemi
Frondicularia inversa
Lenticulina(A) schlonbachi
L(M) foeda
L(S) cf. jarvisi
Tristix acutangula
T insignis
Höglundina caracolla
Frondicularia cf microdisca
Lenticulina(M) striatocostata
L(L) subalata
Dentalina linearis
Haplophragmoides cushmani
Nodosaria cf. regularis
Pseudonodosaria sp
Vaginulina cf. angustissima
Lagena cf. sulcata
Citharina strigillata
Lagena apiculata
Vaginulina complanata var perstriata
Ramulina fusiformis
Lingulonodosaria nodosaria
Vaginulina striolata
Lenticulina(V) humilis praecursoria
Ammovertella cellensis
Ammobaculites subcretaceous
Lenticulina(A) pachynota
Lenticulina(L) saxonica
Glomospira gordialis
Ammodiscus tenuissimus
Frondicularia concinna
Pseudonodosaria humilis
Nodobacularia nodulosa
Citharina cf discors
C sp.A
C sp.B
Lenticulina(A) cf pachynota
L(A) schreiteri
L(L) guttata var intermedia n.var
L(P) crepidularis
Lingulina sp. A
Citharina harpa
C seitzi
C sparsicostata
Vaginulina arguta
V kochi
Frondicularia hastata
Lenticulina(L) guttata var eichenbergi
L(L) ouachensis wisselmanni
Ramulina spandeli
Epistomina ornata
Lenticulina(L) guttata
L(L) subangulata
L(L) guttata var striata

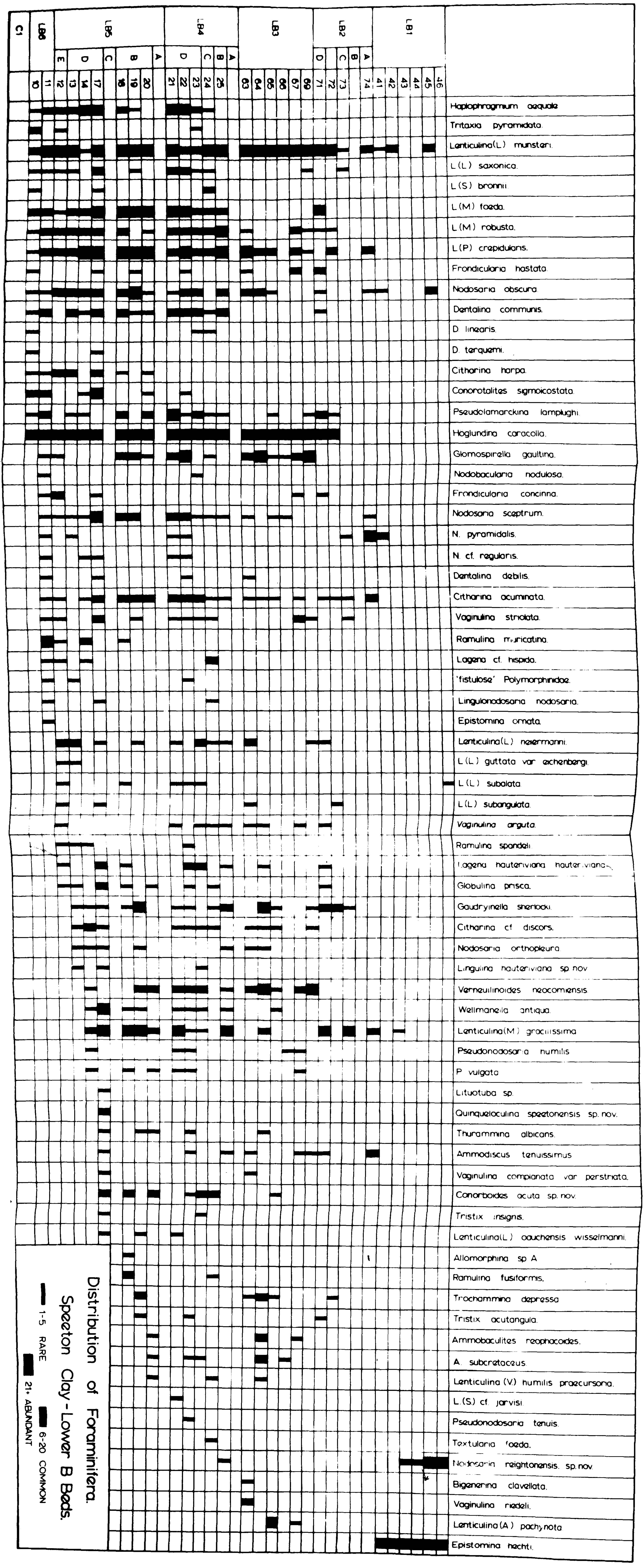
DISTRIBUTION OF FORAMINIFERA

SPEETON CLAY - C BEDS


Distribution of Foraminifera
Speeton Clay - C Beds
1-5 RARE
6-20 COMMON
21+ ABUNDANT

DISTRIBUTION OF FORAMINIFERA

SPEETON CLAY - LOWER B BEDS.


Distribution of Foraminifera.
Speeton Clay - Lower B Beds.
1-5 RARE
6-20 COMMON
21+ ABUNDANT
C1
LB6
LB5
LB4
LB3
LB2
LB1
E D C B A
D C B A
D C B A
10 11 12 13 14 17 18 19 20 21 22 23 24 25 63 64 65 66 67 69 71 72 73 74 41 42 43 44 45 46
Haplophragmium aequale
Tritaxia pyramidata
Lenticulina(L) munsteri
L(L) saxonica
L(S) bronnii
L(M) foeda
L(M) robusta
L(P) crepidulans
Frondicularia hastata
Nodosaria obscura
Dentalina communis
D. linearis
D. terquemi
Citharina harpa
Conorotalites sigmoicostata
Pseudolamarckina lamplughi
Hoglundina caracolla
Glomospirella gaultina
Nodobacularia nodulosa
Frondicularia concinna
Nodosaria sceptrum
N. pyramidalis
N. cf. regularis
Dentalina debilis
Citharina acuminata
Vaginulina striolata
Ramulina muricatina
Lagena cf. hispida
'fistulose' Polymorphinidae
Lingulonodosaria nodosaria
Epistomina ornata
Lenticulina(L) nezermanni
L(L) guttata var eichenbergi
L(L) subalata
L(L) subangulata
Vaginulina arguta
Ramulina spandeli
Lagena hauteriviana hauteriviana
Globulina prisca
Gaudryinella sherlocki
Citharina cf. discors
Nodosaria orthopleura
Lingulina hauteriviana sp. nov.
Verneuilinoides neocomiensis
Wellmanella antiqua
Lenticulina(M) gracilissima
Pseudonodosaria humilis
P. vulgata
Lituotuba sp.
Quinqueloculina speetonensis sp. nov.
Thurammina albicans
Ammodiscus tenuissimus
Vaginulina complanata var perstriata
Conorboides acuta sp. nov.
Tristix insignis
Lenticulina(L) ouachensis wisselmanni
Allomorphina sp. A
Ramulina fusiformis
Trochammina depressa
Tristix acutangula
Ammobaculites reophacoides
A. subcretaceus
Lenticulina (V) humilis praecursoria
L.(S) cf. jarvisi
Pseudonodosaria tenuis
Textularia foeda
Nodosaria reightonensis sp. nov.
Bigenerina clavellata
Vaginulina riedeli
Lenticulina(A) pachynota
Epistomina hechti