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186. CERTAIN SMALLER BRITISH PALEOCENE FORAMINIFERA PART V. DISTRIBUTION

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ABSTRACT

The foraminiferal fauna was found to be restricted to the Pegwell Marls and the Reculver Silts, members of the Thanet Formation which are found east of the Medway only. One hundred and thirty-two species were recovered from sections at Pegwell Bay, Haine Pit and Reculvers and the outcrop was sampled at various sites to as far west as Cheam. Lagenidae, Polymorphinidae, Buliminidae, Nonionidae and Discorbidae dominate the fauna.

It was found possible to divide the section at Pegwell into four zonules based upon what appear to be four distinct ecological foraminiferal associations. The foraminiferal faunules show a relation to the cycle of sedimentary deposits and thus to the progress of the Thanetian marine transgression. The upper zonule at Pegwell can also be recognized at Reculvers. Inland the members of the formation overstep each other and the zonules become less well defined, passing into unfossiliferous sands beyond Sittingbourne.

The microfauna emphasizes the Paleocene (lower Landenian) age of the formation and includes pelagic and benthonic species typical of the Paleocene of the U.S.A. and the Middle East. There are close similarities to other Landenian faunas of the Northwest European basin which appears to have been isolated to some extent from the rest of Europe but shows evidence of connections with Tethys and the Gulf Coast region of the U.S.A.

INTRODUCTION

This paper concludes the presentation of the results of a revision of the Foraminifera of the Thanet Formation of Kent in the United Kingdom. It is concerned with the vertical and lateral distribution of the fauna and its ecological and stratigraphical significance.

Burrows and Holland, in their pioneer work on the microfauna (1897) recovered thirty-four species substantiated by the present work. These authors made an attempt to assess the relative abundance of the Foraminifera recovered at Pegwell Bay but with limited data were unable to suggest any zonal subdivisions.

The lithological succession, the sections sampled and sampling methods are described in Part I (Haynes, 1956). As stated, megafossil evidence suggests that the Thanet Formation is middle Paleocene or lower upper Paleocene in age and equivalent to the lower Landenian of the Netherlands. The formation is made up of sandy silts, silty marls and silty clays with the mode of particle size in the silt or clay grade (marl is used here in the sense of a calcareous, semi-friable clay). The beds are glauconitic throughout and show a high proportion of flint grains in the Stourmouth Clays and white mica in the Reculver Silts. A band with marcasite occurs in the lower Pegwell Marls and a band with disseminated gypsum near the top of the same member.

One hundred and thirty-two species of Foraminifera were recovered. These species were washed from samples of the richly fossiliferous Pegwell Marls and Reculver Silts exposed at Pegwell Bay, Haine Pit, and Reculver Towers. No microfossils were recovered from the Stourmouth Clays at Pegwell or from the Kentish Sands which replace the other members of the Thanet Formation west of Sittingbourne.

Washed material was sieved (100 to the inch mesh) and the total number of specimens was calculated to one hundred grams of original sediment. The distribution chart therefore refers to species in each sample which did not pass through the 100 grade sieve. *N.B.* This sieve limit was chosen after it was observed that its use separated the fauna from the bulk of silt and fine sand without greatly distorting the statistical results. Counts on unsieved material showed similar results percentagewise but indicated that the numbers of small, elongate species such as *Bulimina thanetensis* Cushman and Parker are probably low. The number of specimens of each species at each horizon is represented on the chart in a semi-proportionate pictographic form. This, if variations in rate of sedimentation and sedimentary processes are kept in mind, gives an idea of the absolute vertical variation in numbers. In the discussion that follows the numbers of the species in each sample are converted to percentages and the species in each recognizable association are grouped as follows: as dominants, if making up more than ten percent of the fauna at any one horizon within the zone; as subsidiary, if making up between two and ten percent of the fauna at any one horizon within the zone; as accessory, if making up less than two percent of the fauna at all horizons within the zone.

As stated in Part I there is no evidence of a mechanical relation between the fauna and the lithology. However, it is probable that current mixing of the fauna has taken place, particularly in the Reculver Silts, without marked size sorting.

The apparent restriction of microfossils to the Pegwell Marls and Reculver Silts coincides with the known distribution of macrofossils. Thus of the older workers, Gardner (1883) found the formation unfossiliferous west of Rainham while Prestwich (1852) found that organic remains became "very rare" west of Canterbury. It is possible that this represents the original distribution of Thanetian faunas; or it may be that the absence of organic remains, except in patches and layers west of Canterbury, is due to the permeability and consequent leaching of the beds. As Prestwich remarked "where the sands are sufficiently argillaceous, casts often remain." This appears to be so in the case of certain species of Foraminifera at Durolevum. Prestwich, however, was doubtful if the formation had ever been as fossiliferous in the west as in the east, "for it is possible," he says, "that the causes which have favoured the preservation of the shells when dead may also have tended to their development when living." This later suggestion is lent support by the following observations. Firstly, a change of modal particle size from silt to sand between the Thanet Beds and the Woolwich Beds at Reculvers is associated with the disappearance of the Thanet microfauna. Secondly, the character of the microfauna in the Pegwell section shows variations apparently closely related to lithological variation. It is therefore possible that the Kentish Sands were largely barren at the time of accumulation.

The microfauna of the Thanet formation is remarkable in that larger Foraminifera and porcelaneous genera are apparently completely absent. Species of the families Lagenidae (30), Polymorphinidae (32), Nonionidae (9) and Discorbidae (24) dominate the fauna which includes species of the families Chilostomellidae (4), Buliminidae (5), Uvigerinidae (3), Virgulinidae (1), Ceratobuliminidae (1), Epistominidae (3), Amphisteginidae (1), Globigerinidae (3), Globorotaliidae (1), and Arenacea (13).

Of the calcareous species twenty-eight were found to be granular, the rest radiate hyaline. Although numerous species of Polymorphinidae were recovered no fistulose specimens were observed.

DISTRIBUTION OF FORAMINIFERA

A. The Type Section at Pegwell Bay

The most complete section of the Thanet formation showing all the members recognized except the Kentish Sands is seen in the cliffs of Pegwell Bay on the northeast side of the Richborough-Stourmouth syncline. It has been described and figured by Prestwich (1852), Whitaker (1872), Gardner (1883), Burrows and Holland (1897), and in almost its present state of preservation by Osborne White (1928).

The accompanying range chart shows the distribution of Foraminifera through the section. (The stratigraphical column in Part I illustrates the relations and thicknesses of the various members and the horizons of the samples taken from them to true vertical scale.) There appear to be at least four distinct faunal groups with different species dominant in each. The ranges of these groups coincide with the lithological divisions which seems good evidence for regarding them as ecological associations or faunules.

Faunule 1 coincides with the basal four metres of the lower Pegwell Marl member, samples P16 to P24. Faunule 2 coincides with the uppermost two and a half metres of marcasitic, lower Pegwell Marls, samples P25 to P28. Faunule 3 coincides with the upper Pegwell Marl member, samples P30 to P46. Faunule 4 coincides with the cross-bedded, Reculver Silts, samples P47 to P54. The pale banded Stourmouth Clays did not yield fossils.

Faunule 1—Bulimina thanetensis Zonule. The included range chart illustrates a fauna of the following character. (*N.B.* Unfossiliferous horizons P17, 18, 19 left out to economise space)

Dominant species

Over ten percent of the total fauna at any one horizon within the zonule: *Alabamina obtusa, Bulimina thanetensis, Cibicides proprius, C. succedens, Hollandina pegwellensis.*

Subsidiary species

Between two and ten percent of the total fauna at any one horizon: *Anomalinoides nobilis, Astacolus crepidula* (in Burrows and Holland's sense) = *Cristellaria wetherellii* Jones, 1852, *Glomospirella woodi, Pullenia quaternaria, Textularia thanetana.*

Accessory species

Rare species making up less than two percent of the total fauna at all horizons within the zonule. Thirty-two species were recovered.

This fauna is best developed at horizon P16, in the *Crepidula* Band or Black Band and becomes progressively diminished higher in the zonule. The pale band (P17, P18) immediately above the Black Band is barren while the fauna is reduced almost to being wholly arenaceous at P23 and foreshadows Faunule 2. At the lowest fossiliferous horizon, P16, *Bulimina thanetensis* makes up the greater part of the fauna, 76% of the total, while *Alabamina obtusa* makes up 10%. At the top of the zonule, at horizon P24, there is a tendency for the faunule to come closer to that found in the *Cibicides proprius* Zonule (3), with increase of *Cibicides proprius* (up to 50% of the total fauna) and *Hollandina pegwellensis* (up to 18% of the total fauna) relative to the percentages of *Bulimina thanetensis, Alabamina obtusa* and *Cibicides succedens.*

It is noteworthy that *Cibicides succedens* which reaches 16% of the total fauna at horizon P22 occurs only rarely outside this zonule, one or two specimens being found at the bottom of Zonule 3.

Among the accessory species members of the Arenacea, Polymorphinidae and Lagenidae are best represented while Discorbidae and Nonionidae are poorly represented.

Thirty samples were collected through the one metre band of dark, grey-brown marl at the base of Zonule 1 (the Black Band). The top seven samples were collected through every two inches, the lower samples inch by inch. In each case one thousand specimens were counted from unsieved washed material. This study revealed that the typical species of Faunule 1 occur throughout, the top sample only proving barren. Ecological conditions appear to have been stable during the accumulation of the band.

Dominant and subsidiary species

Bulimina thanetensis varied from 41% to 86% of the total fauna.

Alabamina obtusa varied from 6% to 30% of the total fauna.

Anomalinoides nobilis varied from 1% to 6% of the total fauna.

Charltonina canterburyensis varied from 1% to 5% of the total fauna.

Cibicides succedens varied from 1% to 3% of the total fauna.

Hollandina pegwellensis varied from 1% to 4% of the total fauna.

Cibicides proprius 9% at one horizon.

This band differs from the higher strata of Zonule 1 in the extreme dominance of *B. thanetensis* and *A. obtusa* and the presence of *C. canterburyensis* as a subsidiary species. *Astacolus crepidula* (Burrows and Holland's sense) = *Cristellaria wetherellii* Jones, occurs throughout. The interesting variations shown by this species will be discussed and illustrated later.

Faunule 2.—Glomospirella woodi Zonule. The marcasitic clays of this zonule yielded seven arenaceous species in numbers too small for statistical analysis: *Cyclammina challinori, C. incisa, Glomospirella woodi, Haplophragmoides burrowsi, H. obliquicameratus, Involutina cretacea, I. pyrotecnica.*

Faunule 3.—Cibicides proprius Zonule.

Dominant species

Bulimina thanetensis, Cibicides cassivellauni, C. proprius, Gyroidina danvillensis var. *gyroidinoides, Hollandina pegwellensis.*

Subsidiary species

Anomalinoides nobilis, Gyroidinoides voluptus, Pullenia quinqueloba, Praeglobobulimina ovata.

Accessory species

Forty species were recovered. This faunule differs from that of the *Bulimina thanetensis* Zonule (1) in that *Gyroidina danvillensis* and *Cibicides cassivellauni* have become dominants whereas *Alabamina obtusa* and *Cibicides succedens* are accessory. In addition *Cibicides proprius* (38% of the total fauna at horizon P37), *Hollandina pegwellensis* (39% of the total fauna at P38) and *Gyroidina danvillensis* var. *gyroidinoides* (25% of the total fauna at P30) are almost equal in abundance to *Bulimina thanetensis* (42% of the total fauna at P42).

The subsidiary species are also different from those in the *Bulimina thanetensis* Zonule (1) and there are more accessory species. These last include *Cibicides cunobelini* and *Cibicides mariae* which become dominant in Zonule 4, and species of Nonionidae which also become more abundant in the Reculver Silts.

The abundance of the faunule is much reduced in the gypsiferous band near the top of the zonule, only a few of the species being represented, including *Textularia thanetana, Cibicides proprius, Praeglobobulimina ovata, Anomalinoides nobilis* and *Gyroidina danvillensis.*

Faunule 4.—Cibicides cunobelini Zonule.

Dominant species

Cibicides cunobelini, C. mariae, Textularia thanetana.

Subsidiary species

Anomalinoides nobilis, Bulimina thanetensis, Cibicides cantii, C. cassivellauni, C. cassivellauni var. *buximargo, Gyroidina danvillensis* var. *gyroidinoides, Hollandina pegwellensis, Nonion applinae, Protelphidium hofkeri.*

Accessory species

Thirty-nine species were recovered. As is well shown by the range chart and the foregoing list the faunule recovered from the cross-bedded silts of this zonule is markedly different from that of the *Cibicides proprius* Zonule (3). Only one specimen of *Cibicides mariae* was recovered from Zonule 3 whereas it is a dominant in the *Cibicides cunobelini* Zonule (4). Similarly *Cibicides cunobelini* (58% of the total fauna at horizon P51) and *Textularia thanetana* (13% of the total fauna at P51) were accessory only in Zonule 3. Of the five species which dominate in Zonule 3, four are subsidiary in this zonule while *Cibicides proprius* is accessory only. Among the accessory species members of the Nonionidae and Discorbidae are more important and Globigerinidae appear for the first time.

B. Other Sections Sampled

The section at Reculver Towers

The best section of the Reculver Silts, apart from that at Pegwell, can be observed west of Reculver Towers on the coast northwest of Thanet. The formation dips westwards below the Woolwich Beds and is also restricted eastwards by a slight anticlinal flexure which carries the beds to beach level at Reculver Towers. The maximum exposure, about fourteen feet, is found beyond the wooden steps at the small headland. The section that accompanies Part I illustrates the relations of the beds of the Reculver Silts and the overlying base bed of the Woolwich formation. In this work the top of the Reculver Silts is taken as the top of the shelly silts 1 metre, 34 cms. above the upper dogger band.

The characteristic fauna of the *Cibicides cunobelini* Zonule (4), recognized at Pegwell, is also found in the Reculver Silts at Reculver. This cliff section is ten miles from Pegwell, a distance which appears to be reflected in quantitative differences in the faunule. Besides *Cibicides cunobelini* (80% of the total fauna at horizon RB8), *Cibicides mariae* (26% of the total fauna at horizon RB9) and *Textularia thanetana* (14% of the total fauna at RB6) two other species may also be considered dominants; these are *Protelphidium hofkeri* (10% of the fauna at RB19) and *Asterigerina aberystwythi* (15% of the fauna at RB11).

The same subsidiary species occur as at Pegwell with the difference that *Bulimina thanetensis* and *Cibicides cassivellauni* are further reduced in importance and accessory only. *Cibicides proprius,* rare in the faunule at Pegwell is absent at Reculver.

It is interesting to note that as at Pegwell *Cibicides cunobelini* tends to increase relatively to the rest of the fauna up through the section: Percentages are 35; 33; 40; 48; 31; 49; 51; 64; 71; 64; 80; 66; 62; through horizons RB9 - RB19.

Inland sections sampled east of Sittingbourne Haine Pit

The Stourmouth Clays and the lower Pegwell Marls are exposed at Haine Pit (Map reference, 1 inch geology map, Old Series, 1°23′E.51°2′N.) recently opened for the quarrying of clays for brick making. The lower part of the strata equivalent to the *Bulimina thanetensis* Zonule (1), including the *Crepidula* Band and horizon P21, are barren while the clays equivalent to horizons P22, P23, and P24 yielded a few arenaceous forms: *Cyclammina incisa, Involutina cretacea, Pseudoclavulina anglica, Textularia thanetana.* Casts of *Praeglobobulima ovata* composed of clusters of minute pyrite balls were also recovered.

In the strata equivalent to the *Glomospirella woodi* Zonule (2), three further arenaceous species were found in addition to the seven recovered at Pegwell: *Hormosina* sp., *Trochammina pentagona, Verneuilina* sp. Single specimens of *Pullenia quinqueloba, Nonionella robusta* var. *perdita* and *Protelphidium sublaeve* were also recovered together with several casts of *Praeglobobulimina ovata.*

Woodnesborough.—A fossiliferous sample was obtained from what appear to be sandy equivalents of the Pegwell Marls at Woodnesborough (1°18′E.51° 16′N.) from a disused railway cutting five hundred yards north of the road to Sandwich. The fauna included the following species: *Alabamina obtusa, Anomalinoides nobilis, Astacolus platypleura, Bulimina thanetensis* (14% of total fauna), *Cibicides cassivellauni, Cibicides proprius* (26% of total fauna), *Epistominella vitrea, Gyroidina danvillensis* var. *gyroidinoides, Gyroidinoides voluptus, Hollandina pegwellensis, Haplophragmoides burrowsi, Haplophragmoides* cf. *H. obliquicameratus, Involutina cretacea, Nonionella robusta* var. *perdita, Praeglobobulimina ovata, Pullenia quinqueloba, Trochammina pentagona.*

This fauna is much the same as Faunule 3 with the addition of *Epistominella vitrea,* restricted to the *Cibicides cunobelini* Zonule (4) at Pegwell.

Canterbury.—Samples which proved unfossiliferous were collected from Reculver Silts exposed both east and south of Canterbury.

Ensing.—Sandy equivalents of the Pegwell Marls were sampled at Ensing tunnel (59′E.51°15′N.). Samples were collected at five-foot intervals in a shallow water course thirty yards east of the tunnel. One sample yielded numerous specimens of *Pseudoclavulina anglica,* restricted to horizon P22 at Pegwell, and also recovered were *Involutina cretacea, Glomospirella woodi, Textularia thanetana* and casts of *Praeglobobulimina ovata.* Ten feet higher in the section *Involutina cretacea, Textularia thanetana* and a cast of *Bulimina thanetensis* were recovered.

Durolevum.—Badly leached but fossiliferous samples were collected from what appear to be sandy equivalents of the Pegwell Marls on the east side of the Roman Camp near Newlands (49′E.51°20′N.). Four samples were collected through the twelve feet of bluish sandy clays exposed in a recent quarry. These yielded the following fauna with many species in the form of casts: *Alabamina obtusa, Astacolus platypleura, Bulimina thanetensis, Ceratobulimina tuberculata, Cibicides cassivellauni, C. cunobelini, Cibicides proprius, Cibicides succedens, Epistominella vitrea, Glandulina laevigata, Gyroidinoides voluptus, Involutina cretacea, Nonionella robusta* var. *perdita, Praeglobobulimina ovata, Textularia thanetana, Virgulina dibollensis.*

This fauna seems to be intermediate between that of the *Cibicides proprius* Zonule (3) and the *Cibicides cunobelini* Zonule (4) at Pegwell which may be explained by the fact that the beds are argillaceous sandy silts intermediate between the Pegwell Marls and Reculver Silts. Thus *Cibicides proprius* and *Cibicides succedens* are found together with *Epistominella vitrea* and *Virgulina dibollensis.*

Inland sections sampled west of Sittingbourne

No microfossils were recovered from the numerous sections sampled in the Kentish Sands exposed west of Sittingbourne.

Conclusion

The microfauna of the Thanet Beds is restricted to the Pegwell Marls and Reculver Silts. At Pegwell four faunules can be distinguished. These are recognizable for some miles inland, but beyond Canterbury where the Pegwell Marls become sandy and nearer to the Reculver Silts the faunal groups are apparently less clearly defined. West of Durolevum the Pegwell Marls and Reculver Silts pass into the unfossiliferous Kentish Sands.

ECOLOGY

Previous authors have built up a picture of the Thanet Beds as the deposit of a shallow transgressive shelf sea. This sea is held to have opened northwards and to have encroached southwards onto land areas which are now southeastern England, northern France, Belgium and north Holland, north Germany, Denmark and Sweden. Open sea connections with basins of deposition in southwest Europe are supposed to have been cut by the already emergent "Wealden Island," Stamp (1921) and Wills (1951). The prevailing climate as suggested by the dominant mollusks which included the cool water genera *Astarte* and *Cyprina* was probably temperate or mediterranean with cool currents, Chavan (1946).

The absence of both larger and porcelaneous Foraminifera and the low average size of the fauna support the conception of a cool Thanetian Sea. Deposition in shelf waters of shallow to moderate depth is indicated by the general character of the foraminiferal fauna with *Cibicides* and Discorbidae in a dominant position, particularly in the Reculver Silts. At the present time attached species of *Cibicides* are apparently most abundant in waters of the phototropic zone, down to about fifty metres in clear waters in temperate regions. According to Lowman (1949-1951) an abundance of *Cibicides* and Rotalidae is characteristic of the mid continental shelf (40-80 metres) of the Gulf of Mexico. On the other hand the abundance of *Astacolus, Globobulimina* and *Pullenia* in the Pegwell Marls indicates that rather deeper conditions prevailed at the height of the Thanetian transgression. The suggestion of Gardner (1883) that the Thanet Beds were laid down in the Laminarian zone—between low water and forty metres depth—is thus only in part supported. Pelagic species are apparently absent from the Pegwell Marls and rare in the Reculver Silts emphasizing the isolation of the Thanet sedimentary basin and the lack of oceanic connections.

Environmental significance of the faunules.—The foraminiferal faunules show a relation to the cycle of sedimentary deposits and thus to the progress of the Thanet marine transgression.

The character of the Bullhead Bed seems to indicate that the land surface was rapidly and quietly inundated as the pebbles are angular not rounded by prolonged washing. The conglomerate contains a derived Cretaceous fauna but no Foraminifera of Thanetian age and may represent a briefly reworked residual clay-with-flints layer.

The pale banded, sandy Stourmouth Clays show a high percentage of flint grains and are apparently quite barren of fossils. This member may represent quiet estuarine deposition with conditions unfavorable for Foraminifera.

The *Bulimina thanetensis* faunule comes in abruptly in the dark marls of the Black Band. It is noteworthy that this fauna comes nearest to the fauna described by Ten Dam (1944) as "littoral marine" from the equivalent Dutch Paleocene. Ten Dam found this fauna in deposits intercalated with brackish water beds and continental beds with plant remains. The extreme dominance of *Bulimina thanetensis* and *Alabamina obtusa* in the fauna favors the idea of rather unbalanced transitional marine conditions. As does the apparent return to a Stourmouth Clay environment during the deposition of the overlying pale loam (P17, P18, P19). The subsidiary importance of *Pullenia* and *Astacolus* (including the characteristic *A. wetherellii,* visible in hand specimen) and the presence of five genera of the Polymorphinidae together with the comparative rarity of Discorbidae may indicate moderate rather than very shallow depths. For instance Lowman (1949) found Lagenidae typical of the outer shelf in the Gulf of Mexico and Phleger (1956) found *Pullenia quinqueloba* to have a similar distribution. *Involutina* occurs throughout Zonules 1 and 2 and also appears to be a cool water (generally deep) genus. On the other hand cooler surface temperatures may have allowed these forms to range up into shallower depths in the Thanetian. Factors such as the dark mud bottom and quiet accumulation with gentle current action may also have been of fundamental importance.

The faunule diminishes in abundance through horizons P21 and in P22 and at P23 is largely reduced to arenaceous species. *Glomospirella* and *Involutina* present throughout are joined at this horizon by *Cyclammina* and *Haplophragmoides.* In the marcasitic clays of Zonule 2 these appear to be the only genera present.

Modern ecological work has shown that arenaceous genera such as *Haplophragmoides, Trochammina, Bathysiphon, Cyclammina* and *Ammobaculites* can exist under bottom conditions that are not tolerated by normal marine assemblages. Faunas made up exclusively of certain of these genera or largely dominated by them have been found to be characteristic both of environments where salinity varies markedly as in brackish lagoons, estuaries and salt marshes and of environments where oxygen content is low as in lagoons and seas where circulation is restricted by geographic barriers. Thus Lowman (1949) found faunas composed of up to 90% of *Ammobaculites* in certain weakly brackish environments in the Gulf of Mexico. Where the brackish environment is also stagnant, as in marshes, *Haplophragmoides, Trochammina* and *Ammoastuta* were found on a bottom of black plant muck. Where stagnant bottom conditions prevail together with more normal marine salinities *Cyclammina* and *Bathysiphon* are found in association with *Haplophragmoides* and *Trochammina*. Parker, Phleger and Peirson (1953) in their study of San Antonio Bay and its environs found *Ammoastuta, Arenoparrella, Miliammina* and *Trochammina* restricted to the marsh facies together with *Discorinopsis*. Similar patterns of distribution have been found in Mississippi Sound, Phleger (1954), in the south-east Mississippi Delta area, Phleger (1955), along the central Texas coast, Phleger (1956), and in Todos Santos Bay, Baja California, Walton (1955), among many coastal areas recently studied.

There are obvious dangers in applying these results to the interpretation of the geological past. The ecologic range of certain genera may have changed or have become more restricted and too little is yet known of the influence of food supply and sedimentary conditions. However, the experience of the writer, particularly with Cretaceous foraminiferal assemblages in Western Canada, indicates that many arenaceous genera have not changed their characteristic milieu since the Mesozoic. The faunal changes in the lower Pegwell Marls may thus represent a gradual change to more restricted marine conditions. These conditions appear to have become dominant in Zonule 2. A poorly aerated bottom with normal marine salinities, rather than brackish influences, is suggested by the presence of *Cyclammina* with *Haplophragmoides, Ammodiscus* and *Glomospirella* and the absence of *Ammobaculites* and *Miliammina*. The occurrence of iron sulphide also indicates reducing conditions, although not necessarily above the sedimentary interface.

Strongly transgressive marine conditions apparently returned with the deposition of the upper Pegwell Marls. The *Cibicides proprius* faunule resembles the faunas from the Black Band but *Bulimina thanetensis* and *Alabamina obtusa* are reduced in importance, *Cibicides* is much more prominent together with *Gyroidina, Hollandina, Pullenia* and *Praeglobobulimina*. Species of *Astacolus* (apart from *A. wetherellii*) are more abundant and arenaceous species are much less frequent. Abundant echinoid spines and sponge spicules indicate good aeration. This phase appears to represent the maximum of the marine transgression with quiet relatively deep waters and subsidence outpacing deposition. The faunule resembles modern assemblages that are characteristic of the outer shelf (outer neritic environment) in the Gulf of Mexico, Lowman (1951) and Phleger (1956), and may similarly indicate depths greater than 50 metres.

The transgressive phase of the Thanetian sedimentary cycle ends with the *Cibicides cunobelini* Zonule (4). The characters of this zonule suggest that deposition more than balanced subsidence and very shallow waters covered the Thanet area. Marked cross bedding indicates that the silts were accumulated in what may have been shoal water conditions—*Asterigerina, Cibicides, Rosalina, Nonionella, Epistominella* and *Textularia* dominate the fauna.

It is noteworthy that Lowman (1951) found *Epistominella, Nonion* and *Nonionella* among the dominant genera on the poorly sorted, muddy sands of the inner shelf (inner neritic environment, down to 40 metres) west of the Mississippi Delta. *Asterigerina* with *Amphistegina* and *Gypsina* is a dominant genus on clean sand bottoms on the inner shelf east of the delta. Moore (1957) found *Asterigerina* characteristic of reefs that are awash at low tide along the northern Florida Keys. *Epistominella vitrea*—abundant in the Reculver Silts but absent from the Pegwell Marls—is well represented off the Central Texas coast today in waters from 15-69 metres depth (Phleger, 1956). *Rosalina* is also typical of the turbulent zone and the inner shelf.

There is a close correspondence between the cyclical pattern of the Gulf Coast Tertiary and that of the Tertiary of the Anglo-French basin, Stamp (1921), Lowman (1949). According to Lowman each major cyclical unit on the Gulf Coast shows five phases when fully developed. It is noteworthy that the Thanet cycle also appears to show these phases.

(a) Initial transgression with deposition of a transitional member such as the *Marginulina* zone of the Anahuac and the *Nonionella cockfieldensis* Beds of the Jackson cycle. The lower Pegwell Marls and the underlying Stourmouth Clays can be taken to represent this phase.

(b) Rapid transgression, slow deposition, and a tendency for the limestone province of the eastern Gulf to invade the clastic western province with the deposition of such members as the lower Midway Marls, the Cane River Marl, Weches Marl, Crockett Marl, Moodys Branch Marl, the Vicksburg limestone and the *Heterostegina* limestone. The upper Pegwell Marls can be taken to represent this phase of deepening and slow deposition.

(c) A gradual but oscillatory change to regressive conditions in the upper part of the shale members. This phase seems to be represented by the Reculver

Silts in the Thanet cycle though the gypsiferous band near the top of the Pegwell Marls may indicate a period of standstill.

(d) A sharp change to less fossiliferous shales and sands which also show the effects of oscillatory regression. This phase is represented by the Woolwich Beds in the Thanet cycle. At Reculver only *Textularia thanetana* penetrates into the lower sands of the Woolwich Beds and the overlying red and white sands are barren of microfossils.

(e) A sharp change to continental sands. This phase is represented in the Thanet cycle by the Reading Beds.

There was apparently continuous deposition throughout the cycles and the chief breaks appear to be at the base of the transgressive members. The abrupt entry of marine sedimentation is well shown by the Headon cycle (Bhatia, 1957, Oligocene, Whitecliff Bay, Isle of Wight). The marine phases of this cycle resemble those of the Thanet cycle though less complete and with different facies represented. Marine sedimentation appears to have begun with the deposition of the chocolate clays of the Brockenhurst zone which is estimated to indicate depths greater than 20 fathoms, whereas the passage to fresh-water beds occurs very gradually through the *Venus* Beds. The Brockenhurst zone thus shows interesting similarities with the Black Band.

Stamp (1921) explained cyclic sedimentation in the Tertiary of the Anglo-French-Belgian basin as the result of intermittent earth movements in an enclosed or partly enclosed basin causing oscillations in the water level. Lowman supposes the rhythms to be the result of processes in the source area. However, the basic similarity of the cycles on both sides of the Atlantic with marine incursions gradually becoming overwhelmed by non-marine and deltaic sedimentation suggests movements of wider significance. It seems reasonable to suppose that uplift of source areas and deepening of sedimentary basins with drowning of land margins occurred simultaneously as a result of earth movements hinged along the continental margins and connected with the Alpine orogeny.

STRATIGRAPHICAL POSITION OF THE FAUNA

The fauna as an indicator of age.—The Paleocene age of the Thanet Beds is well illustrated by the foraminiferal fauna.

Cretaceous/Lower Tertiary—22 species (8 Cretaceous only—possible derived because silicified)
Paleocene—54 species
Eocene—35 species (22 range into the later Tertiary)

Faunal comparisons within the Landenian of N. W. Europe.—Bonte (1934) recorded several forms from Lille which included the following in common with the Thanet fauna: *Cristellaria gibba* (possibly *Astacolus platypleura*), *Globulina gibba, Guttulina problema, Nodosaria raphanistrum* (possibly *Dentalina bifurcata*), *Polymorphina striata.*

Brotzen (1948) recorded a number of species from the Sables de Bracheux, the following also occur in the Thanet Beds: *Bulimina paleocenica, B. rosenkrantzi* (probably only infraspecifically distinguishable from *Bulimina thanetensis* and *B. trigonalis*), *Cibicides succedens, Globulina gibba, Guttulina problema, Nonion* cf. *N. graniferum* (probably *Protelphidium hofkeri*), *Praeglobobulimina ovata, Alabamina obtusa,* and *Uvigerinella europea.*

Netherlands.—The "littoral marine" fauna described by Ten Dam (1944) from the Landenian of Holland shows the following species in common with the Thanet Beds: *Astacolus platypleura, Alabamina obtusa, Bulimina trigonalis* (only infraspecifically distinguishable from *Bulimina thanetensis*), *Cibicides proprius, Cibicides succedens, Dentalina consobrina, D. glaessneri, Eponides haidingeri* (*Hollandina pegwellensis*), *Gyroidina angustiumbilicata* (possibly *Gyroidina danvillensis* as interpreted here), *Lagena gracilicosta, L. hexagona, Marginulina costifera, Praeglobobulimina ovata, Protelphidium sublaeve, Pseudoclavulina anglica, Pullenia quaternaria, P. quinqueloba.* This fauna most resembles Faunule 1 of the Thanet formation.

North Germany.—The microfauna of the Paleocene of North Germany has not been described in detail but Staesche and Hiltermann (1940) have published plates illustrating a fauna which includes *Astacolus platypleura.* Hiltermann (1947) has subdivided the German Tertiary on the basis of Foraminifera and cited *Cristellaria multiformis* Franke (*Astacolus platypleura*) as the zone fossil for the Paleocene.

Scandinavia.—The Thanet microfauna shows many species in common with the Paleocene of Sweden, Brotzen (1948): *Alabamina obtusa, Angulogerina wilcoxensis, Anomalinoides midwayensis* (the Swedish forms appear to be closely related to *Cibicides cunobelina* which is conceivably a sub-species of *Anomalinoides midwayensis*), *Anomalinoides nobilis, Astacolus wetherellii, Astacolus platypleura, Bulimina rosenkrantzi* (= *B. thanetansis*), *Ceratobulimina tuberculata, Cibicides succedens, Cibicidoides proprius, Globigerina pseudobulloides, G. triloculinoides, Globigerinella aspera, Globulina gibba, G. ampulla, Guttulina lactea, G. problema, Nonion* cf. *N. graniferum* (possibly *Protelphidium hofkeri*), *Rosalina koeneni, R. ystadiensis, Spiroplectammina wilcoxensis* (possibly *Textularia thanetana*), *Praeglobobulimina ovata, Pseu-*

doclavulina anglica, Pseudopolymorphina geijeri. P. palaeocenica, Pullenia quinqueloba, Pulsiphonina prima, Pyrulina fusiformis, Uvigerinella europea.

Brotzen correlates the Swedish Paleocene with the lower part (Zeelandian) of the Danish Paleocene, Koenen (1885), Franke (1927). These deposits are also correlated with the upper Midway of Texas. In his view the middle and upper Kerteminde marls of Denmark are older, characterised by *B. trigonalis,* and are Thanetian in age. However the close relations shown between the faunas of the Swedish Paleocene and the Thanet Beds indicate that separation of these deposits into different stages is probably over discriminatory.

The chief differences are that there are more Midway Epistominidae in the Swedish Paleocene than in the Thanet Beds and that *Loxostomum applinae* and *Ceratobulimina perplexa* which occur in both Sweden and Texas were not recovered. But although *Ceratobulimina perplexa* is cited as the best guide fossil for the base of the Paleocene it is reported rare at Klagsham and absent at Tygelsjo. *Loxostomum applinae* is absent from the Ystrad section. It seems likely that only minor age differences are involved (not of evolutionary stage significance) and that the differences between the faunas can also be accounted for largely by environmental controls.

It is interesting to note that Hofker (1955) has found a fauna immediately above the Maestrichtian, Md of Holland, "nearly identical" with that of the Swedish Paleocene and from layers comparable with the Tuffeau de Ciply of Belgium (type Montian) and the Vincentown formation of New Jersey. Nakkady (1957), however, supposes Zeelandian deposition to have occurred *before* the type Montian, "with a slight vertical extension to the base of the Thanetian." It is significant that Nakkady finds no species peculiar to the Montian of Egypt. He attempts to draw the lower boundary with the Danian on the appearance of species including *Nummulites deserti* de la Harpe, *Operculina libyca* (Schwager) and *Discocyclina nudimargo* (Schwager). The upper limit of the Montian is drawn at the appearance of *Alveolina oblonga* d'Orbigny and *A. ellipsoidalis* Schwager. As this *Alveolina* horizon has hitherto been considered Ypresian this effectively excludes the Landenian. There is thus a good possibility that the stage terms Zeelandian, Montian and lower Landenian, as used, are at least partially synonymous. In any case there would seem to be little value in attempting to base stages on faunal changes that are not marked enough to be distinguishable from the effects of local facies changes, particularly within a sedimentary cycle, or upon single faunizones not markedly different from overlying and underlying zones.

U.S.A. Gulf Coast and Trinidad.—The following species occur also in the Midway of the S. E. United States and adjacent areas, Cushman (1951), Plummer (1926): *Alabamina obtusa, Angulogerina wilcoxensis, Cibicides mariae* (described as *C. newmanae*), *Globigerina pseudobulloides, G. triloculinoides, Globulina ampulla, Globulina gibba, Guttulina lactea, G. problema, Involutina cretacea, Lagena apiculata, Pullenia quinqueloba, Pulsiphonina prima.*

It is noteworthy that Plummer found *A. obtusa* confined to the sandy layers of the lower Midway, that is below the *Loxostomum applinae, Ceratobulimina perplexa* faunule. *Cibicides newmanae* (*C. mariae*) was also found in the lower Midway, particularly in the upper sands, which resembles its position in the Reculver Silts.

As noted above the upper Midway has been correlated with the so called Zeelandian of N. W. Europe and the lower Midway thus separated two stages —as upper Danian—from the Thanetian. This is thought unlikely. It is more probable that both upper and lower Midway correspond closely in age to the Landenian.

U.S.A. Atlantic Coast.—The Paleocene Vincentown formation has the following species in common with the Thanet Beds, McLean (1951, 1952, 1953, 1955), Hofker (1955): *Alabamina obtusa, Cibicides succedens, Dentalina glaessneri, Gavelinella simplex* (probably *Cibicides mariae*), *Globigerina pseudobulloides, G. triloculinoides, Globorotalia velascoensis, Guttulina problema, Rosalina koeneni.*

Middle East.—As has been shown by Cuvillier and others (1955), Grimsdale (1951), Nakkady (1957), and other authors, the following species occurring in the Thanet Beds are characteristic of the Paleocene in the Middle East and N. Africa: *Globigerina pseudobulloides, G. triloculinoides, Globorotalia velascoensis* and *Alabamina obtusa.*

Conclusion.—(1) The following Thanet species appear to be of value in world wide correlation of the Landenian: *Alabamina obtusa, Cibicides mariae, Globigerina pseudobulloides, G. triloculinoides, Globorotalia velascoensis, Pulsiphonina prima.* Troelsen (*in* McLean, 1955) considers Scandinavian Paleocene specimens of *Globigerina pseudobulloides* and *Globigerina trioculinoides* to be derived from the Danian. I think it more likely that the occurrence of these forms is an indication of the close correspondence in time of deposits now split among three or four stages.

(2) The following benthonic Thanet species are of value in regional correlation: *Anomalinoides nobilis, Astacolus platypleura, Bulimina thanetensis* = *B. trigonalis* = *B. rosenkrantzi, Hollandina pegwellensis.*

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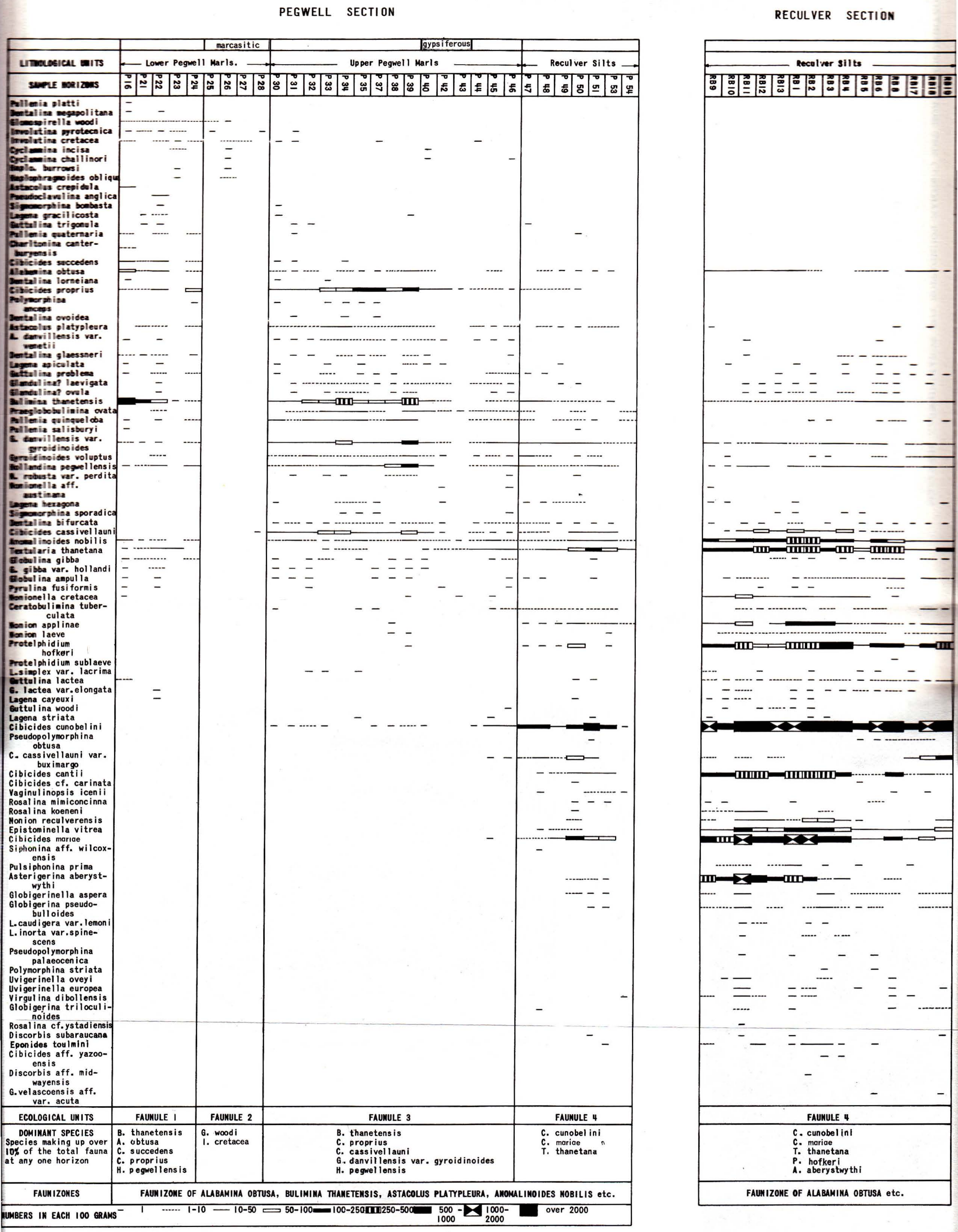

FIGURE 1

Distribution of Foraminifera at Pegwell and Reculver

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187. THE GENERA *NUTTALLIDES* FINLAY, 1939, AND *NUTTALLINA,* N. GEN.

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ABSTRACT

The generic description of the genus **Nuttallides** Finlay, 1939, is emended to include the internal structure and apertural details. This genus has a toothplate which extends in each chamber from the septal foramen towards a depressed marginal groove, interpreted as a closed protoforamen. The species **Nuttallides subtrümpyi** Finlay is placed in the synonymy of **N. trümpyi** (Nuttall).

The new genus **Nuttallina**, from the Upper Cretaceous of Western Australia, has a toothplate similar to that of **Nuttallides.** Both genera are placed in the family Epistominidae.

INTRODUCTION

The form described in this paper as *Nuttallina coronula,* n. gen., n. sp. was first found by the writer in the Toolonga Calcilutite of the Murchison River area, Western Australia, and later in the Korojon Calcarenite of the Giralia Anticline. The writer showed the specimens to Dr. M. F. Glaessner, of the University of Adelaide, who suggested a possible relationship with the genus *Nuttallides* Finlay, 1939. Specimens of the type species of *Nuttallides* (*Eponides trümpyi* Nuttall) from the Aragon Formation of Mexico were examined and found to have an internal structure similar to that of the specimens from Western Australia. The generic description of *Nuttallides* evidently required emending to include the internal structure and apertural details, and this has been done to show the relationship between *Nuttallides* and *Nuttallina,* n. gen. In general structural features, *Nuttallides* is similar to the genus *Alabamina* Toulmin.

The writer wishes to thank Dr. N. de B. Hornibrook of the New Zealand Geological Survey, who forwarded topotype and other specimens of *Nuttallides subtrümpyi* Finlay, and topotype specimens of *N. carinotrumpyi* Finlay, *N. cretatrumpyi* Finlay and *N. tholus* Finlay; Professor J. J. Graham of Stanford University, U.S.A., who checked the writer's identification of *Nuttallides trümpyi* (Nuttall); and Dr. M. F. Glaessner of the University of Adelaide, Australia, who first suggested a possible relationship between the genus *Nuttallides* and *Nuttallina,* n. gen.

The figured specimen and sections of *Nuttallides trümpyi* (Nuttall) from the Aragon Formation of Mexico are deposited in the Department of Micropaleontology, United States National Museum, Washington, D. C. under the USNM Nos. 626138-626144. The figured specimen from New Zealand is deposited in the palaeontological collection of the Geological Survey of New Zealand under No. TF 1029/4. The holotype, paratypes and sections of *Nuttallina coronula,* n. gen., n. sp. are deposited in the Commonwealth Palaeontological Collection, Canberra, under the numbers C.P.C. 1530-1540; topotype specimens have been deposited in the United States National Museum under USNM No. 626145.

Family EPISTOMINIDAE

Genus **Nuttallides** Finlay, 1939, (emended)

Type species.—Eponides trümpyi Nuttall, 1930. Original designation.

Test trochoid, evolute dorsally, involute ventrally, unequally biconvex, with the ventral surface the more strongly convex, periphery poreless. Umbilical area with a poreless boss. Test calcareous, chamber walls radiate hyaline, finely perforate on both dorsal and ventral surfaces; septal walls single, imperforate. Aperture ventral, at base of chamber, with a slight lip, extending from the umbilical boss to a small groove at the periphery, formed parallel to the plane of coiling and bordered marginally by a small fold of the apertural face. Each chamber with a toothplate extending from the septal foramen diagonally across the chamber towards the peripheral groove.

Remarks.—The generic description of *Nuttallides* given by Finlay (1939) requires emending to include the internal structure and apertural characteristics. The details of the sutures given by Finlay are of specific and not generic significance.

The genus *Nuttallides* has some features suggesting a relationship with the genus *Alabamina* Toulmin, 1941, the type genus of the family Alabaminidae. The marginal groove of *Nuttallides,* formed parallel to the plane of coiling, is regarded by the writer as homologous with the groove in *Alabamina,* called by Brotzen (1948) the "scrobis septalis," and the small forward fold of the chamber at the periphery as homologous with the "tectum" of *Alabamina.* According to the interpretation of Hofker (1951) the groove to which the reduced toothplate of *Alabamina* ("infundibulum" of Brotzen) is attached is a closed protoforamen. The same interpretation may be applied to the groove of

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Nuttallides; the aperture in this genus is therefore a deuteroforamen, and the genus belongs to Hofker's suborder Biforaminata deuteroforaminata.

The toothplate of *Nuttallides* is more strongly developed than that of *Alabamina,* and extends the full width of the chamber from the septal foramen. The internal feature of *Alabamina* called by Brotzen the "foramen infundibulum" is absent from *Nuttallides,* and the poreless ventral boss and poreless margin of *Nuttallides* do not occur in *Alabamina.* Another difference is in the wall structure, which is granular in *Alabamina* and radiate in *Nuttallides.* In this respect, and in having a ventral boss, *Nuttallides* resembles the genus *Epistomina,* but does not have as well developed or as complex a toothplate as that genus.

The genus *Nuttallides* is in its combination of characters intermediate between the genera *Alabamina* and *Epistomina.* The classification of these forms depends on the significance given to the different features. Brotzen (1948) suggested that the marginal groove of *Alabamina* is a reduced marginal aperture, and included this genus in the Epistominidae. Hofker (1951) considered the reduced marginal aperture (protoforamen) and the sutural aperture formed by the deuteroforamen to be significant, and proposed the family Alabaminidae. This view receives some support from the difference in wall structure between *Alabamina* and *Epistomina,* although Hofker did not consider this feature.

The taxonomic significance of the toothplate and the wall structure is not fully understood, but the writer prefers to place *Nuttallides* in the Epistominidae rather than in the Alabaminidae. The intermediate position of *Nuttallides* may indicate the origin of the Alabaminidae within the Epistominidae.

Nuttallides trümpyi (Nuttall)

Plate 18, figures 1-13

1930, *Eponides trümpyi* NUTTALL, Jour. Paleontology, 4 (3), p. 287, pl. 24, figs. 9, 13, 14.
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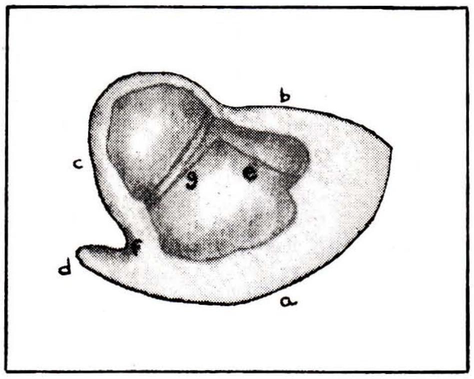
1953, *Eponides trümpyi* NUTTALL. HAMILTON, Jour. Paleontology, 27 (2), p. 235, pl. 31, figs. 22, 23.
1956, *Eponides trümpyi* NUTTALL. ASCOLI, Riv. Ital. Paleont., 62 (3), pp. 158, 161, 163, 182, pl. 14, fig. 7.

Diagnosis.—An unequally biconvex species with a large flattened ventral boss, rounded to subacute poreless margin, angulate ventral sutures and a toothplate forming a thin high ridge in each chamber.

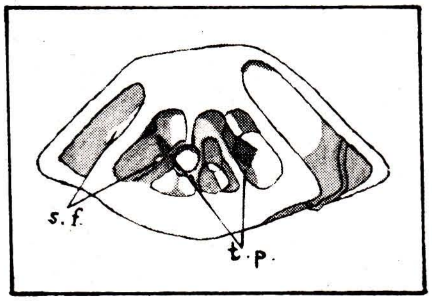
Description.—Test trochoid, unequally biconvex, the ventral surface more strongly convex than the dorsal. Periphery of test slightly lobate, particularly on last chambers, with a rounded to subacute poreless margin of clear shell material. Test calcareous, chamber walls radiate hyaline, finely perforate on both dorsal and ventral sides; septal walls single, imperforate. All chambers visible from the dorsal side, forming 3½-4 whorls, only those of the last whorl visible from the ventral side, with usually 7 chambers in the last whorl. Proloculus globular, chambers increasing slowly in size as added. Umbilical area on the ventral side with a distinct clear poreless boss, usually flattened across the top, giving the ventral surface a truncated appearance in side view. Sutures on ventral side narrow, distinct, smooth throughout or slightly depressed in the last two or three chambers, with a marked angularity about ⅓ of their length from the umbilical boss, the angle extending forward in the direction of coiling. Sutures of the central part of the dorsal side of dry specimens obscured by shell material, on moistened specimens seen to be curved, at first almost radial, later becoming more strongly reflexed and almost tangential to the spiral whorl, with the chambers long and narrow. Aperture ventral, at the base of the chamber, a long narrow slit with a small but distinct lip, extending from the umbilical boss to a small groove at the periphery, parallel to the plane of coiling. Marginally from the groove is a small fold of the apertural face, extending forward beyond the aperture. A well developed toothplate occurs in each chamber, extending from the septal foramen towards the groove at the periphery (*see* text figure 1). The toothplate begins in each chamber at the sutural angle,



TEXT FIGURE 1

Internal view of last chamber of *N. trümpyi,* showing toothplate. × about 120. a. Periphery of test. b, c. Proximal and distal walls of chamber respectively. d. The "tectum." e. Septal foramen. f. Position of marginal groove. g. Toothplate.

extends diagonally as a thin high ridge across the floor of the chamber, and is attached to the following septal wall at the marginal groove. At the point of origin on the septal foramen the toothplate extends almost the full height of the chamber towards a small poreless ridge formed by a thickening of the chamber wall (Pl. 18, fig. 9 and text fig. 2); the thickening of the chamber wall has not been observed to continue for any distance, and seems to be confined to the chamber wall at the sutural angle. The toothplate tapers gradually from the septal foramen to its point of attachment on following septal wall.



TEXT FIGURE 2

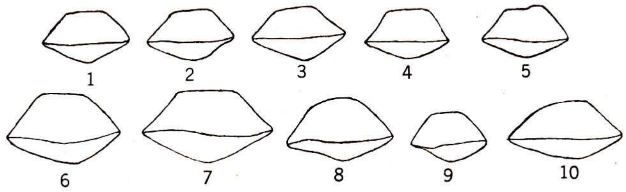
Camera lucida drawing of vertical section of *N. trümpyi*. Specimen from Mexico. × about 55. Showing toothplates, and thickening of the chamber wall in one chamber. s.f. Septal foramen. t.p. Toothplate.

Dimensions.—

	Max. Diam.	*Height*
Specimen from Mexico	0.518 mm.	0.296 mm.
Specimen from New Zealand	0.675 mm.	0.352 mm.

Remarks.—The specimen figured from Mexico is from the Aragon Formation; that from New Zealand is from the type locality of *N. subtrümpyi* Finlay. *N. subtrümpyi* Finlay is regarded by the writer as a synonym of *N. trümpyi* (Nuttall). Finlay (1939) stated in his description of *N. subtrümpyi* "shell of entirely the same build and general features as *trümpyi,* with similar dorsal and ventral sutures." The toothplate of the New Zealand specimens is the same as that in specimens from Mexico. None of the features mentioned by Finlay can be used to separate the New Zealand specimens from those from Mexico. The peripheral margin varies from rounded to subacute in specimens from both areas. No plano-convex New Zealand specimen has been seen by the writer; the dorsal surface varies from slightly to distinctly convex. Specimens from Mexico also have a flattened ventral boss. The similar outlines of specimens from both Mexico and New Zealand are shown in text figure 3.

Thirty specimens of *N. trümpyi* from the Aragon Formation of Mexico have been measured. The maximum diameter of the test in the measured specimens ranges from 0.333 mm. to 0.629 mm. and the height from 0.175 mm. to 0.342 mm.; the mean of the ratio diameter/height is 1.737. The number of chambers in the last whorl of 25 specimens has been counted; three have 6 chambers, twenty have 7 chambers and two have 8 chambers.



TEXT FIGURE 3

Comparison of outlines of specimens of *N. trümpyi* from Mexico and New Zealand. × about 15. 1-5. Specimens from Mexico. 6-10. Specimens from New Zealand.

Fifty specimens from New Zealand have also been measured. These specimens have a greater absolute size than those from Mexico. The maximum diameter ranges from 0.444 mm. to 0.814 mm. and the height from 0.278 mm. to 0.435 mm.; the mean of the ratio diameter/height is 1.781. A count of the number of chambers in the last whorl of 23 specimens gave thirteen specimens with 7 chambers, seven with 8 chambers and three with 9 chambers.

The diameter/height growth patterns of the specimens from Mexico and New Zealand have been compared by calculating the statistic z, using the method given by Imbrie (1956). Comparing the slope of the growth lines, the calculated value of z is 1.077, and therefore a significant difference cannot be demonstrated. A test for positional difference at a point where the distance between the growth lines approaches a maximum gave a value for z of 1.045, which again is not significant. Therefore, as far as the ratio diameter/height is concerned, there is no significant difference in the growth patterns of specimens from New Zealand and Mexico.

These statistical results, together with the observational data, lead the writer to regard *N. subtrümpyi* Finlay as a synonym of *N. trümpyi* (Nuttall).

Of the other species of *Nuttallides* described by Finlay (1940, 1947), the writer has not been able to observe a toothplate in *N. carinotrumpyi* or *N. tholus. N. carinotrumpyi* is a small form from the Paleocene and lower Eocene of New Zealand. *N. tholus,* occurring in the upper Senonian of New Zealand, is quite different from other species of *Nuttallides,* and would as stated by Finlay (1947) belong to another lineage of *Nuttallides.* This species was regarded by Finlay as the New Zealand representative of *Globorotalites micheliniana* (d'Orbigny), which Finlay (1940) referred to the genus *Nuttallides.* It seems probable that the species described by Finlay as *Nuttallides* *tholus* should not be placed in the genus *Nuttallides*. The species *N. cretatrumpyi* described by Finlay (1947) from beds regarded as Danian in age has the same type of toothplate as *N. trümpyi* (Nuttall).

Forms identified as *Eponides* sp. cf. *E. trumpyi* were recorded by Küpper (1956) from the Maestrichtian of the Gosau Basin.

The position of the species described as *Asterigerina crassaformis* by Cushman and Siegfus (1935) is uncertain. Bermudez (1952) did not recognize supplementary chambers in this species, and placed it in *Nuttallides*. Hofker (1956) again observed supplementary chambers, and referred the species to the genus *Asterigerinoides* Bermudez, 1952. Vertical sections of *Nuttallides trümpyi* are very similar to the vertical section shown by Hofker (1956, text-figure 66d), but the toothplate of *Nuttallides* does not extend completely across the chamber to form supplementary chambers.

Genus **Nuttallina** Belford, n. gen.

Type species.—Nuttallina coronula, n. sp.

Test trochoid, concavo-convex to biconvex, with the ventral surface the more strongly convex. Dorsal side evolute, ventral side involute, with a small open umbilicus. Periphery with a wide poreless keel. Test calcareous, chamber walls radiate hyaline, perforate on both dorsal and ventral sides; septal walls single, imperforate. Aperture ventral, at base of chamber, with a narrow lip, beginning just above the peripheral margin of the chamber and extending into the umbilicus. Each chamber with a toothplate extending diagonally across the chamber from the septal foramen towards the peripheral margin of the following septal wall.

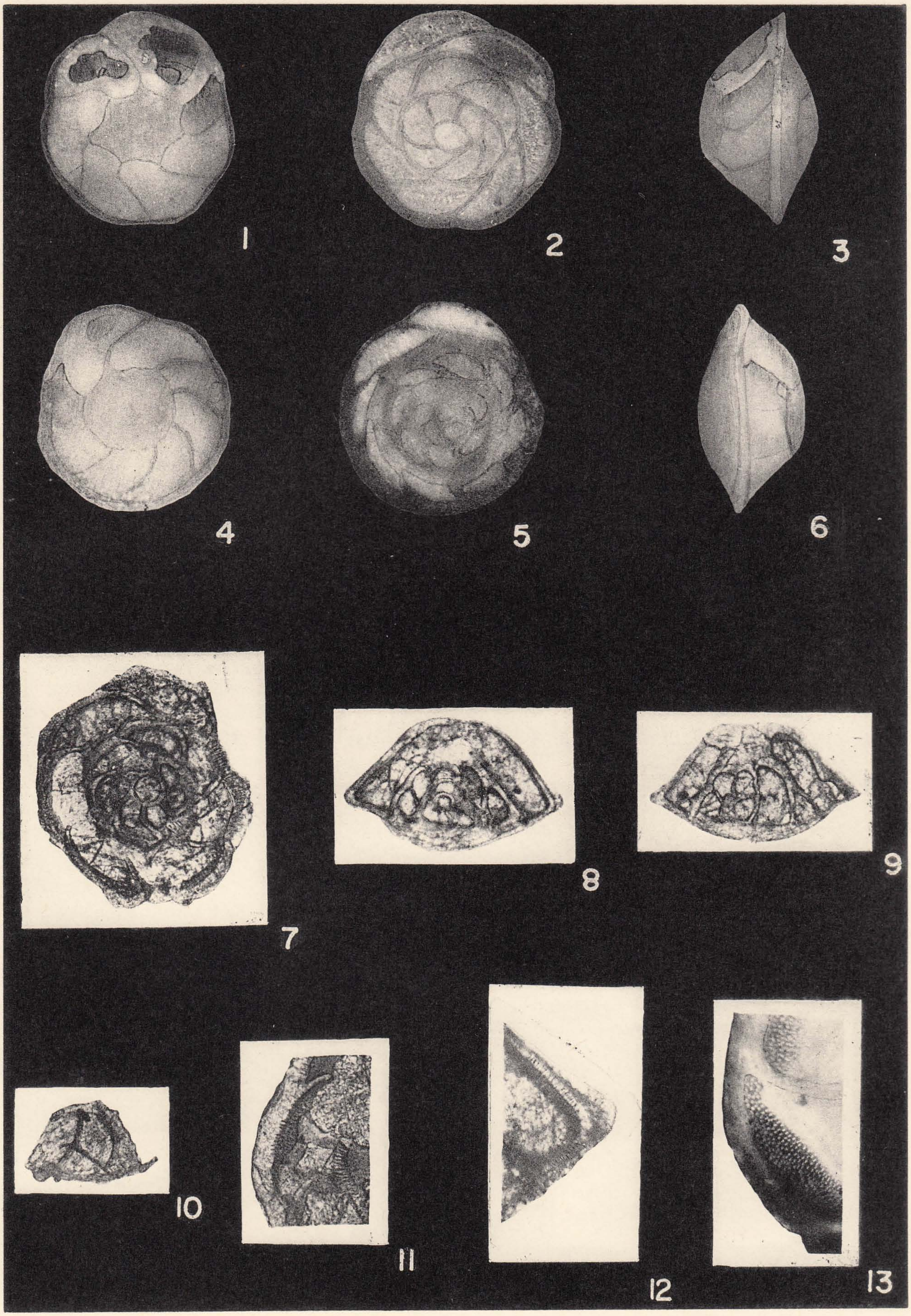
Remarks.—The genus *Nuttallina* is closely related to the genus *Nuttallides* Finlay, and is here included in the family Epistominidae. The toothplate of *Nuttallina* both in its point of origin and direction across the chamber is similar to that of *Nuttallides*, but in *Nuttallina* the toothplate has a strongly folded upper edge that has not been observed in *Nuttallides*. The aperture of *Nuttallina* is in some specimens bordered marginally by a small fold of the apertural face, and the ventral umbilicus may be partly covered by a small triangular lip. These features are not constant, and are therefore not included in the generic description. The aperture of *Nuttallina* is a deuteroforamen; the protoforamen has been strongly reduced, and there is no marginal groove or other feature to indicate its position. In Hofker's classification, this genus would also be placed in the suborder Biforaminata deuteroforaminata. The perforate radial shell wall, the single imperforate septal walls, the poreless margin and position of the toothplate are features common to both *Nuttallides* and *Nuttallina*. The ventral umbilicus of *Nuttallina*, the extension of the aperture into the umbilicus, and the nature of the toothplate separate the two genera.

The species described by White (1928) as *Gyroidina florealis* may belong to the genus *Nuttallina*. This species was recorded by Cushman (1946) as *Pulvinulinella ? florealis* (White), placed in *Nuttallides* by Bermudez (1952), and referred by de Civrieux (1952) to the genus *Osangularia*. According to Cushman (1946) the apertural characters of this species are difficult to determine, but other features are those of *Nuttallina*. Information on the internal structure, whether present or absent, and its nature if present, would assist in determining the relationships of this species.

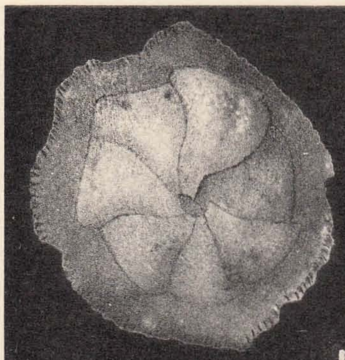
EXPLANATION OF PLATE 18

All figures are retouched photographs.
Magnifications are approximate.

FIGS.		PAGE
1-13.	*Nuttallides trümpyi* (Nuttall).	94
1-3.	Specimen from the Aragon Formation, Mexico (USNM No. 626138). × 60. 1. Ventral view with last two chambers opened, showing toothplates. 2. Dorsal view, specimen in xylol. 3. Side view, showing biconvex test and flattened ventral boss.	
4-6.	Specimen from New Zealand (NZGS No. TF1029/4). × 46. 4. Ventral view. 5. Dorsal view, specimen in xylol. 6. Edge view.	
7.	Horizontal section showing globular proloculus and perforations of test. (USNM No. 626139). × 60.	
8, 9.	Vertical sections showing biconvex test and flattened ventral boss. A toothplate may be seen in figure 9, and also the thickening of the chamber wall. (USNM Nos. 626140, 626141). × 60.	
10.	Section across one chamber showing the toothplate crossing from the septal foramen towards the marginal groove. (USNM No. 626142). × 60.	
11.	Part of horizontal section, showing perforate chamber wall, and imperforate margin and septal wall. (USNM No. 626143). × 110.	
12.	Part of vertical section shown in figure 8, showing poreless margin. × 110.	
13.	Part of dorsal view of specimen in figure 1, specimen in xylol. Showing the perforate chamber wall, imperforate margin and septal wall. × 250.	



Belford: *Nuttallides* Finlay and *Nuttallina*, n. gen.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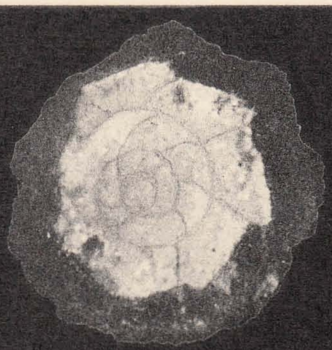
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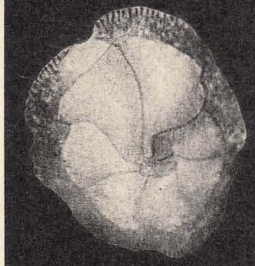
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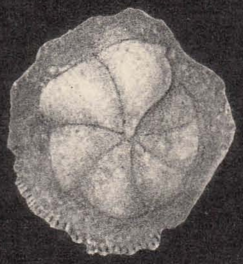
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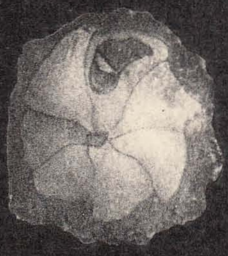
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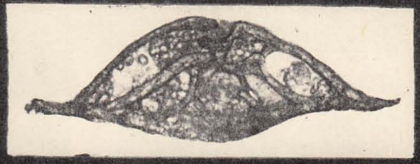
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14

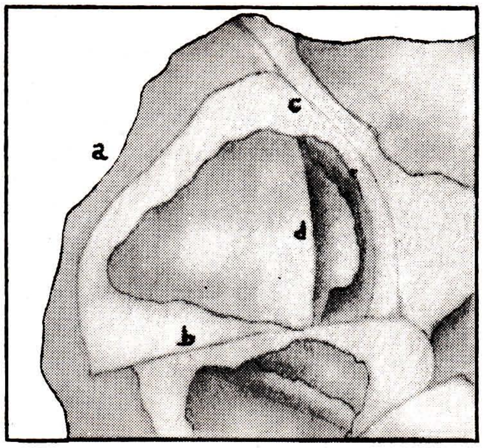
Belford: *Nuttallides* Finlay and *Nuttallina,* n. gen.

Nuttallina coronula Belford, n. sp.

Plate 19, figures 1-14

Diagnosis.—A somewhat depressed, concavo-convex to biconvex species, with a wide frilled poreless keel, sinuous ventral and reflexed dorsal sutures, small ventral umbilicus, and a folded toothplate in each chamber.

Description.—Test trochoid, somewhat depressed, concavo-convex to biconvex, with the ventral surface the more strongly convex. In specimens with a concave dorsal surface, the central part of the test is always raised. Periphery with a wide thin poreless frilled keel. Test calcareous, chamber walls radiate hyaline, finely perforate on both dorsal and ventral sides; septal walls single, imperforate. All chambers visible from the dorsal side, forming 3-3½ whorls, only those of the last whorl from the ventral side, with 6-7 chambers in the last whorl. Proloculus globular, chambers increasing slowly in size as added, with the proximal margin of each chamber extending beyond the distal margin of the previous chamber, giving a serrated appearance to the outline of the chambers. Ventral surface with a small open umbilicus, in some specimens (including the holotype) partly covered by a small triangular lip. Sutures on ventral side narrow, distinct, slightly depressed, sinuous. Sutures on dorsal side obscure on dry specimens, on moistened specimens seen to be straight or only slightly curved and strongly reflexed, the chambers long and narrow. Apertural face very low, aperture ventral, a narrow slit at the base of the chamber, with a small lip, extending from just above the peripheral margin of the chamber into the umbilicus, and in some specimens bordered marginally by a small fold of the apertural face. Each chamber with a well developed toothplate extending from the septal foramen diagonally across the floor of the chamber towards the peripheral margin of the following septal wall, in a direction which is often almost parallel to the suture. The toothplate begins on the septal foramen just below the umbilicus, and consists of a thin high ridge with the upper edge strongly folded towards the umbilicus (*see* text figure 4).



TEXT FIGURE 4

Nuttallina coronula, n. gen., n. sp. Paratype D. Internal view of chambers showing toothplates. a. Periphery of test. b, c. Proximal and distal chamber margins, respectively. d. Toothplate.

Dimensions.—

	Max. Diameter	*Height*
Holotype	0.722 mm.	0.204 mm.
Paratype A	0.592 mm.	0.167 mm.
Paratype B	0.537 mm.	0.148 mm.
Paratype C	0.555 mm.	0.204 mm.
Paratype D	0.481 mm.	0.194 mm.

Remarks.—The shape of this species in side view varies considerably, from concavo-convex to strongly biconvex. The holotype and two paratypes are plano-convex, one paratype is concavo-convex, and one biconvex. The small lip covering the umbilicus does not occur on all specimens, but possibly only the better preserved specimens show this feature. The folded upper edge of the toothplate is also not seen in all specimens. *Nuttallina coronula* is distinguished from the similar form described by White (1928) as *Gyroidina florealis* by its more compressed test, more

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EXPLANATION OF PLATE 19

All figures are retouched photographs.
Magnifications are approximate.

Figs.		Page
1-14.	*Nuttallina coronula,* n. gen., n. sp.	97
1-3.	Holotype (C.P.C. No. 1530). × 50. 1. Ventral view showing small lip over umbilicus, sinuous sutures and wide frilled keel. 2. Dorsal view, specimen in xylol, showing shape of chambers on dorsal side. 3. Edge view showing plano-convex test.	
4-5.	Paratype A (C.P.C. No. 1531). × 50. 4. Ventral view. 5. Edge view.	
6-7.	Paratype C (C.P.C. No. 1533) × 50. 6. Ventral view. 7. Edge view showing biconvex test.	
8.	Paratype B (C.P.C. No. 1532). × 50. Ventral view showing toothplate in penultimate chamber.	
9-14.	Vertical sections, × 54. Figs. 9-12 (C.P.C. Nos. 1535-1538) show the shape of the test, small ventral umbilicus, and the aperture extending into the umbilicus. Fig. 13 (C.P.C. No. 1539) shows the small umbilicus and a toothplate. Fig. 14 (C.P.C. No. 1540) is a thick section showing the toothplates of the last two chambers forming thin ridges in the chambers.	

sinuous ventral sutures and more strongly developed frilled keel.

The specific name is the Latin *coronula,* diminutive of *corona,* crown, halo, rim, border.

Occurrence.—Holotype (C. P. C. No. 1530) from outcrop of Toolonga Calcilutite, Pillarawa Hill, Murchison River area, Western Australia, from beds about 14 feet above base of the formation (Santonian). Paratype A (C. P. C. No. 1531) from same locality and level as holotype. Paratype B (C. P. C. No. 1532) from outcrop of Toolonga Calcilutite on scarp 1 mile south of Toolonga Point, Murchison River area, Western Australia, from beds 28 feet above base of the formation (lower Campanian). Paratype C (C. P. C. No. 1533) from outcrop of Korojon Calcarenite, 7 miles E.N.E. of No. 10 Bore, Cardabia, Western Australia, 38 feet above base of the formation (upper Campanian). Paratype D (C. P. C. No. 1534) from same locality and level as holotype. One vertical section (C. P. C. No. 1535) from same locality and level as holotype. Four vertical sections (C. P. C. Nos. 1536-1539) from outcrop of Toolonga Calcilutite on Meanarra Hill, Murchison River area, Western Australia. One vertical section (C. P. C. No. 1540) from same locality and level as Paratype C.

This species has been found in Western Australia in beds ranging in age from uppermost Santonian to upper Campanian. It occurs more frequently in the uppermost Santonian and lower Campanian beds of the Murchison River area.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME IX, PART 4, OCTOBER, 1958

188. ON THE ORGANIZATION OF FORAMINIFERAL COLLECTIONS[1]

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Servicio de Hidrografía Naval, Argentina

ABSTRACT

The organization of foraminiferal slides and samples in research laboratories is discussed.

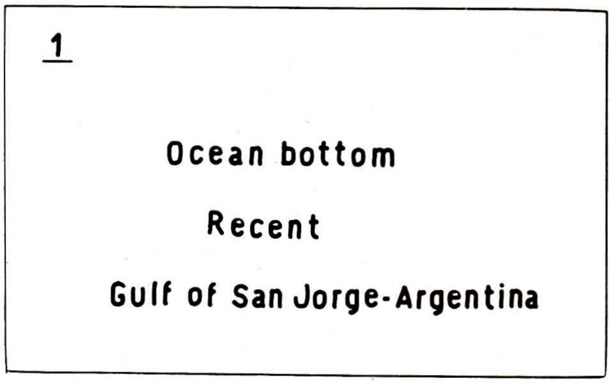
INTRODUCTION

The collections of any research laboratory are its material for daily reference, source of new investigation, and the basis for subsequent checking of published work. Their value is not only of local but of internationally scientific importance. Therefore, it is easily understandable that careful attention should be paid to their correct organization.

There are many publications dealing with the problems of laboratory equipment and methods of working. They describe different types of slides and the corresponding storage cabinets, installations for rapid washing, picking, etc., but I have not yet encountered advice and suggestions on the arrangement of collections. There are many details which at first appear to be unimportant but which, in reality, save much time and add to the convenience of the daily work of the student. This gap in the literature gives reason for the hope that this article will be of interest to some of my colleagues. It should be emphasized that the ideas expressed below are not the products of my own invention but are the results of an acquaintance with various laboratories in Europe, South America, and, thanks to the generosity of the John Simon Guggenheim Memorial Foundation, in the United States. My task was simply to select what I considered the best and describe it. Most of the recommendations come from the study of the organization of the collections of the United States National Museum (Washington, D. C.) which I consider one of the best. I am greatly indebted to Dr. A. R. Loeblich, formerly curator of the foraminiferal collections of this institution, for his valuable suggestions.

STORAGE OF SAMPLES

All samples received should be immediately catalogued, each being given a number and its own individual card. The best method is to have one series of catalogue numbers without any subdivision into categories such as fossil and Recent, cores and dredge samples, native or from abroad, and so on. With one series of catalogue numbers much space, trouble and time are saved. All numbers follow the order in which the samples are received and the samples should be stored according to their numerical order. All differentiations should be made not in the storage but on cards. These serve the purpose of locating the material needed as quickly and conveniently as possible. For this reason these cards should not bear any data except the catalogue number, name of stratum, age and locality, which can be placed in the order shown on Figure 1.



1

Ocean bottom

Recent

Gulf of San Jorge-Argentina

FIGURE 1

The cards should be separated first of all according to Recent and Fossil material. The card file of Recent material can be conveniently arranged according to the method of collection, either bottom samples or cores. The subsequent arrangement within each of these two types should be made on geographical lines. This can be done in different ways: by oceans and seas, or by latitude and longitude. Finer subdivisions can be made within the first of these by stating depth and/or geographical coordinates. As was emphasized above, the main aim of all these arrangements is the rapid location of the samples desired. Therefore, it is quite possible that details of the arrangement will need to be changed according to the special aims of the laboratories or the special character of the material.

The cards of the fossil material should be put in chronological order and within each geological division they should be preferably arranged in alphabetical order as to locality. If all these cards for fossil material are in one drawer it is better to have differently colored cards for each age.

In the case of a consulting company which takes charge of the samples of different oil companies, the

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[1] Comunicacion Miscelanea No. 1003, Departamento de Oceanografia, Servicio de Hidrografia Naval, Rep. Argentina.

Catalogue number	Name of stratum	Age	Locality	Collector	Original number given by collector	Date of collection	Short description of sample	Aproximate weight	Date of reception in laboratory	Remarks

FIGURE 2

cards may be filed alphabetically according to the company name. The cards of each company may be put alphabetically if each well has a name and a number, but if the well has no name but only a number it should be placed on a W-card (well) and then filed by number. Surface sample cards are filed separately from well cards using the same system.

As mentioned previously, little data are to be written on the cards. For all details concerning the samples there should be a special catalogue. This may be arranged in columns (*see* Figure 2). It is also very convenient to have a map or, even better, several where the approximate position of the sample is shown. These maps should, of course, be on a large scale. The red circles with the corresponding catalogue numbers put thereon would indicate the situation of every station (sample). For the exact position we can always consult our catalogue. These maps as supplementary aids to card files are excellent; they are very illustrative and help greatly in choosing the samples necessary for comparison or other tasks.

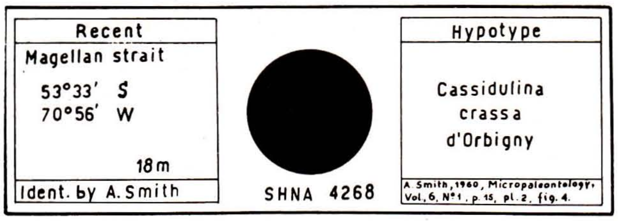
If time permits, it is very desirable to prepare washed material of all samples. For this purpose only a part of each sample should be used, the remainder being saved as a control for subsequent checking or investigation of other microfossils such as diatoms, Radiolaria, microforaminifera, etc. After washing through a sieve (generally with openings of 74 microns, unless the investigator has special needs) the residue should be put in a standard container, bottle, box, etc., marked with the same number as the original sample but with the added notation "washings" and stored separately from the washed material. The existence of a washed sample should be indicated on the card as well as in the catalogue.

STORAGE OF SPECIMENS

It is well known that different types of slides are used by workers to mount foraminiferal specimens and it is not my purpose to describe them here. Probably the most convenient and doubtless the most widely used type (in the western hemisphere) consists of three parts: a piece of cardboard (7.5 x 2.5 cm.) with a cavity in the center, a corresponding glass slide cover, and an aluminum holder. The so-called Franke-slide, without an aluminum holder and with a cover-glass instead of the glass slide, has the advantage of being cheaper and is also quite adequate. It is more used in European countries.

It is desirable that every laboratory possess slides of at least three kinds: 1. The so-called "single-hole slide" with a round cavity in the middle. This type is good for small and medium sized specimens; 2. The square hole slide with a large quadrangular cavity, which is appropriate for very large specimens; 3. The so-called "faunal slide" or "assemblage slide" with a field divided by cross lines into usually thirty or sixty small squares. This is appropriate for faunal assemblages, exchange of material, etc. It is best to have these various slides with varying depths, for instance, 1, 2, 3, and 4 mm.

Each slide should bear the following data referring to the contained specimens: name of collection, catalogue number, age, locality, name of form, donor or by whom the form is identified, and an indication of its being a type specimen if such is the case, together with the place of publication. It is convenient if the slide has prepared spaces for filling in this information and one such form is suggested here (*see* Figure 3).


Recent
Magellan strait
53°33' S
70°56' W
18m
Ident. by A. Smith

SHNA 4268

Hypotype
Cassidulina
crassa
d'Orbigny
A. Smith, 1960, Micropaleontology, Vol. 6, N°1, p. 15, pl. 2, fig. 4.

FIGURE 3

The locality is given as the name of a strait together with the latitude, longitude and depth. These can be conveniently abbreviated as shown. If the space does not permit their inclusion the latitude and longitude may be omitted but should be given in the catalogue. On the line above these data, in the upper left-hand corner, the age of the specimen is noted. If the specimens are fossil, it is desirable for the space where the age is written to be in different colors using those which are internationally assigned to the different geologic periods. Rather than painting in the appropriate color, it is more convenient to paste on a colored slip upon which the age can be written.

The lower left-hand corner is designed for the inscription concerning the collector or the person by whom the specimen was identified. This information is important since it enables the worker to obtain additional information if desired.

The upper right-hand corner should be left without any inscription if ordinary specimens are concerned, but if the specimen is a type this should be noted here. It is convenient to use different colors for the different kinds of types in this case also. The most useful "types" found in almost all collections are the following: 1. Holotypes and paratypes, so-called primary types. They can be marked by a red label; 2. Topotypes, which may be easily obtained by exchanging material. They can be indicated by a green label; 3. Hypotypes, which may also be called "plesiotypes" by some investigators and which include the specimens of which figures have been published. These can be indicated by a blue label. There are also other types

		Catalogue number
		Date
		Name
		Locality
		Collected by
		Identified by
		Received from
		Number of specimens
		Remarks

FIGURE 4

used by workers for which appropriate colors may be chosen. For types which have been figured, the reference, including plate and figure numbers, should be noted in the lower right-hand corner.

Each slide should be entered in a special catalogue which contains additional data to that included on the slide itself. The suggested columns of this catalogue are shown in Figure 4.

The arrangement of the slides in the cabinet can be according to: 1. Order of completed or published work. The species of a certain region or stratum are thus stored together. 2. Systematical. 3. Alphabetical.

The first method has the single advantage of presenting the whole fauna as it was studied. But if the collection contains specimens from many faunas it is extremely difficult to locate a certain species, especially so for visiting scientists.

Neither is the systematical arrangement very satisfactory. Each change in our very erratic systematics will necessitate a rearrangement of the slides which takes time and effort. In addition, as in the first case, it will be difficult for the visitor to locate a given species.

Alphabetical order is, without any doubt, the most convenient. Although we may mix our slides with those received from others, we can very quickly find the required species and a collection arranged in this way is more accessible for everyone. It is also advisable to separate benthonic and planktonic species.

If a species already represented in the collection is later transferred to another genus this can be indicated by placing a dummy slide giving the necessary synonymy in the new position.

In addition to the slides of individual species, it is desirable to prepare faunal slides to illustrate whole assemblages. These specimens are mounted on the "faunal slides" and, if possible, each species should be represented by a different number corresponding to its relative abundance. Such a faunal slide should be prepared for each stratum, if the laboratory also studies fossil forms.

In conclusion, it is suggested that each species slide contain as many specimens as possible because (1) it is always better to represent each species by all possible variations and (2) each laboratory should have some material for exchange since this is the best way to enrich collections and thus better our own knowledge and the quality of our work.

I can anticipate some objections. "Yes, all this is very fine, but it takes too much time which we cannot spare from our research!" I do not think that this argument is reasonable. By once taking a lot of time for organization of our collections we save a great deal of time and effort in the future. It is well known that correct organization facilitates any work greatly.

Possibly I have missed some details. I shall be grateful for all corrections and additions. The experience of many is always better than that of one worker.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME IX, PART 4, OCTOBER, 1958

189. *CINCORIOLA,* A NEW GENERIC NAME FOR *PUNJABIA* HAQUE, 1956[1]

A. F. M. MOHSENUL HAQUE
Pakistan

Dr. T. F. Banner of the British Petroleum Company Ltd., England, has kindly drawn my attention to the fact that the genus *Punjabia* Haque, 1956, is a homonym of *Punjabia* Eames, 1952 (Roy. Soc. London, Phil. Trans., ser. B, No. 631, vol. 236, p. 38), a genus of Gastropoda. I, therefore, propose *Cincoriola,* the new generic name in place of *Punjabia.*

The generic name *Cincoriola* is derived from cinco (five) and rio (rivers). The name *Punjabia* was also derived from a word meaning "five rivers," i.e. Punjab, a former province of West Pakistan.

The type species of *Cincoriola* is *Cincoriola ovoidea* = *Punjabia ovoidea* Haque, 1956 (Paleontologica Pakistanica, vol. 1, p. 152).

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[1] Published by permission of the Director, Geological Survey of Pakistan Quetta.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME IX, PART 4, OCTOBER, 1958

190. ECOLOGY AND LIFE ASSOCIATION OF FOSSIL ALGAE AND FORAMINIFERA IN A PENNSYLVANIAN LIMESTONE, McALESTER, OKLAHOMA[1]

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ABSTRACT

At a locality near McAlester, Oklahoma, the limestone cap rock of the Secor coal, Pennsylvanian, is associated with calcareous coal balls and has a sedimentary structure and fossil content that indicate a local cataclysm in deposition. Nodules of the limestone contain fossils of numerous, well preserved algae that served as supports for various species and genera of sessile Cornuspirinae. In the same nodules similar cornuspirid species are attached to productid brachiopod shells. The assemblage includes remains of echinoids, holothurians (?), and other marine organisms. Evidence indicates that originally the algae, foraminifers, and brachiopods belonged to the same community and that the algae are of marine origin; therefore this biota lived in shallow water and in the photic zone. Attachment of sessile cornuspirids to a perishable support such as sea weed is demonstrated for perhaps the first time in the fossil record and confirms earlier proposals by the writer that (a) free, unbroken specimens of sessile tolypamminids and cornuspirids were originally attached to perishable supports such as sea weed and (b) owing to possibility of rafting, occasional free specimens of sessile, shallow water forms alone can not be a reliable criterion of the depth of deposition of the sediment in which such foraminifers are preserved.

INTRODUCTION

In a coal mine south of McAlester, Oklahoma, nodules of marine limestone lie on and are intermixed with the upper layers of the Secor coal of Pennsylvanian age. Although the sedimentary succession of marine limestone above coal beds is a prevalent and characteristic feature of the Pennsylvanian rocks of the Mid-Continent and the Eastern Interior coal measures, intermixture of nodules of marine limestone with coal, which is a terrestrial deposit, indicates a disruption of the normal sequence.

The limestone nodules from this locality are unusually interesting in fossil content. All of those examined are calcareous and contain minute to large proportions of detritus of land plants, which range from fragments preserved as fusain (fossil charcoal) to entire organs that are impregnated by calcium carbonate and preserved in very fine detail. In a minority of the nodules, land plants are the only fossils found. In the majority, however, the land plant detritus is preserved in a matrix of marine limestone. In a few of the nodules, thalli of a new group of Algae (S. H. Mamay, personal communication, August 1957) were found in life association with marine foraminifers and productid brachiopods. Except for the minority of nodules whose fossil content consists exclusively of land plants, the floras and faunas in these nodules are depositional or post mortem aggregates of fossils that belonged to different environments.

Several properties of the fossils and limestone nodules have a significant bearing on the environment and history of the Secor coal and overlying rocks. This paper will deal particularly with the living habits and ecology of the algae and Foraminifera in the nodules and very briefly with the geologic meaning of this deposit.

ACKNOWLEDGMENTS

The contribution by Charles B. Read, U. S. Geological Survey, of the valuable collection on which this paper is based is gratefully acknowledged. The interpretation here adopted for the origin of these nodules is partly an extension of the theory proposed by Mamay and Yochelson (1953, p. 240-241; and personal communications, August, 1957) for the origin of coal balls. Criticism of the manuscript by S. H. Mamay, E. Yochelson, and Ruth Todd have resulted in clarifying a number of issues.

SOURCE OF THE COLLECTION

The following catalog entry gives the locality and stratigraphic source of the collection:

f12369b, 12/4/56, U.S.G.S. Collections of Foraminifera. (= U.S.G.S. Paleobotany Coll. 8764)

PENNSYLVANIAN.—Boggy shale, lower part. Limestone cap rock of the Secor coal.

OKLAHOMA.—Pittsburg County. Waste heap of the abandoned Lemont slope mine approximately 4 miles south-southeast from McAlester; near the common corner of sections 26, 27, 34 and 35, T. 5 N., R. 14 E. Collected by C. B. Read of the U. S. Geological Survey, 1939.

About a hundred and fifty nodules and chunks of limestone were collected by Read. Most of the collection consists of entire nodules but several pieces are chunks of limestone whose original source—whether from a nodule or a limestone bed—is not evident.

Mamay and Yochelson (oral communication, 1957)

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[1] Publication authorized by the Director, U. S. Geological Survey.

revisited this locality in 1956 in search of more material but found that the mine had been abandoned many years ago and filled. No other exposure of the Secor coal in this area showed the presence of a limestone cap rock. The mine owner, Mr. Joseph Lemont, informed Mamay and Yochelson that a limestone cap rock was encountered in the mine at the same place the coal balls were found in the coal bed. Hendricks (1937, pp. 62-63) described the Secor coal of this area but did not indicate the existence of a limestone cap rock at any of the exposures then extant. It is evident that marine limestone was only locally deposited above the coal, or if deposited, only locally preserved.

CONTENT OF THE COLLECTION

It is unfortunate that the sedimentary character of such an important fossil record is now inaccessible for direct study and analysis, but significant biological information is obtainable from it nevertheless. If the fossil content, the fossil associations, and the character of the enclosing limestone material are considered in the light of information on similar floras and faunas and rocks of similar character and history, the meaning of this collection for the environment and history of the time is materially enhanced. To provide such a background, the nodules will be described and the sedimentary history of similar rocks will be outlined before an analysis of the algal and foraminiferal association is presented.

A cursory microscopical survey of about 80 nodules was made to determine their floral and faunal content. For the survey, the nodules were sawed in two vertically, ground smooth with fine abrasive, and very lightly etched with hydrochloric acid to remove the abrasion frost. By immersing the etched surfaces with a thin film of water, the fossils could be seen with considerable clarity under the stereomicroscope.

The survey of the nodules revealed a large range of floral and faunal content that ranges from life associations to aggregates of fossils from different environments. In lieu of a comprehensive census of the species in each nodule, the types of association are described to indicate the ranges of their fossil content and the principal environments involved. Though a correlation seems to exist between the fossil content and the structure and petrology of the nodules, the divisions here employed are based on the kinds of fossil assemblages that they contain. It is to be emphasized the divisions are not a classification of the nodules as lithic bodies and that these divisions are intergradational, not discrete entities.

1. *Nodules with adherent coal, containing land plants (coal balls).*—Several nodules are irregularly shaped chunks of limestone bearing coalified plant stems and impressions of the plant debris that originally surrounded them when the sediment was in a plastic, unlithified state. Their interiors are crowded with the remains of land plants apparently to the exclusion of other fossils. The matrix is dark gray limestone and has a high content of disseminated pyrite. Adherent coal, surficial casts of plant stems, and high content of land plant debris indicate that these nodules are coal balls and that they came from the coal bed.

The fossil plants are preserved in the forms of angular fragments of mineral charcoal (fusain), more or less macerated and carbonized plant tissues, and calcareous petrifactions of parts and entire organs of plants.

2. *Nodules containing aggregates of marine mollusks and land plants.*—The fossil plant content of this type of nodule resembles that of type 1 above, but is relatively smaller in amount. No marine plants were recognized. The limestone containing this aggregate of fossils of land plants and marine animals is medium gray and contains less pyrite and carbonaceous matter than the coal balls. Pelecypod and gastropod shells are abundant and those above a certain size are broken but not appreciably abraded. The shell detritus in the nodule seems to have a slightly concentric or agglutinate arrangement.

3. *Nodules containing an aggregate of land plant detritus and marine fossils of different habitats.*—This type of nodule is more abundant than the other types combined. The remains of land plants are present in various but generally smaller amounts than in nodules of types 1 and 2. The mollusks that characterize type 2 are also present in small to large numbers, but, in addition, sessile cornuspirid foraminifers, brachiopods, echinoids (and perhaps other echinoderms), and ostracodes are found. The land plants, mollusks, and the foraminifer-brachiopod biota lived in different habitats and are normally preserved in different facies of sediments. The amount of pyrite and extent of replacement varies greatly but is commonly less than in nodules of type 2.

4. *Nodules containing a great predominance of marine algae and marine fauna.*—The nodules of this type contain only traces to minor amounts of land plant detritus. Except for the small and scattered fragments of fusain, the land plant material is more macerated than in the other types of nodules. The matrix consists of medium gray, carbonate silt with finely divided and more sparsely disseminated pyrite. Perhaps the two most striking features of these nodules are (a) the abundance of delicate but unbroken shells of sessile cornuspirid foraminifers that have been freed from their original supports, and (b) the presence of thalli of a new form of Algae (Mamay, personal communication, August 1957). The rest of the fauna is restricted in variety, but includes endothyrids

and fusulinids (both very rare), productid brachiopods, a phosphate shelled brachiopod (?), echinoids, crinoids, holothurians (?), pelecypods, gastropods, and ostracodes. Bottom dwelling foraminifers are very rare. This type of nodule differs from type 3 only in small degree.

It must be emphasized again that these four divisions are based on faunal and floral content.

Several of the nodules contain small burrows half a centimeter in diameter. It is notable that the burrow fillings are slightly lighter than the matrix and, in contrast with the matrix, the fossil content is smaller and the particles recognizable as fossils are broken. It is not yet determined whether borings were made before or after the nodular mass was formed.

The remainder of this paper deals principally with the fossils in nodules of the fourth type of which one nodule provided the finest material.

SEDIMENTARY ENVIRONMENT

Though the bedding structure and disposition of the nodular limestone and coal balls is not accessible for direct study, considerable information is available from other deposits of similar material and from the rock sequences that are prevalent in the coal measures of the province.

Marine sediments above or in immediate contact with the top of coal beds is a common sequence in the Pennsylvanian rocks of the Mid-Continent province and is especially characteristic of the Eastern Interior Coal Field. This order of succession is an integral feature of the kind of cyclothem described by Weller (1930, pp. 97-135) from the Pennsylvanian system of Illinois, which is here called the *Illinois cyclothem* to distinguish it from other kinds of cyclical or repetitious sequences that are found in sedimentary rock formations of other provinces and ages.

The Illinois cyclothem comprises a widely consistent, repetitious succession of rock types whose lithogeny records the environmental changes of the place and time in considerable detail. Various aspects of the lithogenesis, biology, and ecology of the sedimentary units in the Illinois and related kinds of cyclothems have been described by Weller (1930, pp. 97-135), Henbest (1935, pp. 511-513), Elias (1937, pp. 403-432), and Weller (1956, pp. 17-50; 1957, pp. 325-364) and will not be reviewed here. A very brief outline of the history of the parts of the cyclothem that are represented by the Secor coal and the deposit of nodules suffices to indicate the abnormality and significance of the deposit.

Table 1 lists the principal units in a typical Illinois cyclothem. Particular attention is directed to the fossil content and ecology of units J, K, A, and B, the interval represented by the Secor nodules. Regarding unit J, the conditions necessary for the accumulation of plant material in a peat bog include a deterrent to bacterial decay. Usually the deterrent is the stagnant toxic water of bogs or a climate of low temperature or a combination of both. The ancient Secor bog was located near sea level and in all probability was immersed in stagnant toxic water.

In the formation of the Illinois cyclothem, peat deposition ended with subsidence of the lowland and

Base of Cyclothem 3	Marine phase	A. Siltstone, calcareous; fissile shale; or carbonaceous siltstone. Marine or brackish water fossils.
Cyclothem 2	Terrestrial phase	K. Siltstone, local; fossils of aerial parts of plants.
		J. Coal, "bone" coal, carbonaceous siltstone.
		I. Underclay, "stigmarian" or root clay.
		H. Sandstone and siltstone, channeloid.
		(Cutouts at various levels, intraformational disconformities)
	Transitional	G. Siltstone, shaly; septarian concretion and marine mollusk zones.
	Marine phase	F. Limestone.
		E. Siltstone, marly to shaly.
		D. Limestone.
		C. Siltstone, shaly to marly.
		B. Limestone.
		A. Siltstone, calcareous; fissile shale; or carbonaceous siltstone. Marine or brackish water fossils.
Top of Cyclothem 1	Terrestrial phase	K. Siltstone, local, fossils of aerial parts of plants.
		J. Coal

TABLE 1

Lithic units in an Illinois cyclothem. As this is a simplified outline, the letter designations of the lithic units are intended only for the discussion in this paper. The cyclothemic boundaries and interpretation correspond to those proposed by this writer in 1935 (pp. 511-513).

swamps, accompanied by a rapid invasion of the sea. Locally, however, thin sheets of terrestrial siltstone were laid down on the peat bogs in advance of the marine invasion. Inasmuch as this terrestrial silt was deposited on low lying, swampy areas and was water logged, many of the plants buried in this alluvium were preserved and comprise the chief source of Pennsylvanian plant fossils. As the strand line advanced across the area, silt and plant material were locally eroded from units J and K and added to the detritus of silt and plant material being locally received from the land. The combined sediment accumulated to form unit A, the basal, marine to brackish water phase of cyclothemic deposition. Unit A, like unit K, was also local or rarely present in some cyclothems. Wherever units K and A were both absent, unit B was deposited directly on the peat. In many of such situations, limestone B shows none of the indications displayed by the Secor nodules of having been in contact with or immersed in the hydrogen sulfide-bearing water of the peat bog. The sediment and fauna in the nodules of types 3 and 4 correspond more nearly to that of limestone B in Table 1 than to any other unit in the cyclothem.

As the strand line advanced, a succession of marine environments migrated in its wake. Each environment was characterized by distinctive biota and sediments. Generally, each of those environments was separately recorded in the rock succession.

In contrast with the sequence just described, the deposit of nodules as a whole as well as many individual nodules from within and above the Secor coal contain aggregates of fossils and detritus that normally are separately preserved in units J, K, A, and B. It is also significant that the masses of limestone have a nodular and somewhat agglutinate structure and bear evidence of having been immersed as unlithified nodules in the waters of the ancient Secor peat bog.

Mamay and Yochelson (1953; personal communication, August, 1957) ascribe the origin of such mixtures of sediment and fossils to storm action. Their theory is supported by the evidence so far studied by this writer. About a half dozen deposits of such nodules have been found in the Pennsylvanian rocks of the Mid-Continent and the Eastern Interior provinces.

ALGAL AND FORAMINIFERAL ASSOCIATION

The nodule of type 4, whose fossil assemblage comprises the principal subject of this paper, was about 3½ cm. thick and slightly more than 10 cm. across. It was lenticular with rounded edges. A large part of the nodule was digested with formic acid by Mamay to free the algal thalli. A small part was reserved for sectioning.

The nodule consisted of a medium gray limestone of rather fine texture. A large part of its content consisted of minute algal thalli that were closely matted together but not deformed. The thalli were filled with calcite and were preserved in remarkable detail. The matrix was a fine, calcareous silt containing a variety of marine fossils.

The other nodules containing similar biota are similar lithologically but none were found to contain such an abundance of algae. The limestone contains finely disseminated pyrite and some of the ostracodes and other fossils are replaced with pyrite. Among the fossils, the replacement is taxonomically selective. The shells of *Endothyra* sp. (two specimens) and juvenaria of fusulinids (also very rare), and many of the mollusk shells were pyritized, but very few echinoid spines, Cornuspirinae, and algae were replaced.

The calcarenitic part of the nodule shows a vague concentric structure. Whether this slight concentricity is a result of agglutinate growth, differential compaction, or some other agent is not yet clear. Whatever origin is postulated, it should be noted that the carbonate silt contains delicate unbroken shells and very little fragmentary plant material. Almost all of the free foraminifer shells resemble those attached to the algal thalli. These conditions weigh against the idea that nodules of this kind are very large burrow fillings.

As indicated above, the fossils in this and similar nodules comprise depositional aggregates. In the aggregate of the nodule that contained the greatest abundance of algae and attached Foraminifera, at least two life associations can be identified. The components of the two life associations and the aggregate as a whole are listed as follows:

I Life association of Algae and attached Foraminifera:

1. Algae
2. *Calcitornella* sp.
3. *Calcivertella* sp.
4. Species of Cornuspirinae indeterminate in sections whether *Calcitornella, Calcivertella, Plummerinella,* or perhaps *Orthovertella.*

II Life association of Cornuspirinae and Productidae:

1. *Calcitornella* sp.
2. Species of Cornuspirinae indeterminate whether *Calcitornella, Calcivertella,* or a new genus homeomorphic with *Trepeilopsis* of the Tolypamminidae.
3. Species of Productidae, not generically identifiable in section.

III Aggregate of plant and animal fossils (entire fossil content of nodule):

1. Individual specimens of species in Items I and II above, including free, unbroken, and una-

braded shells of Opthalmidiidae like those attached to the algae (abundant).

2. Land plants (fragments of fusain and highly macerated tissues, amount small, detrital).
3. *Globivalvulina* sp. (rare).
4. *Endothyra* sp. (single specimen. Another specimen in a similar nodule).
5. Fusulinidae (immature, rare, none found in this nodule).
6. Productid shells and spines.
7. Gastropod shells.
8. Echinoid spines.
9. Holothurian ossicles (?).
10. Echinoderm ossicles of unidentified orders.
11. Ostracodes.

Certain other parts of the aggregate may represent life associations or dwellers in the same habitat, but are not definitely identifiable as such. One example of the attachment of a calcitornellid to an echinoid spine was recognized but with insufficient assurance to list. The marine fauna, excepting the mollusks, and the sediment correlates approximately with unit B, table 1.

LIVING HABITS OF THE FORAMINIFERS

Nearly all the foraminifers in this nodule are sessile forms of Cornuspirinae. These are characterized by a simple shell structure which consists of a proloculus followed by a long "undivided" tube. Both the proloculus and tube are invariably cemented to a support and the foundation layers conform to the topography of the support. The genera having such growth habit are especially characteristic of and abundant in faunas of shallow marine water.

In fertile waters, such sessile foraminifers grow on stones, metazoan invertebrate shells, or in masses and on top of each other. This shell form and attachment habit arose in at least two families of Foraminifera—the agglutinate shelled Tolypamminidae and the porcellaneous shelled Cornuspirinae (family Ophthalmidiidae). This growth habit has also developed into apparent symbiosis of sessile tubular foraminifers with algae as in *Osagia* and *Ottonosia.* Though phyletically distinct, the sessile genera of the Tolypamminidae and Ophthalmidiidae not only have a considerable diversity and number but show remarkable parallelisms in growth form and habit.

EVIDENCE ON ENVIRONMENT

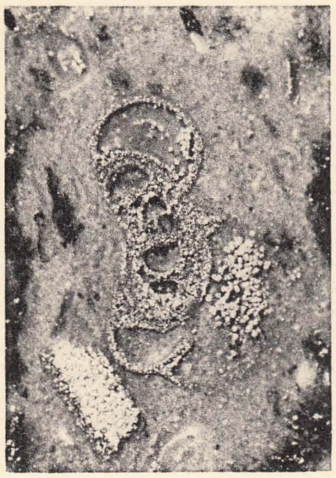
The observations cited above and those noted below in the discussion of the species and explanation of the illustrations give significant information on the environment of the biota and on the deposition of the limestone. The sessile cornuspirid foraminifers of Pennsylvanian and early Permian age are especially characteristic of marine communities inhabited by stony algae, bryozoans, and brachiopods and seem to have lived in or near the photic zone. The Cornuspirinae are exclusively marine dwellers. The presence in the same sample of similar species of cornuspirids attached both to productid shells and spines as well as to the algal thalli is additional indication that the algae are marine. With the possible exception of some species of the mollusks and ostracodes, the animal fossil assemblage in this nodule is composed of exclusively marine forms and seems to have belonged to the same community. The scattered algal and animal fossils in the detrital parts of the nodule show little or no break-

EXPLANATION OF PLATE 20

All figures are unretouched photographs. The specimens in figures 1 to 7 are exposed in half sections. The remainder are exposed in thin sections. All the photographs were made by lighting at an angle of about 20° above the plane of section, except figures 9, 11, and 13, which were made by normal bright field illumination with an apochromatic system, n.a. 0.65.

Figs. 1 to 7 inclusive, f-12369b (rock slice),	U.S.N.M. No. 40930
Figs. 8, 9, and 14, f-12369b (slide 2),	U.S.N.M. No. 40931
Figs. 10 to 11, f-12369b (slide 1),	U.S.N.M. No. 40932
Figs. 12 to 13, f-12369b (slide 3),	U.S.N.M. No. 40933

Figs.		Page
1.	*Endothyra* sp. × 50. Shell pyritized. Surface etched to low relief.	110
2, 14b.	*Calcivertella* sp. cfr. *C. adherens* Cushman and Waters. 2, × 70; 14b, × 50.	110
3, 5.	*Calcitornella*? sp. A. × 70. Specimens attached to productid spines.	110
4b, 6, 7, 14a.	*Calcitornella* sp. B. 4b, × 70, shell encloses edge and conforms to cellular topography of algal thallus. 6, × 50; 7, × 70, shells extend through the foramina of two algal thalli, fill the pores and spread out on each side. 14a, × 50, thallus partly enclosed by shell. In each example, the foundation layers of the foraminifera conform in detail to the surface of the support.	110
4a, 8-11.	New genus (?) aff. *Calcitornella.* 4a, × 70, attached to algal thallus. 8, × 50, free specimen, thin section. 9 same but × 100 and illuminated as a transparency. 10, × 70, free specimen, thin section. 11, same but × 200, illuminated as a transparency.	111
12-13.	Genus A aff. *Calcivertella.* 12, × 70, free specimen, thin section nearly in horizontal plane. 13, same but × 300 and illuminated as a transparency. Proloculus pyritized.	110
14c.	Genus B, aff. *Calcitornella* and *Plummerinella.* × 50.	111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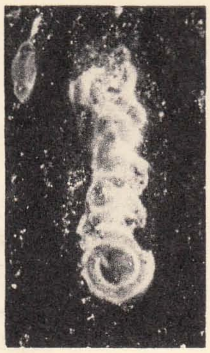
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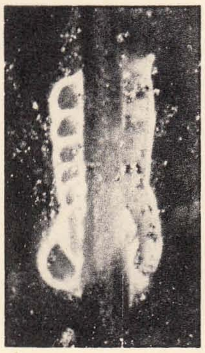
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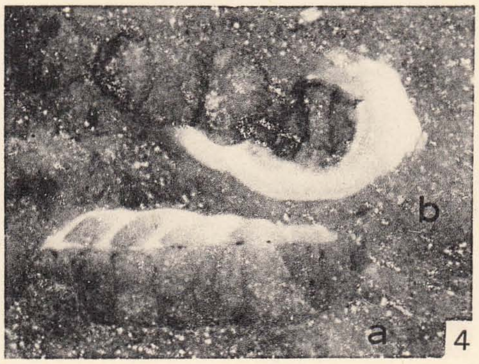

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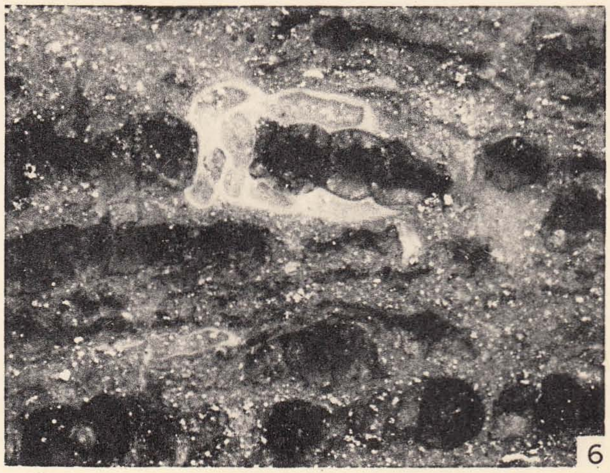
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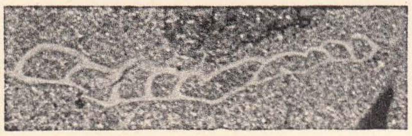
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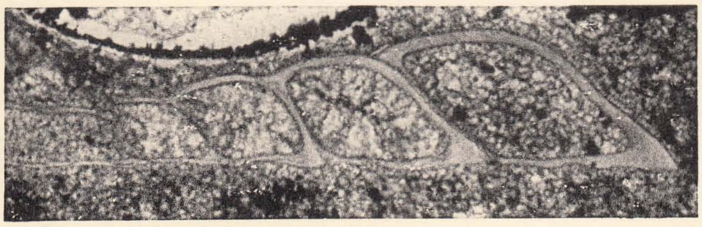
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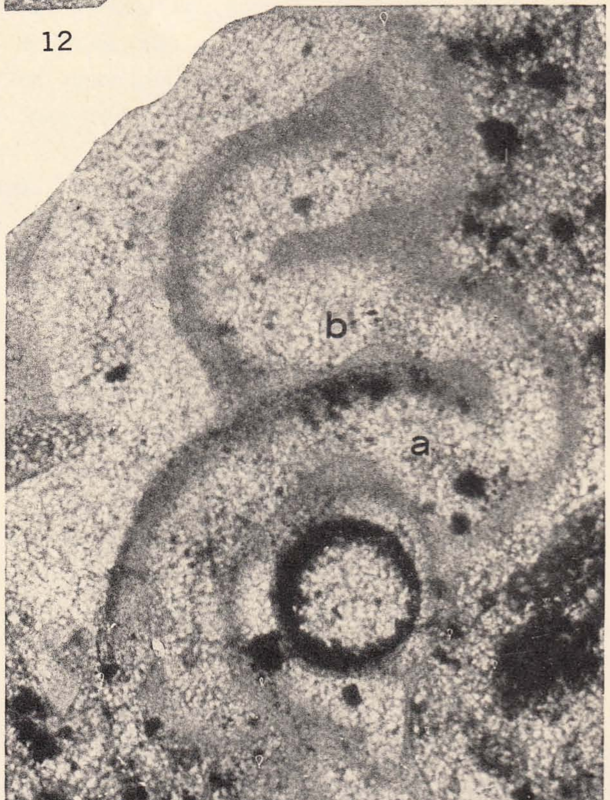

13

Henbest: Pennsylvanian Algae and Foraminifera, Oklahoma age or wear, though most of them, particularly the productids, have delicate spinose shells. This absence of breakage and attrition is additional reason for concluding that the marine shells were not transported as free specimens from the sea into a body of fresh water inhabited by the algae.

Instances from other localities of the attachment of *Serpulopsis* Girty, 1911, a sessile genus of the Tolypamminidae, to spore cases and to fragments of fusain were identified by this writer for Mamay and Yochelson (1953). These examples of the attachment of *Serpulopsis* to land plant detritus were found in lumps of marine limestone from within coal beds. No instances of attachment by tolypamminids or by cornuspirids to land plant detritus have been found in a cursory survey of the Secor limestone nodules, but the discovery of such attachment to fragments of fossil charcoal would not be surprising. The Tolypamminidae have agglutinate shells and, as most species depend on fine sand or silt grains for their shell aggregate, their habitat is probably determined by the source of supply; i. e., supports on or near the bottom. This suggests that the algae lived at a distance above the bottom.

A striking feature of this foraminiferal assemblage in the Secor nodules is the absence of sessile genera of Tolypamminidae and great rarity of bottom dwelling foraminifers of any kind. Their absence might be taken to suggest that the lowest stratum of water in which this marine sediment accumulated was stagnant and toxic. In opposition to this idea, however, it should be noted that productid brachiopods, echinoids, and perhaps holothurians were present in abundance. The problem here is complicated by the excellent and detailed preservation of the algal thalli. Some mode of quick fixation and prevention of decay was necessary to preserve the minute details of their cell structure. In summary, the algae, foraminifers, and metazoan invertebrates required well aerated water, but the nature of their preservation, lack of breakage and attrition, and segregation in nodules call for transportation in mass from the source of origin into a medium of quick fixation and preservation. Such a medium is provided in the stagnant and toxic waters of a peat bog like that which formed the Secor coal. A local cataclysm, such as suggested by Mamay and Yochelson (1953, pp. 240-242; and personal communication August, 1957) seems the most likely explanation for this complicated history.

A possibility that the algae were carried from fresh water into the sea and served post mortem as supports for the cornuspirid foraminifers also needs examination. The experiment of Stopes and Watson (1909, pp. 202-203) on the preservative character of sea water might be cited as support for such an interpretation. The conditions created by the Stopes and Watson experiment, however, were so artificial and peculiar that it is difficult to decide just what the experiment proved. The supposed preservative character of sea water was not demonstrated because the confined column of "fresh sea water" that they used was polluted by the other ingredients of the experiment and in a very few hours would have killed any ordinary marine flora and fauna that live as scavengers in well aerated sea water.

The life span of the sessile cornuspirids is not known, but such information as exists indicates a season or a minimum of several weeks. That microscopic details of the cell structure in these delicate algae would resist decay for more than a few hours or days if washed from fresh into normal sea water seems most unlikely.

A close association of living species of Foraminifera with marine algae has been repeatedly recognized (for example, Myers, 1943, p. 23). Abundant, free shells of living and extinct species of multilocular foraminifers such as *Rosalina, Cibicides,* and *Dyocibicides* show by their growth form that they lived in attachment to a support. Inasmuch as the fossil shells of these and similar genera are always free, the support was either perishable or the attachment was maintained by sarcode. Whether the attachment was permanent or optional is not clear, but the shell form indicates that it was a fixed habit of living. Live specimens of *Rosalina* may adhere so firmly to seaweed that they must be pried off with a needle for studying (Ruth Todd, oral communication, August 1957). So far as the writer is aware, the attachment of Foraminifera to soft-bodied algae, preserved in the cap rock of the Secor coal, are the first examples noted from the fossil record.

The association in the Secor coal cap rock has considerable ecologic significance. In the writer's experience, the sessile Foraminifera of late Paleozoic age are most abundant in association with pelecypods, brachiopods, and bryozoans whose sedimentary environment or whose associations with calcareous algae and algal-protozoan symbionts such as *Osagia* indicate growth in or very near the zone of light. The example of life association between the cornuspirids and algae from Oklahoma provides further and important evidence that these Cornuspirinae lived in the photic zone and explains the probable origin of most of the abundant free specimens of sessile Foraminifera in rocks of Devonian to Recent age.

ECOLOGIC SIGNIFICANCE OF FREE SPECIMENS OF SESSILE FORAMINIFERA

Many late Paleozoic limestones contain an abundance of tolypamminid and cornuspirid shells whose structure, like the example from Oklahoma, shows unmistakable evidence of permanent attachment habit but are preserved as free specimens. The former idea that such specimens were originally attached to hard objects such as shells or shell fragments and were freed by the attrition and destruction of their supports by wave action could be only a partial explanation. It did not explain the existence of free, unbroken shells whose delicacy, shape and fine preservation eliminated the possibility of their surviving the mechanical or chemical destruction of durable supports.

It was that combination of evidence that caused Love, Henbest, and Denson (1953, text column 4) to conclude that (a) the well preserved, free specimens of the sessile cornuspirids and tolypamminids were originally attached to perishable supports such as seaweed, (b) rafting to the locality of preservation was quite possible, and consequently (c) the presence in a limestone of rare or widely scattered, free shells of such shallow water, sessile foraminifers comprise an unsafe criterion for the depth of deposition.

CLASSIFICATION AND DESCRIPTION OF THE SECOR FORAMINIFERS

Most of the foraminifers in these nodules belong to sessile forms of the Cornuspirinae. The morphology and growth habits of such sessile foraminifers are variable. Consequently, generic and specific divisions are difficult to recognize where specimens can be viewed only in a single section. For this reason, specific names will not be applied to the foraminifers in the sections here illustrated.

Order FORAMINIFERA

Family LITUOLIDAE

Genus **Endothyra** Phillips, 1846

Endothyra Phillips, Geol. Poly. Soc., West Riding, Yorkshire, Rept., Proc. 1844-45 (1846), p. 277.—Brady, Paleontographical Soc., year 1876, pp. 92-6. —Henbest, Cushman Foundation, Foraminiferal Res., Contrib., vol. 4, pp. 63-65, 1953.

Endothyra sp.

Plate 20, figure 1

Two axial sections of pyritized shells were found. The shell consists of at least three volutions. The equatorial diameter is about 0.4 mm. The thickness at the axis is 0.1 mm. and at the largest chamber 0.14 mm. The species is umbilicate, skew coiled, and the foramen in the first volution has a semicircular shape. *Endothyra,* an extinct Mississippian to Triassic (?) form, was abundant in or near the photic zone. Its lower range in depth is unknown.

Family OPHTHALMIDIIDAE

Subfamily CORNUSPIRINAE

Genus **Calcivertella** Cushman and Waters, 1928

Calcivertella sp. cfr. **C. adherens** Cushman and Waters, 1928

Plate 20, figures 2 and 14b

The specimen illustrated lies between two algal thalli in an area containing little but mats of the algae. The specimens were originally attached but have subsequently been dislodged. Three stages of growth are shown, namely; *first,* the proloculus, *second,* the one spiral volution, and *third,* the regular zig-zag loops which effect a rudimentary sort of septation in the tube. It is not clear whether the tube takes a wandering course after the zig-zag stage (which would comprise a fourth stage of growth).

Genus A aff. **Calcivertella**

Plate 20, figures 12 and 13

The species shown in figures 12 and 13 is represented by a free specimen. The preservation is somewhat obscure, but a rudimentary septation of two kinds is discernible. One consists of levee-like ridges in two loops above the pyritized proloculus. The other consists, as in *Calcitornella* Cushman and Waters, 1928, of single layered partitions between zig-zag loops. This form resembles *Plummerinella* Cushman and Waters, 1928, to some extent but does not appear to have a regular spiral plan of growth.

Genus **Calcitornella** Cushman and Waters, 1928

Calcitornella? sp. A

Plate 20, figures 3 and 5

Several calcitornellid shells were found attached to the spines and shells of productids. The specimen illustrated by figure 3 suggests homeomorphy with genus *Trepeilopsis* Cushman and Waters, 1928 of the Tolypamminidae and may represent an undescribed genus. It is to be noted, however, that the tube does not seem to coil around the productid spine. The direction of growth on the right side seems to be parallel to the spine. The left side may actually be a longitudinal-vertical section through a zig-zag structure like that of the specimen in figure 2. If so, this would be classed as a species of *Calcivertella.* The cross section of *Calcitornella* (?) shown in figure 5 is attached to a brachiopod spine.

Calcitornella sp. B

Plate 20, figures 4b, 6, 7, 14a

In figure 4, two species may be represented. The upper specimen along with those in figures 6 and 7 are designated here as species B.

Each of these specimens is attached to algal thalli in ways that unmistakably indicate that the thallus served as the support for the foraminifer. The specimen in figure 4 conforms to the cellular topography and encloses the edge of the thallus. The specimens in figures 6 and 7 grow through a foramen in each thallus and spread out on both sides and also conform to the topography of the border cells. The evidence of original attachment and to a different part of a thallus is strikingly illustrated in figure 14A.

Genus b, aff. **Calcitornella** or **Plummerinella**

Plate 20, figure 14c

This free specimen has a kind of septae that differs from those so far demonstrated in *Calcitornella* Cushman and Waters, 1928, and *Plummerinella* Cushman and Waters, 1928. The septules seem to be pendant from the ceiling but may extend laterally into partitions that reach the floor. The foundation face (upper right) indicates original attachment to a support. The foundation layer is thin and, at places, the sarcode may have lain directly on the support, a condition occasionally found among species of *Apterrinella* Cushman and Waters, 1928, *Serpulopsis* Girty, 1911, and *Ammovertella* Cushman, 1928.

New Genus (?) aff. **Calcitornella**

Plate 20, figures 4a, 8-11

The lower specimen in figure 4 attached to an algal thallus, resembles the species in figures 8 to 11. This genus resembles *Cornuspira* Schultze, 1854, in its tendency for partly embracing planispiral volutions, but being an attached form, it is asymmetrical and has a prominently developed foundation structure on the side of attachment, which comprise significant differences from the free-growing symmetrical shell of *Cornuspira*. The photographs by reflected light, figures 4, 8, and 10, like those of figures 2, 3, 5, and 7 show the characteristic textureless appearance of porcellaneous shell walls in the cornuspirid Foraminifera. Figures 9 and 11 give details of the shells material as shown in thin section at high magnifications. No pores or granularity (not ascribable to secondary alteration) were seen.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME IX, PART 4, OCTOBER, 1958

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

ALEXANDROWICZ, S. Transgressive Miocene deposits in the Makoszowy Mine and their stratigraphic position (English summary of Polish text).—Acta Geol. Polonica, v. 8, No. 1, 1958, p. 149-178, pls. 24, 25, text figs. 1-6 (maps, sections), charts 1, 2 (distrib. and abundance tables).—Foraminifera listed and assemblages illustrated.

ARANA, TRINIDAD DEL PAN. Estudio de los Microforaminiferos miocénicos del Aljarafe (Sevilla).—Bol. Real Soc. Española Hist. Nat., secc. Geol., v. 55, No. 5, Año 1957 (1958), p. 131-186, pls. 5-8, text figs. 1-25 (map, sections, distrib. table, graphs).—Percentage composition by species is graphically shown for numerous levels.

ASANO, KIYOSHI. The Foraminifera from the Adjacent Seas of Japan, collected by the S. S. **Soyo-maru**, 1922-1930. Part 4, Buliminidae.—Sci. Repts. Tohoku Univ., 2nd ser. (Geol.), v. 29, 1958, p. 1-41, pls. 1-7, text figs. 1-4.—Sixty-four species and subspecies, 6 species and 1 subspecies new.

Some Paleogene smaller Foraminifera from Japan.—Sci. Repts. Tohoku Univ., 2nd ser. (Geol.), v. 29, 1958, p. 43-75, pls. 8-13, text figs. 1-12 (pl.), tables 1-3.—Six groups of new species from 3 Eocene and 3 Oligocene assemblages. Forty-one species and one subspecies, all new, described and illustrated; all but 4 having Asano and Murata as co-authors.

BARNARD, TOM. Some Mesozoic adherent Foraminifera.—Palaeontology (Pal. Assoc. London), v. 1, pt. 2, May 1958, p. 116-124, pls. 22-25, text figs. 1, 2.—Nine genera are discussed: 5 agglutinated (1 new), 1 imperforate calcareous, and 3 hyaline calcareous. An account is given of the evolution of **Bullopora** from Lower Lias to Upper Cretaceous. **Arenonina** gen. nov. (type species **A. cretacea** sp. nov.).

BERGQUIST, HARLAN R. Micropaleontologic study of the Umiat field, northern Alaska, **in** COLLINS, FLORENCE RUCKER.—U. S. Geol. Survey Prof. Paper 305-B, April 11, 1958, p. 199-204.—Occurrence of **Verneuilinoides borealis** faunal zone of Albian age, as well as of various species of Upper and Lower Cretaceous Foraminifera, in 11 test wells. Discussion of ages of formations.

Micropaleontologic study of the Gubik test wells, northern Alaska, **in** ROBINSON, FLORENCE M.—U. S. Geol. Survey Prof. Paper 305-C, April 2, 1958, p. 259-262.—Two wells penetrated some 500 feet of Upper and Lower Cretaceous. Formations are identified and their ages indicated by Foraminifera.

Micropaleontologic study of the Topagoruk test wells, northern Alaska, **in** COLLINS, FLORENCE RUCKER.—U. S. Geol. Survey Prof. Paper 305-D, April 28, 1958, p. 311-314.—Lower Cretaceous (from the **Verneuilinoides borealis** faunal zone), Upper Jurassic, and Triassic Foraminifera.

BOLLI, HANS M. The foraminiferal genera **Schackoina** Thalmann, emended, and **Leupoldina**, n. gen. in the Cretaceous of Trinidad, B.W.I.—Eclogae Geol. Helvetiae, v. 50, No. 2, 1957 (1958), p. 271-278, pls. 1, 2, text fig. 1 (geol. map).—**Schackoina** emended to include bulbous chamber extensions, and **Leupoldina** erected for forms with two or more protuberances symmetrically arranged on each side of the equatorial plane. **Leupoldina** n. gen. (type species **L. protuberans** n. sp.). Three new species and one new subspecies from the Lower Cretaceous.

BOLTOVSKOY, ESTEBAN. Problems in taxonomy and nomenclature exemplified by **Nonion affine** (Reuss).—Micropaleontology, v. 4, No. 2, April 1958, p. 193-200.—Four species and one variety found, on the basis of holotypes or topotypes, to be synonymous with **N. affine**, plus 13 lots of specimens illustrated under other names, extending the range from Eocene to Recent. Interesting discussion of infraspecific categories and basic laws of biology.

BRAZHNIKOVA, N. E., and JARTHEVA, M. V. K Voprosu Ob Ehvoljuthii Roda **Monotaxis**.—Voprosy Mikropaleontologii, vyp. 1, 1956, p. 62-68, pl. 1, text fig. 1 (evolution diagram).—Four new species described and illustrated, two in **Monotaxinoides** gen. nov. (genotype **M. transitorius** sp. nov.).

BRONNIMANN, PAUL. Morphology and stratigraphic significance of **Pseudorbitoides israelskyi** Vaughan and Cole.—Eclogae Geol. Helvetiae, v. 50, No. 2, 1957 (1958), p. 582-604, pls. 1, 2, text figs. 1-11.—Detailed re-study based on topotype and other material.

New Pseudorbitoididae from the Upper Cretaceous of Cuba, with remarks on encrusting Foraminifera.—Micropaleontology, v. 4, No. 2, April 1958, p. 165-178, pls. 1-7, text figs. 1-11.—Three new genera, 2 conical and 1 stellate: **Conorbitoides** (genotype **C. cristalensis** n. sp.), **Ctenorbitoides** (genotype **C. cardwelli** n. sp.), and **Aktinorbitoides** (genotype **A. browni** n. sp.). Associated fauna, including two species of encrusting Foraminifera intergrown with algae, suggest reefal to fore-reefal facies.

BRONNIMANN, PAUL, and BROWN, NOEL K., JR. "Taxonomy of the Globotruncanidae"—Remarks.—Micropaleontology, v. 4, No. 2, April 1958, p. 201-203.—Re-discussion of generic and specific relationships in this family.

CASTERAS, M., CUVILLIER, J., ARNOULD, M., BUROLLET, P. F., CLAVIER, B., and DUFAURE, P. Sur la présence du Jurassique supérieur et du Néocomien dans les Pyrénées Orientales et Centrales Françaises.—Bull. Soc. Hist. Nat. Toulouse, tome 92, fasc. 3-4, 1957, p. 297-347, pls. 1-14, text figs. 1-8.—Numerous Foraminifera listed and illustrated in sections.

CHANG, LI-SHO. Stratigraphy of Taiwan and its correlation with the adjacent areas.—Formosan Sci., v. 12, No. 1, March 1958, p. 13-28, geol. map, table 1 (correl. table).

CHANG, L. S., and YEN, T. P. The Oligocene Tawuan foraminiferal faunule from southern Taiwan.—Proc. Geol. Soc. China, No. 1, March 1958, p. 41-53, pls. 1-4, text fig. 1 (map), table 1.—Twenty-six species, 1 new and 10 indeterminate, are recorded and illustrated. Arenaceous forms and globigerinids comprise most of the faunule.

CICHA, IVAN. **Robulus meznericsae** n. sp. (Foraminifera, Protozoa) vom Burdigal des Vahgebietes (NW teil des Pannonischen Beckens).—Vestnik Ustredniho Ustavu Geol., roc. 33, cislo 1, 1958, p. 66-68, pl. 1.

CICHA, IVAN, PAULIK, JAROSLAV, and TEJKAL, JIRI. Bemerkungen zur stratigraphie des Miozäns des Südwestlichen Teiles des Ausserkarpatischen Beckens in Mähren (German summary of Czech text).—Sbornik Czech. Republic Ustred. Ustavu Geol., v. 23, ser. pal., 1956, p. 307-364, pls. 14-16, table.—Table lists occurrence and abundance of numerous Foraminifera. A few are illustrated.

COLE, W. STORRS. Names of and variation in certain American Larger Foraminifera—No. 1.—Bull. Am. Paleontology, v. 38, No. 170, March 28, 1958, p. 175-213, pls. 18-25.—Synonyms of 3 species of **Operculinoides** and of one species each of **Amphistegina, Lepidocyclina,** and **Asterocyclina** are listed and variations are illustrated. It is suggested that ecological variants may have been named as distinct species.

Larger Foraminifera from Carriacou, British West Indies.—Bull. Am. Paleontology, v. 38, No. 171, April 18, 1958, p. 215-233, pls. 26-29.—Fourteen species are illustrated from upper Eocene, upper Oligocene, and Miocene rocks. Discussion of synonyms of and variation in the Miocene species **Operculinoides cojimarensis.**

Names of and variation in certain American Larger Foraminifera, particularly the camerinids—No. 2.—Bull. Am. Paleontology, v. 38, No. 173, May 29, 1958, p. 257-284, pls. 32-34.—Review of 13 species, Paleocene to Miocene, in 5 genera. **Planocamerinoides** (type species **Nummulites exponens** Sowerby, 1840), new generic name for **Assilina** d'Orbigny, 1839, which is a synonym of **Operculina.**

CONKIN, JAMES E., and CONKIN, BARBARA M. Revision of the genus **Nummoloculina** and emendation of **Nummoloculina heimi** Bonet.—Micropaleontology, v. 4, No. 2, April 1958, p. 149-158, pl. 1, text figs. 1-25, tables 1-5.—Discoidal miliolid in thin sections of Lower Cretaceous limestones from Mexico, Texas, and Florida.

CRESPIN, IRENE. Microfossils from the south-west part of the Canning Basin, Western Australia.—Australia Bureau Min. Resources, Geol. and Geophys., Rept. No. 29, 1956, Appendix C, p. 54, 55.—Permian and Lower Cretaceous Foraminifera listed.

The occurrence of **Hantkenina** in Western Australia.—Micropaleontology, v. 4, No. 3, July 1958, p. 317-319, text figs. 1-5.—Two doubtfully identified species from middle to upper Eocene of a bore hole. Associated smaller Foraminifera are listed.

DIHDKOVS'KIJ, V. J. Do Pitannja Pro Fihlogenetichnij Rozvitok Rodu **Articulina.**—Akad. Nauk Ukrain. RSR, Geol. Zhurnal, tom 18, vyp. 1, 1958, p. 46-62, pls. 1-3, text figs. 1-5.—Five species of **Articulina,** 4 new, and 4 new subspecies.

DROOGER, C. W. Foraminiferen, **section in** Neue Helvétien-Faunen aus der Molasse zwischen Aare und Emme (Kt. Bern).—Mitteil. Naturforsch. Gesellschaft Bern, Neue Folge, Band 16, 1958, p. 7-10, pl. 1.—Four species illustrated, none new.

EMILIANI, CESARE. Temperature and age analysis of deep-sea cores.—Science, v. 125, No. 3244, March 1, 1957, p. 383-387, text figs. 1, 2 (graphs), tables 1-3.—Comparisons of results obtained by 3 different methods.

Ancient Temperatures.—Sci. American, Febr. 1958, p. 2-11, 3 photographs, 5 graphs, 3 maps.—Interesting account of use of oxygen isotopes.

Paleotemperature analysis of core 280 and Pleistocene correlations.—Jour. Geol., v. 66, No. 3, May 1958, p. 264-275, text figs. 1-5 (graphs), tables 1-3.—Paleotemperatures of the last 300,000 years of a core from the middle North Atlantic.

FALLOT, PAUL, DURAND DELGA, MICHEL, and MAGNÉ, JEAN. Datos sobre el Eocèno inferior del Rif Septentrional (Marruecos).—Notas y Comunicaciones Instit. Geol. Min. España, Año 1957, No. 48, p. 181-193, 1 photo (thin section).

FORMAN, McLAIN, J., and SCHLANGER, SEYMOUR O. Tertiary reef and associated limestone facies from Louisiana and Guam.—Jour. Geol., v. 65, No. 6, Nov. 1957, p. 611-627, pls. 1-8, text figs. 1-5.—Different types of Foraminifera are used in the recognition of facies of the reef complexes.

FRANCHINO, A. Il Flysch e la Scaglia della Brianza orientale tra Olginate e Cernusco Montevecchia.—Riv. Ital. Pal. Stratig., v. 64, No. 1, 1958, p. 47-64, pls. 3, 4, text figs. 1, 2 (map, columnar sections).—Lists of Foraminifera and thin section photographs from Upper Cretaceous and Paleocene.

FUKUTA, OSAMU. Upper Cretaceous Foraminifera from the Rumoi Coal Field, Hokkaido, Japan.—Geol. Survey Japan, Rept. No. 172, 1957, p. 1-17, pl. 1, text fig. 1 (map), tables 1-3.—Twenty-nine species, 2 new and 12 indeterminate, suggest correlation with Navarro or Taylor.

GUILLAUME, HENRI, and REICHEL, MANFRED. **Neotrocholina friburgensis** n. sp., foraminifère de l'Urgonien alpin.—Eclogae Geol. Helvetiae, v. 50, No. 2, 1957 (1958), p. 285-288, pl. 1, text figs. 1, 2.

HEDLEY, R. H., and UNDERWOOD, C. M. Living Foraminifera and empty shells from the North Kent Coast.—Ann. Mag. Nat. Hist., ser. 12, v. 10, Oct. 1957, p. 721-732, pl. 26, map.—Thirty-eight species recorded and some illustrated from 10 stations between 6 and 12 feet in depth. Sixteen of the species found living, as indicated by staining.

HOFKER, J. Foraminifera of the Dutch Hervian.—Meded. Geol. Stichting, n. ser., No. 10, 1956, p. 19-33, pl. 1, range chart, map.—Forty-six species, only 5 illustrated. The Hervian as represented in four mining shafts is subdivided into three parts.

Foraminifera from the Cretaceous of southern Limburg, Netherlands. XXIV. The development of **Pararotalia tuberculifera** (Reuss).—Natuurhist. Maandblad, 46^{e} Jrg., Nos. 3-4, April 26, 1957, p. 32-39, text figs. 1-18.—Description and illustrations of the three generations and evolution of the species from a **Globorotalia**-like ancestor. **Neorotalia** a synonym of **Pararotalia.**

XXV. Some more planctonic Foraminifera from the Lower Md in the quarry Curfs, Houthem.—Natuurhist. Maandblad, 46ᵉ Jrg., Nos. 5-6, June 28, 1957, p. 57, 58, text figs. 1-9.—Eight species of Dano-Paleocene age.

XXVI. **Globorotalia praetuberculifera** nov. spec.—Natuurhist. Maandblad, 46ᵉ Jrg., Nos. 5-6, June 28, 1957, p. 59-60, text figs.—The ancestral form of **Pararotalia tuberculifera** developed in the Cretaceous-Tertiary boundary.

XXVII. On **Karreria fallax** Rzehak.—Natuurhist. Maandblad, 46ᵉ Jrg., Nos. 7-8, August 30, 1957, p. 98-100, text figs. 1, 2.—A non-porous arenaceous species of the Danian and Paleocene, probably belonging in the Trochamminidae. Illustrations of primitive non-attached forms as well as the typical attached ones.

XXVIII. **Siphogenerinoides eleganta** Plummer.—Natuurhist. Maandblad, 46ᵉ Jrg., Nos. 7-8, August 30, 1957, p. 101, 102, text figs. A-E.—Occurs at Cretaceous-Tertiary boundary and is typical of Dano-Paleocene. Probable synonymity of **Loxostoma applinae.**

XXIX. **Praebulimina quadrata** Plummer.—Natuurhist. Maandblad, 46ᵉ Jrg., Nos. 7-8, August 30, 1957, p. 101-103, text figs.—Occurrence indicates Dano-Paleocene age of Chalk Tuff.

XXX. The development of **Rotorbinella mariei** (Van Bellen).—Natuurhist. Maandblad, 46ᵉ Jrg., Nos. 9-10, Oct. 31, 1957, p. 123, 124, text figs. 1, 2.—Increasing size and prominence of ornamentation of this tropical species in the Dano-Paleocene.

XXXI. **Textularia agglutissima** nov. spec.—Natuurhist. Maandblad, 46ᵉ Jrg., Nos. 11-12, Dec. 31, 1957, p. 149, text figs. 1, 2.—From the Cretaceous-Tertiary boundary.

Upper Cretaceous **Bolivinoides** guide forms.—Micropaleontology, v. 4, No. 3, July 1958, p. 329-334, pls. 1, 2.—Evolutionary development of 4 species (or subspecies) through a continuous sequence from lower Campanian to Maestrichtian in Belgium, based chiefly on number of pustules on the last-formed sutures.

JENKINS, D. GRAHAM. The true nature of **Bolivina hentyana** Chapman, 1916.—Micropaleontology, v. 4, No. 3, July 1958, p. 335, 336, text figs. 1-3.—An echinoid spine.

KANMERA, KAMETOSHI. Fusulinids from the Yayamadake Limestone of the Hikawa Valley, Kumamoto Prefecture, Kyushu, Japan. Part III. Fusulinids of the Lower Permian.—Mem. Fac. Sci., Kyushu Univ., ser. D, Geol., v. 6, No. 3, March 1958, p. 153-215, pls. 24-35, text fig. 3 (range chart), tables 1-19.—Twenty-seven species (6 species and 2 subspecies new and 2 indeterminate).

KAPTARENKO-CHERNOUSOVA, O. K. K Voprosu O Vidoobrazovanii I Sistematike Jurskikh Ehpistominid.—Voprosy Mikropaleontologii, vyp. 1, 1956, p. 49-61, pl. 1, text fig. 1 (evolution diagram).—Five genera, 3 of which are new: **Praelamarckina** gen. nov. (genotype **P. humilis** sp. nov.), **Lamarckella** gen. nov. (genotype **L. media** sp. nov.), and **Garantella** gen. nov. (genotype **G. rudia** sp. nov.). Illustrations, but no descriptions, of 28 species and varieties, all but 3 indicated to be new.

KOPETZKY, GOTTFRIED. Das Miozän zwischen Kainach und Lassnitz in Südweststeiermark.—Mitteil. Mus. Bergbau, Geol. und Technik Landes. "Joanneum," Graz, heft 18, 1957, p. 1-112, maps, section, distrib. table.—Occurrence and abundance of 146 species and varieties of Foraminifera in the Tortonian.

KRASHENINNIKOV, V. A. Mikrostruktura Stenki Nekotorykh Kajnozojskikh Foraminifer I Metodika Ee Izuchenija V Poljarizovannom Svete.—Voprosy Mikropaleontologii, vyp. 1, 1956, p. 37-48, pls. 1, 2, text fig. 1.—Study of calcareous wall sections under polarized light.

KUWANO, YUKIO. On the staining method for living Foraminifera (in Japanese with English summary).—Misc. Repts. Tokyo Research Instit. Nat. Resources, Nos. 41-42, Sept. 30, 1956, p. 67-75.—Criteria for recognizing living individuals in the dried state.

MAGNÉ, JEAN. Tableau des associations de microfaunes caractéristiques du Crétacé et du Tertiaire du Titteri (Appendix to **Chevilly, F. de, Kieken, M.,** and **Spengler, A. de**).—Publ. Serv. Carte Géol. Algérie (n. ser.), Bull. no. 8, 1956, p. 74-87.—Tabular listing of associated Foraminifera from Aptian to Miocene.

MAMONTOVA, E. V. Foraminifery Toarskikh Otlozhenij Na Severnom Sklone Bol'shogo Kavkaza (Kuban'-Laba) (in Russian).—Leningrad Univ., Uchenye Zapiski, No. 225, ser. Geol. Nauk, vyp. 9, 1957, p. 160-213, pls. 1-5.—Forty-one species (18 new and 2 new names) and 3 varieties (2 new) described and illustrated from the Jurassic. Nearly the entire fauna belongs in the Lagenidae.

MARIE, PIERRE. **Goupillaudina,** nouveau genre de Foraminifère du Crétacé supérieur.—Bull. Soc. Géol. France, sér. 6, tome 7, fasc. 6, 1957, p. 861-876, pl. 43, text figs. 1-4, table 1.—An operculinelliform genus of the Rotaliidae, found in littoral deposits in western Europe: **Goupillaudina** n. gen. (type species **G. daguini** n. sp.). Seven species, all but one new.

MARIE, PIERRE, and PERRIAUX, JACQUES. Contribution a l'étude de la microfaune des marnes plaisanciennes des Alpes-Maritimes.—Bull. Soc. Géol. France, sér. 6, tome 7, fasc. 6, 1957, p. 767-774, table 1 (distrib. table).—Foraminifera listed.

MAYNC, WOLF. Note sur **Pseudocyclammina jaccardi** et sa synonymie.—Revue de Micropaléontologie, v. 1, No. 1, June 1958, p. 9-16, pls. 1, 2.—**P. sequana,** as well as some other species and varieties, falls into synonymy with **P. jaccardi** (Schrodt) 1894. Illustrations of free specimens and thin sections.

M.-MACLAY, A. D. Nekotorye Fuzulinidy Permi Kryma (in Russian).—Leningrad Univ., Uchenye Zapiski, No. 225, ser. Geol. Nauk, vyp. 9, 1957, p. 93-159, pls. 1-14, tables 1-11.—Twenty-nine species (9 new and 1 indeterminate) in 15 genera (1 new): **Russiella** (type species **R. pulchra** n. sp.).

MONCHARMONT ZEI, MARIA. Foraminiferi e molluschi di un livello tirreniano presso Nova Siri Scalo (Matera).—Boll. Soc. Nat. Napoli, v. 66, 1957 (1958), p. 53-68, pls. 1-3, distrib. table.—Lists of species and photographs of two assemblages.

VAN MORKHOVEN, F. P. C. M. A simplified method of grinding Foraminifera.—Micropaleontology, v. 4, No. 2, April 1958, p. 209, 210, text fig. 1.—Grinding by frosted glass watched under the microscope.

NOUET, GILBERT, and NABOS, GENEVIÈVE. Sur l'Argovo-Rauracien de la région de Mamers et une espèce particulière de **Discorbis** qu'on y rencontre.—Soc. Géol. France C.R.S. séances No. 11, June 3, 1957, p. 216-219, text figs. a-f.—**Discorbis** described and illustrated but not named.

NYGREN, PAUL W. The Oquirrh formation. Stratigraphy of the lower portion in the type area and near Logan, Utah.—Utah Geol. Min. Survey, Bull. 61, Febr. 1958, p. 1-67 (mimeographed), pls. 1-4, text figs. 1-5, tables 1-3.—Fusulinids are used in age zonation.

PERRODON, ALAIN. Étude Géologique des Bassins Néogènes sublittoraux de l'Algérie Occidentale.—Publ. Serv. Carte Géol. Algérie, (n. sér.), Bull. No. 12, 1957, p. 1-328, pls. 1-7 (photographs), text pls. 1-4 (maps, sections), 96 text figs.—Zonation of Miocene based partly on smaller Foraminifera.

POBEDINA, V. M., VOROSHILOVA, A. G., RYBINA, O. I., and KUZNETSOVA, Z. V. Spravochnik Po Mikrofaune Sredne- i Verkhnemiotsenovykh Otlozhenij Azerbaidzhana.—Baku, 1956, p. 1-189, pls. 1-29, text figs. 1-22.—Numerous species of upper Tertiary age are illustrated from various horizons with their associated ostracodes and otoliths. About 35 new species and varieties of smaller Foraminifera are described and illustrated.

POZARYSKA, KRYSTYNA. Lagenidae du Crétacé Supérieur de Pologne.—Palaeontologia Polonica, No. 8, 1957, p. 1-190, pls. 1-27, text pls. 1-6, text figs. 1-45, range chart.—An important monograph. In the general part are included observations on facies relations, possible identity with described North American species, aberrant and regenerated individuals, modes of destruction of tests by other organisms, and some problems of the genera **Tribrachia, Lagena,** and **Cristellaria.** The systematic part is a well illustrated catalog of 195 species and subspecies (5 species and 3 subspecies new and 8 indeterminate, and 1 species given a new name) that are included in 23 genera. Stratigraphic range between Albian and Paleocene is graphically shown for all species.

REGGIORI, G. Gli affioramenti cretacei della zona nord-occidentale del Lago di Varese.—Riv. Ital. Pal. Stratig., v. 64, No. 1, 1958, p. 27-46, pls. 1, 2, text fig. 1 (map).—Lists of Foraminifera and thin-section photographs.

REJTLINGER, E. A. Novoe Semejstvo Lasiodiscidae.—Voprosy Mikropaleontologii, vyp. 1, 1956, p. 69-78, pls. 1, 2, text fig. 1 (evolution diagram).—**Eolasiodiscus** gen. nov. (genotype **E. donbassicus** sp. nov.) and the new family Lasiodiscidae erected.

RESIG, JOHANNA M. Ecology of Foraminifera of the Santa Cruz Basin, California.—Micropaleontology, v. 4, No. 3, July 1958, p. 287-308, text figs. 1-16 (maps, graphs, range charts, section, drawings), tables 1, 2. —Comparison of the restricted distribution ranges of living Foraminifera with the broader distribution ranges of empty tests of the same species in a deep submarine basin. Faunal criteria for recognition of sill depth. Two depth-temperature zones, separated at 350 fathoms, are recognized. Two new species are described.

SAID, RUSHDI, and BARAKAT, M. G. Jurassic microfossils from Gebel Maghara, Sinai, Egypt.—Micropaleontology, v. 4, No. 3, July 1958, p. 231-272, pls. 1-6, text figs. 1-5 (map, sections, microphotographs), table 1 (distribution and frequency table).—Descriptions and illustrations of 128 species of Foraminifera, 35 new and 23 indeterminate, from a 1900-foot section extending from Bajocian to Kimmeridgian. Two new genera: **Paleogaudryina** n. gen. (genotype **P. magharaensis** n. sp.) and **Arenovirgulina** n. gen. (genotype **A. aegyptiaca** n. sp.).

SAID, RUSHDI, and KAMEL, TOSSON. The distribution of Foraminifera in the Egyptian Mediterranean Coast.—Egyptian Journ. Geol., v. 1, No. 2, 1957, p. 143-155, text figs. 1, 2 (graphs), tables 1, 2.—An interesting paper in which is graphically represented the presence of 3 foraminiferal zones in beach deposits (i.e., (a) **Streblus,** (b) Miliolidae and Nonionidae, and (c) Peneroplidae and Amphisteginidae), the zones corresponding with the geomorphological zones of the 650 km. stretch of coast westward from the mouth of the Nile.

SAIDOVA, K. M. Kolichestvennoe Raspredelenie Foraminifer V Okhotskom More.—Doklady Akad. Nauk SSSR, tom 114, no. 6, 1957, p. 1302-1305, text figs. 1-3 (maps).

O Raspredelenii Foraminifer V Tolshche Osadkov Okhotskogo Morja.—Doklady Akad. Nauk SSSR, tom 115, no. 6, 1957, p. 1213-1216, text fig. 1 (map).

SANDON, H. Neglected animals—the Foraminifera.—New Biology, No. 24, (Penguin Books), Oct. 1957, p. 7-32, text figs. 1-4, pls. 2, 3.—Interesting observations on biology of Foraminifera.

SEIGLIE, GEORGE A. Notas sobre algunos foraminiferos planctónicos del Cretácico Superior de la cuenca de Jatibonico.—Mem. Soc. Cubana Hist. Nat., v. 24, No. 1, April 1958, p. 53-89, pls. 1-7, text figs. 1, 2 (maps).—Twenty species, none new.

SHCHEDRINA, Z. G. Itogi Izuchenija Fauny Foraminifer Morej SSSR.—Voprosy Mikropaleontologii, vyp. 1, 1956, p. 23-36.

SUMMERSON, C. H. Arenaceous Foraminifera from the Middle Devonian limestones of Ohio.—Journ. Pal., v. 32, No. 3, May 1958, p. 544-558, pls. 81, 82, text figs. 1-7.—From the Columbus limestone, interpreted as a warm and rather shallow environment, are described and illustrated 35 species, 18 new and 1 indeterminate, in 10 genera, 2 new: **Weikkoella** n. gen. (type species **W. spherica** n. sp.) in the Astrorhizidae and **Fairliella** n. gen. (type species **F. dicantha** n. sp.) in the Saccamminidae.

TAI, YOSHIRO. Microbiostratigraphical study of the Cenozoic strata of the Western Setouchi Province, Japan (in Japanese).—Geol. Rept. Hiroshima Univ., No. 5, March 1957, p. 1-58, tables 1-12, text figs. 1-4 (maps, columnar sections).—Correlation of foram faunules with Miocene lithologic units in five basins. Numerous tables give quantitative data on distribution and abundance of species.

TOLLMANN, A. Die Mikrofauna des Burdigal von Eggenburg (Niederösterreich).—Sitz. Österr. Akad. Wissenschaften, Math.-nat. Kl., Abt. I, Band 166, heft 3, 4, 1957, p. 165-213, pls. 1-7, text figs. 1, 2 (map, section).—Thirty-four species and subspecies of Foraminifera, 1 species and 1 subspecies new. Numerous additional species are listed.

TORIYAMA, RYUZO. Geology of Akiyoshi. Part III. Fusulinids of Akiyoshi.—Mem. Fac. Sci., Kyushu Univ., ser. D, Geol., v. 7, March 15, 1958, p. 1-264, pls. 1-48, charts 1, 2, text figs. 1, 2 (index map and correlation table), tables 1-95.—In the Pennsylvanian 21 species (5 new and 8 indeterminate) and in the Permian 80 species and varieties (17 species and 4 varieties new and 15 indeterminate).

VASICEK, MILOSLAV, and RUZICKA, BOHUSLAV. Namurian Foraminifera from the Ostrava-Karvina Coal District.—Prague Narodni Mus., Sbornik, v. 13-B, No. 5, 1957, p. 341-362, pls. 42-44, text figs. 1-4.—A Carboniferous fauna of smaller Foraminifera from which 4 new species and 1 new genus are described: **Cepekia** n. gen. (genotype **C. cepeki** n. sp.) in the Endothyridae.

VOLOSHINOVA, N. A. O Novoj Sistematike Nonionid. Vvedenie.—Trudy Vses. Neft. Nauch.-issl. Razved. Instit., vyp. 115, 1958, p. 117-191, pls. 1-16, text figs. 1-3.—A reclassification in which Nonionidae with 3 subfamilies (Nonioninae, Nonionellinae subfam. n., and Melonisinae subfam. n.) is separated from Elphidiidae with 2 subfamilies (Elphidiinae and Cribroelphidiinae subfam. n.). In the Nonionidae are included 11 genera, 2 new: **Porosononion** Putrja gen. n. (type species **Nonionina subgranosa** Egger) and **Nonionellina** gen. n. (type species **Nonionina labradorica** Dawson). In the Elphidiidae are included 8 genera, 3 new and 1 new subgenus: **Faujasinella** gen. n. (type species **Elphidium semiinvoluta** Mjatliuk), **Planoelphidium** gen. n. (type species **Polystomella laminata** Terquem), **Porosorotalia** gen. n. (type species **Notorotalia clarki** Voloshinova), and **Rimelphidium** subgen. n. of **Cribroelphidium** (type species **Elphidium vulgare** var. **vulgare** Voloshinova). Three Montfort genera (**Florilus, Melonis,** and **Cellanthus**) are reinstated. Thirty-nine species and varieties are discussed, 11 new and 2 new names. Figures of these and others are included, illustrating the genera discussed.

ZAKHAROVA, L. V. Stratigrafija Verkhnemelovykh Otlozhenij Groznenskoj Oblasti, Severnoj Osetii I Kabardy.—Akad. Nauk SSSR, Trudy Geol. Mus. im A. P. Karpinskogo, vyp. 1, 1957, p. 34-83, text figs. 1, 2 (map, columnar sections), tables 1-7.

ZINONI, A. Microfaune Plioceniche del Golfo di Orosei (Sardegna).—Riv. Ital. Pal. Stratig., v. 64, No. 1, 1958, p. 65-74, pl. 5.—Lists of species from 3 rich sublittoral samples of Pliocene age from Sardinia.

Correction: In reviewing HOFKER, JAN, Foraminiferen der Oberkreide von Nordwestdeutschland und Holland: Beih. Geol. Jahrb., Heft 27, Dec. 1957, p. 1-464, text figs. 1-495, the genotype of **Angulogavelinella** was erroneously quoted as **Rosalina lorneiana** d'Orbigny instead of correctly as **Discorbina gracilis** Marsson.

RUTH TODD

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