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The Foraminifera of the Lias Series in Jutland, Denmark

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Foraminifererne i Lias Serien i Jylland

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Preface

The abundance of fossils has permitted a detailed subdivision of the Lias Series in NW Europe and presents excellent possibilities for both local and long-range correlations. These deposits are thus ideal for demonstration of the value of index fossils as well as for the study of the validity of the method as the subdivision at several places has been carried beyond the limit of error for the purpose of correlation. The results of these very detailed studies show that index fossils often are valid indicators of geologic time, but that the vertical ranges of single species nevertheless may differ considerably from place to place. It is thus evident that safe correlations cannot be based on single specimens of index fossils, but that the whole fauna should be considered, irrespective of how well the vertical range of the index species has been examined at the key section. The amount of megafossils – obtained by sampling of drilled wells – is, however, usually insufficient for these studies. Such samples may, nevertheless, supply ample material for the examination of microfossils, which under these circumstances supply valuable contributions to the subdivision and correlation of the penetrated sections. No wonder that micropaleontologic studies have gained supremacy in such cases over all other methods of correlation during the last decades, and it can hardly be doubted that further exploration within this field may yield even better results in the future.

The present publication is intended as a description of the microfossils in the beds which according to the microfauna and the megafossils were referred to the Lias and penetrated by wild-cat wells drilled in Jutland. The Lias outcrops in Bornholm and the occurrence in the two Skagen wells have not been considered, as no microfossils have been extracted of samples from these localities. The stratigraphic nomenclature recommended by the Stratigraphic Commission of The American Association of Petroleum Geologists has been strictly adhered to and has given rise to some nomenclatural difficulties. Thus the type localities of the various Lias Stages are to be found in France and England. But the microfauna of the Yorkshire Lias has unfortunately not been further examined since the famous publication by Tate & Blake in 1876. The present author has for this reason refrained from direct correlation over the long distance to the Dorset Coast, but has preferred correlations over the much smaller distance to the Lias Series of NW Germany described in such detail by Franke (1936) and Bartenstein & Brand (1937). The German subdivisions – Lias Alpha, Beta, Gamma, Delta, Epsilon and Zeta – have thus been adopted as time-stratigraphic unities and considered as preliminary stage names. In accordance with general practice Lias Alpha and Beta are considered Lower Lias, Gamma and Delta Middle Lias, and Epsilon and Zeta Upper Lias. Roughly speaking Lias Alpha corresponds to the Hettangian Stage and includes the lower part of the Sinemurian Stage; Lias Gamma partly to the Pliensbachian Stage; and Lias Delta generally to the Domerian Stage.

In the records of the various species the following terms have been used:

rare,	corresponds	to	1– 5	specimens
scarce,	–	–	6–10	–
common,	–	–	11–30	–
abundant,	–	–	over 30	specimens

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I. Abstract

The foraminiferal fauna of the Danish Lias Series is described in the present publication. This series is mainly deposited in a large basin between the Funen-Falster Uplift and the Scandinavian Shield. The deposits along the southern border are unknown; along the northern shore the Höganäs Formation was deposited. The three wells, Gassum No. 1, Vinding No. 1 and Vejrum No. 1 are located in the middle part of the basin, where the Lias Series consists of a sequence of marine beds including at least the Lias Alpha, Beta, Gamma and Delta. The microfauna of these beds is very similar to that described from equivalent beds in Germany, France and England, and though an emersion of the Funen-Falster Uplift presumably has taken place during the Lias epoch, the Danish basin has probably been interconnected with the German and English basins.

The microfauna of these beds can be divided into the following supergroups, the *Geinitzina tenera group,* the *Spandelina bicostata* group, the *Nodosaria – Pseudoglandulina* supergroup, the *Marginulina radiata* supergroup, and the *Marginulinopsis matutina* supergroup. Besides the various species and subspecies of these supergroups the following species have been observed, *Eoguttulina liassica, "Frondicularia" nitida, "Bolivina" liasica,* and *Lamarckina nov. sp.* With the exception of the *Nodosaria – Pseudoglandulina* supergroup the other supergroups consist of one or more phylogenetic lines. Previous authors have been greatly troubled by the fact that distinct limits do not occur between the various species, and even in some cases between the various genera in each of the supergroups. As a matter of fact these supergroups appear to be phylogenetic unities in which the genetic stock shows a gradual evolution through time along one or several different phylogenetic lines which may be traced by the presence of passage forms.

Geinitzina tenera group. The species and subspecies of this group have previously been referred to the genus *Frondicularia* by some authors, and to the genus *Lingulina* by others. The similarity of the Lias forms to these two genera, however, seems to be due to convergence, and owing to the absence of pores and probably a true radiate aperture these forms have been referred to the genus *Geinitzina* of the Nodosinellidae. The genus is only known from the Paleozoic era but evidently a few forms survived and are to be found in the Jurassic. The group consists of two phylogenetic lines, the *G. tenera tenera* line and the *G. tenera pupa* line. In both lines the phylogenetic trend seems to be toward nodosarian types. This is attained in *G. tenera subprismatica* of the former line by accentuation of the marginal keel and the two median ribs at the cost of the additional ribs and by a more rounded section. *G. tenera subprismatica,* however, is a short-lived form with restricted vertical distribution and is an excellent index fossil for the Lias Beta and Gamma. In the *G. tenera pupa* line a similar result is arrived at in a different way, namely by the equal development of all the ribs.

Spandelina bicostata group. The forms in this group have by previous students been referred to the genus *Frondicularia.* As was the case with *Geinitzina tenera* the similarity is probably due to convergence, and these species and subspecies are for the very same reasons referred to the genus *Spandelina* in the family Nodosinellidae. The phylogenetic trend is a gradual reduction of the ribs from the fully costate *S. bicostata sulcata* of the Lias Alpha to the completely smooth *S. bicostata terquemi* in the Lias Gamma and Delta.

Nodosaria – Pseudoglandulina supergroup. This group does not show any noticeable evolution during the Lias. The species are evidently stabilized and

conservative and thus of little value as index fossils, but most probably they will appear to be valuable indicators of facies.

Marginulina radiata supergroup. The ancestral form is *Marginulina radiata* from which the *Dentalina matutina*, the *Marginulina prima*, the *Marginulinopsis radiata* and the *Planularia inaequistriata* lines probably branched off. The trend of evolution is a gradual increase in coiling of the initial end, parallel to the phylogenetic trend in the *Marginulinopsis matutina* supergroup. However, the evolution of the *Marginulina radiata* supergroup is delayed if compared to the *Marginulinopsis matutina* supergroup. Thus the *Lenticulina* stage is already reached in the Lias Gamma by the latter group.

Margulinopsis matutina supergroup. This supergroup is presumably at a higher stage of evolution than the above-mentioned supergroup, and the presence of fewer passage forms in the supergroup in question is in accordance with this assumption. The *Marginulinopsis matutina* supergroup is supposed to consist of three phylogenetic groups, the *Vaginulina listi* line, the *Marginulinopsis prima* line and the *Lenticulina gottingensis* line. A common ancestral form is supposed, but is unknown and probably extinct before the Lias epoch.

In all coiled species the microspheric form is evidently more coiled than the corresponding megalospheric form. Thus the conclusions arrived at by application of the biogenetic law of recapitulation are distinctly at variance with the observed phylogeny.

The examination of the Lias forms has revealed that all the Nodosariidae seem to have radiate apertures. Due to the apparent lack of such an aperture and the difference in the wall texture the species – previously referred to *Frondicularia* and *Lingulina* – are in this publication referred to the genera *Geinitzina* and *Spandelina* of the Nodosinellidae. Contrary to common belief the Nodosariidae of the Lias Series are considered a primitive group in rapid evolution. This especially applies to the *Marginulina radiata* supergroup and the *Marginulinopsis matutina* supergroup, while the species of *Nodosaria* and *Pseudoglandulina* appear to have been stabilized already at the beginning of the Lias. It is for this reason concluded that the genus *Nodosaria* is derived from the Nodosinellidae and is the oldest genus of the Nodosariidae. The phylogenetic trends in the family Nodosariidae are thus the change from a central aperture to a marginal position of the aperture and the subsequent progress in coiling. According to these characters the family is then subdivided into the following subfamilies, the Nodosariinae with the genera *Nodosaria* and *Pseudoglandulina*, the Marginulinae with the closely related genera *Dentalina*, *Marginulina* and *Vaginulina* and the Lenticulinae with the genera *Vaginulinopsis*, *Marginulinopsis*, *Saracenaria* and *Lenticulina*. The genus *Robulus* does not occur in the Lias, and it is thus an unsolved question whether this and related forms should be referred to another subfamily. No species have been observed which can be referred to the family Enantiomorphinidae, but the Polymorphinidae are represented by the species *Eoguttulina liassica*. It is for this reason considered doubtful that the Enantiomorphinidae should represent the passage from the Nodosariidae to the Polymorphinidae.

II. Introduction

Ever since the Permian Denmark has been an area of more or less slow subsidence, but the movement has been differential and at least during the Permian, Triassic and Jurassic the subsidence proceeded at a faster rate north and south of an area running, largely, from Ringkøbing through Jutland, Funen and Falster, the Funen–Falster Uplift. The rate of deposition was rapid, at least during the Triassic; it seems to have kept pace with the rate of subsidence. Thus the great marine transgression in the Rhaetic appears to have extended over a surface with very slight differences in elevation, and the Rhaetic Series therefore consists of a monotonous sequence of gray sand- and siltstones and dark-colored shales. Owing to the lack of microfossils the beds of the supposed Rhaetic age in Northern Jutland cannot be biostratigraphically subdivided; but in the southern part of the country sufficient material has been extracted from the cores to allow a correlation of the various wells with the Rhaetic Series of Germany. Roughly speaking the Rhaetic Series of Rødby No. 1 can be subdivided into three lithologic zones, 1) the upper, dark shales, 2) the middle, sandy and silty beds and, 3) the lower, argillaceous and calcareous beds. In the upper shales a number of megaspores with a circular fold has been observed similar to the type in Germany described by WICHER (1938, 1951) and considered as a good index fossil for the upper part of the Rhaetic. The middle zone is barren. In the lower zone ostracods are found in abundance. These ostracods have been referred to *Darwinula sp.* WICHER (1951). Megaspores of the above-mentioned type have not been observed in any of the other wells, but *Darwinula sp.* is found accompanied by other ostracods in the lower parts of the Rhaetic of Ullerslev No. 1 and Gassum No. 1. Of particular interest is the occurrence of a thin, oolitic bed in Rødby No. 1 at the depth of 2302′, in the zone with ostracods. Such thin oolites have been observed in the zones with similar ostracods in Ullerslev No. 1 as well as in Gassum No. 1 and can probably be correlated as below.

	Rødby No. 1	Ullerslev No. 1	Gassum No. 1
Depth	2302′ (701.7 m)	3156′–3158′ (961.9–962.6 m)	5571′–5577′ (1698.0–1699.9 m)

According to the above facts there seems to be little difference between the beds referred to the Rhaetic epoch, at Rødby No. 1 (on the southern flank of the axis), at Ullerslev No. 1 (on the northern flank of the axis) and in Gassum No. 1 (north of the axis), and the inference is thus drawn that the Rhaetic transgression encroached on a completely peneplaned surface.

The balance between the rates of subsidence and of deposition was evidently disturbed during the Lias epoch; probably owing to a decrease in the amount of deposition. It seems pretty likely that the Funen–Falster Uplift at least partly has divided the area into two different basins of deposition. This conclusion is drawn from the Lias deposits in Rødby No. 1, which according to the microfauna are found in a shallow-water facies. Thus the present facts seem to indicate that the Danish Lias basin has been, at least partly, separated from the German Lias basins by the Funen–Falster Uplift. The similarities in both the mega- and microfaunas of the various basins in Northern Europe, however, are considered to justify the conclusion that all the basins have been interconnected irrespective of the presence of the various axes.

As mentioned above Rødby No. 1 is situated on the southern flank of the uplift, and the sequence penetrated thus represents the marginal deposits of the North German Lias basin. The southern margin of the Danish Lias basin is unknown, as the wells Vejrum No. 1, Vinding No. 1 and Gassum No. 1 evidently are located in the deeper parts of the Danish basin. Børglum No. 1, Frederikshavn No. 1, 2 and 3 and Haldager No. 1 are evidently placed at the northern margin of the Danish basin. The sequence, penetrated by these wells, is largely limnic, and these beds are similar to the Swedish Höganäs Formation.

Marine Lias Alpha and Beta are found in Vejrum No. 1 and Vinding No. 1, while marine Lias Gamma and Lias Delta further occur in Gassum No. 1. Vejrum No. 1 is located on the top of the Vejrum saltdome and thus almost no paleo-geographic conclusions can be drawn from this occurrence, except that marine Lower Lias has been deposited at this location. Both Vinding No. 1 and Gassum No. 1 are placed on local uplifts, probably caused by flowage in the deep-seated Permian salt beds, and the thickness observed is thus probably only the minimum thickness. It is accordingly dangerous to draw too many ecologic conclusions from the microfaunas observed in these beds. Any conclusions about the depth of the basin, the ecology, the exact and the comparative thickness of the various stages and the possible occurrence of stages, not present in the wells, can thus only be drawn with extreme caution; they will probably have to be corrected if more wells are drilled in this basin in the future. The only safe conclusion is that a Liassic basin of no small size existed in the northern part of Denmark; that this basin was probably, at least partly, closed towards south by the Funen–Falster axis but, nevertheless, interconnected with the German and English basins; the coastal deposits along the southern margin are still undiscovered, while marginal, partly limnic, beds are known from Vendsyssel. The greatest extension of the basin was reached by the Lias Gamma transgression, and marine beds of this age are found among the limnic beds in the northern part of the country. Thus these beds are by and large equivalent to the Swedish Höganäs Formation. No definite indication of a greater depth of the basin in the Lias Gamma has been observed in Gassum No 1.

In conformity with the above-mentioned facts little attention has in this publication been paid to the paleo-geographic and paleo-ecologic conditions of the Lias Series, but evidently the assumably fairly shallow Liassic basins, formed in Northern Europe after the great Rhaetic transgression, provided an "ecologic niche" for the evolution of the rather peculiar Liassic microfauna. This fauna is thus supposed to be provincial, and in this "ecologic niche" it had excellent possibilities of evolution; thus several phylogenetic lines may be traced from a few, rather primitive forms in the lowermost part of the Lias Alpha to considerably more advanced ones in the Lias Delta. It will probably be difficult to trace the further development of these lines owing to the evidently poor living conditions presented by the environment in the Lias Epsilon which seems to be barren over the largest part of Northern Europe. When living conditions improved in the Lias Zeta a microfauna, in most respects greatly differing from the microfauna of the Lower and Middle Lias, invaded the basin and in many cases seems to have continued through most of the Dogger, but marine beds of Upper Lias and Dogger ages with a prolific microfauna have never been encountered in the Jurassic beds of Denmark.

As the various Lias basins have been interconnected it further seems reasonable to believe that a similar evolutionary process has taken place over the whole area. Accordingly it is assumed that the various evolutionary stages have upper and lower limits which are more parallel with geologic time than most other events and thus appear excellent for correlation within each individual basin as well as between the various basins. The microfauna of the Lias Series outside Europe is practically unknown, a regrettable fact as the clue to the understanding of the evolution of the biserial forms and the Polymorphinidae as well as the oldest forms of the Ceratobuliminidae may be found in these beds. Thus the forms – belonging to these groups – occur sporadically only in the Lias Series of Northern Europe, and their evolution is consequently supposed to have taken place mainly in other "ecologic niches" than those known at the present time.

III. Historical Review

The very first records of foraminifera from the Lias are given by H. E. STRICKLAND in 1846. Under his examination of the bedding surfaces of the Lower Lias shale from Wainlode Cliff and Cleeve Bank he observed small white dots, which under the microscope were disclosed to be tests of foraminifera. Two species were described, namely *Orbis infimus* and *Polymorphina liassica*. Both species are not uncommon in the Lias and have later been recorded by other students though the latter was referred to the genus *Eoguttulina*, while some confusion reigned as to the correct classification of the former species. Thus BLAKE in TATE & BLAKE (1876) referred the form to *Cornuspira*, and FRANKE (1936) referred it to *Ammodiscus*. BARNARD (1950) records the species from Southern England and classifies it as *Spirillina infima*, which is in better harmony with the original description.

In the "Prodrome de paléontologie stratigraphique universelle des animaux mollusque et rayonnés" D'ORBIGNY (1849) reports several foraminifera from the Lias of France. The fauna list consists of 18 species, which of course at that time were all new. In the publication D'ORBIGNY gives a short diagnosis of every species, though unfortunately without any type figures. It is thus a piece of good luck that MACFADYEN succeeded in finding the holotypes, which are preserved in the "Muséum National d'Histoire Naturelle de Paris". MACFADYEN (1936) redescribes and illustrates these holotypes with a thorough discussion of the various conditions concerning his very interesting discovery, first of all a verification of the genuineness of these holotypes. According to his description a few specimens of each species are enclosed in a slide prepared by two glass plates glued together. Each slide has two labels, the upper one giving the name of the species and the lower one the locality, namely Lias Moyen, Metz. Thus MACFADYEN arrives at the following conclusion: "I consider that these slides may be accepted as containing the types of the species for the following reasons. The serial numbers, names, localities and Lias age written on the labels are those of the 'Prodrome' in each case, in what appears to be the early handwriting of Terquem, who originally communicated the specimens to d'Orbigny. Seventeen species out of eighteen originally described were found together in company with other slides unquestionably belonging to d'Orbigny, in a part of the Muséum National d'Histoire Naturelle in Paris, an entirely likely resting place for the types. The seventeen characteristic slides are found by themselves, with none other like them. Clearly not of modern make they differ completely from d'Orbigny's cardboard slides. They were probably, I think, made by Terquem, whose facility in making very neat and somewhat similar slides is attested by the great numbers of them now to be found in many museums in France." It will probably appear very fortunate to every micropaleontologist who examines MACFADYEN's excellent analysis of this problem that the slides mentioned have been discovered by such an eminent student of the foraminifera, and it is to be hoped that his examination of this subjects in every respect will be adopted as a guide by all other students in similar cases. Both the publications by STRICKLAND and D'ORBIGNY contained more or less accidental observations of a rather restricted number of foraminifera from the Lias; the first real examinations of a complete Lias microfauna was given by J. B. BORNEMANN in his dissertation published in 1854. BORNEMANN's idea was to give a detailed lithologic description of the Lias Series in the vicinity of Göttingen in Germany as well as a detailed description of the fossils. Besides the megafossils he described 33 species of foraminifera. What makes BORNEMANN's dissertation particularly valuable is the fact that it not only contains thorough descriptions and figures of the species mentioned, but that the further records the beds which contain foraminifera and especially mentions the corresponding megafossils that make a pretty exact dating of the age of the microfauna possible. The Lias Series at Göttingen rests on varicolored marls and sandstones belonging to the Keuper Series. The lowermost beds of the Lias Series consist of bluish gray, nonfossiliferous clay interbedded with argillaceous limestone and shaly sandstone. On top of these beds is found brown shale with *Gryphaea arcuata,* and owing to the occurrence of *Schlotheimia angulata* and *Arietites bucklandi,* these beds can be referred to the angulata and bucklandi zones of the upper Lias Alpha.

The Lias Alpha is covered by nonfossiliferous shale, and above that occur the Belemnite Beds which contain the microfauna described. In these beds are found *Aegoceras capricornu* and *Aegoceras davoei,* which are important index fossils for the Lias Gamma. The Belemnite Beds with the microfauna are covered by a bed of bluish gray clay with *Amaltheus amaltheus* and *Amaltheus costata,* both important index fossils for the Lias Delta. The uppermost bed of the section is the Posidonian Shale, which is conventionally referred to the Lias Epsilon. It is thus evident that the whole fauna described by BORNEMANN belongs to the Lias Gamma. All the forms observed are described as new species for the very obvious reason that BORNEMANN has been unable to compare his fauna with that from the Middle Lias of Metz as the fauna described by D'ORBIGNY was not illustrated. BORNEMANN, however, compares the number of species of every genus found at Göttingen and Metz, and states that obviously there is some similarity between the faunas from these two places. Such a comparion is, of course, rather dangerous, and as a matter of fact these two faunas have less in common than BORNEMANN seemed to believe. Thus only *Marginulina rugosa* BORN. (= *prima* D'ORB.) and *Vaginulina hausmanni* BORN. (= *Frondicularia terquemi* D'ORB.) occur at both places, while *Dentalina matutina* is not recorded from Göttingen. The presence of *Frondicularia terquemi* and *Frondicularia bicostata* (including *Frondicularia baueri*) at Metz probably indicates a Lias Delta age of these beds, while the Lias Gamma at Göttingen contains *Frondicularia sulcata* and *Frondicularia dubia.* Although the publications of Lias foraminifera by D'ORBIGNY and BORNEMANN precede those of O. TERQUEM, the latter should naturally be considered the true father of our knowledge of the Lias microfauna. The reasons for this statement are first of all the very considerable extent of his survey covering all subdivisions of the Lias, as well as the very great number of new species described by him combined with the fact that the specimens, first described by D'ORBIGNY, were originally handed down by TERQUEM. Thus the influence of this zealous student can hardly be overestimated and will certainly be felt for a good many years to come. With an interest and enthusiasm, which are contagious to the reader, he describes a considerable number of localities, subdivides and correlates the beds, describes and illustrates the microfauna of every bed, discusses the similarities and dissimilarities between the Lias fauna and the faunas at that time known from the Cretaceous and the Tertiary, and compares all these faunas with the recent faunas of the Mediterranean and other seas. It cannot be denied that his ideas may appear old-fashioned to the student of today, but nobody will surely read his famous "Mémoires" without admiring his astonishing energy. As a pioneer in the field and at a time where the concept of the species was very vaguely defined, he erects a multitude of new species which for his successors have created serious difficulties, as a considerable number of them may only be individual variants of forms previously described. Although his descriptions are accompanied by numerous and carefully drawn illustrations, the identification of his species is very much hampered by a multitude of small inexactitudes probably in many cases caused by the ineffective microscope. According to his own statement it seems as if his examinations were made by means of an ordinary, monocular microscope with a magnifying power of not more than twenty times. It is thus obvious that a redescription of his holotypes would be of the greatest significance for the future evaluation of the Lias microfauna and that it is a necessity at the present moment to be more than usually cautious if we try to compare the Lias microfaunas from elsewhere with the faunas described by TERQUEM. It is, moreover, evident that the identification of the species, originally described in his "Mémoires", is difficult owing to the small size of his figures, drawn and examined through an ineffective microscope with too low power.

Inspired by the publications of D'ORBIGNY, BORNEMANN and TERQUEM, J. KÜBLER & H. ZWINGLI (1870) made a survey of the microfauna in the Jurassic of Switzerland. The rocks belonging to the Jurassic System of Switzerland are generally difficult to prepare, which is probably the reason of the rather small number of forms recorded from the Lias. From beds, which the authors refer to the Lias Beta, they record a total number of 18 species, while no foraminifera were observed in the Middle Lias, and 5 species are recorded from beds referred to the Posidonian Shale of the Lias Epsilon. All forms mentioned by the authors are described as new species, and as all specimens pictured are embedded in balsam, it is very difficult to decipher their illustrations. The microfauna of the Lias Series in Switzerland has further been described by R. HAEUSLER (1881) who reports the presence of 157 species from the Aargauer Limestone. Of these species HAEUSLER reports that only 61 were confined to the Aargauer Limestone, while 48 occur in the equivalent sediments of Western Switzerland and England. The comparison of the fauna collected by HAEUSLER with other microfaunas is, however, difficult as about 18 species only are recorded from the Lower Lias, and all these species are new ones. In 1887 R. HAEUSLER published some additional remarks on the microfauna of the Swiss Jurassic; one on the Miliolidae and another on the species referred to the genus *Lagena*.

BORNEMANN's work in Germany was continued by O. BURBACH who in 1886 published an examination of a Middle Lias fauna from Grossen Seeberg at Gotha. The Lias at this place rests on the Rhaetic and consists of fine-grained sandstone from the Lias Alpha covered by shale, marl and limestone from the Lias Beta and Gamma. On top of these beds is found the Amaltheus Clay of Lias Delta age which carries the microfauna described. After the death of BURBACH, F. DREYER continued the examination and the rest of the fauna was published as a joint publication in 1888. A considerable number of species is reported in these papers. Most of the forms are referred to species previously known, in many cases to Cretaceous and Tertiary species; comparatively few of them are new. Although the descriptions are very thorough and accompanied by excellent illustrations, these publications are of little interest to the stratigrapher as the specimens described are embedded in balsam, and for that very reason the characters generally used for the systematic classification in this group cannot be studied even if the slides should be accessible.

The interest in the microfauna in the French Lias seems to have been small since the extensive works by TERQUEM and BERTHELIN; the only work published since the previous century is that of J.-M. PAYARD (1947). However, his work mainly deals with the Upper Lias and is thus of little interest for the subject of the present publication. No British publications have been mentioned on the above pages though the first Lias foraminifera were recorded by STRICKLAND, as stated in the first part of this chapter. This is not due to lack of interest on the part of British scientists as demonstrated by the records made by such famous British rhizopodists as T. RUPERT JONES, W. K. PARKER and H. B. BRADY. But while the foraminifera of the Lias on the Continent were studied by men like D'ORBIGNY, who was a paleontologist as well as a zoologist, and TERQUEM and BORNEMANN, who must chiefly be classified as paleontologists, most of the British rhizopodists were chiefly zoologists as, for instance, the British authors mentioned above. From the study of the recent foraminifera the latter scientists arrived at the view that the foraminifera were rather uninteresting forms. These ideas were advanced particularly by WILLIAMSON (1848, 1858). According to his view unicellular forms were inferior organisms which, consequently, could not be organized as species and hardly as genera but constituted a group of very variable forms which should all be referred to a few, or perhaps even a single species; consequently the fossil forms were considered extremely persistent and could not have undergone any evolution. The study of them could accordingly be of no importance for stratigraphy. It is pretty evident that such ideas were not very stimulating for the examination of fossil microfaunas, and it is very comprehensible that little advance within this field was made till recently in Great Britain. Nevertheless, some attention to the Lias microfaunas was given in the papers of T. RUPERT JONES (1853), T. RUPERT JONES & W. K. PARKER (1860), H. B. BRADY (1867), and W. D. CRICK & C. D. SHERBORN (1891, 1892). The value of these publications, however, is greatly reduced by the fact that Jurassic forms are identified with recent ones as far as possible, which makes comparison with other Jurassic faunas very difficult and prevents any use of the fauna lists for stratigraphic purposes. The report by H. B. BRADY is fairly typical of the above-mentioned publications. In the said paper all the Jurassic foraminifera are referred to previously known recent, Tertiary and Cretaceous species with the exception of one, namely *Geinitzina tenera*. It is thus obvious that only little information can be gained of the microfauna, unless BRADY's own slides are found and examined. Of some interest are his figures of forms, by him referred to *Cristellaria rotulata* and *C. cultrata*. These two specimens may probably be referred to *Lenticulina acutiangulata*, a view which to some extent is confirmed by the fact that the specimens are found in a limestone containing *Amaltheus margaritatus* and *A. spinatus*. The most striking fact as regards BRADY's work is his almost complete indifference to previous publications by such eminent students as TERQUEM and BORNEMANN. In CRICK & SHERBORN's publications is described a microfauna from the same biozone, namely the margaritatus zone of the Lias Delta, which contains several important index fossils for this zone, as far as it has been possible to identify them from the illustrations and the text. Thus *Lingulina pupa, Marginulina prima* (= *prima prima*), and *Frondi-*

cularia terquemi (possibly *Spandelina bicostata*) are reported from these beds, and these forms are important markers for the corresponding beds in Gassum No. 1.

Considering the ideas thus prevailing among the majority of British scientists of that time, J. F. BLAKE represents independent views as advanced by him in the chapter on the microfauna in the joint publication by R. TATE & J. F. BLAKE (1876) dealing with the Lias in Yorkshire. In his introduction he states that the study of foraminifera of the Jurassic in Great Britain has been neglected owing to the difficulty of their nomenclature; he mentions the main principles of the two conflicting schools which he calls the English school and the Continental school. He admits the importance of the principle of the English school that "the element of time is to be excluded from the definition of the species", and that the presence of passage forms should be expected in all classes of animal life, if a gradual development of life is accepted. Thus the concept of a "true species" is greatly dependent on the fact whether passage forms are known or not. He arrives at the conclusion that the difference in age alone does not justify the erection of a new species, but if just the slightest difference in morphology exists between two similar forms, and if this character is constant and only found in either the older or the younger form, the difference in age should be considered a very important factor. In that case he thinks it correct that a new species is established, even if the morphologic difference is small and of a type which would not have been considered of taxonomic importance if the two forms had been inhabitants of the same sea. Finally BLAKE states that the "foraminifera therefore of the Lias are not here jumbled together under a few names of recent forms, with the remark that they all very much resemble each other; but I have taken names from the described forms of any age when they fairly represent the Liassic forms; but when there is any sufficiently distinct character I have used the names of TERQUEM or BORNEMANN, who have perhaps given too many, and in some cases unnecessary ones." Due to his sound principles in dealing with the concept of the species, and to the fact that his forms are eminently drawn and described, and further, that the presence of the various species in each of the megafossil biozones is carefully stated, the investigation of the Lias microfauna by BLAKE ranges high compared to many of the other contributions of his time concerning the Lias microfauna.

This is especially of great importance for the correlation of the Yorkshire Lias and the Lias Series in Denmark. The Yorkshire basin seems to be the western part or at least a basin interconnected with the Danish basin; due to BLAKE's thorough investigation and orderly representation of the facts many important correlations can be made. Thus *Planularia inaequistriata* is recorded from the angulatus and bucklandi zones of the Lias Alpha in Yorkshire, a fact which agrees very well with the occurrence of this form in Denmark. BLAKE includes in this form the species *Cristellaria articulata, C. eugenii, C. pickettyi* and *C. ligata* described by TERQUEM. Further, he thinks that the form described by BRADY as *Planularia bronni* should be included. Although BRADY's figure of this form resembles *P. inaequistriata* the record, however, seems subject to doubt, as *P. bronni* is recorded from beds with *Amaltheus margaritatus*.

About *Lingulina tenera* BLAKE reports that it "is most abundant and very characteristic of the Lias, and apparently peculiar to it." *Lingulina striata* is reported from the planorbis zone, a fact which agrees very well with the occurrence of *Geinitzina tenera striata* in the Danish Lias Series. Under the name of *Dentalina burgundiae* is recorded a form which, according to the illustrations, is similar to *Marginulina prima praerugosa. Marginulina prima* seems to be a pretty common form in nearly all zones of the Lower and Middle Lias in Yorkshire. *Dentalina funiculosa* seems, according to the figures, to be identical with *Dentalina matutina.* The bifurcation of the ribs mentioned in the description by BLAKE cannot be observed on the figure, which shows all the typical characters of *D. matutina.* The species is recorded from the Lias Beta and from the Lias Gamma of Yorkshire, but not from the Lias Alpha, a fact which is typical of this species. *Frondicularia sulcata* is recorded from the planorbis, angulatus and bucklandi zones, i. e. the complete Lias Alpha. From the Lias Beta BLAKE records *Frondicularia terquemi* which, however, according to the illustrations, should rather be referred to *Spandelina bicostata baueri* and *Spandelina bicostata bicostata* and not to the typical Middle Lias form.

The presence of foraminifera in the Lias Series of Southern Germany was mentioned by G. W. GÜMBEL (1891), and P. F. REINSCH (1877) published a small report in which he records 17 species from the Lias Gamma and Lias Delta of Franken. SCHICK (1903) further discovered 53 species in the Lias of Swaben covering the complete succession of stages from Lias Alpha and including the Lias Zeta. These examinations were continued by A. ISSLER, who in 1908 published the results of his survey in Schwaben. His paper is a thorough and conscientious work, but as common at his time all his specimens are embedded in balsam, which makes his illustrations extremely difficult to decipher. It may further be assumed that the impossibility of turning over the specimens in the balsam in most cases must have prevented any closer examination. Great pains have been taken on the isolation of the various faunas from each bed and on careful correlation of the different beds in the section by means of the content of megafossils. ISSLER takes great interest in the distribution of the various species, but, nevertheless, he has not drawn the conclusion that valuable markers might be found by an examination of the microfauna. Thus he mentions that *Cristellaria inaequistriata* is closely related to *C. costata* and *C. arietis,* and that all these forms are restricted to the Lias Alpha. He further seems to have observed the close relationship between *Marginulina burgundiae* and *M. prima* as, according to his figures, both forms are united under the name *M. burgundiae.* Of the species of the *Spandelina bicostata* group he mentions *Frondicularia sulcata, F. pulchra, F. baueri, F. bicostata* and *F. terquemi.* ISSLER is evidently aware that some of these forms are closely related, as he suggests that *F. sulcata,* which probably includes *F. dubia,* and *F. pulchra* should be united under the name *F. multicostata,* and he further mentions that *F. terquemi* is confined to the Middle Lias. The stratigraphic value of the foraminifera in the Lias Series of Schwaben has further been discussed by W. FAGGINGER-AUER (1938) and I. USBECK (1952).

A. FRANKE (1936) published a comprehensive monograph of the foraminifera of the Lias in Germany with extensive descriptions of 321 species and subspecies, 116 of which are new. This number of species is fabulous for a single series like the Lias with only small facies-changes in a restricted area. In advance it may be maintained that it must be the result of a rather uncritical splitting of species on the basis of criteria of little taxonomic value. A critical perusal of the monograph thus discloses that megalospheric and microspheric forms of the same species have often been described as two different species, and although some efforts have been made to identify the species with those defined by earlier authors, the majority of those described by them have been pretty uncritically accepted. Moreover characters of supposed generic value have been respected, though facts indicate that they are neither of generic value nor even of specific value. Thus several forms, which undoubtedly should be referred to the same species, have been referred to two different species of two different genera owing to the normal variation while FRANKE supposed such characters to be of generic importance. The above-mentioned statements are well illustrated in FRANKE's treatment of the normal variation in *Marginulina prima*. The typical form of this species shows very little curvature of the initial end, and the reference of this species to the genus *Marginulina* may thus be subject to doubt. However, a minority of the specimens shows a distinct curvature, and a very few are dentaline. FRANKE refers the majority of the specimens to *Marginulina prima*, but the few aberrant, dentaline specimens are referred to the new species, *Dentalina insignis*. Moreover the microspheric form of *Marginulina prima* is referred to the species *Marginulina burgundiae*. It is obvious that in case the very large material, which was studied by FRANKE, were revised, the number of species would undoubtedly shrink to a much more reasonable quantity. In spite of these facts FRANKE's monograph is a very important publication for the student of the Lias microfauna, and it will probably retain its value as the best manual in the future to any worker engaged in the study of the morphology of the Lias foraminifera. This is not only due to the great number of species described but also to the very systematic arrangement, the pretty exact definition of the various species, and comprehensive morphologic descriptions. Both the vertical and the horizontal distribution of each species is recorded, but few conclusions concerning the value of the species as markers have been drawn. Although published in 1936 the views expressed in the monograph are chiefly those of the previous century, and it stands as a grand monument and a great compilation of the investigations made through nearly a century by able scientists.

Although FRANKE did not draw any stratigraphic conclusions from his examination, the scientific world had not long to wait for such an evaluation; it was published in 1937 by H. BARTENSTEIN & E. BRAND. The main purpose of this joint publication is to state the stratigraphic importance of the foraminifera in the Lias and Dogger Series in Germany. According to the preface the Lias fauna has mainly been treated by E. BRAND, while H. BARTENSTEIN has described the fauna of the Dogger Series. FRANKE's definitions of the various species are largely accepted and only in few cases disputed, but nevertheless the number of species of the Lias Series is somewhat reduced. Thus only a total number of 208 species and subspecies is recorded no more than 3 species and 3 subspecies of which are new, while 43 of the species are not recorded by Franke. The systematic part of this publication is well arranged and clear; species described by Franke are for the sake of brevity treated summarily only. As in earlier papers microspheric forms are in most cases treated as separate species, and little attention seems to have been devoted to this problem; a fact which to some degree may have added to the fairly great number of species recorded. The text is illustrated by a number of plates with photomicrographs of the various fauna assemblages. This alone shows the main difference of this publication compared to the papers and monographs previously mentioned which did not contain or report the various assemblages, but described and pictured each individual species in respect of morphology only.

According to the descriptions and the map of the localities, the material mostly consists of samples from outcrops and cores from two wells and largely covers the occurrences of the northern Lias basin in Germany. Of great importance for the identification of the various species is the fact that the above authors have had the material and holotypes of Franke and Bornemann at their disposal. After a thorough description of every locality, the exposed beds, the microfauna of each bed, and the corresponding ages of these beds, usually known from the megafossil contents described by earlier students of the very well-known Lias Series in Germany, the authors summarize the results of their investigations in a special chapter on the stratigraphic importance of the microfauna.

The first important question was to find an index fossil to distinguish the Lias Series from the Dogger Series and the Rhaetic Series. A discrimination between the Lias and the Rhaetic is generally not very difficult due to the fact that the Rhaetic microfauna consists of ostracods only, if any, but to find an index fossil for the Lias which does not occur in the Dogger Series, is more difficult as the fauna change between the Lias and Dogger occurs in between the Lias Zeta and Lias Epsilon. Thus the typical markers of the Lias do not occur in the Upper Lias stages. *Frondicularia tenera* and its various subspecies seem in many respects to be the best index fossil for the Lias, as this form occurs in abundance in nearly all facies of the Lias, but the occurrence – though scarce – in the Dogger makes the choice of this form less tempting. Thus Bartenstein & Brand finally suggest *Marginulina prima* as the index fossil for the Lias, irrespective of the fact that this species seems to become extinct at the end of the Lias Delta and never has been recorded from the Upper Lias. The presence of this species in nearly all beds and all facies of the Lias Series makes this form an excellent marker for the Lower and Middle Lias. Another excellent marker is *Dentalina matutina,* but it is secondary in importance to *Marginulina prima* owing to the fact that *D. matutina* does not occur in the Lias Alpha and usually is very common in the Lias Beta, though less common in the Middle Lias. Besides, *D. matutina* appears to be more influenced by changes in facies than *M. prima.*

After these statements Bartenstein & Brand discuss the further subdivision of the German Lias based on the microfauna. The psilonotum zone contains a very poor microfauna without any markers except *Marginulina prima* and *Frondicularia tenera.* In the Schlotheimia and Arietites zones a fairly rich fauna occurs, and *Cristellaria inaequistriata* is an excellent marker for these two zones, but any discrimination between them is, according to the authors, very difficult if not impossible. The fauna of the Lias Beta is fairly rich, and in Germany *Nodosaria issleri* is a very good marker for this stage. From these beds *Vaginulina listi, Frondicularia tenera prismatica, Dentalina matutina* and *Nodosaria columnaris* are further recorded. BARTENSTEIN & BRAND report *Frondicularia tenera octocosta as* typical of the Lias Beta. However, according to the examination of the Danish material this form should probably not be considered a subspecies as accessory ribs occur in many of the various subspecies. Thus this character should most naturally be considered a normal variation within each subspecies. According to FRANKE *Vaginulina listi* occurs in other parts of the Lias, but it seems quite true, as reported by BARTENSTEIN & BRAND, that it has its main occurrence in the Lias Beta. These authors, further, draw attention to the abundant occurrence in the Lias Beta of *Dentalina matutina,* in which they include *D. claviformis.* However, they consider *D. primaeva* a separate species and state that it does not occur in the Lias Beta.

The Middle Lias is characterized by the occurrence of *Bolivina rhumbleri,* which is found in nearly every sample from this stage and thus is an excellent marker. In Germany the Middle Lias may be further subdivided as *Flabellina paradoxa* seems to be confined to the Lias Gamma. This species is unfortunately not observed in the Danish Lias Series. It is a very peculiar form and the reference of it to *Flabellina* should be considered with skepticism. The contact between the Lias Gamma and the Lias Delta is, according to BARTENSTEIN & BRAND, difficult to ascertain by means of the microfauna, as the top of the *Flabellina paradoxa* zone is difficult to determine, but it is supposed to be close to the contact. The Lias Delta is characterized by the occurrence of *Lenticulina acutiangulata* and *Saracenaria sublaevis.* Of these two species *L. acutiangulata* already occurs in the davoei zone of the Lias Gamma, while *S. sublaevis* does not occur below the upper part of the margaritatus zone of the Lias Delta and continues upwards to the upper contact of the spinatus zone. Thus *L. acutiangulata* gives a lower limit for the Lias Gamma – Lias Delta contact and *S. sublaevis* an upper limit for it. The Posidonian Shale of the Lias Epsilon in Germany contains no microfauna. The microfauna, which appears in the jurensis zone of the Lias Zeta, is definitely different from the microfaunas of the Lower and Middle Lias. The fauna shows greater similarity to the Dogger microfauna, and is characterized by the occurrence of *Lenticulina d'orbignyi.*

After having completed the subdivision of the NW German Lias Series by means of the microfauna, BARTENSTEIN & BRAND examine how far this subdivision can be carried in horizontal directions, i. e. whether this subdivision is of more than local importance. In NW Germany the psilonotum zone contains a very poor fauna with no distinctive markers; a better microfauna is found in the Planularia inaequistriata zone; in the Nodosaria issleri zone this fauna is richer, and finally a very rich fauna with a great number of forms is observed in the Bolivina rhumbleri zone. According to the investigation by ISSLER of the Lias Series in Schwaben, S. Germany, quite similar conditions are revealed there. In this area the psilonotum zone carries a poor microfauna which grows richer in the Schlotheimia zone, but the marker *Planularia inaequistriata* is only recorded from the Arietites zone in Schwaben, a fact which Bartenstein & Brand suppose is due probably to incomplete examinations of the zones in question.

From Alsace *Planularia inaequistriata* is reported from the Schlotheimia zone at several localities by Klähn (1921). This publication is unfortunately one of the very few papers on the Lias microfauna which it has been impossible to locate in Denmark, and only the discussion of its results by Bartenstein & Brand has been accessible to the writer. From Lorraine, Terquem has recorded *Planularia inaequistriata* from the Arietites zone, but not from the Schlotheimia zone, a fact which according to Bartenstein & Brand may be due to the poor state of preservation of the microfauna of the Schlotheimia zone at the localities described by Terquem from this area.

Bartenstein & Brand mention that according to Blake the psilonotum zone in Yorkshire appears to carry a surprisingly rich microfauna. From the Arietites and planicosta zones Blake records *Marginulina inaequistriata.* It thus seems a fact that *Planularia inaequistriata* is a very valuable marker for the Lias Alpha over the whole of NW Europe.

Although the Middle Lias in Southern Germany according to the descriptions contains a very rich microfauna, the marker *Bolivina rhumbleri* has never been reported from the area, and the occurrence of this species in the Middle Lias of Lorraine is subject to doubt. At last Bartenstein & Brand discuss the distinct change in microfauna between the Lias Delta and the Lias Zeta, and conclude that this break can be traced through the whole Lias Series of NW Europe.

In a short chapter Bartenstein & Brand discuss the mutual relationship of some of the more prominent species and their probable lines of descent. In the case of *Lenticulina münsteri* and *Lenticulina acutiangulata* they suppose that a gradual development of sutural ribs has taken place leading over to *Lenticulina polygonata* and *Lenticulina subalata,* respectively. The material from the Danish Lias Series does not confirm this statement, but rather seems to indicate a gradual increase in coiling in the course of time in all species referred to the genus *Lenticulina.* This character, however, does not seem to have been examined by Bartenstein & Brand. *Geinitzina tenera,* which was originally described as *Lingulina tenera* by Bornemann, is according to Klähn by Bartenstein & Brand referred to the genus *Frondicularia.* They further state that the form with six ribs is the typical form which they refer to the subspecies *Frondicularia tenera tenera.* The subspecies *Geinitzina tenera subprismatica* was originally described by Franke and referred to *Nodosaria subprismatica.* The true relationship of this subspecies is realized and its restricted occurrence recorded. Furthermore, it is mentioned that tendencies to a development towards *Frondicularia pupa* were observed but that sufficient intermediate forms were not found in the material.

The work of Bartenstein & Brand (1937) was followed up by Wicher, who in 1938 puslished a set of tables showing typical assemblages of the German Lias from the Lias Alpha and including the Lias Delta. Besides these plates photomicrographs are presented of the most significant forms. In the text Wicher points out that the presence of megaspores with circular folds is typical of the Rhaetic in Germany, while megaspores in the Lias – if present at all – usually may be referred to *Lycostrobus scotti*. Such megaspores with circular folds are present in the Rhaetic of Rødby No. 1, but unfortunately they have not been observed in other sections of the Rhaetic in Denmark. Further WICHER in a few pages gives the most important biostratigraphic results drawn from his long experience of oil exploration in Germany. According to the introduction WICHER's publication is mostly meant as a help for the practical oil geologist in Germany to arrive at a preliminary stratigraphic subdivision and identification of the Lias, where this series is penetrated by the drilling of wells.

As mentioned in the above pages, the study of the microfauna of the English Lias did not advance much during the previous century in conformity with the preconceived idea that such low animals as the foraminifera could hardly be organized as distinct species and consequently could not have evolved through time. No wonder that nothing of importance was published about this subject during the first part of this century. The paper published by W. A. MACFADYEN (1941) heralded a new epoch in the scientific study of the microfauna of the Lias in Great Britain. Thus his examination of the samples from the Green Ammonite Beds from the Dorset coast is the first paper which in England introduces modern views on the treatment of microfaunas. MACFADYEN's study, however, covered a small part only of the whole section, as all his samples were collected from the davoei zone (Lias Gamma), and this inspired T. BARNARD to undertake a comprehensive study of the whole section, for which reasan a geat many samples were collected, covering every zone and subzone. After a discussion of the literature, dealing with the Liassic foraminifera and the method of collection and separation, BARNARD discusses the problems of classification and nomenclature. He mentions that much trouble was caused by the voluminous literature, the great variety in general morphology, and the fact that the classifications "put forward in the past have been based primarily on Recent genera. The group, however, reaches its acme in the Jurassic, and it is often found that many of the forms occurring there will not fall into these clearly defined genera." BARNARD (1950) does not, however, attempt to suggest a new classification based on his studies.

In his systematic descriptions BARNARD records a total of 47 species from the Lias Alpha, Beta and Gamma, 6 species and 2 varieties of which are new. Of special interest is the fact that BARNARD follows MACFADYEN, and considers *Lingulina pupa* a variety of *Lingulina tenera*. It is peculiar that he records *Lingulina tenera pupa* as occurring through the whole section from the Ostrea zone (Lias Alpha) to the davoei zone (Lias Gamma), as this form in the Danish Lias Series seems to be confined to the Lias Gamma and Delta. As BARNARD, however, in his description mentions that the chief difference between the two forms is that *Lingulina tenera pupa* shows numerous fine striations in between the main costae, it seems possible that he actually includes *Geinitzina tenera tenuistriata* in *Lingulina tenera pupa*.

After his description of the various forms of the *Frondicularia sulcata* group BARNARD mentions that the forms show "a progressive reduction in the number of the ribs present." He records *Frondicularia sulcata* from the angulatum and bucklandi zones (Lias Alpha); *F. dubia* from the semicostatum

(Lias Alpha) to the davoei zone (Lias Gamma); *F. bicostata* from raricostatum zone to the davoei zone (Lias Gamma), and *F. terquemi* from the davoei zone only. This vertical distribution is very similar to that of the species in the Danish Lias Series; *Planularia inaequistriata* is according to the records confined to the Lias Alpha.

According to BARNARD the forms which can be referred to the genus *Lenticulina* constitute a "plexus" of very variable forms. Thus he refrains from the description of separate species, but treats the whole group as an evolving plexus of forms showing examples of parallelism as well as convergence. The trend in the development is either a progressive uncoiling to straight forms with coiled initial ends, or a partial uncoiling leading to curved forms with a coiled initial end. This development was supposed to have been repeated time and again. The evolution is illustrated by several sketches, but a detailed examination of the number of chambers is lacking, and no attention seems to have been paid to the question of the occurrence of microspheric forms in the cycles.

A complete chapter has been devoted to the discussion of the ranges and stratigraphic significance of the foraminifera, the most important result of his investigation. BARNARD mentions that *Marginulina prima* and *Lingulina tenera* occur abundantly, but that these forms have too large a range to be of any importance for the detailed stratigraphic subdivision of the English Lias Series. The writer quite agrees in this statement, but wants to emphasize that the statement illustrates the importance of these two forms as markers for the Lower and the Middle Lias all over NW Europe. The Ostrea and planorbis zones yielded very few distinguishable forms, a fact which is probably due to the very bad state of preservation of the microfauna in these beds. The number of specimens and species increases in the angulatum zone, for which zone *Planularia inaequistriata* and *Frondicularia sulcata* are important markers. Moreover *Marginulina prima* appears for the first time in this zone. In the uppermost zone of the Lias Alpha, the semicostatum zone, *Dentalina matutina* is found, a species which seems to continue to the top of the raricostatum zone in the lower part of the Lias Gamma. Both *Frondicularia sulcata* and *Planularia inaequistriata* disappear suddenly at the top of the semicostatum zone. Thus the Lias Alpha in South England seems, largely, to be characterized by the occurrence of *Frondicularia sulcata* and *Planularia inaequistriata,* and the typical marker for the Lias Beta seems to be *Dentalina matutina.* In the Lias Gamma of the Dorset coast only long-ranging forms of little value stratigraphically occur.

BARNARD's very valuable contribution on the Lias foraminifera is not only one of the most important papers ever written on this subject in Great Britain, but also allows us to hope for a new dawn for the study of the microfaunas in that country. Thus his descriptions are lucid and thorough, and due respect has been paid to the presence of microspheric specimens in the material. If such forms are found, the difference between them is commented on, and in several cases attempts have been made at delineating the various trends of evolution and thus arrive at a logical grouping of the species according to the development of the said forms through time. Such efforts have resulted in a very detailed stratigraphic subdivision.

Summarizing the above historical review it may be stated that the Lias

Series has been extensively investigated in respect of the contents of microfossils, a very large number of which has been described and recognized as separate species. As all students have agreed that the majority belongs to the family Nodosariidae, it is generally accepted as a fact by most micropaleontologists that this family reached its climax in the Jurassic Period. The great variability in the Liassic forms has by some authors been considered to indicate that the microfauna in the Lias Series of NW Europe is a provincial fauna and thus less suited for the study of the evolution in the family Nodosariidae which is supposed to have taken place mostly during the Triassic Period, as the family evidently is fully developed already in the Lias Epoch.

The problems of future research will thus mostly be to compare and identify the observed forms with those already known, and to try as far as possible to group the various forms according to observed indications of relationship, which in most cases will lead to the reference of many of the previously recognized species as subspecies under a main species. The presence of highly advanced forms like species of the genera *Frondicularia* and *Lingulina* is further subject to doubt. The said species show stronger affinities to the species in the Permian system, referred to the genera *Spandelina* and *Geinitzina.* The reference of these seemingly rather advanced forms to the last-mentioned genera changes the general aspect of the microfauna of the Lias Series, and it is the opinion of the author that this fauna – contrary to generally accepted views – is a primitive fauna, which may give important information about the origin and classification of the family Nodosariidae. This further explains the variability in the morphology of the various forms and the often repeated complaints by many previous authors of the difficulty in the discrimination between the various species, and even the genera.

IV. Principles of Classification

Obviously it is extremely difficult to make a classification of a population in rapid evolution continued during the greater part of an epoch and uninterrupted by major changes of facies. As will appear from the following pages the ancestral forms of most of the phylogenetic lines are extremely variable, but a subdivision of them into smaller units is very difficult owing to the presence of intermediates, which will be hard to place within the suggested species or subspecies. Moreover, some of the ancestral forms also show affinities to several genera, so that even the determination of the genus may be subject to doubt. *Marginulina radiata* is a very good example in this respect as it shows affinities both to *Marginulina prima* and *Dentalina matutina.* FRANKE (1936) even referred it to the genus *Vaginulina.* During geologic time evolution is a gradual process, and in many cases generic characters seem to develop more or less independent of characters generally supposed to be of specific or subspecific rank. It is thus evident that no definite discontinuities are found, and the limits between the species or subspecies of the various phylogenetic groups are only arbitrary and leave passage forms which are difficult to place. Thus in many cases new genera are formed, although the species characters are not noticeably changed. On top of these difficulties comes the much discussed problem of horizontal classification versus vertical classification and the possible presence of geographic races. Another fact should not be forgotten on account of these problems as it may appear eventually to be of even greater importance. Several authors have pointed out that the majority of the genotypes are from much younger beds than the Jurassic. Thus the type species for the genus *Lenticulina* is from the Cretaceous, those of *Saracenaria, Vaginulinopsis, Planularia, Frondicularia* and *Marginulina* from the Tertiary, and those of *Astacolus, Vaginulina, Dentalina, Nodosaria* and *Lingulina* are recent species. It is consequently quite possible that at least some of these species are not of the same genetic stock as the Lias species, and it will be necessary to trace all the phylogenetic lines up through the various systems to be sure whether the similarities are due to homology or to reversion and convergence. It must be borne in mind that it has been impossible for the present author to carry through this investigation within a restricted period, and he has therefore been obliged completely to disregard the above problem in this publication.

It has been much discussed whether the classification should be primarily based on morphology or phylogeny. The present author would strongly recommend a classification based on morphology, provided that it is not directly at variance with larger phylogenetic subdivisions. Since the very beginning the zoological classification has been based on morphology, and though the concept of the species has changed owing to discoveries in genetics and phylogeny the old principles of classification still seem to provide a nomenclature which is flexible enough to meet requirements. In a way morphology comes first as it is a necessity for the definition of any nomenclatural unit, and a nomenclature is necessary for the discussion of the phylogeny in a certain group of taxonomic units. Moreover morphology is based on facts which can be demonstrated; phylogeny is mostly based on speculation, and no two students will probably ever agree in all details; a factor which will be a serious obstacle to the stability of nomenclature if it is primarily based on phylogenetic assumptions. The problem concerning vertical or horizontal classification is mainly caused by overemphasis on the phylogenetic conclusions. As a matter of fact a zoological nomenclature must necessarily be horizontal, and the palaeozoologist is thus more or less compelled to adapt his results to this classification if cooperation between these two intimately connected branches shall not be prevented. Besides the above-mentioned problems of agreement in phylogenetic assumption a classification based primarily on phylogeny will often have serious disadvantages. Thus various phylogenetic lines will frequently result in similar forms due to parallelism, as is more often the rule than the exception in closely related phylogenetic lines. A strict adherence to the demand of monophyly will thus result in the erection of genera which are not easily discriminated on morphology alone and consequently complete chaos will arise when the phylogenetic line cannot be traced further owing to changes in facies, interruption of sedimentation, or other similar disturbances which may influence the fauna of a given standard profile.

The use of a trinomial nomenclature to combat the excessive number of species of foraminifera was suggested by H. E. THALMANN (1934). Unfortunately, THALMANN did not suggest the use of subspecies as a mere morphologic unity smaller than the species but suggested that his examples should be considered geographic races. This view was opposed by RUTTEN (1935), who stated that the contemporaneity of the forms, mentioned by THALMANN, might be disputed, and as RUTTEN wanted to reserve the term subspecies for geographic races alone he opposed the suggestion by THALMANN. H. HILTERMANN (1951), however, pointed out the value of the concept of the subspecies as shown by HILTERMANN & KOCK (1950) in their very detailed analysis of the species of *Bolivinoides* in the Senonian. In an interesting article BOLTOVSKOY (1954) opposes the view generally held among micropaleontologists that two subspecies of the same species may be present in the same area. First BOLTOVSKOY discusses the various concepts of the species and arrives at the conclusion, that the criteria for a species should be that 1) it breeds freely and gives fertile descendants, 2) all individuals are linked together by transitional forms and 3) that two different species may occupy the same area, as is impossible in the case of two subspecies (the geographic criterion). From these definitions BOLTOVSKOY arrives at the conclusion that the assumption of two closely related subspecies, occupying the same area, is an absurdity. C. W. DROOGER (1954) states that the paleontologists for very obvious reasons cannot operate with the neontological concepts of the species due to the involvement of the time factor in paleontology. Thus in many cases the paleontologist will have to define species with arbitrary boundaries and in numerous cases a specific name may be justifiable as just "a label invented for the sake of convenience". The concept of the subspecies as a geographic race, as it is defined by the zoologists, will be inconvenient for the paleontologists as synchronism is difficult or impossible to ascertain. Thus DROOGER suggests "the extension of the subspecies concept in paleontology to include series of populations at a single locality in the course of time". The writer is of opinion that the whole discussion about the concept of the subspecies in paleontology is caused mainly by overemphasis on the horizontal classification by zoologists, who want to reserve this term for the geographic race. However, the paleontologist is mostly concerned with vertical changes, and the author completely agrees with DROOGER that the concept of the subspecies should include not only evolutionary units kept from interbreeding by geographic barriers, but just as well evolutionary units, prevented from interbreeding by difference in time, chrono-subspecies.

During the investigation presented in this publication, an attempt has been made at sifting out such characters that show variation during geologic time and at basing the classification of the various forms on them. These forms have been considered as subspecies wherever feasible. It is anticipated that some scientists may think that the classification of former species as subspecies is carried too far. Thus nobody would believe that *Spandelina bicostata terquemi* and *S. bicostata sulcata* are not separate species if specimens of each species were placed together, as the two specimens in such a case will appear to have very little in common; the same would apply to *Geinitzina tenera tenera* and *G. tenera pupa*. However, if the whole population is studied and the various characters traced through time it is obvious that all the forms referred to *Spandelina bicostata* and *Geinitzina tenera*, respectively, are linked together with passage forms and show a continuous development from the primitive forms of the Lower Lias to the more advanced forms in the Middle Lias. Thus all forms, by previous authors described as separate species, actually belong to one great unity and, as mentioned by several students, the boundaries between the various forms are often quite arbitrary. In the *Marginulina radiata* supergroup and in the *Marginulinopsis matutina* supergroup it is not justifiable to subdivide into subspecies as the most important characters showing variation through time is the degree of coiling which is a character of generic rank; it is obvious that changes in such a character cannot be used for subdivisions on the subspecific level.

In the Rules of Nomenclature no allowance is made for the previously much used terms *var.* (varietas) and *form.* (forma), and names recorded as these categories are thus unprotected. Nevertheless, these terms are quite useful in some cases and have consequently been employed occasionally in this publication. Where the present author for instance has been fully convinced that the difference between two forms is due to normal variation only it has nevertheless appeared that the horizontal distribution of the two forms in some cases shows dissimilarities which it has been considered of importance to record. Under such circumstances these forms cannot very well be classified, neither as chrono-subspecies nor as geographic races; they are supposed to be indicators of small variations in facies, and one of them has been recorded as a variety of the other. The term form. has in this publication exclusively been reserved for the microspheric form when it has previously been recorded as a separate species. Thus the microspheric form of *Marginulina prima* has previously been recorded as *Marginulina burgundiae*. Consequently the microspheric form of this species is in this publication recorded as *Marginulina prima* form. burgundiae. In this connection attention is drawn to the fact that the names of forms and varieties are never italicized as are subspecific names.

V. Classification of the Superfamily Nodosariidea

Apart from some arenaceous species and the species *"Bolivina" liasica* and *Lamarckina nov. sp.* the majority of the genera and species have been referred to the superfamily Nodosariidea (= Lagenidea GLAESSNER, 1945). This superfamily includes the families Nodosariidae SCHULTZE, Polymorphinidae D'ORBIGNY and Enantiomorphinidae MARIE. In the present publication the genera *Spandelina* and *Geinitzina* are further referred to this superfamily; by GALLOWAY (1933) they were placed in the family Nodosinellidae which by the present author is supposed to be the ancestral family within the superfamily Nodosariidea. No forms belonging to the family Enantiomorphinidae have been detected in the material from the Lias Series of Denmark, and of

Polymorphinidae presumably the most primitive form only, *Eoguttulina liassica*, is observed.

GALLOWAY (1933) included the genera *Spandelina* and *Geinitzina* together with several other genera in the family Nodosinellidae which "constitute a natural family which appears well characterized in the Paleozoic". That later authors have not agreed in this statement is illustrated by the fact that the various genera, by GALLOWAY referred to the Nodosinellidae, have been referred to different families. Thus GLAESSNER (1945) refers the genera *Spandelina* and *Geinitzina* to the family Nodosariidae. However, the present investigation has revealed that these two genera differ from the Nodosariidae to such a degree that it is considered safer to refer them to a separate family. Thus the Nodosariidae in the Lias all have a calcareous, fibrous, perforate wall and a radiate aperture, while the wall of the Nodosinellidae is calcareous, fibrous, but evidently imperforate, and the aperture is a simple round or oval opening usually without any indications of the original presence of a radiate aperture.

FAMILY NODOSINELLIDAE RHUMBLER, 1895

Nodosinellidae RHUMBLER, 1895, Nachr. Ges. Wiss. Göttingen.
Nodosinellidae GALLOWAY, 1933, A Manual. Bloomington.

Diagnosis.

Schale sandig oder mehr oder wenig kalkig. Perforat oder imperforat, polythalam, aus einer gerade gestreckten oder doch nur wenig gebogener Reihe einzelner Kammern zusammengesetz. (RHUMBLER, 1895).

Test usually free, monothalamous or polythalamous; chambers arranged in a rectilinear series, loosely or closely joined; wall calcareous, finely granular, or fibrous or with granular outer layer and fibrous inner layer, or with coarse meshwork, or granular and perforate, never typically hyaline, porcelaneous or agglutinated, as are post-Paleozoic forms; aperture terminal, single, simple, round or oval, or absent (Emend. GALLOWAY, 1933).

Remarks.

Besides several other forms of less importance for the present publication this family includes three evidently closely related genera, *Monogenerina, Geinitzina* and *Spandelina*. The taxonomic position of these three species has been very much discussed. Thus the genus *Monogenerina* was described by SPANDEL (1901) and according to the general appearance of the test SPANDEL considered the genus to be related to the genus *Bigenerina*, although it was difficult to decide whether the wall of the test was arenaceous or calcareous. CUSHMAN (1933) described the wall as finely arenaceous, with much cement and a thin outer covering, and he considers that this genus, as well as the genera *Geinitzina* and *Spandelina*, derives from the genus *Bigenerina* of the Textulariidae. As mentioned above the description of the genoholotype of *Monogenerina* by SPANDEL is not at variance with this conclusion, but this does not apply to the two other genera. Thus the genus *Spandelina* was originally described by CUSHMAN & WATERS (1928) and according to the genoholotype the wall should be calcareous and even perforate. As

CUSHMAN & WATERS further refer both smooth and costate species to the genus *Spandelina* it is obvious that this genus can hardly be placed in the family Textulariidae, and as both *Monogenerina* and *Geinitzina* are closely related to *Spandelina* all the three genera can only with great difficulty be placed in the family Textulariidae; consequently CUSHMAN (1933) feels compelled to redefine both *Spandelina* and *Geinitzina*. For that reason CUSHMAN described the wall of the test of *Spandelina* as "calcareous, finely arenaceous with a thin coating. – – – Without the thin outer covering the wall of Spandelina appears perforate, especially when calcitized as is common", and the species *Textularia cuneiformis* JONES with a biserial initial part in the microspheric test is by CUSHMAN designated as the genoholotype of *Geinitzina*. GALLOWAY does not agree with CUSHMAN and refers the three closely related genera to the family Nodosinellidae and describes the wall as "calcareous, finely granular or fibrous". The problem has been thoroughly discussed by CHAPMAN, HOWCHIN & PARR (1934). According to the published description and figures they state that the genus *Monogenerina* on account of the large aperture and the general form most likely must be related to the family Textulariidae, and consequently they transfer the Australian species *Monogenerina pyramidis* to the genus *Nodosaria* on account of the wall, which is hyaline and perforate in this species. These authors further maintain that the genoholotype of *Geinitzina* must necessarily be chosen from SPANDEL's type material, and as "Spandel described and figured both species of *Geinitzella* as uniserial, therefore *Geinitzina*, if used at all, must be restricted to uniserial forms, unless, as is exceedingly unlikely, the species he had were actually biserial". CHAPMAN, HOWCHIN & PARR further stated that the very fact that SPANDEL placed the genus *Geinitzina* in the family "Nodosaridae" indicates that the wall of the genoholotype is calcareous and perforate. Concerning *Spandelina* the authors maintain that it was originally described as a calcareous, perforate form, and that the presence of costate species indicates a relationship not to the arenaceous families but to families characterized by hyaline tests. In accordance with the views expressed by CHAPMAN, HOWCHIN & PARR, GLAESSNER (1945) refers *Monogenerina* to the family Textulariidae with some reservations and *Spandelina* and *Geinitzina* to the family Lagenidae. The present author has neither had the possibility nor the time to go into this question on typical material, but after a study of the literature pertaining to it he feels inclined to think that these three genera are calcareous forms which should be referred to the family Nodosinellidae as suggested by GALLOWAY. This assumption is based on the following considerations. That SPANDEL (1901) seems unable to determine the nature of the wall in the genoholotype of *Monogenerina* seems to indicate that the walls of the specimens at his disposal are recrystallized, and most likely at least calcareous. That the walls of *Geinitzina* and *Spandelina* are calcareous appears to be beyond doubt, and that all these three genera are closely related looks highly probable. The texture of the walls is difficult to determine, evidently owing to the fact that it is often recrystallized. It may thus be possible that the granular wall, as described by GALLOWAY, is a result of recrystallisation and that the walls of well-preserved specimens seem to be fibrous. The deviating views about the presence of pores would confirm this assumption and further indicate that the pores, if present at all, are extremely small.

Genus Geinitzina Spandel, 1901

Synonymy: *Geinitzella* SPANDEL, 1898.

Diagnosis.

Das Genus Geinitzella ist einerseits verwandt mit dem Genus Ortocerina, anderseits mit dem Genus Lingulina; es unterscheidet sich jedoch wesentlich von beiden, weshalb eine generische Abtrennung gerechtfertigt erscheint. – Die Diagnose des Genus Geinitzella lautet: "Kammern aus gerader Axe aufgereiht, allgemeine Form keilförmig zusammengedrückt, auf den Breitseiten mit in der Axenrichtung verlaufenden Depressionen, sodass die Kammern in Querschnitt Sandalenformen erhalten, Kammeroberfläche (= Deckel) leicht gewöllbt, häufig jedoch von der Schmalseite aus nach der Mitte eingesenkt, Mündingspaltformig, Embryonalkammer kugelig" (SPANDEL, 1898).

Das von mir errichtete Geschlecht Geinitzina, nannte ich früher Geinitzella, da aber dieser Name bereits verwendet war, habe ich denselben, wie bemerkt, umgeändert. Die Geinitzinen sind gekennzeichnet durch niedrige, auf einer geraden Achse aufgereihte Kammern, das Gehäuse hat eine keilförmige Form und ist zusammengedrückt, auf beiden Breitseiten befindet sich je eine in der Achsenrichtung verlaufende Depression so dass die Kammern im Querschnitt Sandalenform haben. Die Kammeroberfläche ist bei den älteren Kammern nur leicht gewölbt, bei den jüngeren Kammern von der Schmalseite nach der Mitte zu mehr oder weniger eingesenkt; in der Mitte dieser Einsenkung liegt die einfache runde oder wenig in die Länge gezogene Münding (SPANDEL, 1901).

Remarks.

CUSHMAN (1928) designated *Textularia cuneiformis* JONES (not D'ORBIGNY) as the genotype "whereby changing the definition of the genus from a uniserial form, as intended by Spandel, to a biserial form" (GALLOWAY, 1933). Although CUSHMAN & WATERS (1928) in their genus diagnosis of *Spandelina* report the wall as calcareous and even perforate, CUSHMAN (1933) maintains that it is calcareous, finely arenaceous with much cement, and refers the genera *Monogenerina, Geinitzina* and *Spandelina* to the family Textulariidae on account of the supposed arenaceous wall and the suggested presence of a primordial, biserial stage. GALLOWAY considers *Geinitzina* as a subgenus of *Spandelina* which is defined as an elongated, uniserial, compressed, lingulinoid or frondicularoid form with a calcareous, finely granular or fibrous wall and a single terminal, elliptical aperture. GLAESSNER (1945) refers both *Geinitzina* and *Spandelina* to the family Lagenidae. According to GLAESSNER the test of *Geinitzina* is much compressed especially along the median line; outline triangular; young microspheric chambers in a curved series, adult chambers in a single, rectilinear series, usually arched in the early stages, becoming more transverse in the adult; wall calcareous, hyaline, perforate; aperture generally elliptical, occasionally radiate.

The writer has been unable to examine typical material from the Permian and must therefore refrain from any further discussion of the conflicting views about the Paleozoic forms referred to the genera *Geinitzina* and *Spandelina*. However, it is a fact that the group of species in the Lias by previous authors referred to and obviously related to *Lingulina tenera* and *Frondicularia bicostata,* is characterized by a fibrous wall which is imperforate in the sense that the pores – if present at all – have a diameter smaller than the thickness of the calcite fibres of the test and thus avoid detection. Further, the texture and the composition of the wall are a very important character, the recognition of which has been the basis for the main subdivision of the order in larger groups. Recent investigations have even shown that differences in the structure and composition of the wall are among the chief characters for the discrimination between the various families. It is safe to conclude, that the *Lingulina tenera* group and the *Frondicularia bicostata* group do not belong within the family Lagenidae; a conclusion which is further supported by the fact that they are characterized by the presence of a simple rounded to elliptical aperture, while the aperture of the Lagenidae is typically radiate. However, the subspecies of the *Lingulina tenera* group satisfy the requirements of the diagnosis of the genus *Geinitzina* in having a uniserial, straight, compressed test, triangular in shape with median grooves and an elongated or rounded, simple aperture. They completely agree with the diagnosis by GALLOWAY (1933) even to the presence of a fibrous, imperforate wall, and at least, the microspheric initial test of the most primitive member of the group – *Geinitzina tenera striata* – is slightly curved in conformity with the diagnosis by GLAESSNER (1945). This group of subspecies is consequently referred to the genus *Geinitzina,* while the closely related forms – by previous authors referred to *Frondicularia bicostata* – are referred to the genus *Spandelina* on account of the presence of inverted, chevron-shaped chambers.

Genus Spandelina Cushman & Waters, 1928

Diagnosis.

Test uniserial, the chambers in a generally rectilinear series, the earlier ones at least compressed in typical forms, especially in the microspheric form; sutures usually distinct and compressed in the early stages, at least of the microspheric form obliquely slanting back from the central region, wall calcareous, perforate, aperture single, terminal, elliptical or rounded (CUSHMAN & WATERS, 1928).

Remarks.

CUSHMAN & WATERS further report that the "various forms of this genus at first glance appear to be allied to the Lagenidae, but their source is evidently from Geinitzina and Monogenerina." In the diagnosis it is only required that the initial chambers should be compressed, and at least in the microspheric form inverted chevron-shaped. These reservations are evidently a necessary allowance for the accomodation within this genus of the subgenus *Spandelinoides*, which is characterized by the addition of inflated chambers of nodosarian character. However, the present author is inclined to believe that *Spandelinoides* is a synonym of *Geinitzina*, as the diagnosis of the former agrees in nearly all respects with that of the latter. Further, "the addition of inflated chambers of nodosarian character" is commonly occurring in the subspecies of *Geinitzina tenera* and is especially typical of *Geinitzina tenera pupa*. According to the above diagnosis of the genus it is evident that CUSHMAN & WATERS considered the wall of the genus as calcareous and even perforate, but CUSHMAN in his textbook defines the wall as calcareous, finely arenaceous, with much cement, and places the genus in the family Textulariidae together with *Monogenerina* and *Geinitzina*. In this respect neither GALLOWAY (1933) nor GLAESSNER (1945) follow CUSHMAN, as GALLOWAY refers the genus to the family Nodosinellidae, while GLAESSNER refers it to the family Lagenidae.

FAMILY NODOSARIIDAE (SCHULTZE, 1854) RHUMBLER, 1895

Nodosarida SCHULTZE, 1854. Ueber d. Org. Leipzig.
Cristellarida SCHUTZE, 1854. Ueber d. Org. Leipzig.
Lagenida REUSS, 1861. Sitzber. k. Akad. Wiss. Wien.
Nodosaridea REUSS, 1861. Sitzber. k. Akad. Wiss. Wien.
Vaginulinidea REUSS, 1861 Sitzber. k. Akad. Wiss. Wien.
Frondicularidea REUSS, 1861. Sitzber. k. Akad. Wiss. Wien.
Cristellaridea REUSS, 1861. Sitzber. k. Akad. Wiss. Wien.
Nodosaridae RHUMBLER, 1895. Nachr. k. Ges. Wiss. Göttingen.
Lagenidae CUSHMAN, 1925. Smithson. Miscl. Coll, Washington.
Lagenidae CUSHMAN, 1933. Foraminifera, Sharon, Mass.
Nodosariidae GALLOWAY, 1933. A Manual. Bloomington, Ind.
Lagenidae GLAESSNER, 1945. Principles. Melbourne.

Diagnosis.

Schale stets kalkig, sehr fein perforiert; Kammern perlschnurartig aneinandergereiht in gerader, gekrümmter oder planispiral Reihe. Bei den Lageninen trennen sich die neue entstandenen Kammern sofort nach ihrer Entstehung als selbständige monothalame Schalen ab. (SCHULTZE, 1854).

Remarks.

As is evident from the synonyms above SCHULTZE (1854) placed the coiled and curved Nodosariidae in the subfamily Cristellarida and only included the genera *Nodosaria, Dentalina, Frondicularia* and *Vaginulina* in the family Nodosarida. REUSS (1861) erected the family Lagenida, though only including the genera *Lagena* and *Fissurina*. Thus he placed the majority of the genera of the Nodosariidae in the various subfamilies of the families Rhabdoidea and Cristellaridea. RHUMBLER (1895) included all the genera in the family Nodosaridae comprising the subfamilies Nodosarinae, Lagenidae, Cristellarinae and Polymorphinae. CUSHMAN (1933) raised the subfamily Polymorphinae to family rank and placed the other three subfamilies in a new family which he named the family Lagenidae. Thus evidently designating the genus *Lagena* as the type genus of the family.

Family names do not enjoy the same protection as names of genera and species in the Rules of Nomenclature. This, however, is supposed to mean neither that family names cannot be changed, nor that they can be changed at will, but only that it is supposed that strict adherence to the same prescriptions, given for the genera and species, is apt to cause too much instability. Thus the name of a family shall not necessarily by changed just on account of the priority of an older name but only if the type genus is moved out of the family or for other similar reasons, and in such cases the present author is of opinion that the rules, given for names of genera and species shall be followed insofar as they do not lead to obvious absurdities. The designation of *Lagena* as the type species for this family is undoubtedly a very bad choice, as much seems to indicate that this genus is polyphyletic. Thus the species, by some authors referred to the genera *Fissurina* and *Entosolenia,* most likely belong to the families Ellipsoidinae and Buliminidae, respectively, and even if these species are removed from the genus *Lagena* a considerable part of the remaining species with radiate apertures may as well be derived from the Polymorphinidae as from the Nodosariidae. In defence of this choice the fact remains only, that the name Lagenidae is in common usage, and that the type genus illustrates the most important characters of the family. Against this view it may be stated that the name Lagenidae is illegally introduced by CUSHMAN (1925). Thus, as mentioned before, the two families Nodosarida and Cristellarida, erected by SCHULTZE, were united in one family named Nodosaridae by RHUMBLER (1895). The error in spelling was corrected by RHUMBLER (1923). That CUSHMAN raises the subfamily Polymorphinae to family rank does not affect the name of the rest of the family, which still must keep the name of the designated type genus *Nodosaria.* Accordingly the correct name of the family must be Nodosariidae (SCHULTZE, 1854) RHUMBLER 1895.

The genera *Nodosaria* and *Dentalina* are, together with *Lagena,* by nearly all authors of text-books on the foraminifera considered among the most advanced genera in the family Nodosariidae, while the genus *Lenticulina* is generally supposed to be the most primitive member of this family. The phylogenetic trend in this family should then be a gradual uncoiling leading from involute forms to evolute forms. Thus *Nodosaria* should be derived from *Lenticulina* through the genera *Astacolus, Vaginulinopsis, Marginulina, Vaginulina* and *Dentalina.* Against this theory it may be maintained that the genus *Lenticulina* by no means appears as a primitive form, but has embracing chambers which are generally supposed to be typical of gerontic genera (compare genus *Nodosaria* and genus *Pseudoglandulina*). Furthermore, an examination of the occurrence of the genus *Lenticulina* in older systems than the Jurassic reveals that only very ill-preserved specimens have been recorded and according to the illustrations and description, studied by the present author, the occurrence of this genus before the Jurassic seems highly doubtful. This is in perfect agreement with the results of the study of the Lias forms, stated in this publication. Thus no forms, that can be referred to this genus, seem ever to have been observed in the Lias Alpha, and the species in the Middle Lias seem to have been developed gradually from the genus *Marginulina* during the Lias Beta and the earlier part of the Middle Lias. The assumption that *Lenticulina* should be the ancestral form in the family Nodosariidae has even been criticized by HOWCHIN, CHAPMAN & PARR (1934) who maintained that this genus did not occur in the Paleozoic beds and suggested that the Nodosariidae were derived from a straight ancestral form. A similar view was already expressed by RHUMBLER (1895) who considered *Nodosinella* the ancestor of *Nodosaria*. The writer quite agrees with these assumptions. According to the observations made in the Danish Lias Series he firmly believes that the genera *Nodosaria* and *Pseudoglandulina* are the oldest forms of the Nodosariidae, and that *Lenticulina* may be derived from *Marginulina*. The family Nodosinellidae in many respects shows important similiarities to the family Nodosariidae and is considered the ancestral family of the families Nodosariidae and Polymorphinidae. That the genus *Nodosaria* is derived from the Nodosinellidae is confirmed by the tendency of the genera *Geinitzina* and *Spandelinoides* to produce nodosarian forms.

As mentioned above RHUMBLER united the Nodosarida SCHULTZE and Cristellarida SCHULTZE in a single family, the Nodosariidae, which he subdivided into the following subfamilies, the Nodosarinae, the Lageninae, the Cristellarinae and the Polymorphinae. CUSHMAN removed the Polymorphinae, and subdivided the family into two subfamilies, the Nodosariinae and the Lageninae; the latter subfamily includes the genus *Lagena* only, the former the other genera of the family. GALLOWAY subdivides the family into three subfamilies according to the assumed presence of three phylogenetic lines in the family. The first subfamily, the Frondiculariinae, includes the genera *Lenticulina, Saracenaria, Astacolus, Hemicristellaria, Flabellina, Frondicularia, Vaginulina, Planularia, Flabellinella,* and *Kyphopyxa;* the second subfamily, the Nodosariinae, includes the genera *Marginulina, Dentalina, Nodosaria, Lagenonodosaria, Lagena, Amorphina, Amphicoryne, Psecadium, Glandulina, Lagenoglandulina, Oolina,* and *Obliquina;* the third subfamily, the Robulinae, consists of *Robulus, Hemirobulina, Rimulina, Lingulinopsis, Lingulina, Gonatosphaera* and *Fissurina.* While CUSHMAN simply states that the origin of the family Nodosariidae is unknown GALLOWAY derives the supposed ancestral genus *Lenticulina* from the genus *Orobias* belonging to the Permian family, Endothyridae, and states that this form "must have evolved into Lenticulina by the migration of the aperture from the base of the septal face to the outer corner of the septal face."

CHAPMAN, HOWCHIN & PARR stated that in "the Permian, most of the species are rectilinear, with a few dentaline ones, but closely coiled forms have not been recorded from rocks of this epoch." They arrive at the following conclusion: "As we now find the microspheric stage of Geinitzina triangularis to begin with a gently curved series of chambers, it seems that the straight forms were derived from curved forms. It is also suggested that all are species of the Nodosariidae, and that this family evolved, not from a closely coiled ancestor, but from a curved or openly coiled one. The closely coiled genera such as Lenticulina and Robulus are probably not primitive types, as has been thought, but a specialized development from an openly coiled one."

WEDEKIND (1937) raised the family to the rank of order. Thus the order Nodosarioidea should consist of three phylogenetic groups, namely the suborders Cristellariacea, Lenticulinacea, and Polymorphinacea. The suborder Cristellariacea is characterized by the lack of a radiate aperture and is subdivided into three families, the Nodosariellidae, the Marginunellidae, and the Cristellariidae. The species of this suborder is according to WEDEKIND predominating in the Triassic and the Jurassic. In the Neocomian the suborder Cristellariacea is substituted by the suborder Lenticulinacea, which during the Cretaceous and the Tertiary shows phylogenetic trends parallel to those of the older suborder. The suborder Lenticulinacea is by WEDEKIND subdivided into the families Nodosariidae, Marginulinidae and Lenticulinidae. It is quite evident that WEDEKIND considers the coiled forms as developed from the straight nodosarian forms. However, the author cannot agree with the subdivision of WEDEKIND's order Nodosarioidea. By the examination of the Danish Lias Series it has been revealed that only the species – in this publication referred to the Nodosinellidae – are characterized by the lack of a typically radiate aperture, but that such an aperture is always present in well-preserved specimens of the *Nodosaria-Pseudoglandulina, Marginulina radiata* and *Marginulinopsis matutina* supergroups. At least remnants of such an aperture can always be found if the present material is carefully scrutinized. Furthermore WEDEKIND does not give adequate descriptions and illustrations of his several new genera, which for this reason are invalid according to the Rules of Nomenclature.

H. BARTENSTEIN (1948) gives a very elucidating description of the genus *Lenticulina* and closely related genera. Contrary to CHAPMAN, HOWCHIN & PARR and WEDERKIND BARTENSTEIN adheres to the common belief that *Lenticulina* is the ancestral form from which the other forms have developed by gradual uncoiling. On account of the presence of passage forms BARTENSTEIN considers the genera *Astacolus, Marginulinopsis, Vaginulinopsis, Robulus, Hemirobulina, Planularia* and *Saracenaria* as subgenera of the genus *Lenticulina*. The writer has been greatly tempted to follow BARTENSTEIN in this view which is undoubtedly logical due to the presence of passage forms. Nevertheless, classification and nomenclature have a practical purpose, and the present author finds it impractical to include a very great number of rather diverging forms in a single genus, and for this reason he considers these forms as separate genera, although they are undoubtedly closely interrelated. The publication by BARTENSTEIN, however, has been much consulted on account of his very clear descriptions and definitions of the various genera and subgenera.

BROTZEN (1953) discussed the problems of the nomenclature and emphasized GLAESSNER's statement in 1945 that "the multitude of Jurassic and early Cretaceous types is placed in the narrow framework constructed to suit the form ranges of the comparatively few surviving forms. In his small article BROTZEN mentions that the *Nodosariae* of the Permian are widely different from the modern types and states the desirability of a reclassification of the Nodosariidae, based on a detailed examination of the Permian, Triassic, and Jurassic faunas.

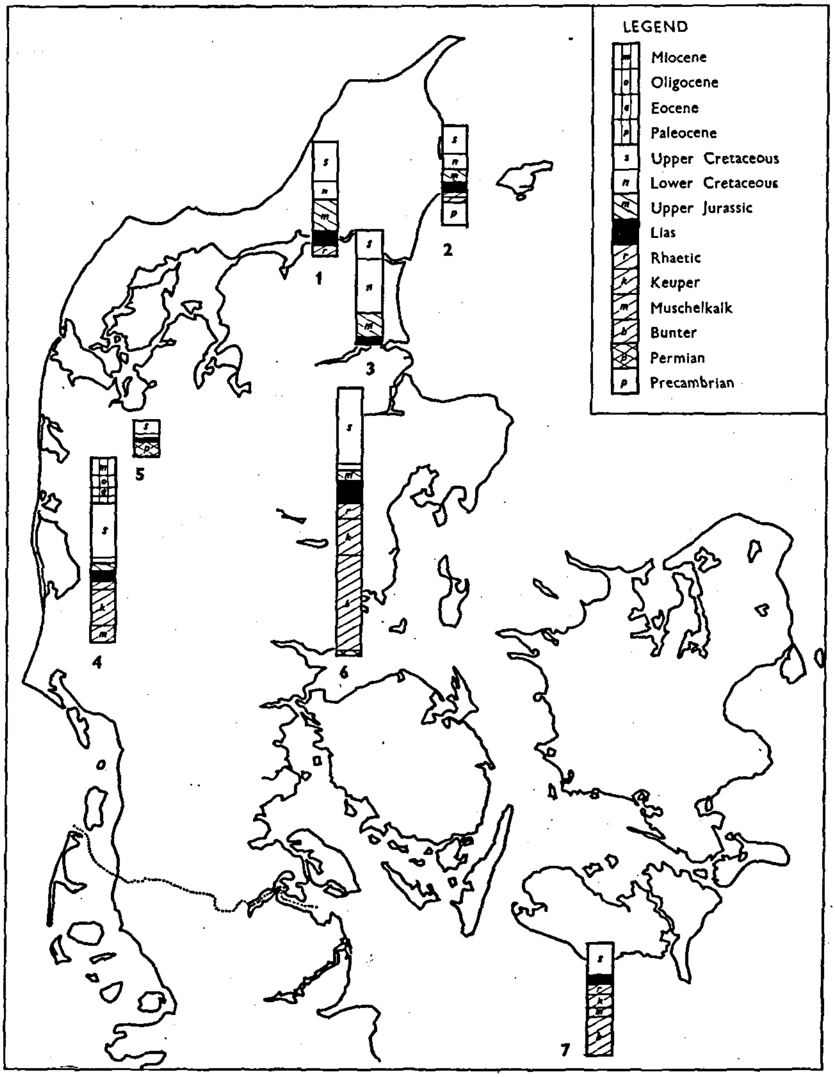
From his investigation of the foraminifera in the Danish Lias Series the present author has thus arrived at the conviction that the coiled Nodosariidae are developed from the uncoiled forms as suggested by CHAPMAN, HOWCHIN & PARR (1934); that the ancestral family of the superfamily Nodosariidea is the Nodosinellidae; and that species belonging to the genera *Geinitzina* and *Spandelina* survived into the Jurassic. It is furthermore assumed that the genus *Nodosaria* is the ancestor of the other genera of Nodosariidae, and that this genus should be derived from a genus belonging to the familiy Nodosinellidae and closely related to the genera *Geinitzina* and *Spandelinoides,* which both show a tendency to produce nodosarian forms. According to these points of view it seems reasonable to subdivide the family Nodosariidae into the following subfamilies, the Nodosariinae, comprising the genera *Nodosaria* and *Pseudoglandulina,* the Marginulinae, comprising the genera *Marginulina, Dentalina, Vaginulina* and *Saracenella,* and the Lenticulinae, including the rest of the genera. No species referable to the genus *Robulus* has been observed in the Danish Lias Series, but it seems possible that this genus and its related genera may constitute another subfamily. It is obvious that the genus *Dentalina* is more closely related the the genus *Marginulina* than to the genus *Nodosaria* of which it has been considered a subgenus by other authors (cf. GLAESSNER, 1945).

In the microspheric forms the degree of coiling is always more pronounced than in the corresponding megalospheric forms. Thus phylogenetic conclusions from the ontogenetic stages of the microspheric form of the Lenticulinae are distinctly at variance with the trend of evolution observed in nature, which shows that the biogenetic law of recapitulation cannot be applied in this case. The coiling of the initial part of the test in the Nodosariidae is thus considered a practical means for the protection of the initial end, which is particularly thin and rarely preserved in the Lias forms referred to this family.

FAMILIES ENANTIOMORPHINIDAE AND POLYMORPHINIDAE

As previously mentioned no species referable to the family Enantiomorphinidae have been observed. This family will thus not be discussed further in this publication. It may, however, be mentioned that MARIE (1941) considered the family as intermediate between the Nodosariidae and the Polymorphinidae.

The family Polymorphinidae is considered the last family of the superfamily Nodosariidea. As mentioned before only the ancestral form of the family, *Eoguttulina liassica,* has been observed in the Danish Lias Series.



Text-Fig. 1. Location Plat. 1) Børglum No. 1; 2) Frederikshavn Nos. 1, 2 and 3; 3) Haldager No. 1; 4) Vinding No. 1; 5) Vejrum No. 1; 6) Gassum No. 1; 7) Rødby No. 1.

VI. Description of the Wells

Gassum No. 1

Location: 56° 33'76 N 2° 34'36 W of the Observatory of Copenhagen; south of village Gassum, Randers Amt.
Elevation: Ground 175′ (53 m).
Rotary Table 190′ (58 m).

Stratigraphic Section.

0′ –	97′	(30 m)	Glacial drift, Pleistocene.
97′ –	3287′	(1002 m)	White chalk, Senonian (probably including Turonian and Cenomanian).
3287′ –	3575′	(1090 m)	Dark gray shale, Neocomian.
3575′ –	3753′	(1144 m)	Light gray to greenish gray sand; upper part with plant remains; lower part glauconitic, Passage beds.
3753′ –	3904′	(1190 m)	Greenish gray, sandy shale with streaks of sandstone, Upper and Middle? Jurassic.
3904′ –	4980′	(1518 m)	Dark gray shale, Lias.
4980′ –	5601′?	(1707 m)	Dark gray shale interbedded with light gray sand, Rhaetic.
5601′?–	7120′	(2170 m)	Varicolored claystone with beds of sandstone and rock salt, Keuper.
7120′ –	11345′	(3458 m)	Reddish brown, more or less argillaceous sandstone, Bunter.
11345′ –	11359′	(3462 m)	Reddish brown, sandy clay, Permian.

Upper Contact of Lias.

As the upper contact of the Lias has been chosen the lithologic break at 3904′. This contact was cored and appears to be a distinct line; the rock below the contact is a fairly hard claystone with an uneven break, greenish gray but with irregular patches of deep red and purple colors. These reddish colors are presumably due to a content of hematite, and it is suggested that they are evidence of weathering of the uppermost part of the Lias Series.

Lower Contact of Lias.

This contact should be placed between 4970′ and 5030′ due to the facts that the core 4950′–4970′ contains *Psiloceras* sp. and a microfauna of Liassic age, while the core 5030′–5045′ contains *Taeniodon ewaldi,* typical of the Rhaetic of Germany. As an increase in hardness of the rocks below 4980′ has been reported by the well geologist, this depth has been chosen as the base of the Lias Series.

Lithology.

The whole section consists of a rather monotonous sequence of dark gray shale, generally fairly hard, with frequent, and probably lenticular, concretions of clay-ironstone and small knots and veinlets of pyrite; from approximately 4700′ and downwards local thin beds of fine grained sandstone occur.

Megafossils.

The megafossils have been examined by HANS FREBOLD and the following is an excerpt from his report on this subject.

Upper part of Lias Delta (Upper Pliensbachian, Zone of *Amaltheus spinatus*).

This zone is proved paleontologically by the presence of the index ammonite in the core 4016′–4025′.

Lower part of Lias Delta (Upper Pliensbachian, Zone of *Amaltheus margaritatus*).

The index ammonite is found in the core 4080′–4092′ and continues downwards to the core 4300′–4310′.

Upper part of Lias Gamma (Middle Pliensbachian, Zone of *Aegoceras capricornu*).

The index ammonite is found in the core 4300′–4310′, where it appears associated with Amaltheids.

Lower part of Lias Gamma (Lower Pliensbachian).

In the cores 4349′–4357′ and 4400′–4418′ the ammonites *Polymorphites* sp. and *Amn.* ex group *natrix* have been found, indicating the presence of lower parts of Lias Gamma.

Upper part of Lias Beta (Upper Sinemurian).

In the core 4450′–4466′ only some badly preserved ammonite fragments have been found. An exact determination of these is impossible to make – they may belong either to *Tragophylloceras* or *Oxynoticeras*. The first group occurs in the Lias Gamma, the latter in the upper part of Lias Beta. The core 4500′–4518′ contains *Aegoceras planicosta*, a zone-ammonite of the upper part of Lias Beta.

Lower part of Lias Beta? (?Lower Sinemurian).

The cores 4550′–4570′ and 4599′–4616′ did not contain ammonites nor other index fossils. The core 4649′–4668′ yielded *Oxytoma inaequistriata*. It is probable that the cores 4550′–4570′ and 4599′–4616′ belong to the lower part of Lias Beta.

Upper part of Lias Alpha? (?Lower Sinemurian).

The core 4649′–4668′ contains *Oxytoma inaequivalvis*. The core 4702′–4722′ contains *Gryphaea* sp. aff. *arcuata*.

Lower part of Lias Alpha (Hettangian).

The cores 4800′–4820′ and 4850′–4870′ contain *Schlotheimia angulata*. The core 4950′–4970′ contains *Psiloceras* sp.

	Lias Delta							Lias Gamma			Lias Beta				Lias Alpha						
	3967' - 3972'	4016' - 4024'	4080' - 4092'	4143' - 4150'	4184' - 4194'	4222' - 4230'	4265' - 4286'	4300' - 4310'	4349' - 4357'	4400' - 4417'	4450' - 4466'	4500' - 4518'	4550' - 4570'	4599' - 4616'	4649' - 4668'	4702' - 4722'	4750' - 4768'	4800' - 4820'	4850' - 4870'	4900' - 4920'	4950' - 4970'
Ammodiscus asper	s	a	a	a	a	r	a	c	a	r	a	a	r	—	—	—	—	—	—	—	—
Reophax sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—
Geinitzina tenera striata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	s
– – *substriata*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	s
– – *tenuistriata*	—	—	—	—	—	—	—	—	—	—	—	r	—	r	—	—	—	s	c	—	—
– – *subprismatica*	—	—	—	—	—	—	—	—	r	—	—	r	—	—	—	—	—	—	—	—	—
– – *tenera*	—	—	—	—	—	—	—	r	r	—	r	—	—	—	—	—	—	—	—	—	—
– – *pupoides*	—	—	—	—	—	—	—	—	—	s	c	r	c	—	—	—	—	—	—	—	—
– – *praepupa*	—	—	—	—	—	—	—	—	—	s	c	—	—	—	—	—	—	—	—	—	—
– – *pupa*	—	c	c	a	c	s	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– – *carinata*	s	c	s	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Spandelina bicostata sulcata	—	—	—	—	—	r	—	—	—	—	—	c	r	r	—	—	—	r	r	—	c
– – *dubia*	r	—	—	r	—	—	—	—	—	—	—	r	r	—	—	r	—	—	r	—	—
– – *baueri*	r	r	r	—	—	r	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—
– – *bicostata*	—	r	—	r	s	—	s	r	—	—	—	s	r	—	—	—	—	—	—	—	—
– – *terquemi*	r	—	r	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nodosaria prima	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– *simoniana*	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—
– *columnaris*	—	c	—	—	—	—	—	—	—	—	s	c	—	r	—	—	—	—	—	—	—
– *radiata*	—	c	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—
– *metensis*	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	c
– *hortensis*	—	c	—	—	—	—	—	—	—	—	—	s	s	—	—	—	—	—	—	—	—
– *mitis*	r	—	—	—	—	—	—	—	r	—	s	c	r	—	—	—	—	—	—	—	—
– *oculina*	—	—	—	—	—	—	—	—	—	—	—	c	r	—	—	—	—	—	—	—	—
– *costata*	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– *fontinensis*	—	—	—	—	r	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– *dispar*	—	—	—	—	—	—	—	—	—	—	—	s	r	r	—	—	—	—	—	—	—
– *issleri*	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—
Pseudoglandulina vulgata	r	r	r	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—
– – var. pupoides	—	c	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– – var. irregularis	s	r	—	—	—	r	—	r	r	—	—	—	—	—	—	—	—	—	—	—	—
– – *multicostata*	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dentalina matutina matutina	s	r	r	r	r	—	—	r	s	c	c	a	a	—	—	—	—	—	—	—	—
– – *claviformis*	c	r	c	—	r	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Marginulina radiata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c	—	—	—	—
– *prima prima*	a	c	c	c	c	r	a	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– – *rugosa*	—	—	—	—	—	—	r	r	s	a	—	s	—	—	—	—	—	—	—	—	—
– – *praerugosa*	—	—	—	—	—	—	—	—	—	r	—	a	a	r	s	s	—	—	—	—	—
Vaginulina listi	—	—	—	—	—	—	—	—	—	—	—	c	—	—	—	—	—	—	—	—	—
Marginulinopsis radiata	—	—	—	r	r	—	r	—	r	r	r	s	s	c	—	—	—	—	—	—	—
– *quadricostata*	—	r	—	r	c	r	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– *breoni*	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– *matutina*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	r	—	s	c
– *lituoides*	—	—	—	—	—	—	—	—	—	—	c	a	—	—	—	—	—	—	—	—	—
– *prima*	s	r	s	r	r	r	c	r	—	—	—	—	—	—	—	—	—	—	—	—	—
Vaginulinopsis exarata	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—
Astacolus varians	—	—	—	r	a	a	s	s	r	r	s	a	a	r	c	r	a	r	s	c	s
– – var. convolutus	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Planularia stilla	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	c	a	r	r	—	—
– *inaequistriata*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—
– *eugenii*	—	—	—	r	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Saracenaria hannoverana	c	—	s	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– *sublaevis*	—	c	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lenticulina gottingensis	c	c	r	—	—	—	c	s	s	c	a	a	—	—	—	—	—	—	—	—	—
– *polygonata*	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
– *acutiangulata*	r	r	r	r	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Darbyella turbiniformis	c	a	c	—	r	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Eoguttulina liassica	—	r	—	—	—	—	—	r	—	—	—	r	r	—	—	—	—	s	—	—	s
"Bolivina" liasica	r	r	—	a	c	—	a	c	—	—	—	—	—	—	—	—	—	—	—	—	—

Vinding No. 1

Location: 56° 17'43 N 3° 52'73 W. of Observatory of Copenhagen. Between the villages Vinding and Tvis, Ringkøbing Amt.
Elevation: Ground 186' (57 m).
Rotary Table 202' (62 m).

Stratigraphic Section.

0' – 470'	(143 m)	Glacial drift, Pleistocene.
470' – 601'	(183 m)	Micaceous sand and black clay, probably Miocene.
601' – 975'	(297 m)	Micaceous sand and black clay, Chattian.
975' – 1100'	(335 m)	Gray Septaria Clay, Upper Rupelian.
1100' – 1170'	(357 m)	Gray Septaria Clay, Lower Rupelian.
1170' – 1270'	(387 m)	Søvind Marl, Bartonian.
1270' – 1350'	(411 m)	Lillebælt Clay, Lutetian.
1350' – 1495'	(456 m)	Røsnæs Clay, Upper Ypresian.
1495' – 1570'	(479 m)	Gray shale with tuff beds, Lower Ypresian.
1570' – 1813'	(553 m)	Dark gray shale with hard beds, Paleocene.
1813' – 2215'	(675 m)	White chalk, Danian.
2215' – 4255'	(1297 m)	White chalk, Senonian.
4255' – 4277'	(1303 m)	Reddish brown marlstone, Albian.
4277' – 4280'	(1304 m)	Dark gray shale, probably Barremian.
4280' – 4461'	(1359 m)	Gray shale, Hauterivian.
4461' – 4500'	(1372 m)	Argillaceous silt, probably Valendis.
4500' – 4782'	(1458 m)	Gray sandy shale, probably Upper and Middle ? Jurassic.
4782' – 5252'	(1601 m)	Dark gray shale, Lias.
5252' – 5561'	(1695 m)	Dark gray shale with thin beds of sandstone and in the lower portion with streaks of limestone, Rhaetic.
5561' – 7150'	(2170 m)	Varicolored shale with beds of sandstone and streaks of anhydrite, Keuper.
7150' – 7985'	(2434 m)	Varicolored marlstone with beds of anhydrite, Muschelkalk.

Upper Contact of Lias.

Both the upper and lower contacts of the Lias are difficult to place. Liassic markers occur in abundance in the ditch samples below 4800', and the Lias contact should consequently be placed somewhat above this depth. The core 4782'–4788' consists of 5' of dark gray shale with concretions of clay-ironstone. The microfauna of this core is extremely poor and consists of *Ammodiscus sp.* only which gives no indication of age. The megafauna of this core consists according to HANS FREBOLD of lamellibranches and *Pentacrinus sp.* together with several, very small, pyritized ammonites. The classification of these ammonites is very difficult on account of their small size, but they may possibly be referred to *Aegoceras planicosta,* which is the index fossil for the lower portion of Lias Beta. As the top of the Lias cannot very well be placed much higher than 4800′ the depth 4782′ is chosen as the upper contact.

Lower Contact of Lias.

The lower contact of this Series is even more difficult to place than the upper contact. The core 5352′–5360′ contains no microfauna but *Avicula costata* has been observed in it. The beds of this interval should thus re referred to the Rhaetic, and the lower contact of the Series is accordingly to be placed above 5352′. The core 5156′–5162′ consists of 4′ of dark gray shale. The microfauna of this shale is very sparse and consists mainly of ostracods with two specimens of indeterminable foraminifera of the *Astacolus* type and a single holothurian plate. Although no markers have been extracted the presence of foraminifera and holothurian plates clearly indicates the marine character of these beds which are consequently referred to the Lias Series. Thus the contact should be placed somewhere between 5162′ and 5352′, and the slight change in lithology at 5252′ has thus been chosen as the contact.

Lithology.

The interval consists of a monotonous section of dark, bluish gray, medium hard to hard, somewhat fissile shale; concretions of brownish clay-ironstone and pyrite in veinlets and as small nodules; scattered, poorly preserved fossils.

Megafossils.

The megafossils were examined by HANS FREBOLD, and the following lines are an excerpt from his letter dated Oct. 23, 1947. In the core 4782′–4788′ occurred, besides other fossils, several small pyritized ammonites. None of them were well-preserved but the ribs are characteristic of forms of the group of *Aegoceras planicosta* and *Aegoceras capricornu.* It was impossible to decide with certainty to which species the specimens should be referred but *Aegoceras planicosta* was assumed to be the most reasonable choice, and the corresponding beds were consequently referred to the Lower Lias Beta.

The core 4993′–5007′ contained a fauna, mostly of small lamellibranches. A single specimen of a small ammonite belongs apparently to *Arietites* sensu lato and these beds are for that reason referred to the upper part of Lias Alpha.

Microfauna.

The core 4782′–4788′ left after preparation a fairly large residue consisting mainly of small clusters of tiny crystals of siderite. From the residue was extracted a large number of *Ammodiscus asper.* The microfauna gives no clue to the determination of the age of these beds.

From the core 4993′–5007′ was extracted the following fauna:

Holothurian plates, rare.
Marginulina prima praerugosa, common.
Geinitzina tenera tenuistriata, common.
Planularia inaequistriata, two specimens.
Astacolus sp., two specimens.
Ostracods, abundant.

Of these species both *Marginulina prima praerugosa* and *Geinitzina tenera tenuistriata* occur in Lias Alpha and Lias Beta, while *Planularia inaequistriata* is confined to the Lias Alpha for which it is the most reliable index fossil. The beds are consequently referred to the Lias Alpha, which is in harmony with the fact that Hans Frebold reports the presence of an ill-preserved specimen belonging to the *Arietites* group from this core.

In the core 5156′–5162′ occurs the following microfauna.

Astacolus sp., scarce.
Ostracods, common.
Holothurian plates, rare.

Except for the fact that this microfauna clearly indicates a marine character of these beds, it does not allow any age determination.

The ditch samples of the interval 4782′–5252′ contain a fauna which is a mixture of Lower Cretaceous and Jurassic forms the majority of which unquestionably are downfall from the upper beds. Most remarkable is the fairly common occurrence of specimens of *Reinholdella sp.* which indicates the presence of Middle and/or Upper Jurassic beds above the Lias Series. Liassic index fossils occur abundantly in the ditch samples below 4800′. The most important of these forms are *Dentalina matutina matutina*, *Geinitzina tenera tenuistriata*, *Vaginulina listi* and *Marginulina prima praerugosa*. *Geinitzina tenera tenuistriata* and *Marginulina prima praerugosa* occur throughout the greater part of the Lower Lias while *Dentalina matutina matutina* and *Vaginulina listi* occur in the Lias Beta, but not in the Lias Alpha. Beds younger than the Lias Alpha must thus be present in the section. A closer determination of the beds above the Lias Alpha is difficult, as both *Dentalina matutina matutina* and *Vaginulina listi* have been observed in the Middle Lias. However, they have their main occurrence in the Lias Beta, and if present in the Middle Lias *Dentalina matutina matutina* is usually accompanied by the subspecies *Dentalina matutina claviformis*. As no specimens of the latter form have been observed, and as there is an abundance of the two other species, the reference of the beds in question to the Lias Beta can hardly be doubted. In this respect it is a peculiar fact that the ditch sample 5000′–5005′ contains two small fragments which are rather indeterminable, but may be of *“Bolivina” liasica*. This species is an excellent marker for the Middle Lias and usually occurs abundantly in these beds. This observation may be an indication of the presence of a thin streak of Middle Lias in the uppermost part of the Lias section. Except for these very insignificant fragments the whole fauna of the ditch samples distinctly indicates the presence of beds belonging to the Lias Beta.

The top of the Lias Alpha is difficult to place due to the fact that the index fossil, *Planularia inaequistriata,* does not occur in the ditch samples above 5100′. As the beds of the core 4993′–5007′ undoubtedly should be referred to the Lias Alpha the sample lag thus seems to have been considerable. As on the other hand the core 5156′–5162′ is probably taken in the lower part of the Lias Alpha the top of this zone cannot be expected to be found much higher than the core 4993′–5001′, and 4900′ is thus chosen as the approximate top of the Lias Alpha.

Vejrum No. 1

Location: 56° 26′03 N 3° 59′36 W of Observatory of Copenhagen. Near village Vejrum between the towns Holstebro and Struer. Ringkøbing Amt.
Elevation: 126′ (38 m.).

Stratigraphic Section.

0′ – 234′	(71 m)	Sand and gravel, Pleistocene.
234′ – 726′	(221 m)	White chalk, Senonian.
726′ – 742′	(226 m)	Gray shale, Neocomian.
742′ – 772′	(235 m)	Gray shale, Lias.
772′ – 806′	(246 m)	Gypsum and anhydrite, cap rock.
806′ – 1577′	(481 m)	Rock salt, Permian.

Upper Contact of Lias.

The upper contact of the Lias occurs in the core 734′–750′. The clay is very sticky and the core very much twisted; consequently the contact cannot be observed but may be determined by means of the microfauna only. The fauna of the sample 8′ below the top of the core still consists of Lower Cretaceous forms, while the sample 9′4″ below the top contains a fairly rich Liassic fauna. The top of the Lias is consequently placed at 742′.

Lower Contact of Lias.

The Lias Series is in this well resting on the cap rock of the Permian rock salt. The core 766′–776′ consists of abt. 6′ of gray tough clay and 1′ of anhydrite and gypsum. According to this the base of the Lias Series should be placed at 772′ which is confirmed by the fact that the driller's log reports a change of formation at this depth.

Lithology.

The interval consists of a dark gray, sticky, calcareous clay with scattered fossils.

Megafossils.

Some fragments have been shipped to A. Rosenkrantz for determination, but unfortunately appeared to be rather indeterminable, and no definite conclusion about the age of the beds could be arrived at.

Microfauna.

Core 734′–750′ (9′4″–11′4″).

Dentalina sp., scarce.
Dentalina matutina matutina, common.
Nodosaria mentensis, rare.
Nodosaria radiata, rare.
Nodosaria dispar, rare.
Marginulina prima praerugosa, common.
Vaginulina listi, scarce.
Marginulinopsis radiata, rare.
Spandelina bicostata sulcata, scarce.
Spandelina bicostata baueri, rare.
Spandelina bicostata bicostata, rare.
"Frondicularia" nitida, scarce.

Of the species *Dentalina matutina matutina, Vaginulina listi, Spandelina bicostata baueri,* and *S. bicostata bicostata* occur in most of the Lias except the Lias Alpha. On the other hand *Marginulina prima praerugosa* is confined to the Lias Alpha and the Lias Beta. Thus it cannot be doubted that the beds in this core belong to the Lias Beta.

Core 750′–766′.

Dentalina sp. scarce.
Nodosaria hortensis, rare.
Nodosaria prima, rare.
Ammodiscus asper, rare.
Marginulina prima praerugosa, rare.

This faupna does not give much information about the classification of the corresponding beds. All the species are distributed through the whole of the Lias Series except *Marginulina prima praerugosa* which is confined to the Lower Lias.

Core 766′–776′.

Dentalina sp. scarce.
Planularia inaequistriata, scarce.
Marginulina prima praerugosa, rare.
Marginulinopsis matutina, rare.
Marginulina prima praerugosa, common.
Pseudoglandulina sp., rare.
Geinitzina tenera tenuistriata, common.
Spandelina bicostata sulcata, rare.

Of the above-mentioned species *Marginulina prima praerugosa* and *Geinitzina tenera tenuistriata* are confined to the Lower Lias. *Planularia inaequistriata* is the index fossil for the Lias Alpha.

The contact between the Lias Alpha and the Lias Beta is difficult to determine owing to the rather untypical fauna in the core 750′–766′. However, as *Planularia inaequistriata* appears to be pretty dependent on facies changes, which seem to a slighter degree to affect *Dentalina matutina,* the depth 750′ has been chosen as the contact.

Rødby No. 1

Location: 54° 41′62 N 1° 10′37 W of Observatory of Copenhagen. Close west of Ringsebølle, Maribo Amt.
Elevation: Ground 7′ (2.1 m).
Rotary Table 18′ (5.5 m).

Stratigraphic Section.

0′ – 106′	(32 m)	Glacial drift, Pleistocene.
106′ – 1407′	(429 m)	White Chalk, Senonian.
1407′ – 1450′	(442 m)	Gray clay, Turonian.
1450′ – 1517′	(462 m)	White Chalk, Cenomanian.
1517′ – 1549′	(472 m)	Reddish brown marlstone, Albian.
1549′ – 1752′	(534 m)	Clay and fine Sand, Lias.
1752′ – 1839′	(560 m)	Dark gray shale, Lias.
1839′ – 2350′	(716 m)	Interlaminated sandstone and claystone, Rhaetic.
2350′ – 2840′	(866 m)	Calcareous claystone with anhydrite, Keuper.
2840′ – 3185′	(972 m)	Gray limestone, Muschelkalk.
3185′ – 5035′	(1535 m)	Reddish brown claystone with green parts and interbedded with sandstone, Bunter.

Upper Contact of Lias.

The contact between the Albian and the Lias occurs in the core 1540′–1560′, consisting of 7′ of reddish brown marlstone resting on 1′ of olive brown argillaceous siltstone. According to this observation the contact should be placed at 1547′, but the electric logs show the contact at 1549′.

Lower Contact of Lias.

Megaspores with a circular fold are found in the core 1839′–1859′, and as the core 1827′–1839′ contains marine fossils the lithologic break at 1839′ is chosen as the contact, as confirmed by the electric log survey.

Lithology.

1549′ (472 m)–1552′ (473 m) Argillaceous siltstone, glauconitic, moderate yellow to light olive brown.

1552′ (473 m)–1752′ (534 m) Interlaminated shale and silt, the shale dark to very dark gray, distinctly laminated with small streaks and thin beds of lighter colored more silty clay at places with concretions of clay-ironstone and lignitic beds; the silt light to very light gray, at places consolidated to a sideritic sandstone.

1752′ (534 m)–1839′ (561 m) Shale, dark greenish gray, distinctly laminated by lighter colored laminae, at places with very thin laminae of light gray silt; concretions of clay-ironstone; at 1754′ bone bed.

Megafossils.

The following is an abstract of a internal report by PETER H. BAADSGAARD, who has examined the megafossils from the cores.

Interval 1630′–1690′.

Dentalium sp. indet.
small gastropods and lamellibranches.

This contains an indefinite fauna which is, however, Liassic in character.

Interval 1754′–1755′.

The bone bed material has not been fully determined but *Hybodus sp.* and *Saurichthys sp.* are present.

Interval 1798′–1807′.

Paleoneilo galatea.
Grammatodon cypriniformis.
Astarte cf. ryensis.
Chlamys interpunctata.
Ammonites (Aegoceras) "centaurus".

This fauna indicates an age of Lower to Middle Lias Gamma, and is probably equivalent to part of the Lias marine series in the island of Bornholm.

Interval 1810′–1816′.

This interval is practically barren of fossils, but includes a single specimen which is probably *Liostrea irregularis.*

Interval 1825′–1827′.

Protocardium phillippiana.
Psiloceras cf. planorbis.

These two forms, and especially the latter, indicate the lower part of Lias Alpha.

Interval 1835,5′–1837,5′.

The fairly abundant fauna of this interval is dominated by the very characteristic *Modiola minuta,* and includes *Eotrapezium hyllingense* as well as *Liostrea irregularis* and other molluscs, which range from the Lower Lias down into the Rhaetic. This fauna is typical of the pre-planorbis beds of the English Lias.

According to the above records BAADSGAARD arrives at the following stratigraphic subdivision.

1630′ – 1690′	Lias – correlation unknown.
1755′	Lias Bone Bed – not correlated.
1798′ – 1807′	Lias Gamma, jamesoni – ibex zone.
1810′ – 1816′5	Lias Alpha.
1825′ – 1827′	Lias Alpha, planorbis zone.
1835′5– 1837′5	Lias, pre-planorbis beds.

Microfauna.

The microfauna of these beds is extremely poor and definitely indicates shallow water and coast-near sediments.

Core 1540′–1560′.
Core 1560′–1580′.
Core 1580′–1588′.
No microfossils observed.

Core 1588′–1603′.
Geinitzina tenera tenuistriata, rare.
Ostracods, common.
Holothurian plates, scarce.

Core 1603′–1623′.
Spandelina bicostata bicostata, rare.
Astacolus varians var. convolutus, rare.
Ostracods, common.
Holothurian plates, common.
Megaspores, common.

Core 1623′–1643′.
Holothurian plates, abundant.
Ostracods, common.

Core 1650′–1670′.
Astacolus varians var. convolutus, rare.
Ostracods, rare.
Megaspores, one specimen.

Core 1670′–1690′.
Holothurian plates, common.
Ostracods, scarce.
Megaspores, rare.
Dentalina sp., one fragment.
Marginulina (*sp. indet.*), scarce.

Core 1670′–1690′ (bottom sample).
Marginulina (*sp. indet.*), scarce.
Ostracods, abundant.
Holothurian plates, common.

Core 1690′–1710′.
Core 1710′–1717′.
Core 1717′–1737′.
Core 1737′–1753′.
A few megaspores observed.

Core 1753′–1773′.
Trochammina sp., rare.
Megaspores, rare.

Core 1791′–1802′.
Marginulinopsis (*sp. indet.*), rare.
Astacolus varians var. convolutus, rare.
Eoguttulina liassica, rare.

Core 1802′–1807′.
Lamarckina nov. sp., abundant.
Geinitzina tenera tenuistriata, scarce.
Astacolus sp. indet., scarce.
Eoguttulina liassica, rare.
Trochammina sp., common.
Ostracods, scarce.

Core 1807′–1827′.
Geinitzina tenera tenuistriata, common.
Eoguttulina liassica, rare.

Core 1827′–1839′.
Trochammina sp., abundant.
Geinitzina tenera tenuistriata, common.
Marginulina sp., rare.
Eoguttulina liassica, rare.

According to the contents of microfossils the shale in the interval 1752′–1839′ is undoubtedly marine, while the silty shale above seems to consist of interbedded marine and limnic beds. Thus the beds of the intervals 1547′–1588′ and 1690′–1752′ seem to be chiefly limnic, while the section 1588′–1690′ appears to be mainly marine.

The observed microfauna is extremely poor, the high contents of *Trochammina sp.* may indicate shallow water and the presence of megaspores coastnear sediments. The whole fauna definitely indicates Lias, but a further stratigraphic subdivision of the beds is impossible due to the poverty of the microfauna.

Børglum No. 1

Location: 57° 22′54 N 2° 44′28 W of Observatory of Copenhagen. Approx. 1 km. N of village Børglum and 2 km. W of village Vejby.

Elevation: Ground 63′ (19 m).
Rotary Table 74′ (23 m).

Stratigraphic Section.

0′ – 409′	(125 m)	Glacial drift, Pleistocene.
409′ – 1550′	(472 m)	White chalk, Senonian.
1550′ – 1602′	(488 m)	Dark gray, calcareous clay, Turonian.
1602′ – 1673′	(510 m)	Light gray, calcareous clay, Cenomanian.
1673′ – 2480′	(756 m)	Dark gray, silty claystone, Neocomian.
2480′ – 3770′	(1149 m)	Sandstone, siltstone and claystone, Upper and Middle Jurassic (probably including Valendis).
3770′ – 4500′	(1372 m)	Dark gray claystone with thin laminae of light gray silt, Lias.
4500′ – 5010′	(1537 m)	Fine to medium grained sandstone, interlaminated with dark shale, Rhaetic.

Upper Contact of Lias.

Evidently the beds from the base of the Cenomanian and down into the Rhaetic seem to belong to a single sedimentary cycle; most of the contacts appear to be transitional and accordingly very difficult to place. Lias microfossils occur in the ditch samples below 4085; the upper contact of the Lias should therefore be placed above this depth. The core taken in the interval 3874′–3884′ contains a fairly poor fauna of arenaceous specimens of the genus *Trochammina* (*sp. indet.*). There can be no doubt that these beds are marine, but the poor fauna is supposed to indicate shallow or maybe even brackish water. It seems probable that these beds should be included in the Lias. In the ditch samples the above-mentioned form occurs below 3825′. The most likely depth to choose for the top of the Lias thus seems to be the lithologic break at 3770′ as confirmed by electric log correlation with Haldager No. 1.

Lower Contact of Lias.

The lower contact is even more difficult to place than the upper contact. The beds in the core 4494′–4513′ are barren as all the beds below 4500′. Evidently the contact between the Lias and the Rhaetic is transitional. For that reason the lithologic break at 4500′ has been chosen as the contact.

Lithology.

3770′ (1149 m)–4058′ (1237 m) Dark gray, silty claystone with thin laminae and seams of light gray silt; carbonized plant remains and concretions of clay-ironstone.

4058′ (1237 m)–4086′ (1245 m) Light gray, silty sandstone with thin beds of claystone as above.

4086′ (1245 m)–4500′ (1372 m) Dark gray, silty claystone as above.

Megafossils.

The megafossils extracted from the richly fossiliferous beds in the core 4294′–4314′ have been examined by PETER H. BAADSGAARD, and the following is an abstract from his internal report. The 32 species mentioned below were identified.

Echinoid spines indet.
Serpula quinquesulcata.
Zeilleria cf. *numismalis.*
**Palaeoneilo galatea.*
**Palaeoneilo bornholmensis.*
Nuculana (Ryderia) doris.
**Grammatodon cypriniformis.*
Barbatia pulla.
**Astarte spp.*
**Astarte (Neocrassina)? fortuna.*
**Tancredia johnstrupi.*
**Protocardia truncata.*
**Pleuromya* cf. *corrugata.*
Oxytoma spp.
Limea acuticostata.
Chlamys cf. *subulata.*
Chlamys textoria.
**Entolium lundgreni.*
**Plicatula spinosa.*
**Plicatula orbiculoides.*
Tutcheria cingulata.
**Arcomya* cf. *decora.*
Turbo heliciformis.
**Actaeonina nathorsti.*
**Katosira craticia.*
Procerithium (Rhabdocolpus) sp.
**Dentalium elongatum* var. *gracile.*
**Aegoceras* cf. *centaurus.*
Ammonites cf. *Oxynoticeras oxynotum.*
**Pseudohastites charmouthiensis.*
Bairdia aff. *dispersa.*
Bairdia amalthei.

According to BAADSGAARD the 16 forms, marked with an (*), are species particularly indicative of the lower part of the Lower Pliensbachian, i. e. the zones jamesoni and ibex (centaurus) of the Lias Gamma.

Microfauna.

Core 3874′–3884′.

Trochammina sp., abundant.
Ammobaculites fontinensis, rare.

The fauna is of little value for the zonal subdivision, but indicates shallow or maybe brackish water. *Ammobaculites fontinensis* is recorded from the Lias Delta and the whole Dogger series.

Core 4095′–4105′.

Ammodiscus asper, common.
Spandelina bicostata bicostata, rare.
Geinitzina tenera carinata, rare.
Dentalina matutina claviformis, rare.
Nodosaria radiata, rare.
Pseudoglandulina vulgata, rare.
Marginulina prima prima, rare.
Megaspores, scarce.
Ostracods, scarce.

With the exception of *Nodosaria radiata* and *Ammodiscus asper* all the other forms are typical of the Middle Lias. The presence of *Geinitzina tenera carinata* and *Marginulina prima prima* definitely indicates that the beds should be referred to the Lias Delta or uppermost part of the Lias Gamma.

Core 4294′–4314′.

Spandelina bicostata bicostata, rare.
Geinitzina tenera tenera, rare.
Geinitzina tenera pupoides, common.
Geinitzina tenera praepupa, scarce.
Nodosaria quadrilatera, rare.
Nodosaria fontinensis, rare.
Pseudoglandulina vulgata var. irregularis, rare.
Dentalina sp., rare.
Dentalina matutina matutina, scarce.
Dentalina matutina claviformis, rare.
Marginulina prima rugosa, common.
Marginulina prima form. burgundiae, rare.
Astacolus varians, rare.
Marginulinopsis prima, rare.
Lenticulina gottingensis, rare.
Ostracods, common.

The presence of *Geinitzina tenera tenera, G. tenera pupoides, G. tenera praepupa* and *Marginulina prima rugosa* unquestionably indicates that the beds in this core should be referred to the Lias Gamma.

Core 4494′–4513′.
Barren.

Frederikshavn No. 1

Location: 57° 26′02 N 2° 03′40 W of Observatory of Copenhagen. In western outskirts of the town.
Elevation: Ground 31′ (9 m).
Rotary Table 42′ (13 m).

Stratigraphic Section.

0′ – 680′	(207 m)	Glacial drift, Pleistocene.
680′ – 1105′	(337 m)	White chalk, Senonian.
1105′ – 1165′	(355 m)	Dark gray shale, Turonian.

1165′ – 1185′	(361 m)	Glauconitic sand, Cenomanian.
1185′ – 1705′	(520 m)	Sand and sandy clay, Neocomian.
1705′ – 1909′?	(582 m)	Fine grained sand, Wealden.
1909′ – 2490′	(759 m)	Interbedded sand and clay, Upper and Middle Jurassic.
2490′ – 2973′	(906 m)	Dark gray shale with beds of fine grained sand, Lias.
2973′ – 3227′	(984 m)	Sand interbedded with clay, Rhaetic.
3227′ – 3337′	(1018 m)	Brownish gray claystone, Keuper?
3337′ – 4230′	(1289 m)	Arkose.
4230′ – 4321′	(1317 m)	Granite Gneiss, Precambrian.

Upper Contact of Lias.

The upper contact of the Lias is difficult to place. The first index fossils for the Lias occur in the core taken in the interval 2720′–2727′, and the top of the Lias should accordingly be placed above this depth. It is thus natural to include the whole sandy section in the interval 2668′–2782′ in the Lias Series. However, above this section, in the interval 2490′–2668′, occurs a section of dark gray shale with concretions of clay-ironstone which lithologically is very similar to the rocks in the Lias Series below. For this reason they are incorporated in the Lias Series, and the top of the Lias is consequently placed at 2490′.

Lower Contact of Lias.

The lower contact is somewhat easier to place. The core from the interval 2827′–2837′ still contains a microfauna indicating Lias, while the core 2990′–3000′ contains lignitic grains. The lower contact should thus be placed somewhere between the two cores, and the lithologic break at 2973′ has consequently been chosen as the contact.

Lithology.

2490′ (759 m)–2668′ (813 m) Dark greenish gray, silty claystone often somewhat shaley, non-calcareous and with concretions of clay-ironstone.

2668′ (813 m)–2782′ (848 m) Very fine grained, silty and argillaceous sand, greenish gray, non-calcareous, slightly fossiliferous and with seams of lignite, interbedded with claystone.

2782′ (848 m)–2973′ (906 m) Dark gray, silty claystone, at places thin streaks of sand, slightly calcareous.

Microfauna.

The fauna in the cores, taken in the interval 2720′–2777′, contains *Darbyella turbiniformis* and *Lenticulina acutiangulata* together with *Marginulina prima prima* which indicates Lias Delta or uppermost part of Lias Gamma. The beds below in the interval 2787′–2837′ contain *Lenticulina gottingensis, Geinitzina tenera pupoides, Pseudoglandulina vulgata* var. irregularis and *Marginulina prima rugosa* which indicate that these beds should be referred to the Lias Gamma.

No cores were taken in the lower part of the interval 2782′–2973′. The upper part of this interval undoubtedly belongs to the Lias Gamma, but no microfossils, which indicate the presence of marine beds of the Lower Lias, have been observed in the ditch samples below. It is consequently supposed that these beds are non-marine Lower Lias.

	Frederikshavn No. 1															No. 2		
	2495' – 2505'	2515' – 2525'	2525' – 2535'	2535' – 2545'	2545' – 2548'	2720' – 2727'	2737' – 2747'	2747' – 2757'	2757' – 2767'	2767' – 2777'	2787' – 2797'	2797' – 2807'	2807' – 2817'	2817' – 2827'	2827' – 2837'	2560' – 2568'	2568' – 2588'	2785' – 2805'
Jaculella liassica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—
Ammodiscus asper	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	c
Reophax sp.	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ammobaculites fontinensis	r	c	r	c	r	—	—	—	—	—	—	—	—	—	—	r	—	—
Trochammina sp.	—	—	r	c	—	—	—	—	—	—	—	—	—	—	—	—	r	a
Geinitzina tenera pupoides	—	—	—	—	—	—	—	—	—	—	—	r	r	c	r	—	—	—
– – *praepupa*	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	r	—
Spandelina bicostata baueri	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	r
– – *bicostata*	—	—	—	—	—	—	—	—	—	—	—	—	—	s	—	—	r	—
– – *terquemi*	—	—	—	—	—	r	—	—	—	—	—	—	r	—	—	r	r	—
Nodosaria radiata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r
– *mitis*	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—
– *oculina*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—
Pseudoglandulina vulgata	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—
– – var. irregularis	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	r	—
Dentalina matutina matutina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	s
– – *claviformis*	—	—	—	—	—	—	—	—	—	—	s	—	—	—	—	—	—	r
– *haeusleri*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	r
Marginulina prima prima	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—
– – *rugosa*	—	—	—	—	—	—	—	—	—	—	c	—	c	s	—	c	s	s
– – *spinata*	—	—	—	—	—	—	—	—	—	—	—	—	—	s	—	—	—	—
Vaginulina listi	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c	—	—
Marginulinopsis radiata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—
– *quadricostata*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—
– *prima*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	s	—
Astacolus varians	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c	s	—
– – var. convolutus	—	—	—	—	—	—	—	—	—	—	r	r	r	r	—	—	—	—
Lenticulina gottingensis	—	—	—	—	—	—	—	—	r	r	r	r	—	r	r	r	—	c
– *acutiangulata*	—	—	—	—	—	r	r	r	—	—	—	—	—	—	—	—	—	—
Darbyella turbiniformis	—	—	—	—	—	—	—	r	r	r	—	—	—	—	—	—	—	—
"Bolivina" liasica	—	—	—	—	—	—	—	—	—	—	—	r	r	—	—	—	—	—

Frederikshavn No. 2

Location: 57° 25'76 N 2° 03'92 W of Observatory of Copenhagen. Approximately 700 m SW of Frederikshavn No. 1.
Elevation: Ground 40' (12 m).
Rotary Table 51' (16 m).

Stratigraphic Section.

0' – 693'	(211 m)	Sand, silt and clay, Pleistocene.
693' – 1020'	(311 m)	White chalk, Senonian.
1020' – 1076'	(328 m)	Dark gray clay, Turonian.
1076' – 1100'	(335 m)	Glauconitic sandstone, Cenomanian.
1100' – 1610'	(491 m)	Fine grained sand, Neocomian.

1610′ – 1809′	(551 m)	Fine grained sand, Wealden.
1809′ – 2400′	(732 m)	Fine sand and sandy clay, Upper and Middle Jurassic
2400′ – 2898′	(884 m)	Dark gray shale interbedded with sand, Lias.
2898′ – 3160′	(963 m)	Sand and claystone, interbedded, Rhaetic.
3160′ – 3310′	(1009 m)	Varicolored claystone, Keuper.
3310′ – 3542′	(1080 m)	Arkose.

Upper Contact of Lias.

Since the electric logs show excellent correlation the contacts of this well can safely be placed in conformity with it, and the top of the Lias Series has consequently been placed at 2400′.

Lower Contact of Lias.

According to the electric log this contact should be placed at 2898′.

Lithology.

2400′ (732 m)–2580′ (786 m) Dark gray shale, with beds of light gray silt and nodular concretions of clay-ironstone and gray limestone.
2580′ (786 m)–2697′ (822 m) Light greenish gray, silty sand.
2697′ (822 m)–2898′ (884) m) Dark gray, silty and sandy shale with thin beds of very fine grained sand and silt.

Megafossils.

The megafossils of the Lias Series in this well have been examined by PETER H. BAADSGAARD, and the results of his study are to be found in the abstract below.

Core 2560′–2568′.
Core 2568′–2588′.

The fauna of these two cores is generally poor, both in numbers and species.

Grammatodon cypriniformis.
Palaeoneilo galatea.
Astarte spp.
Oxytoma sp.
Dentalium sp.
Gastropods-unidentified.

Core 2785′–2805′.

This core contains a fairly rich fauna of which the principal elements are:

Plicatula orbiculoides.
Plicatula spinosa.
Grammatodon cypriniformis.
Protocardia cf. truncata.
Chlamys textoria.
Palaeoneilo bornholmensis?
Palaeoneilo oviformis.
Palaeoneilo galatea.
Astarte sp.
Trochus laevis.
Turbo compositus.

Core 2885′–2905′.

The only fossil identified is *Chlamys textoria* which is indicative of the higher parts of the Lower Lias.

The presence of *Palaeoneilo galatea, Grammatodon cypriniformis* and *Plicatula spinosa* especially, together with the general uniformity of the fauna, indicates that the whole of the interval 2560′–2905′ represents marine (Lower) Liassic strata within the limits of Upper Alpha to Middle Gamma.

Microfauna.

See p. 49.

As was the case in Frederikshavn No. 1 beds with a pretty rich microfauna alternates with beds with a very sparse microfauna of arenaceous forms. The fauna in the interval 2560′–2588′ is peculiar as it differs from that of the corresponding interval in Frederikshavn No. 1 in the complete absence of *Darbyella turbiniformis, Lenticulina acutiangulata* and *Marginulina prima prima.* Although the correlation between the two wells by the electric logs cannot be doubted the faunas of the corresponding beds have little in common.

Frederikshavn No. 3

Location: 57° 27′52 N 2° 02′64 W of Observatory of Copenhagen. At northern end of the town approximately 2 kilometers N of Frederikshavn No. 1.

Elevation: Ground 23′ (7 m).
Rotary Table 34′ (10 m).

Stratigraphic Section.

11′ – 954′	(291 m)	Sand and clay, Pleistocene.
954′ – 1048′	(319 m)	White chalk, Senonian.
1048′ – 1107′	(337 m)	Dark gray, silty shale, Turonian.
1107′ – 1131′	(345 m)	Glauconitic, silty sand, Cenomanian.
1131′ – 1645′	(501 m)	Silty clay and sand, Neocomian.
1654′ – 1830′	(558 m)	Silty clay and sand, Wealden.
1830′ – 2385′	(727 m)	Silty clay and sand, Upper and Middle Jurassic.
2385′ – 2855′	(870 m)	Silty clay and sand, Lias.
2855′ – 3065′	(934 m)	Silty clay and sand, Rhaetic.
3065′ – 3220′	(981 m)	Varicolored claystone and sand, Keuper.
3220′ – 3307′	(1008 m)	Arkosic sandstone.

Upper and Lower Contacts of Lias.

All contacts in this well are placed according to the electric logs which show perfect correlation with those of Frederikshavn Nos. 1 and 2.

Lithology.

2385′ (727 m)–2564′ (782 m) Dark gray shale, with beds of silt and concretions of clay-ironstone.
2564′ (782 m)–2673′ (815 m) Gray, silty sand.
2673′ (815 m)–2855′ (870 m) Dark gray, silty and sandy shale with thin beds of sand.

Microfauna.

In the ditch samples *Marginulina prima prima* occurs below 2535′, *Lenticulina acutiangulata* below 2610′, *Dentalina matutina matutina* below 2625′ and *"Bolivina" liasica* below 2675′.

Haldager No. 1

Location: 57° 07′05 N 2° 47′90 W of Observatory of Copenhagen.
Elevation: Ground 6′ (2 m).
Rotary Table 17′ (5 m).

Stratigraphic Section.

11′ – 70′	(21 m)	Glacial drift, Pleistocene.
70′ – 1302′	(397 m)	White chalk, Senonian.
1302′ – 1320′	(402 m)	Dark gray shale, Turonian.
1320′ – 1375′	(419 m)	Glauconitic marl, Cenomanian.
1375′ – 2710′	(826 m)	Dark gray, silty clay; at the bottom silty sand, Neocomian.
2710′ – 4614′	(1406 m)	Dark gray shale and sandstone, locally glauconitic, in certain places with carbonized plant remains and beds of lignite, Upper and Middle Jurassic.
4614′ – 5000′	(1524 m)	Dark gray shale and sandstone, Lias.

Upper Contact of Lias.

The top of the Lias has been placed at the lithologic break at 4614′.

Lower Contact of Lias.

The Lias Series was not penetrated.

Lithology.

4614′ (1406 m)–4870′ (1484 m) Dark gray, silty shale with streaks of sandstone and plant remains.
4870′ (1484 m)–4934′ (1504 m) Gray, very fine grained, silty sandstone.
4934′ (1504 m)–5000′ (1524 m) Dark gray, silty shale.

Microfauna.

The core taken in the interval 4710′–4720′ contains no microfauna. From the core 4980′–5000′ is extracted the following species, *"Bolivina" liasica, Lenticulina gottingensis, Geinitzina tenera praepupa, Dentalina* sp.

VII. Description of the Species

SUPERFAMILY ASTRORHIZIDEA

FAMILIY ASTRORHIZIDAE

SUBFAMILY HYPERAMMININAE

Jaculella liassica Brand

Jaculella liassica, BARTENSTEIN & BRAND, 1937, p. 129, pl. 2B, fig. 1; pl. 3, figs. 4a, b; pl. 4, fig. 3, pl. 5, fig. 4.

Occurrence.

Lias Gamma: Frederikshavn No. 2, 2560′–2568′, rare.

FAMILY AMMODISCIDAE

Ammodiscus asper (Terquem)

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, scarce; 4016′–4024′, abundant; 4080′–4092′, abundant; 4143′–4150′, abundant; 4184′–4194′, abundant; 4222′–4230′, rare; 4265′–4286′, abundant.

Lias Gamma: Gassum No. 1, 4300′–4310′, common; 4349′–4357′ abundant; 4400′–4417′, rare; Frederikshavn No. 2, 2568′–2588′, rare; 2785′–2805′, common; Børglum No. 1, 4095′–4105′, common.

Lias Beta: Gassum No. 1, 4450′–4466′, abundant; 4500′–4518′, abundant; 4550′–4570′, rare; Vinding No. 1, 4782′–4788′, abundant.

Lias Alpha: Vejrum No. 1, 750′–766′, rare.

SUPERFAMILY LITUOLIDEA

FAMILY REOPHACIDAE

Reophax sp.

Occurrence.

Lias Gamma: Frederikshavn No. 1, 2495′–2505′, rare.

Lias Alpha: Gassum No. 1, 4900′–4920′, scarce.

FAMILY LITUOLIDAE

SUBFAMILIY HAPLOPHRAGMININAE

Ammobaculites fontinensis (Terquem)

Haplophragmium fontinensis TERQUEM, 1870, p. 235, pl. 24, figs. 29, 39.
Ammobaculites fontinensis FRANKE, 1936, pl. 127, pl. 12, fig. 24.

Occurrence.

Lias Gamma: Frederikshavn No. 1, 2495′–2505′, rare; 2515′–2525′ common; 2525′–2535′, rare; 2535′–2545′, common; 2545′–2548′, rare; Frederikshavn No. 2, 2560′–2568′, rare; Børglum No. 1, 3874′–3884′, rare.

FAMILY TROCHAMMINIDAE

SUBFAMILY TROCHAMMININAE

Trochammina sp.

Occurrence.

Lias Gamma: Frederikshavn No. 1, 2525′–2535′, rare; 2535′–2545′, common; Frederikshavn No. 2, 2568′–2588′, rare; 2785′–2805′, abundant; Børglum No. 1, 3874′–3884′, abundant; Rødby No. 1, 1753′–1773′, rare; 1773′–1791′, rare; 1807′–1827′, common; 1827′–1839′, abundant.

SUPERFAMILY NODOSARIIDEA

FAMILY NODOSINELLIDAE

Geinitzina tenera (Bornemann) subsp. striata (Blake)

Figs. 1, 2.

Lingulina striata, TATE & BLAKE, 1876, p. 455, pl. 18, figs. 16, 16 a.

Description.

Megalospheric form: Test elongated, composed of several chambers in a rectilinear series, distinctly compressed; chambers broader than high, drum-shaped; sutures flush with surface, more or less indistinct, typically linguline to slightly frondicularian; margin indistinctly carinated; ribs numerous, rather fine, irregular off-setting, usually asymmetric, they may at one half of the test be approximately parallel to the side of the test while on the other half of the test they may be distinctly oblique, often with a distinct, smooth interval at the median part of the test. This part may be slightly depressed and corresponds to the median groove; aperture terminal, symmetrical, distinctly elongated, protruded or surrounded by a low wall; proloculum large, spherical, generally smooth, very variable in size.

Microspheric form: This form differs from the megalospheric form only in the very small prooculum, and in the weak but distinct curvature of the test.

Remarks.

According to BLAKE the typical form is closely allied to *Lingulina tenera.* "Its ribs are very fine and irregular, and it puts on several curious shapes (as does L. tenera); and in some the ribs are so unequal as to show the passage to the last-named form". This description of the form as being a very long and pointed form with very fine and irregular ribs fits very well with the specimens from the Danish Lias and their identity with the species, described by BLAKE, can hardly be doubted. This reference is, furthermore, confirmed by the comparison of the Danish specimens with the two excellent figures by BLAKE, with which they agree perfectly, only the ribs are more irregular in the specimens from the Danish Lias. However, it appears reasonable to believe that BLAKE has picked out the specimens with the most regular ribs for the purpose of illustrating more clearly the close relationship between *L. tenera* and *L. striata.* BLAKE's fig. 16 is of special interest as it seems to be a microspheric specimen and has a similar curvature as the few microspheric specimens extracted from the Lias Series in Denmark.

Occurrence.

Lias Alpha: Gassum No. 1, *4950′–4970′*, scarce.

Distribution.

G. tenera striata seems to be confined to the lower part of the Lias and is at the present time only known from the Danish Lias Series and the Yorkshire Lias. It is hardly possible that this very distinctive form by former authors should have been included in *Lingulina tenera*, and the absence of the subspecies in other areas is possibly due to the poor state of preservation of the microfauna in these beds as reported by BARNARD (1950) and by BRAND in BARTENSTEIN & BRAND (1937).

Geinitzina tenera (Bornemann)
subsp. substriata nov. subsp.

Figs. 3–10.

Description.

This form is intermediate between *G. tenera striata* and *G. tenera tenuistriata*. It differs from the first-mentioned form by the presence of a very distinct median groove and the carinated margin, from the latter by the irregularity of the ribs.

Remarks.

The size of the proloculum varies over a wide range, but no specimens observed appear to be microspheric. Though much more regular than the former subspecies, small irregularities in the ribs still indicate the ancestral, curved form.

No figures or descriptions published by previous authors seem to fit this form. FRANKE (1936) reports that specimens of *Lingulina tenera* with intercalated ribs may be rather similar to *L. pupa* but for the fact that *L. pupa* is oval in section and has no marginal keels. As these differences are supposed to be rather inadequate for the discrimination of *G. tenera pupa* and *G. tenera tenera*, it seems quite possible that FRANKE has included some specimens which should rather be referred to *G. tenera pupa* in *Lingulina tenera*. On the other hand he may have included both *G. tenera substriata* and *G. tenera tenuistriata* in the same species, especially as he records *Lingulina tenera* from the Lias Alpha as well as the Lias Beta. BRAND in BARTENSTEIN & BRAND (1937) gives more exact data on this phenomenon as he reports that the presence of intermediate, subsidiary ribs is typical particularly of the specimens of *Frondicularia tenera* in the Lias Alpha, and that no subsidiary ribs have been observed in the specimens from the Lias Gamma and Delta. Thus it seems beyond doubt that forms similar to *G. tenera substriata* and *G. tenera tenuistriata* occur in the Lias Alpha and Lias Beta of Germany. BARNARD (1950) reports that in large specimens of *Lingulina tenera* "the chambers become constricted and that the main ornament becomes obsolete and is replaced by numerous small striae, each striation terminating at the constricted suture". This description, however, fits better the intermediate forms between *G. tenera pupa* and *G. tenera tenera* and especially the microspheric form of *G. tenera pupa.* On the other hand BARNARD records *Lingulina tenera* var. *pupa* as far down as the Lias Alpha. The reason seems to be that TERQUEM (1866) in his description of *Marginulina pupa* included the Lower Lias forms. Thus it is impossible at the present time to decide whether *G. tenera substriata* and *G. tenera tenuistriata* occur in the Lower Lias of England and France.

Occurrence.

Lias Alpha: Gassum No. 1, 4850′–4870′, rare; 4950′–4970′, scarce.

Distribution.

In the Danish Lias Series this form seems to be strictly confined to the Lias Alpha.

Geinitzina tenera (Bornemann)
subsp. tenuistriata nov. subsp.

Figs. 13, 16, 17, 24.

Lingulina tenera, TATE & BLAKE, 1876, p. 455, pl. 18, figs. 15, 15 a.

Description.

Megalospheric form: Test variable in shape; generally broad, but elongated forms occur, distinctly compressed, flattened hexagonal prismatic in section, distinctly tapering towards the initial end; chambers 9–12, broader than high, more or less distinctly chevron-shaped; margin distinctly carinated; 6 main ribs and up to 4 additional ribs, but usually only some of the additional ribs are developed; median groove distinct, bordered by two main ribs; whole test more or less striated by very fine, indistinct, partly discontinuous ribs; sutures flush, indistinct; aperture terminal, symmetrical, distinctly elongated.

Microspheric form: This form does not differ very much from the megalospheric form except for the fact that it owing to the smaller proloculum tapers more towards the initial end and also because it has more chambers in the initial part of the test.

Remarks.

As mentioned in the description the test is generally short and broad, but elongated forms occur quite frequently. Such forms are intermediate between the typical form and *G. tenera subprismatica,* though easily distinguished from the latter by the distinctly compressed test. The very fine, discontinuous ribs may be better developed, and in such specimens the passage to *G. tenera substriata* is illustrated. Some specimens are characterized by well-developed fine ribs, which are more regular than in the typical form as they show the passage from *G. tenera tenuistriata* to *G. tenera pupoides.* As mentioned under the remarks to *G. tenera substriata* it seems reasonable to believe that TERQUEM and BARNARD have included both *G. tenera substriata* and *G. tenera tenuistriata* in *Lingulina pupa,* while FRANKE and BRAND seem to have included these subspecies in *Frondicularia tenera.*

Occurrence.

Lias Beta: Gassum No. 1, 4500′–4518′, rare; 4599′–4616′, rare.

Lias Alpha: Gassum No. 1, 4800′–4820′ scarce; 4850′–4870′, common; Vejrum No. 1, 766′–776′, common; Vinding No. 1, 4993′–5001′, common; Rødby No. 1, 1802′–1807′, scarce; 1807′–1827′, common; 1827′–1839′, common.

Distribution.

The distribution of this subspecies is little known due to the abovementioned facts, although several things seem to indicate that it is confined to the Lower Lias.

Geinitzina tenera (Bornemann)
subsp. subprismatica (Franke)

Figs. 11, 12, 14, 15.

Nodosaria subprismatica, FRANKE, 1936, p. 48, pl. 4, fig. 17.
Frondicularia tenera prismatica, BARTENSTEIN & BRAND, 1937, p. 156, figs. 15 a, b; pl. 13, figs. 34 a–c.

Description.

Test elongated, prismatic, hexagonal in section; 7–9 chambers, about as high as broad, last 5–7 chambers not increasing in size with age; sutures flush with surface, indistinct, ornamented with 6 longitudinal ribs running from the short spine at the base of the proloculum over the whole test until they disappear before reaching the aperture at the last chamber; median groove indistinct, bordered by ribs which are not, or only slightly, higher than the marginal ribs; in the form from the Lias Beta occasionally additional, less developed ribs; a thin and indistinct median ribs is especially typical of this form; aperture terminal, rounded. Microspheric form unknown.

Remarks.

The specimens from the Danish Lias Series fit completely into the description and figures of the typical form apart from the occasional presence of additional ribs, which indicate the passage from *G. tenera subprismatica* to the elongated variant of *G. tenera tenuistriata.*

According to the Rules of Nomenclature it has been considered necessary to apply the original specific name by FRANKE (1936), the more so as BRAND (1937) has confirmed the identity of the two forms by a comparison with the holotype. BRAND states that the form shows similarity to the genus *Nodosaria* but is connected with *Frondicularia tenera tenera* by intermediates so that the form, which by FRANKE was described as *Nodosaria subprismatica,* without doubt must be considered a subspecies of the *Frondicularia tenera* group. Though the relationship of the specimens to the genus *Frondicularia* can seldom be proved due to the rare presence of indistinct, inverted chevron-shaped chambers, the presence of an elongated aperture definitely indicates the relationship to *Frondicularia tenera*. BRAND states that the form is derived from *Frondicularia tenera* by elongation of the test, and subsequently the median ribs are moved together, a fact which causes these ribs to move away from the lateral ribs until the distances between them are nearly equal, and the test in section then appears as a regular hexagon. This development is very clearly illustrated by the material from Denmark. Thus elongated specimens with a reduced number of ribs, but still flattened and referable to *G. tenera tenuistriata*, occur in Lias Alpha. The specimens from the Lias Beta, referred to *G. tenera subprismatica*, are fairly regularly hexagonal but still have more or less indistinct, intermediate ribs which have completely vanished in the specimens from the Lias Gamma. Thus the derivation of *G. tenera subprismatica* from *G. tenera tenuistriata* seems to be well illustrated by the occurrence of intermediate forms.

Occurrence.

Lias Gamma: Gassum No. 1, 4349′–4357′, rare.
Lias Beta: Gassum No. 1, 4500′–4518′, rare.

Distribution.

The occurrence of this subspecies in the Danish Lias Series confirms BRAND's statement that this form is confined to the Lias Beta and Gamma.

Geinitzina tenera (Bornemann) subsp. tenera (Bornemann)

Figs. 18–23.

Marginulina tenera, BORNEMANN, 1854, p. 38, pl. 3, figs. 24 a–c.
Frondicularia hexagona, TERQUEM, 1858, p. 35, pl. 1, figs. 13 a–c.
Frondicularia tenera, TERQUEM, 1858, p. 35, pl. 1, figs. 14 a–c.
Frondicularia hexagona, TERQUEM, 1866, p. 404.
Lingulina tenera, BRADY, 1867, p. 223, pl. 1, fig. 11.
Frondicularia tenera, TERQUEM & BERTHELIN, 1875, p. 36.
Lingulina tenera, SCHICK, 1903, p. 151, pl. 6, fig. 10.
Lingulina tenera, FRANKE, 1936, p. 64, pl. 6, fig. 18.
Frondicularia tenera tenera, BARTENSTEIN & BRAND, 1937, p. 156, pl. 1 A, figs. 11, 19; pl. 2 A, figs. 10 a–c; pl. 2 B, figs. 18 a, b; pl. 3, figs. 25, 26; pl. 5, figs. 67 a, b.
Frondicularia tenera octocosta, BARTENSTEIN & BRAND, 1937; p. 157, fig. 15 c; pl. 3, fig. 27.
Lingulina tenera, MACFADYEN, 1941, p. 51, pl. 3, figs. 52 a, b.
Lingulina tenera, BARNARD, 1950, p. 365, figs. 6 a, c, f, g.
Lingulina tenera var. octocostata, BARNARD, 1950, p. 365, fig. 6 e.

Description.

Megalospheric form: Test rather boad, regular in shape, distinctly compressed, composed of 6 to 8 chambers, much broader than high, linguline to slightly frondicularian; ornamented with two median ribs bordering the distinct median groove and two lateral ribs, occasionally with less developed, additional ribs, often present on one side and larvated or absent on the other; sutures indistinct, slightly curved, not deepened; aperture terminal, elongated.

Microspheric form: This form is similar to the megalospheric form except for the very small proloculum. Often, however, the test is somewhat broader, more attenuated towards the initial end and pentagonal in outline; the additional ribs are usually better developed in the microspheric form.

Remarks.

According to the description and figures of the holotype the specimens from the Danish Lias can no doubt be referred to this form in spite of the fact that BORNEMANN does not mention the presence of additional ribs. Although TERQUEM adopts the definition by BORNEMANN the figured specimens are, nevertheless, ornamented with 8 distinct ribs, while the picture of *F. hexagona* shows 6 ribs only. FRANKE states the occurrence of additional ribs in his material and even maintains that specimens with such ribs may be similar to *L. pupa* from which *L. tenera* can be discriminated by the presence of a carinated margin and the hexagonal section. According to this description it is pretty evident that FRANKE allows a very broad variation in this species which seems to cover most of the subspecies except *G. tenera pupa.* On the other hand FRANKE includes *L. striata* in *L. pupa.* The characters, given by FRANKE, are therefore insufficient for the discrimination between *G. tenera tenera* and *G. tenera pupa.* BRAND mentions the presence of fine additional ribs in the specimens of *Frondicularia tenera tenera* from the Lias Alpha which seems to show that *G. tenera tenuistriata* at least has been present in the material from Germany. Though his definition of *F. tenera tenera* thus seems to cover *G. tenera tenuistriata,* and perhaps even *G. tenera substriata,* the specimens from the Lias Gamma and Delta with additional ribs are referred to a separate subspecies *F. tenera octocosta.* The latter form is recognized as a variety by BARNARD. In the microfauna from the Danish Lias Series this form is by passage forms linked together with *G. tenera tenera,* as defined in this publication, and as the distribution of the form seems to be very similar to that of *G. tenera tenera,* as here defined, the present author is of opinion that the form *octocosta* should be included in *G. tenera tenera.*

The peculiar asymmetry in the size of the additional ribs is supposed to indicate the origin of this subspecies from slightly curved forms.

The specimen pictured by BLAKE appears to be *G. tenera tenuistriata.*

Occurrence.

Lias Gamma: Gassum No. 1, 4300′–4310′, rare; 4349′–4357′, rare; 4450′–4466′, rare; Børglum No. 1, 4294′–4314′, rare.

Distribution.

In the Danish Lias Series this subspecies seems to be strictly confined to the Lias Gamma. The distribution of the form outside Denmark is difficult to evaluate owing to the deviating opinions of previous authors about the definition of the subspecies. However, much seems to indicate that the records from the Lower Lias of *F. tenera* actually are of *G. tenera tenuistriata.*

Geinitzina tenera (Bornemann)
subsp. pupoides nov. subsp.

Figs. 25–29.

Description.

Megalospheric form: Test stout, gradually tapering from the final chamber to the proloculum, pointed oval in outline, strongly compressed, composed of 6 to 8 chambers, much broader than high, linguline to indistinctly frondicularian; sutures indistinct, flush with surface, never constricted; median groove usually fairly distinct, but with rather low and broad continuous ribs and bordered by two median ribs which are distinctly higher than the additional ribs; several additional fine ribs are observed between the other ribs in the median groove as well as outside the two rather high median ribs.

Microspheric form: This form is in all respects very similar to the megalospheric form.

Remarks.

This subspecies is evidently derived from *G. tenera tenuistriata,* and in some cases it may be difficult to discriminate between these two forms. However, *G. tenera pupoides* is generally much more compressed and has finer, lower and much more regular ribs than *G. tenera tenuistriata.*

In a few microspheric specimens asymmetry in the ribs is observed indicating the origin of the form from curved forms.

Occurrence.

Lias Gamma: Gassum No. 1, 4400′–4417′, scarce; Frederikshavn No. 1, 2797′–2807′, rare; 2807′–2817′, rare; 2817′–2827′, common; 2827′–2837′, rare; Børglum No. 1, 4294′–4314′, common.

Lias Beta: Gassum No. 1, 4450′–4466′, common; 4500′–4518′, rare; 4550′–4570′, common.

Geinitzina tenera (Bornemann)
subsp. praepupa nov. subsp.

Figs. 30, 31.

Description.

Megalospheric form: Test elongated, distinctly compressed, especially in the initial part, but tending to be more rounded in section in the adult; composed of 7 to 10 chambers in the initial part, much broader than high, while in the adult part only slightly broader than high; sutures indistinct and flush with surface in the initial part, but slightly constricted between the last chambers; margin distinctly carinated; median groove distinct with two or more indistinct rather low ribs, more or less interrupted at the sutures;

median ribs high and well developed, bordering the median groove, the additional ribs outside the median groove usually well developed; aperture terminal, elliptical.

Microspheric form: Very similar to the megalospheric form except for the smaller proloculum which causes the test to taper more distinctly towards the initial end.

Remarks.

This form is quite evidently derived from *G. tenera tenuistriata* from which it only differs in the more rounded section in the adult part and the more pronounced and more regular ribs. In other respects *G. tenera praepupa* is very similar to *G. tenera pupa* and a discrimination between these two species is very difficult. However, *G. tenera pupa* is generally nearly circular in sections of the adult part, while *G. tenera praepupa* is still distinctly compressed. Furthermore, the two median ribs, bordering the median groove, are generally distinctly higher than the additional ribs in *G. tenera praepupa,* while all the ribs are nearly equally developed in *G. tenera pupa.*

Occurrence.

Lias Gamma: Gassum No. 1, 4400′–4417′, scarce; Frederikshavn No. 1, 2787′–2797′, rare; Frederikshavn No. 2, 2568′–2588′, rare; Børglum No. 1, 4294′–4314′, scarce.

Lias Beta: Gassum No. 1, 4450′–4466′, common.

Geinitzina tenera (Bornemann)
subsp. pupa (Terquem)

Fig. 32–45.

Marginulina pupa, TERQUEM, 1866, p. 429, pl. 17, figs. 7 a–f.
Frondicularia pupa, TERQUEM & BERTHELIN, 1875, p. 36, pl. 3, figs. 1 a–c.
Lingulina pupa, FRANKE, 1936, p. 63, pl. 6, figs. 16 a–b, 17.
Lingulina pupa, BARTENSTEIN & BRAND, 1937, p. 152, pl. 4, figs. 52 a–b, 53 a–b; pl. 5, figs. 32 a–b, 33.
Lingulina tenera var. pupa, MACFADYEN, 1941, p. 52, pl. 3, figs. 52 a–b.
Lingulina tenera var. pupa, BARNARD, 1950, p. 367, figs. 6 b, d.

Description.

Megalospheric form: Test elongated, rounded in section but typically slightly compressed at least in the initial part; composed of 6–8 chambers; sutures slightly to not deepened in the initial part, distinctly, and often strongly constricted between the last two or three chambers, which are nearly circular in section; median groove usually distinct, at least in the initial part of the test, bordered by two distinct ribs, which are only slightly better developed than the several, additional ribs; aperture terminal, often slightly protruded.

Microspheric form: In many respects similar to the initial part of the megalospheric test and often difficult to discriminate from *G. tenera tenera.* However, the small proloculum, the sometimes greater number of ribs in the adult portion of the test and the occurrence of the form in company with megalospheric specimens usually leave little doubt about the correct classification.

Remarks.

According to the description of the holotype by TERQUEM (1866) the specimen seems to represent a stage in the passage from *G. tenera praepupa* to *G. tenera pupa;* furthermore it seems possible that TERQUEM has included *G. tenera tenuistriata* in this definition, which may be confirmed by the record of this form both from the Middle and the Lower Lias. Although FRANKE lists *Lingulina striata* BLAKE as a synonym of *Lingulina pupa* he may include both *G. tenera substriata* and *G. tenera tenuistriata* in *Lingulina tenera.* BRAND (1937) seems to have adopted a definition of *Lingulina pupa,* which is in pretty close agreement with the definition of *G. tenera pupa* in the present publication. In accordance with the above BRAND seems to include at least *G. tenera tenuistriata* in *Frondicularia tenera tenera.* BARNARD (1950) considers *G. tenera pupa* as a mere variety of *Lingulina tenera* characterized by the presence of subsidiary ribs and thus evidently includes *G. tenera tenuistriata* and quite naturally *G. tenera substriata* in *Lingulina tenera* var. pupa which consequently appears as a simple variety accompanying the main species and thus being of little biostratigraphic importance.

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, common; 4080′–4092′, common; 4143′–4150′, abundant; 4184′–4194′, common; 4222′–4230′, scarce; 4265′–4286′, rare.

Distribution.

On account of the above-mentioned assumptions it is difficult to make any definite conclusion about the distribution of this subspecies outside Denmark. However, the above considerations seem to indicate that this subspecies may be confined to the Middle Lias.

Geinitzina tenera (Bornemann)
subsp. carinata nov. subsp.

Figs. 46–55.

Description.

Megalospheric form: Test somewhat elongated, but rather stout specimens are commonly observed, oval in outline, distinctly compressed; margin distinctly carinated; median groove very distinct, usually deeply excavated, thus superficially adding further to the height of the ribs; two main ribs, bordering the median groove, typically very high and thin; additional ribs occur in some specimens but are distinctly weaker than the two main ribs, they are especially observed in elongated specimens; inequalities in the ribs are commonly observed and are of a similar type as those observed in *G. tenera tenera.*

Microspheric form: Very similar to the megalospheric form, but the additional ribs are usually somewhat better developed.

Remarks.

This subspecies differs only from *G. tenera tenera* in the high ribs and deeper median groove, i. e. differences in degree hardly to be considered even of subspecific importance. Consequently it should not have been considered a separate subspecies, if it was not a fact that these characters are sufficient for a discrimination between the forms in the Lias Gamma and those exclusively occurring in the upper part of the Lias Delta. In consequence of the fact hat these two, obviously closely related forms, both seem to be of importance as markers it has been considered practical – and perhaps justifiable – to keep them apart as two different subspecies.

BARNARD records a form from the Lower Lias which seems very similar to *G. tenera carinata.* Thus BARNARD states that the test is very robust and has an appearance similar to var. excavata of TERQUEM, due entirely to the abnormal height of the ribs that gives the test a biconcave cross section. TERQUEM (1866) in his description of *Frondicularia excavata* from the Lower Lias does not mention the presence of ribs. The relationship of *F. excavata* to the present subspecies of *Geinitzina tenera* is thus obscure.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, scarce; 4016′–4024′, common; 4080′–4092′, scarce; Børglum No. 1, 4095′–4105′, rare.

Spandelina bicostata (d'Orbigny) subsp. sulcata (Bornemann)

Figs. 56–59.

Frondicularia sulcata, BORNEMANN, 1854, p. 37, pl. 3, figs. 22 a, c.
Frondicularia pulchra, TERQUEM, 1858, p. 33, pl. 1, figs. 10 a, c.
Frondicularia multicostata, TERQUEM, 1862, p. 438, pl. 5, fig. 14.
Frondicularia striata, BRADY, 1867, p. 229, pl. 3, fig. 48.
Frondicularia venusta, TERQUEM & BERTHELIN, 1875, p.37.
Frondicularia squamosa, TERQUEM & BERTHELIN, 1875, p. 37.
Frondicularia sulcata, TATE & BLAKE, 1876, p. 469, pl. 19, fig. 23.
Frondicularia multicostata, BURBACH, 1886, p. 50, pl. 2, figs. 42, 43.
Frondicularia octocostata, BURBACH, 1886, p. 50, pl. 2, fig. 44.
Frondicularia pulchra, BURBACH, 1886, p. 51, pl. 2, figs. 45, 46.
Frondicularia rugosa, CRICK & SHERBORN, 1891, p. 213, fig. 34.
Frondicularia sulcata, CRICK & SHERBORN, 1891, p. 213, fig. 35.
Frondicularia cf. *baueri,* SELLHEIM, 1893, p. 22, fig. 14.
Frondicularia pulchra, SCHICK, 1903, p. 153, pl. 6, No. 15.
Frondicularia pulchra, ISSLER, 1908, p. 59, p. 13,figs. 130–136.
Frondicularia sulcata, ISSLER, 1908, p. 61, pl. 3, figs. 140–142.
Frondicularia pulchra, FRANKE, 1936, p. 71, pl. 7, fig. 7.
Frondicularia sulcata, FRANKE, 1936, p. 71, pl. 7, fig. 8.
Frondicularia interrupta-costata, FRANKE, 1936, p. 72, fig. 1.
Frondicularia sulcata, BARTENSTEIN & BRAND, 1937, p. 158, pl. 1 A, fig. 12; pl. 2 A, fig. 19; pl. 2 B, fig. 20; pl. 4, fig. 50.
Frondicularia sulcata, BARNARD, 1950, p. 369, figs. 7 a, e, f.

Description.

Megalospheric form: Test elongate, size variable but generally up to or somewhat above 1.0 mm in length, lanceolate with nearly parallel sides or increasing fairly uniformly in breadth from the globular proloculum to the final chamber, compressed, with an indistinct median groove; periphery sharply angular with a thin narrow keel; chambers indistinct, equitant, usually up to 10 in the adult megalospheric form; sutures generally flush with surface, indistinct, rarely deepened between the two last chambers, usually only observed as indistinct, darker lines, sutural angle less than or close to 90°; wall calcareous, imperforate, hyaline; ornamented by numerous, usually 6–8 parallel and continuous, longitudinal ribs, which do not converge towards the apertural end; aperture terminal, more or less protruding, simple and rounded; diameter of proloculum 0.05–0.07.

Microspheric form: Similar to the megalospheric form but seemingly with more chambers, diameter of proloculum 0.025 mm.

Remarks.

In Gassum No. 1, 4850′–4870′ is observed a single specimen with a short and strong spine on the end of the proloculum. This character, however, is supposed to be of no value for the taxonomy, as similar spines occasionally occur in all of the subspecies.

As will be seen from the description *S. bicostata sulcata* shows wide variations both in general outline, in the number and prominence of the ribs, in the size of the marginal keel, which even may be absent, and in the depth of the median groove. Thus it is not surprising that all these varieties by many authors have been considered separate species. However, the material from the Danish Lias, and an examination of the various illustrations and descriptions made by previous students, have convinced the present author that all these variants are connected by intermediate forms and that the variations do not change very much from area to area or from bed to bed. Consequently they are considered evidences of a very wide range in the normal variation, and a considerable number of previously recognized species names is in this publication listed as synonyms of *S. bicostata sulcata* as will be further commented on below.

According to the descriptions and illustrations by BORNEMANN (1854) the ribs disappear on the last chamber. However, this character is supposed to be due to simple variation and has not been considered of sufficient importance for a further subdivision of this form into more subspecies; the specimens from Denmark have thus without hesitation been referred to BORNEMANN's species. Differences in outline are not considered as characters of importance for the classification in these very variable forms, and the fact that the illustrations by BORNEMANN show a form, shorter and broader than the Danish specimens, has thus been disregarded. The material from the Danish Lias agrees perfectly with the description and illustration by FRANKE (1936). However, FRANKE states that *F. sulcata* has no median groove. This statement should probably be taken with some reservation. Thus the median groove on many of the Danish specimens is hardly discernible, if present at all.

While FRANKE states the number of ribs to be from 6 to 10, BARNARD pictures a specimen with 16 ribs. BARNARD further reports a good deal of variation in size and mentions that there is a tendency for the ribs to become obsolete on the last-formed chamber.

F. sulcata has furthermore been recorded by BLAKE, CRICK & SHERBORN, ISSLER and BRAND in BARTENSTEIN & BRAND. The specimen pictured by BLAKE agrees very well in all general characters except that the number of ribs seems to be about 14. CRICK & SHERBORN mention that the form often occurs without the deep median groove, which is very distinct in their pictured specimen. ISSLER records the number of ribs to exceed the 9 described on the holotype. Besides *F. sulcata* several other evidently very closely related species have been described and recorded, and it is rather typical that most of these forms seem to have a distribution very similar to that of *F. sulcata.* These forms are described under the names *F. pulchra* TERQUEM, *F. multicostata* TERQUEM, *F. octocostata* BURBACH, *F. rugosa* CRICK & SHERBORN and *F. interrupta-costata* FRANKE. *F. pulchra,* as it was originally defined by TERQUEM (1858), seems only to differ from the definition of *F. sulcata* by BORNEMANN by having a carinated periphery, which feature by later authors has been shown to be of no taxonomic value. Thus all records of specimens identified with TERQUEM's holotype should be referred to *S. bicostata sulcata.* ISSLER changed TERQUEM's definition to cover all specimens with lower ribs, and the most important factor for discrimination from *F. pulchra* and *F. sulcata* should then be that the sutures are more distinct in the former species. First of all this feature cannot be considered of taxonomic value, secondly it is directly at variance with the diagnosis by TERQUEM (1858) ("formée de loges nombreuses dix à douze à peine visibles"). However, ISSLER is well aware of the similarity of these two species and even suggests that they should be united under the name *F. multicostata* BURBACH; a very sensible idea but a bad choice of name as it is a synonym of *F. multicostata* TERQUEM to which species BURBACH evidently only refers his specimens with grave doubt. FRANKE adopted the definition by ISSLER and considers *F. pulchra* as a passage from *F. sulcata* to *F. terquemi,* but BRAND states that the visibility of the chambers is a character of little taxonomic importance and considers *F. pulchra* a synonym of *F. sulcata.* According to the above considerations it can hardly be doubted that *F. pulchra* is a synonym of *F. sulcata,* and both BLAKE, and BARNARD seem to agree in this point of view.

F. octocostata BURBACH is mainly characterized by the presence of 8 ribs, and as it falls within the normal variation in *F. sulcata* it seems logical to include the former in the latter species, the more so as BURBACH evidently is very much in doubt whether the form should be considered a separate species. *F. rugosa* CRICK & SHERBORN seems to be a variant of *F. sulcata* characterized by fairly strong though somewhat irregular ribs. *F. interrupta-costata* FRANKE is characterized by the interruption of some of the ribs above the sutures. As somewhat similar forms seem to have been described by BARNARD, as variants of *F. sulcata,* and as the same feature has been observed in specimens of other subspecies in the Danish Lias these two species are considered conspecific. It may be stated that the specimens from the Danish Lias definitely fall within the limits of the variation within *S. bicostata sulcata* as this subspecies is defined according to the above considerations. However, generally they belong to a slenderer form with fewer ribs than several of the specimens described from Germany and England. Whether this is caused by the more elongated general outline or is a step in the reduction of the ribs that is steadily proceeding, is difficult to decide but in the latter case the difference might be considered of subspecific rank. The fact that Barnard only records the many-ribbed *F. sulcata* from the Lower Lias below the semicostatum zone, where the more reduced *F. dubia* appears rather suddenly, may support the point of view that the Danish material – and possibly some of the German forms – may belong to the true *S. bicostata sulcata* which then should be considered an intermediate between the many-ribbed form – recorded by Barnard – and *S. bicostata dubia.* It is, however, recommended not to add further to the nomenclatural confusion by the definition of another subspecies before more adequate data are available.

Occurrence.

Lias Delta: Gassum No. 1, 4222′–4230′, rare.

Lias Beta: Gassum No. 1, 4500′–4518′, common; 4550′–4570′, rare; 4599′–4616′, rare; Vejrum No. 1, 734′–750′, scarce.

Lias Alpha: Gassum No. 1, 4800′–4820′, rare; 4850′–4870′, rare; 4950′–4970′, common; Vejrum No. 1, 766′–776′, rare.

Distribution.

The distribution of the various Lias forms is difficult to determine largely owing to lack of sufficient megafossil data and the fact that some students in the preceding century do not seem to have taken very much interest in keeping the samples from the various beds strictly apart. The above-mentioned lack of agreement in the definition and limits of variation for each form further increases the uncertainty, and consequently only few and very rough estimates may be made about the geographic and stratigraphic range of the various species and subspecies. However, the present subspecies seems generally to occur most abundantly in the Lower Lias of NW Europe, but quite a few specimens have been recorded from the Middle Lias as well. It seems to be confined to the Lower Lias of England, but according to Blake and Barnard this fact seems to refer to the many-ribbed form of the subspecies only, and Crick & Sherborn report a more typical form from the Middle Lias of Northamptonshire.

Spandelina bicostata (d'Orbigny) subsp. dubia (Bornemann)

Figs. 60, 61, 65.

Frondicularia dubia, Bornemann, 1854, p. 57, pl. 3, figs. 23 a–c.
Frondicularia delirata, Crick & Sherborn, 1891, p. 7, fig. 37.
Frondicularia dubia, Franke, 1936, p. 72, pl. 7, fig. 6.
Frondicularia dubia, Bartenstein & Brand, 1937, p. 158, pl. 2 A, fig. 13; pl. 3, fig. 41; pl. 5, fig. 41 a; pl. 6, fig. 25.
Frondicularia dubia, Barnard, 1950, p. 370, fig. 7 b.

Description.

This subspecies differs from the typical form in the arrangement of the ribs, which generally are converging toward the apertural end. Thus the two median ribs originate in or near the initial chamber but taper towards the median line of the test. The number of ribs is generally 6, but two of them are often more accentuated due to reduction of the other ribs. Compared to *S. bicostata sulcata* the ribs in the present subspecies are often reduced. The microspheric form has not been observed in the material from Denmark, but according to BARNARD there seems to be little difference between the two generations.

Remarks.

A single specimen has been observed in the core 4850′–4870′ which differs from the typical form in the presence of a short and strong spine at the lower end of the proloculum. As mentioned in the remarks to *S. bicostata sulcata* this feature is not supposed to be of taxonomic value.

As was the case with the specimens referred to *S. bicostata sulcata,* the specimens referred to *S. bicostata dubia* differ from the typical form by their slenderer shape. However, in the core 3968′–3972′ a single specimen was observed which, besides having the typical arrangement of the ribs, has the ovoid shape that characterizes the holotype as pictured by BORNEMANN. In the lower part of the Lias it seems rather difficult to discriminate *S. bicostata dubia* from the very closely related *S. bicostata sulcata* owing to the presence of intermediate forms, which shows that these two forms are only subspecies and not distinct and well-defined species as supposed by several previous authors. The more or less slight reduction of the ribs in *S. bicostata dubia* and the accentuation of two of the ribs seem clearly to indicate that *S. bicostata dubia* is derived from *S. bicostata sulcata* and that it is an intermediate form between *S. bicostata sulcata* and *S. bicostata baueri.*

F. delirata CRICK & SHERBORN, agrees in all respects with *F. dubia* in which species it was included by FRANKE. BLAKE evidently considers *F. dubia* as a synonym of *F. sulcata.* On the other hand BRAND refers the form, by BLAKE described as *F. terquemi,* to *F. dubia.* Actually BLAKE's figure fits very well with the definition of *F. baueri.* TERQUEM does not seem to recognize the form which he presumably has included in *F. pulchra.* SCHICK includes *F. dubia* in *F. baueri.* ISSLER does not record the form but states that the specimens, by SCHICK referred to *F. baueri,* should rather be included in *F. bicostata.* Altogether a nice example of confusion caused by lack of agreement between the various students about the definition of the various species in a continuous series of forms.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare; 4143′–4150′, rare.
Lias Beta: Gassum No. 1, 4500′–4518′ rare; 4550′–4570′, rare.
Lias Alpha: Gassum No. 1, 4702′–4722′, rare; 4850′–4870′, rare.

Distribution.

The distribution of this form is difficult to estimate for the very same reasons as were mentioned in connection with the distribution of *S. bicostata sulcata*. Nevertheless, though both subspecies seem to occur through the whole Lower and Middle Lias of NW Europe, *S. bicostata sulcata* seems to be predominant in the Lias Alpha, while *S. bicostata dubia* seems to gain supremacy in the higher beds.

Spandelina bicostata (d'Orbigny) subsp. baueri (Burbach)

Fig. 66.

Frondicularia terquemi, Tate & Blake, 1876, p. 468, pl. 19, fig. 22.
Frondicularia baueri, Burbach, 1886, p. 52, pl. 2, figs. 48–52.
Frondicularia procera, Burbach, 1886, p. 52, pl. 2, figs. 54, 55.
Frondicularia baueri, Issler, 1908, p. 60, pl. 3, fig. 137.
Frondicularia baueri, Franke, 1936, p. 70, pl. 7, fig. 10.
Frondicularia baueri, Bartenstein & Brand, 1937, p. 158, pl. 3, fig. 36; pl. 4, fig. 49.

Description.

This form differs from the preceding subspecies in the greater reduction of the ribs, the number of which is still 6, though usually the two or four marginal ribs are more reduced and the ribs generally seem to be shorter; no ribs are present in the usually well-developed median groove; the initial end of the few available specimens is broken except in a single specimen which appears to be microspheric. Both the microspheric and megalospheric forms seem to be present in the illustrations by Burbach.

Remarks.

It may be questioned whether this form should be given even subspecific rank. Barnard includes it in *F. dubia*, a determination which is supposed to be unfortunate because – according to the Danish material – it seems to have a vertical distribution, slightly different from that of *S. bicostata dubia*, but more similar to that of the following subspecies *S. bicostata bicostata*, and if included in the first-mentioned form this slight difference in distribution will be concealed. This alone is supposed to be sufficient evidence to support the maintaining of this form as a separate subspecies. The form is difficult to discriminate both from *S. bicostata dubia* and from *S. bicostata bicostata* owing to the occurrence of intermediate forms, and there can thus be no doubt that the subspecies represents a stage in the passage from *S. bicostata dubia* to *S. bicostata bicostata*.

Burbach mentions in his description that it differs from *F. pulchra* in the more oval outline and in the smaller number of ribs. At the present time it seems a fact that the general outline of the test is a matter of little taxonomic importance inside this group compared to the degree of reduction in the ribs.

It is for this reason unfortunate that SCHICK came to the directly opposite point of view, and his record of *F. baueri* probably includes specimens of both *S. bicostata dubia* and *S. bicostata bicostata*. That his pictured specimens undoubtedly should be referred to *S. bicostata bicostata* was pointed out already by ISSLER. SCHICK's publication is consequently not recorded in the above list of references.

F. procera BURBACH seems to be the microspheric form af *S. bicostata baueri*.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare; 4016′–4024′, rare; 4080′–4092′, rare; 4222′–4230′, rare.

Lias Gamma: Frederikshavn No. 1, 2817′–2827′, rare; Frederikshavn No. 2, 2785′–2805′, rare.

Lias Beta: Gassum No. 1, 4500′–4518′, rare; Vejrum No. 1, 734′–750′ rare.

Distribution.

BRAND records the form as not rare in the Lias Beta, Gamma and Delta of Germany, which is in good agreement with the vertical distribution observed in the Danish Lias Series. The distribution in the English Lias is unknown owing to the fact that most English students seem to have included this form in *F. dubia*.

Spandelina bicostata (d'Orbigny)
subsp. bicostata (d'Orbigny)

Figs. 62–64, 67, 68.

Frondicularia bicostata, D'ORBIGNY, 1849, p. 242, No. 256.
Frondicularia bicostata, MACFADYEN, 1936, p. 149, pl. 1, fig. 256 (type figure).
Frondicularia bicostata, TERQUEM, 1858, p. 33, pl. 1, figs. 11 a, c.
Frondicularia heeri, ZWINGLI & KÜBLER, 1870, p. 6, pl. 1, fig. 9.
Frondicularia bicostata, BURBACH, 1886, p. 53, pl. 2, figs. 56, 57.
Frondicularia terquemi, CRICK & SHERBORN, 1891, p. 213, fig. 36.
Frondicularia baueri, SCHICK, 1903, p. 153, pl. 6, figs. 16, 17.
Frondicularia heeri, SCHICK, 1903, p. 154, pl. 6, fig. 18.
Frondicularia bicostata, ISSLER, 1908, p. 60, pl. 3, figs. 138, 139.
Frondicularia bicostata, FRANKE, 1936, p. 70, pl. 7, fig. 9.
Frondicularia bicostata, BARTENSTEIN & BRAND, 1937, p. 158, pl. 2B, fig. 23; pl. 3, fig. 35; pl. 4, fig. 48; pl. 5, fig. 40.
Frondicularia terquemi var. bicostata, MACFADYEN, 1941, p. 61, pl. 4, figs. 2 a, b.
Frondicularia bicostata, BARNARD, 1950, p. 370, fig. 7 c.

Description.

Test similar in shape to the preceding subspecies, very variable both in size and in proportion between breadth and length; median groove distinct and smooth, but bordered by two distinct ribs; usually with two, more or less reduced, lateral ribs. The microspheric form is not observed in the material from the Danish Lias, but is probably figured by BURBACH (1886) (fig. 57).

Remarks.

D'Orbigny originally defined the species as covering specimens with two longitudinal ribs, bordering a median depression. This definition was extended by Terquem who includes the specimens with four ribs in this form. The holotype is pictured by Macfadyen and possesses besides the four ribs another pair of rather reduced ribs; thus the holotype seems to be intermediate between *S. bicostata bicostata* and *S. bicostata baueri.* As *S. bicostata bicostata* seems to have a vertical distribution in the Danish Lias fairly similar to that of *S. bicostata baueri,* it would be tempting to include the latter in the first-mentioned subspecies. A procedure which would directly solve the nomenclatural problem and be quite logical, as the two forms are linked together with intermediates. However, the procedure may have fatal consequences in other respects. Specimens with three pairs of ribs have by many – especially German – authors been recorded as a separate species and the present author is of opinion that *S. bicostata baueri* may possibly have a vertical distribution, at least slightly different from that of *S. bicostata bicostata* if the Lias Series were examined in greater detail. Thus it is considered most practical to recognize *S. bicostata baueri* as a separate subspecies. Furthermore, several authors, as for instance Barnard have preferred to include *S. bicostata baueri* in *F. dubia* to which it is very closely related, and it is believed that the inclusion of *S. bicostata baueri* in *S. bicostata bicostata* would rather add to the confusion already existing than lead to a clearer definition of the various subspecies and elucidate the problems of their distribution and stratigraphic importance. A second possibility would be to register *S. bicostata baueri* as *S. bicostata bicostata* var. baueri in which way the two different forms might be kept apart without nomenclatural difficulties. Nevertheless, this procedure is considered illogical as the reduction of the ribs in this publication generally is considered a character of subspecific value. It is for this reason recommended that the name *S. bicostata bicostata* is preserved for the specimens covered by the definition of *F. bicostata* by Terquem which has been commonly accepted by nearly all other authors since then. The form, by Kübler & Zwingli described as *Frondicularia heeri,* has seemingly very indistinct ribs, which may be due to the embedding of the pictured specimen in balsam, and it is with some doubt considered as a synonym of *S. bicostata bicostata.* The form by Schick recorded as *F. heeri* according to the description and picture unquestionably belongs to *S. bicostata bicostata.*

As mentioned under the remarks to *S. bicostata baueri,* Schick's definition of the various forms is different from that adopted by most later authors, and his record of *F. baueri* thus probably includes both *S. bicostata dubia, S. bicostata baueri* and *S. bicostata bicostata.* As the pictured specimens undoubtedly should be referred to *S. bicostata bicostata* his record is included in the list of synonyms here. In the core 4016′–4024′ of Gassum No. 1 were observed two megalospheric specimens differing from the typical form by the pretty thick ribs some of which are interrupted or reduced above the sutures. The form is evidently intermediate between *S. bicostata bicostata* and *S. bicostata terquemi.* The character is not supposed to be of much taxonomic importance and the form is consequently included in *S. bicostata*

bicostata. The case is supposed to be parallel to that of *F. interrupta-costata* FRANKE, which for the same reason was included in *S. bicostata sulcata.*

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, rare; 4143′–4150′, rare; 4184′–4194′, scarce; 4265′–4286′, scarce.

Lias Gamma: Gassum No. 1, 4300′–4310′, rare; Frederikshavn No. 1, 2817′–2827′, scarce; Frederikshavn No. 2, 2568′–2588′, rare; Børglum No. 1, 4095′–4105′, rare; 4294′–4314′, rare; Rødby No. 1, 1603′–1623′, rare.

Lias Beta: Gassum No. 1, 4500′–4518′, scarce; 4550′–4570′, rare; Vejrum No. 1, 734′–750′, rare.

Distribution.

This subspecies seems to be fairly widely distributed in the Lias of NW Europe with a vertical range covering the Lias Beta, Gamma and Delta.

Spandelina bicostata (d'Orbigny)
subsp. terquemi (d'Orbigny)

Fig. 69.

Frondicularia terquiemi, D'ORBIGNY, 1849, p. 241, No. 255.
Frondicularia terquemi, MACFADYEN, 1936, p. 149, pl. 1, fig. 255 (type figure).
Frondicularia terquemi, TERQUEM, 1858, p. 34, pl. 1, figs. 12a, d.
Frondicularia terquemi, TERQUEM & BERTHELIN, 1875, p. 38, pl. 3, fig. 7.
Frondicularia terquemi, BURBACH, 1886, p. 45, pl. 1–7.
Frondicularia terquemi, SCHICK, 1903, p. 152, pl. 6, fig. 12.
Frondicularia terquemi, ISSLER, 1908, p. 57, pl. 3, figs. 115–118.
Frondicularia terquemi, FRANKE, 1936, p. 69, pl. 7, figs. 11a, b.
Frondicularia terquemi, BARTENSTEIN & BRAND, 1937, p. 155, pl. 4, fig. 54; pl. 5, fig. 38.

Description.

This form is characterized by the complete absence of ribs but a median groove is generally present, though often hardly discernible. Microspheric form not observed in the material from the Danish Lias but, according to FRANKE, it is differing from the megalospheric form in being more pointed at the initial end only.

Remarks.

S. bicostata terquemi represents the last member of the gradual reduction of the ribs leading from *S. bicostata sulcata* through *S. bicostata dubia, S. bicostata baueri* and *S. bicostata bicostata* to *S. bicostata terquemi.* This passage has been commented on by several previous authors. Thus FRANKE directs the attention to the presence of intermediate forms between the typical *F. terquemi* and *F. bicostata,* and MACFADYEN states that *F. bicostata* is "an intermediate link between the fully costate *F. sulcata* and the smooth *F. terquemi*".

Several forms which seem to be very similar to and perhaps at least related to *F. terquemi* are recorded, but their taxonomic position is uncertain and difficult to comprehend owing to inadequate descriptions. This is thus the case with regard to the following species *F. impressa* TERQUEM (1863), *F. excavata* TERQUEM (1866), *F. lignaria* TERQUEM (1866), *F. thuringiaca* BURBACH (1886), *F. securiformis* BURBACH, *F. lanceolata* HAEUSLER (1881), *F. pupiformis* HAEUSLER (1881).

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare; 4080′–4092′, rare; 4143′–4150′, rare.

Lias Gamma: Frederikshavn No. 1, 2720′–2727′, rare; 2807′–2817′, rare; Frederikshavn No. 2, 2560′–2568′, rare; 2568′–2588′, rare.

Distribution.

Recorded from the Middle Lias of France and Germany by several students. BARNARD reports the form from the davoei zone at the Dorset Coast of England. Probably widely distributed in the Middle Lias of NW Europe.

FAMILY NODOSARIIDAE

SUBFAMILY NODOSARIINAE

Nodosaria prima d'Orbigny

Nodosaria prima, D'ORBIGNY, 1849, p. 241, No. 253.
Nodosaria prima, TERQEUM, 1858, p. 29, pl. 1, figs. 6 a, d.
Nodosaria longicauda, SCHICK, 1903, p. 148, pl. 5, fig. 17.
Nodosaria prima, FRANKE, 1936, p. 45, pl. 4, fig. 9.
Nodosaria prima, MACFADYEN, 1936, p. 148, pl. 1, figs. 253 a, b.
Nodosaria prima, BARTENSTEIN & BRAND, 1937, p. 145, pl. 5. fig. 36.
Nodosaria prima, BARNARD, 1950, p. 357, fig. 1 h.

Description.

Test comparatively large with several chambers gradually increasing in size from the spherical proloculum; chambers approximately as high as broad; sutures slightly deepened at the initial end; ornamented with a rather large number of ribs which is increasing towards the apertural end; ribs rather low, broad and rounded, depressed at the constrictions between the chambers; apertural chamber spherical to pear-shaped; aperture radiate on a protruding neck.

Remarks.

This species is generally easily recognized even in fragments owing to its large size and intercalated ribs.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare.

Lias Alpha: Vejrum No. 1, 750′–766′, rare.

Distribution.

The form has been recorded from the whole Lias and Dogger.

Nodosaria simoniana d'Orbigny

Fig. 70.

Nodosaria simoniana, d'Orbigny, 1849, p. 241, No. 254.
Nodosaria simoniana, Terquem, 1858, p. 28, pl. 1, figs. 4 a, b.
Nodosaria simoniana, Macfadyen, 1936, p. 149, pl. 1, fig. 234 (type figure).
Nodosaria simoniana, Bartenstein & Brand, 1937, p. 145.

Remarks.

Only a single fragment has been extracted, but the form is easily recognized in the ribs which are indented at the chamber constrictions. The fragment seems very much like the figure of the holotype drawn by Macfadyen. The description by Franke is at variance with the type description, and his record of this species is thus subject to to doubt.

Occurrence.

Lias Beta: Gassum No. 1, 4500′–4518′, one fragment.

Distribution.

Little is known about the distribution of this rare form, which may be confined to the Lias Beta and Gamma.

Nodosaria columnaris Franke

Fig. 75, 76.

Nodosaria columnaris, Franke, 1936, p. 48, pl. 4, figs. 19 a, b.
Nodosaria columnaris, Bartenstein & Brand, 1937, p. 146, pl. 3, fig. 24.
Nodosaria columnaris, Barnard, 1950, p. 356, fig. 4 c.

Description.

Test composed of 4 to 6 cylindrical chambers, broader than high, all of the same breadth; proloculum large, semispherical with a short spine at the initial end; apertural chamber generally higher than the preceding chambers, slightly higher than broad, pear-shaped; sutures flush with surface at the initial end, usually slightly deepened between the last chambers; wall ornamented with 10 or more high and thin ribs, which run from the initial spine up to the apertural neck without interruptions; aperture radiate on a short neck.

Remarks.

The specimens referred to this species fit very well into the description and illustrations of the type except for the fact that Franke described the chambers as higher than broad. This, however, is at variance with his own illustrations, where at least the younger chambers are broader than high.

N. columnaris is distinguished from *N. radiata* by the cylindrical shape of the test.

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, common.

Lias Beta: Gassum No. 1, 4450′–4466′, scarce; 4500′–4518′, common; 4599′–4618′, rare.

Distribution.

This species seems to occur sporadically through the whole Lias. It has never been recorded from the Dogger.

Nodosaria radiata (Terquem)

Fig. 71.

Dentalina radiata, TERQUEM, 1866, p. 490, pl. 20, figs. 5 a, b.
Dentalina mitis, TERQUEM & BERTHELIN, 1875, p. 28, pl. 2, fig. 9 b.
Nodosaria raphanus, CRICK & SHERBORN, 1891, p. 211, fig. 11.
Nodosaria radiata, FRANKE, 1936, p. 49, pl. 4, fig. 20.

Description.

Test generally composed of 6 chambers, slightly tapering towards the initial end; chambers broader than high, gradually increasing in size towards the apertural end; sutures nearly flush with surface at the initial end, distinctly deepened between the last chambers; wall ornamented with about 10 high and thin ribs, which start at the initial spine and continue to the apertural neck and are depressed at the chamber constrictions; proloculum semispherical with an initial spine; apertural chamber nearly spherical; aperture radiate on a short neck.

Remarks.

The specimens from the Danish Lias differ from the description and figure by TERQUEM in the number of ribs exceeding 6 and in the initial end which according to TERQUEM was described as thinner and distinctly pointed.

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, common.

Lias Gamma: *Frederikshavn* No. 2, 2785′–2805′, rare; Børglum No. 1, 4095′–4105′, rare.

Lias Beta: Gassum No. 1, 4500′–4518′, rare; Vejrum No. 1, 734′–750′, rare.

Nodosaria metensis Terquem

Fig. 72.

Nodosaria metensis, TERQUEM, 1864, p. 377, pl. 7, figs. 5 a, b.
Nodosaria metensis, FRANKE, 1936, p. 47, pl. 4, figs. 15 a–c.
Nodosaria metensis, BARTENSTEIN & BRAND, 1937, p. 146, pl. 1 A, fig. 9; pl. 2 B, fig. 14; pl. 3, fig. 22; pl. 4, fig. 37, pl. 5, fig. 29; pl. 6, figs. 13 a, b.
Nodosaria metensis, BARNARD, 1950, p. 355, fig. 4 f.

Description.

Test composed of 5 or 6 chambers; proloculum spherical, as broad or slightly broader than the following chambers; chambers increasing gradually in height to the oval apertural chamber, which is distinctly higher than broad; sutures very distinctly deepened; wall ornamented with numerous fine and rather low ribs, which run from the spine on the base of the proloculum all over the test and up to the apertural neck and are depressed at the chamber constrictions; aperture radiate; apertural chamber protruded, forming a rather long neck which is easily broken off.

Remarks.

The specimens examined seem to be smaller and thinner than the type and to fit well with the form reported by FRANKE as f. psilonoti, BRAND in BARTENSTEIN & BRAND as form a. Presumably the specimens observed should be considered a subspecies of *N. metensis.* The form differs considerably from var. robusta BARNARD.

Occurrence.

Lias Beta: Gassum No. 1, 4500′–4518′, rare; Vejrum No. 1, 734′–780′, rare.

Distribution.

According to BRAND the typical form is found through the whole Lias, while f. psilonoti is restricted to the Lias Alpha and Lias Beta.

Nodosaria hortensis Terquem

Fig. 73.

Nodosaria hortensis, TERQUEM, 1866, p. 476, pl. 19, fig. 13.
Nodosaria hortensis, MACFADYEN, 1941, p. 43, pl. 3, figs. 41 a, b.
Nodosaria hortensis, BARNARD, 1950, p. 356, fig. 4 d.

Description.

Test composed of 5 to 8 chambers; chambers at the initial end broader than high, the adult ones higher, nearly sperical; proloculum spherical with a basal, short spine; apertural chamber generally higher and less broad than the preceding chambers so that the test often approaches the shape of a spindle; in rare cases the proloculum is broader than the rest of the chambers, and the test is then slightly and gradually tapering towards the apertural end; aperture radiate on a long drawn-out neck; sutures only slightly deepened in the initial part, but with rather strong constrictions between the last two or three chambers; wall ornamented with 8 to 10 high and sharp ribs starting from the spine at the initial chamber and continuing without interruptions up to the apertural neck, generally unaffected by the constrictions between the chambers except at the suture between the last two.

Remarks.

The specimens with large proloculum fit very well with the type descriptions. The species differs from *N. metensis* in the comparatively few and high ribs; from *N. columnaris* in the tapering test, and from both *N. columnaris*, *N. mitis*, and *N. radiata* in the elongated apertural chamber and the very distinct, apertural neck.

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, common.
Lias Beta: Gassum No. 1, 4500′–4518′, scarce; 4550′–4570′, scarce.
Lias Alpha: Vejrum No. 1, 750′–766′, rare.

Distribution.

The distribution of this form in the German Lias is rather uncertain. BARNARD records it from the Lias Gamma (raricostatum zone) of the Dorset coast.

Nodosaria mitis (Terquem & Berthelin)

Fig. 74.

Dentalina mitis, TERQUEM & BERTHELIN, 1875, p. 28, pl. 2, figs. 9 a, c.
Nodosaria mitis, FRANKE, 1936, p. 45, pl. 4, figs. 11 a, b.
Nodosaria mitis, BARTENSTEIN & BRAND, 1937, p. 145, pl. 2 A, fig. 9; pl. 28, fig. 13; pl. 3, fig. 18; pl. 4, fig. 36; pl. 5, fig. 24.

Description.

Test with 5 to 7 chambers, gradually increasing in size from the initial end; chambers broader than high at the initial end, the last two or three chambers nearly spherical; sutures distinctly deepened especially between the last two chambers; usually with 6 high and thin ribs forming a short spine or point at the initial end and continuing over the deepened sutures without any interruptions or constrictions up to the aperture; aperture radiate without any distinct neck.

Remarks.

This species is distinguished from *N. hortensis* by the greater breadth and the shape of the apertural chamber.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare.

Lias Gamma: Gassum No. 1, 4349′–4357′ rare; Frederikshavn No. 1, 2817′–2827′, rare.

Lias Beta: Gassum No. 1, 4450′–4466′, scarce; 4500′–4518′, common; 4550′–4570′, rare.

Distribution.

BRAND in BARTENSTEIN & BRAND reports this form from the whole Lias. It has never been recorded from the English Lias.

Nodosaria oculina (Terquem & Berthelin)

Fig. 77.

Dentalina oculina, Terquem & Berthelin, 1875, p. 31, pl. 2, fig. 20 b.
Nodosaria oculina, Franke, 1936, p. 49, pl. 4, fig. 21.
Nodosaria oculina, Bartenstein & Brand, 1937, p. 147, pl. 3, fig. 19; pl. 5, fig. 25.

Description.

Test more or less spindle-shaped, composed of 6 to 8 chambers; chambers broader than high; sutures flush with surface, occasionally slightly deepened between the last two chambers; proloculum typically pointed, seldom somewhat rounded at the initial end; apertural chamber higher than the preceding chambers, usually somewhat oblong, often somewhat drawn out at the apertural end; aperture radiate, typically without any apertural neck; wall ornamented with 6 to 8 high and narrow ribs which begin at the initial end and continue over the whole test to the aperture.

Remarks.

The species differs from *N. mitis* only by the lack of constrictions between the chambers.

Occurrence.

Lias Gamma: Frederikshavn No. 2, 2568′–2588′, rare.
Lias Beta: Gassum No. 1, 4500′–4518′, common; 4550′–4570′, rare.

Distribution.

Brand in Bartenstein & Brand records this form from the whole Lias and the Dogger Alpha.

Nodosaria costata (Bornemann)

Fig. 78.

Glandulina costata, Bornemann, 1854, p. 43, pl. 2, figs. 11 a–b.
Nodosaria costata, Franke, 1936, p. 50, pl. 4, figs. 24 a, b.

Description.

Test composed of 6 short chambers, cylindrical to indistinctly spindle-shaped; chambers broader than high, except the initial and last chambers; sutures flush with the surface; wall ornamented with 7 high and thin ribs which take their beginning at the pointed initial end of the proloculum and continue over the whole test to the aperture; proloculum conical, pointed at the initial end; apertural chamber egg-shaped; aperture radiate with no neck.

Remarks.

The specimen differs from the description of the type in the slender shape and the presence of more than 5 chambers.

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, rare.

Distribution.

N. costata is a rare form; FRANKE records it from the Lias Gamma and Delta.

Nodosaria fontinensis (Terquem)

Fig. 79.

Nodosaria fontinensis, TERQUEM, 1867, p. 251, pl. 26, figs. 1, 5.
Nodosaria fontinensis, FRANKE, 1936, p. 50, pl. 5, fig. 1.
Nodosaria fontinensis, BARTENSTEIN & BRAND, 1937, p. 148, pl. 6, fig. 24.

Description.

Test composed of several cylindrical chambers, but owing to the fact that only fragments have been extracted the exact number of the chambers cannot be estimated; chambers slightly inflated, of equal sizes, but often a smaller chamber may be intercalated among the normal chambers; sutures strongly constricted for which reason the test breaks very easily; proloculum of about the same size as the following chambers, spherical to indistinctly pear-shaped, in rare cases with a very small spine at the initial end; apertural chamber higher than broad, egg-shaped, very slightly protruded toward the apertural end; wall ornamented with 10 or more low and broad ribs which are depressed at the constrictions between the chambers; aperture radiate without distinct apertural neck.

Remarks.

BRAND reports this species as restricted to the Dogger while FRANKE records it from several Lias outcrops. Most likely BRAND has referred FRANKE's specimens to the very closely allied species *N. mutabilis*. Nevertheless, as the name *N. mutabilis* is invalid, the species should be classified as *N. fontinensis*, and the various subspecies should be renamed. *N. mutabilis* is recorded from the whole Lias and Dogger.

Occurrence.

Lias Delta: Gassum No. 1, 4184′–4194′, rare; 4222′–4230′, rare.
Lias Gamma: Børglum No. 1, 4294′–4314′, rare.

Nodosaria dispar Franke

Fig. 80, 81.

Nodosaria mutabilis, TERQUEM, 1870, p. 251, pl. 26, figs. 6–12.
Nodosaria variabilis, TERQUEM & BERTHELIN, 1875, p. 20, pl. 1, figs. 19 a–f.
Nodosaria dispar, FRANKE, 1936, p. 47, pl. 4, figs. 18 a–d.
Nodosaria mutabilis, BARTENSTEIN & BRAND, 1937, p. 148, pl. 2 B, fig. 16; pl. 3, fig. 20; pl. 4, fig. 38; pl. 5, fig. 23.
Nodosaria variabilis, BARTENSTEIN & BRAND, 1937, p. 148, pl. 28, fig. 13.

Description.

Test composed of 3 to 4, very rarely 5, approximately spherical chambers of variable sizes; sutures more or less deepened, in some cases even strongly so; proloculum large, pear-shaped, usually with a short spine in the initial end; wall ornamented with 8 or more distinct ribs, running over the whole of the test from the initial spine to the radiate aperture. Generally the proloculum is the largest chamber; the third chamber is smaller than the second; in this case the suture between the proloculum and the second chamber is only slightly deepened, and at any rate less deepened than the suture between the second and third chambers; the fourth chamber, if any, is usually larger than the third, and the suture between these two chambers is nearly always strongly depressed.

Remarks.

It is obvious that a number of different species can be erected from a variable form like *N. dispar*. Thus differences in the amount of chambers, their sizes, and the degree of deepening of the sutures have been considered characters of taxonomic value. Nevertheless, such minor variations will usually only be considered of varietal or, possibly, subspecific rank. Thus all these forms presumably constitute a group which should be considered subspecies of *N. mutabilis* TERQUEM, 1870. Unfortunately, the latter name is a homonym of *N. mutabilis* COSTA, 1855, and as *N. variabilis* TERQUEM & BERTHELIN, 1875, is already used by *N. variabilis* NEUGEBOREN, 1852, the species should be named *N. dispar* FRANKE, 1936, according to the Rules of Nomenclature. It is quite likely that a close study of this group might yield interesting results of stratigraphic value, but the available material is much too small for such a study. Possibly *N. dispar* FRANKE is a subspecies of *N. fontinensis* TERQUEM, 1870.

Occurrence.

Lias Beta: Gassum No. 1, 4500′–4518′, scarce; 4550′–4570′, rare; 4599′–4616′, rare; Vejrum No. 1, 734′–750′, rare.

Distribution.

Owing to the many problems in connection with the correct classification of the group of species referred to *N. fontinensis, N. variabilis, N. mutabilis* and *N. dispar*, the distribution of these various forms is rather uncertain. It is thus regrettable that the material from the Danish Lias Series is insufficient for a closer study of this interesting group.

Nodosaria issleri Franke

Fig. 82.

Nodosaria aequalis, ISSLER, 1908, p. 54, pl. 2, fig. 94.
Nodosaria issleri, FRANKE, 1936, p. 53, pl. 5, fig. 6.
Nodosaria issleri, BARTENSTEIN & BRAND, 1937, p. 146, pl. 3, figs. 21 a–b.

Description.

Test stout, cylindrical, composed of 6 chambers; chambers more than twice as broad as high; sutures flush with surface, very indistinct; proloculum nearly spherical; apertural chamber dome-shaped with a distinct neck; wall ornamented with 12 strong and sharp ribs running from the base of the initial chamber over most of the test, until they disappear just over the lower third of the apertural chamber; aperture on a distinct neck.

Remarks.

The specimen described differs from the typical form in the cylindrical test, the smaller number of chambers, and the presence of more than 8 ribs.

Occurrence.

Lias Beta: Gassum No. 1, 4500′–4518′, rare.

Distribution.

N. issleri in its typical form is restricted to the German Lias Beta and is considered a splendid marker for this stage. It is very regrettable that this form seems to be of local importance only. Thus BARNARD does not record it from the English Lias.

Nodosaria quadrilatera (Terquem)

Dentalina quadrilatera, TERQUEM, 1858, p. 45, pl. 2, figs. 14 a, b.
Nodosaria quadrilatera, BARTENSTEIN & BRAND, 1937, p. 149, pl. 4, fig. 35.

Description.

Test composed of 6 chambers, about as broad as high, gradually increasing in size towards the apertural end; sutures only slightly deepened, but nevertheless distinct; ornamented with 4 high and thin, longitudinal ribs, commencing at the base of the proloculum and continuing over the whole test with no interruptions at the sutures; aperture radiate, slightly protruding.

Occurrence.

Lias Gamma: Børglum No. 1, 4294′–4314′, rare.

Distribution.

As far as can be judged from the few records this very rare species seems confined to the Lias Gamma and Delta.

Pseudoglandulina vulgata (Bornemann)

Fig. 85.

Glandulina vulgata, BORNEMANN, 1854, p. 31, pl. 2, figs. 1 a, b.
Glandulina vulgata, FRANKE, 1936, p. 54, pl. 5, figs. 9 a, b.
Pseudoglandulina vulgata, BARTENSTEIN & BRAND, 1937, p. 150.
Pseudoglandulina vulgata, BARNARD, 1950, p. 365, fig. 4 c.
Pseudoglandulina vulgata, BARNARD, 1951, p. 24, pl. 1, fig. 7, text-fig. 15.

Description.

Test oviform to conical, composed of up to 5 low chambers, gradually increasing in size; sutures indistinct, sometimes deepened between the two last chambers; aperture terminal, radiate. The initial part of the microspheric form is more conical and pointed than in the megalospheric form.

Remarks.

In his description of the microfauna of the Upper Lias BARNARD (1951) has very clearly demonstrated the extreme width of variation within this species and thoroughly proved that a multitude of forms, by previous authors considered as separate species, are little more than varieties of this single species. A very complete list of synonyms is given by BARNARD and is consequently not reproduced in this publication.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare; 4016′–4024′, rare; 4080′–4092′, rare; Børglum No. 1, 4095′–4105′, rare.

Lias Gamma: Gassum No. 1, 4400′–4417′, rare; Frederikshavn No. 1, 2817′–2827′, rare.

Distribution.

Probably widely distributed through the whole Lias Series of NW Europe.

Pseudoglandulina vulgata (Bornemann)
var. pupoides (Bornemann)

Fig. 83, 84.

Orthocerina pupoides, BORNEMANN, 1854, p. 35, pl. 3, figs. 16 a, b.
Glandulina pupoides, FRANKE, 1936, p. 56, pl. 5, figs. 14 a, b.
Pseudoglandulina pupoides, BARTENSTEIN & BRAND, 1937, p. 150, pl. 4, fig. 42; pl. 5, fig. 30.

Description.

Megalospheric form: Test cylindrical, spindle-shaped, composed of several – up to 10 – embracing chambers, broader than high, last chamber smaller than the preceding one; aperture central and terminal, distinctly radiate; proloculum large, spherical.

Microsperic form: Test conical, composed of several chambers, gradually increasing in size; in some mature specimens the adult part of the test is cylindrical; final chamber larger or of the same size as the preceding one; proloculum small, spherical. In all other respects similar to the megalospheric form. The wall of the test is very thick, a fact which partly conceals the great difference in size of the proloculum of the megalospheric and microspheric forms.

Remarks.

As mentioned under the description of *P. vulgata,* BARNARD (1951) stated *that P. pupoides is little more than a variety of this form.* It has nevertheless been considered of some importance to keep these varieties apart, as some of them may be of importance, at least for local correlation.

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, common.

Pseudoglandulina vulgata (Bornemann) var. irregularis (Franke)

Fig. 86.

Glandulina irregularis, FRANKE, 1936, p. 57, pl. 5, figs. 15 a, b.
Pseudoglandulina irregularis, BARTENSTEIN & BRAND, 1937, p. 151, pl. 4, fig. 43.

Description.

Differs from the typical form in the irregularity in size of the various chambers.

Remarks.

It has been considered of some importance to separate this form from the other variants of *P. vulgata,* as it seems significant, at least for local correlation.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, scarce; 4016′–4024′, rare; 4222′–4230′, rare.

Lias Gamma: Gassum No. 1, 4300′–4310′, rare; 4349′–4357′, rare; Frederikshavn No. 1, 2807′–2817′, rare; Frederikshavn No. 2, 2568′–2588′, rare; Børglum No. 1, 4294′–4314′, rare.

Distribution.

The variety seems to be confined to the Lias Gamma and Delta of the Danish Lias Series.

Pseudoglandulina multicostata (Bornemann)

Fig. 87.

Orthocerina multicostata, BORNEMANN, 1854, p. 35, pl. 3, figs. 14 a, b, 15 a, b.
Glandulina paucicostata, TATE & BLAKE, 1876, p. 455, pl. 18, fig. 13; pl. 19, figs. 1, 1 a.
Nodosaria multicostata, ISSLER, 1908, p. 54, figs. 95–100.
Glandulina multicostata, FRANKE, 1936, p. 59, pl. 5, fig. 20.
Pseudoglandulina multicostata, BARTENSTEIN & BRAND, 1937, p. 151, pl. 3, fig. 42; pl. 4, fig. 28.
Pseudoglandulina multicostata, BARNARD, 1950, p. 364, fig. 4 a.

Description.

Test conical, composed of 5 rather low chambers, ornamented with 12 thin, longitudinal ribs.

Remarks.

The only specimen observed seems to be rather young with only a single adult chamber.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare.

Distribution.

According to the few records this species seems to have a fairly long range in the Lower and Middle Lias of NW Europe.

SUBFAMILY MARGINULINAE

Dentalina matutina d'Orbigny
subsp. matutina d'Orbigny

Figs. 88, 90–93.

Dentalina matutina, D'ORBIGNY, 1849, p. 242, No. 259.
Dentalina primaeva, D'ORBIGNY, 1849, p. 242, No. 260.
Dentalina matutina, MACFADYEN, 1936, p. 150, pl. 1, fig. 259 (type figure).
Dentalina primaeva, MACFADYEN, 1936, p. 150, pl. 1, fig. 260.
Dentalina matutina, TERQUEM, 1858, p. 43, pl. 2, figs. 11 a, b, 16.
Dentalina primaeva, TERQUEM, 1858, p. 44, pl. 2, figs. 12 a, b.
Dentalina fasciata, TERQUEM, 1866, p. 485, pl. 19, fig. 25.
Dentalina funiculosa, TATE & BLAKE, 1876, p. 461, pl. 18, fig. 28.
Nodosaria (Dentalina) obliquestriata, SCHICK, 1903, p. 148, pl. 5, fig. 18.
Dentalina matutina, ISSLER, 1908, p. 66, pl. 4, figs. 166–170.
Dentalina matutina, FRANKE, 1936, p. 37, pl. 3, fig. 15.
Dentalina primaeva, FRANKE, 1936, p. 38, pl. 3, fig. 17.
Dentalina matutina, BARTENSTEIN & BRAND, 1937, p. 141, pl. 2 B, fig. 21; pl. 3, figs. 15 a, b; pl. 5, fig. 63.
Dentalina primaeva, BARTENSTEIN & BRAND, 1937, p. 141, pl. 5, figs. 62, 65.
Dentalina primaeva, WICHER, 1938, pl. 19, figs. 3, 4.
Dentalina matutina, BARNARD, 1950, p. 359, fig. 5 d.

Description.

Megalospheric form: Test composed of about 9 chambers in a rectilinear series, somewhat compressed, slightly, but usually distinctly, curved, dorsal side straight to slightly concave, ventral side convex; in rare cases the initial end may be very little and hardly perceptibly bent towards the ventral side, only slightly tapering in the adult part, but strongly tapering towards the proloculum in the initial part of the test; chambers very variable, generally broader than high to about as high as broad; young chambers rather uniformly increasing in size; increase in size retarded in the adult chambers; apertural chamber usually of about the same size as the preceding one, or the two last chambers are in some cases smaller (var. typica) or inflated and unornamented (var. primaeva); sutures distinctly oblique, typically flush with surface in the juvenile part, generally slightly depressed in the adult part of the test, especially on the ventral side; ornamentation generally consisting of up to 12 strong ribs, usually regular, but in some cases interrupted, slightly off-setting, generally converging and tapering out towards the median line of the ventral side, generally no ribs on the median line of the ventral side, but in some cases one of the side ribs instead of disappearing may continue as a median rib all down to the initial part of the test; aperture radiate, on an pronounced short neck at the dorsal side of the test; proloculum typically larger than the second chamber, spherical, with a short spine at the base.

Microspheric form: This form seems mainly to differ from the megalospheric form in the slenderer, less compressed test, composed of 11 or more chambers with a fewer number of ribs; the initial ends of most of the specimens are broken off.

Remarks.

According to the description and figure by Macfadyen this specimen is an extreme form, differing greatly from the average of the normal variation (var. typica) as the apertural chamber seems to be somewhat smaller than in the normal form. In the same collection Macfadyen discovered the holotype of *D. primaeva* which differs from the typical form of *D. matutina* in the smaller number of ribs and the inflated, unornamented apertural chamber. Macfadyen considers it most probable that *D. primaeva* is a synonym of *D. matutina,* and the examination of the specimens from the Danish Lias Series fully confirms Macfadyen's statement. Thus the Danish specimens show a wide range of individual variations from var. typica to var. primaeva through intermediate forms. The present author has thus with no hesitation included *D. primaeva* in *D. matutina.* The classification of the specimens by Franke, Brand and Wicher referred to *D. primaeva* seems rather uncertain. According to their descriptions the forms are slenderer and have fewer ribs than *D. matutina,* a fact which in many respects fits well with the microspheric form of *D. matutina.* Nevertheless, the prolocula of the figured specimens appear to be rather large, and it seems probable that these forms may belong to a different subspecies of *D. matutina.* Brand mentions that his specimens are related to *D. matutina.* In his description of *D. fasciata* Terquem mentions that this species is an intermediate form between *D. matutina* and *D. primaeva* and it should thus undoubtedly be included in *D. matutina matutina,* a view which is confirmed by the general appearance of his figure. The classification of the specimens figured and described by Franke as *D. fasciata* is doubtful.

The forms by Terquem (1858–1866) recorded under the names *D. gyrosa, D. renati* and *D. funiculosa* show resemblance to *D. matutina* and it seems most natural that they are conspecific.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, scarce; 4016′–4024′, rare; 4080′–4092′, rare; 4143′–4150′, rare; 4184′–4194′, rare.

Lias Gamma: Gassum No. 1, 4300′–4310′, rare; 4349′–4357′, scarce; 4400′–4417′, common; Frederikshavn No. 2, 2785′–2805′, scarce; Børglum No. 1, 4294′–4314′, scarce.

Lias Beta: Gassum No. 1, 4450′–4466′, common; 4500′–4518′, abundant; 4550′–4570′, abundant; Vejrum No. 1, 734′–750′, common.

Distribution.

According to Franke and Brand this species ranges through the Lias Beta, Gamma and Delta. Barnard records the species from the base of the semicostatum zone to the base of the jamesoni zone. Blake records it from the oxynotus and capricornu zones of the Yorkshire Lias.

Dentalina matutina d'Orbigny subsp. claviformis Terquem

Fig. 89.

Dentalina paucicosta, Terquem, 1866, p. 483, pl. 19, fig. 21.
Dentalina claviformis, Terquem, 1866, p. 490, pl. 20, figs. 4 a, b.
Dentalina paucicosta, Franke, 1936, p. 36, pl. 3, fig. 12.
Dentalina claviformis, Franke, 1936, p. 36, pl. 3, fig. 13.

Description.

This subspecies differs from the typical form only in the more regular ribs which continue from the initial part of the test up onto the apertural chamber, running parallel to the dorsal side and not converging towards the median line of the ventral side of the test.

Remarks.

Brand includes the specimens, by Franke referred to *D. claviformis,* in *D. matutina* on account of the presence of intermediate forms. Thus it seems as if the specimens from the Danish Lias are conspecific with those of Franke. The figure of the holotype by Terquem differs quite considerably from the observed specimens, and the reference of both the Danish and German forms to this species may be subject to doubt. Nevertheless, a renaming of the forms may be apt to add further to the nomenclatural confusion and has been avoided. According to the description by Terquem *D. paucicosta* differs from *D. claviformis* only in the curvature of the test, which is a character of little taxonomic value in this very variable species.

The forms, by Terquem described as *D. lamellosa, D. sculpta, D. octoplicata, D. virgata* and *D. radiata,* all seem to fall within the range of variation in *D. matutina claviformis,* and they consequently all seem conspecific.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, common; 4016′–4024′, rare; 4080′–4092′, common; 4184′–4194′, rare; 4222′–4230′, rare.

Lias Gamma: Frederikshavn No. 1, 2787′–2797′, scarce; Frederikshavn No. 2, 2785′–2805′, rare; Børglum No. 1, 4095′–4105′, rare; 4294′–4314′, rare.

Distribution.

This subspecies seems to be confined to the Lias Gamma and Delta.

Dentalina haeusleri Franke

Dentalina varians, TERQUEM, (partly), 1866, p. 412, pl. 15, fig. 19 a (only).
Nodosaria (Dentalina) varians, SCHICK, 1903, p. 149, pl. 6, fig. 1.
Dentalina haeusleri, FRANKE, 1936, p. 34, pl. 3, figs. 6 a, b.
Dentalina haeusleri, BARTENSTEIN & BRAND, 1937, p. 141, pl. 3, fig. 12.
Dentalina haeusleri, WICHER, 1938, pl. 17, fig. 5.
Dentalina haeusleri, BARNARD, 1950, p. 362, fig. 5.

Description.

Only fragments have been found of this very easily recognizable form.

Occurrence.

Lias Gamma: Frederikshavn No. 2, 2568′–2588′, several fragments; 2785′–2805′, several fragments.

Distribution.

The subspecies is distributed in the Lias Beta and Gamma over the whole of NW Europe, but is of rare occurrence only.

Marginulina radiata Terquem

Figs. 94, 95.

Marginulina radiata, TERQUEM, 1863, p. 200, pl. 9, fig. 10.
Marginulina radiata, TERQUEM, (partly), 1866, p. 505, pl. 21, fig. 17 (only).
Marginulina radiata, TERQUEM & BERTHELIN, 1875, p. 57.
Marginulina raphanus, TATE & BLAKE, 1876, p. 462, pl. 19, fig. 5.
Marginulina curva, FRANKE, 1936, p. 85, pl. 8, fig. 39.
Marginulina radiata, BARTENSTEIN & BRAND, 1937, p. 161, pl. A, fig. 15; pl. 1 B, fig. 17; pl. 2 A, figs. 12, 13; pl. 2 B, fig. 25.

Description.

Test rectilinear, more or less distinctly compressed, in some cases vaginuline, composed of approx. 8 chambers, broader than high; sutures flush with surface or slightly depressed, especially on the ventral side; several ribs irregular, distinctly oblique; proloculum large, distinctly oblong; aperture at the dorsal angle, radiate. Microspheric form differs in the greater number of chambers, the more rounded section and coiled initial part.

Remarks.

This species is highly variable and difficult to define as it seems closely related to both *M. prima praerugosa* and *D. matutina matutina.* The microspheric form should be referred to the genus *Marginulinopsis* and is fairly similar to *Vaginulinopsis exarata* from which it differs in the less compressed test and more irregular ribs. The compressed specimens of the megalospheric form might as well be referred to the genus *Vaginulina.* Thus this species consists of a group of varieties interconnected by passage forms which show a range of variation covered by several genera. There can hardly be any doubt that this is the ancestral form from which both the *Marginulina prima,* the *Dentalina matutina* and the *Marginulinopsis radiata* lines are derived. It further seems reasonable that both *Vaginulinopsis exarata* and *Planularia inaequestriata* are derived from this form, or forms closely related to it. No wonder, therefore, that previous authors evidently differ considerably in their definitions of this species and that the records consequently are incommensurable. The Danish specimens fit very well the description by TERQUEM and seem identic with the species by BRAND. FRANKE refers TERQUEM's species to the genus *Vaginulina,* and according to the description and figures by FRANKE the species *V. radiata* seems to cover material which in this publication is referred to *Marginulinopsis radiata* and intermediate forms which seem to be closely related to *Vaginulinopsis exarata.* They may possibly be considered as a subspecies closely related to the latter form and intermediate between *Marginulina radiata* and *Marginulinopsis radiata.* BRAND prefers to include both *Vaginulina radiata* and *Vaginulina curva* in *Marginulina radiata.* While the specimens from the Danish Lias only partly agree with FRANKE's *Vaginulina radiata* they fit very well the diagnosis of *Vaginulina curva* by FRANKE.

Occurrence.

Lias Alpha: Gassum No. 1, 4750′–4768′, common.

Distribution.

Probably confined to the Lias Alpha.

Marginulina prima d'Orbigny

Marginulina prima, D'ORBIGNY, 1849, p. 242, No. 262.
Marginulina prima, MACFADYEN, 1936, p. 151, pl. 1, fig. 262 (type figure).
Marginulina rugosa, BORNEMANN, 1854, p. 39, pl. 3, figs. 26 a, b.
Marginulina prima var. gibbosa, TERQUEM, 1858, p. 53, pl. 3, figs. 5 a, b.
Marginulina prima var. recta, TERQUEM, 1858, p. 54, pl. 3, fig. 6.
Marginulina prima var. acuta, TERQUEM, 1858, p. 54, pl. 3, fig. 7.
Marginulina spinata, TERQUEM, 1858, p. 55, pl. 3, fig. 8.
Marginulina alata, TERQUEM, 1858, p. 56, pl. 3, figs. 9 a, b.
Marginulina ornata, TERQUEM, 1858, p. 57, pl. 3, figs. 10 a, b.
Marginulina burgundiae, TERQUEM, 1863, p. 196, pl. 9, fig. 3.
Marginulina interrupta, TERQUEM, 1866, p. 426, pl. 17, figs. 4 a–c.
Marginulina burgundiae, TERQUEM, 1866, p. 431.
Marginulina raphanus, BRADY, 1867, p. 225, pl. 2, fig. 21.
Marginulina burgundiae, TERQUEM & BERTHELIN, 1875, p. 54, pl. 4, fig. 17.
Marginulina prima var. praelonga, TERQUEM & BERTHELIN, 1875, p. 54, pl. 4, fig. 18.
Marginulina alata, TERQUEM & BERTHELIN,, 1875, p. 54.
Marginulina spinata, TERQUEM & BERTHELIN, 1875, p. 54.
Marginulina gibberula, TERQUEM & BERTHELIN, 1875, p. 53, pl. 4, figs. 21 a, b.
Dentalina burgundiae, TATE & BLAKE, 1876, p. 461, pl. 18, fig. 29.
Marginulina dentalina, HAEUSLER, 1881, p. 17, fig. 24.
Marginulina raphanus, CRICK & SHERBORN, 1891, p. 211, fig. 18.
Marginulina costata, SCHICK, 1903, p. 137, pl. 4, figs. 20, 21.
Marginulina burgundiae, ISSLER, 1908, p. 67, pl. 4, figs. 171, 174.
Dentalina insignis, FRANKE, 1936, p. 36, pl. 3, figs. 11 a, b.
Marginulina prima, FRANKE, 1936, p. 76, pl. 8, figs. 1–7.
Marginulina burgundiae, FRANKE, 1936, p. 78, pl. 8, fig. 8.

Marginulina incisa, FRANKE, 1936, p. 78, pl. 8, figs. 11, 12.
Marginulina interrupta, FRANKE, 1936, p. 79, pl. 8, fig. 9.
Marginulina interrupta form. spinata, FRANKE, 1936, p. 79, pl. 8, fig. 18.
Marginulina interrupta, MACFADYEN, 1936, p. 151, fig. 262 b.
Marginulina prima, BARTENSTEIN & BRAND, 1937, p. 161, pl. 2 B, fig. 26; pl. 3, figs. 39, 40; figs. 60 a, b; pl. 5, figs. 46 a, b.
Marginulina spinata spinata, BARTENSTEIN & BRAND, 1937, p. 161, pl. 4, fig. 61; pl. 5, fig. 47.
Marginulina spinata interrupta, BARTENSTEIN & BRAND, 1937, p. 161.
Marginulina incisa, BARTENSTEIN & BRAND, 1937, p. 161, pl. 4, fig. 59; pl. 5, fig. 45.
Marginulina burgundiae, BARTENSTEIN & BRAND, 1937, p. 161, pl. 4, fig. 58.
Dentalina insignis, BARTENSTEIN & BRAND, 1937, p. 142.
Marginulina prima, MACFADYEN, 1941, p. 38, pl. 2, figs. 32 a, b.
Marginulina spinata, MACFADYEN, 1941, p. 39, pl. 2, figs. 33 a, b.
Marginulina prima, PAYARD, 1947, p. 151, pl. 2, figs. 30–31.
Marginulina burgundia, PAYARD, 1947, p. 153, pl. 2, fig. 32.
Nodosaria unguis, PAYARD, 1947, p. 172, pl. 2, fig. 23.
Marginulina prima, BARNARD, 1950, p. 372, figs. 5 a, b and g.

Marginulina prima d'Orbigny
form. burgundiae Terquem

Figs. 100–102.

Marginulina burgundiae, TERQUEM, 1863, p. 196, pl. 9, figs. 3 a, d.
Marginulina burgundiae, TERQUEM & BERTHELIN, 1875, p. 54, pl. 4, fig. 17.
Marginulina burgundiae, FRANKE, 1936, p. 78, pl. 8, fig. 8.
Marginulina burgundiae, BARTENSTEIN & BRAND, 1937, p. 161, pl. 4, fig. 58.
Marginulina burgundiae, PAYARD, 1947, p. 153, pl. 2, fig. 22.

Description.

This form only differs from the typical form in the coiled initial part and the very small initial chamber. Proloculum small (approx. 0.05 mm in diameter).

Remarks.

The present form is not connected with the various subspecies of *M. prima* by passage forms and thus cannot be considered a mere variant of this species. It accompanies the various subspecies and shows a line of development parallel to the *praerugosa-prima* line. The small initial chamber definitely indicates that this form is the microspheric form af *M. prima* as suggested by FRANKE and PAYARD.

Occurrence.

Lias Delta: Gassum No. 1, 4143′–4150′, rare; 4184′–4194′, rare; 4265′–4286′, rare.

Lias Gamma: Gassum No. 1, 4400′–4417′, scarce; Frederikshavn No. 1, 2827′–2837′, rare; Frederikshavn No. 2, 2568′–2588′, rare; 2785′–2805′, rare; Børglum No. 1, 4294′–4314′, rare.

Lias Beta: Gassum No. 1, 4500′–4518′, scarce.

Marginulina prima d'Orbigny subsp. prima d'Orbigny

Figs. 98, 99, 103, 104.

Marginulina prima, d'Orbigny, 1849, p. 242, No. 262.
Marginulina prima var. gibbosa, Terquem, 1858, p. 53, pl. 3, figs. 5 a, b.
Marginulina prima var. recta, Terquem, 1858, p. 54, pl. 3, fig. 6.
Marginulina prima var. acuta, Terquem, 1858, p. 54, pl. 3, fig. 7.
Marginulina alata, Terquem, 1858, p. 56, pl. 3, figs. 9 a, b.
Marginulina ornata, Terquem, 1858, p. 57, pl. 3, figs. 10 a, b.

Description.

Megalospheric form: Test very variable in size and general appearance which has caused Franke to subdivide the species in several varieties, usually rounded to slightly oval, somewhat compressed in section, composed of 8–15 chambers in a rectilinear series, considerably broader than high, gradually increasing in size from the fairly large proloculum; ornamented with about 10 high and thin ribs, running uninterrupted over the sutures from the apertural face down to the short spine at the base of the apertural chamber; short, more or less reduced additional ribs may occur in the adult part of old specimens; sutures usually distinct, at nearly right angles to the axis of the test, never depressed but with sutural arched broad and low transversal ribs connecting the higher longitudinal ribs at the sutures; aperture eccentric, radiate, on a short neck inside the serrated, thickened apertural face, which is indented owing to the joining of the ribs in arches along the apertural face; proloculum large but very variable in size (0.07 mm to 0.10 mm in diameter).

The arched sutural ribs form a very typical and most easily recognizable character of this subspecies. They are caused by the great size of the thickened, indented, apertural face which is not completely covered by the following chamber for which reason the outer uncovered rim of the former apertural face appears as an arched broad and low transversal rib, uniting the adjoining ribs at the sutures.

Microspheric form: See *Marginulina prima* form. burgundiae.

Remarks.

The diagnosis by d'Orbigny of this species is very incomplete and the specimen pictured by Macfadyen is evidently either poorly preserved or poorly prepared. It is thus very fortunate that the descriptions by Terquem are accurate down to the smallest details. Thus he very minutely describes the joining of the ribs in arches along the smooth apertural face and the sutural, transversal ribs, and though his pictures seem somewhat stylized the important characters are clearly and distinctly illustrated. These pictures leave no doubt about the position of the aperture which evidently is placed well inside the serrated, apertural face, although this fact is not directly mentioned by Terquem.

According to Terquem *M. alata* and *M. ornata* differ from *M. prima* by the visibility of the sutures and the more compressed test, respectively. As these characters are of little taxonomic value, the names mentioned are included as synonyms of *M. prima* in agreement with most later authors. The difference between *M. prima* and *M. gibberula* is difficult to comprehend, and consequently the latter form is included in the former as suggested both by FRANKE, BRAND and MACFADYEN.

FRANKE mentions the presence of sutural, transversal ribs (Nahtbogen) and his definition at least includes this subspecies. It is in this connection quite interesting that all the figured specimens are chosen from the Lias Gamma and Lias Delta, irrespective of the fact that he records the species from the Lower as well as the Middle Lias. It consequently looks as if it has been difficult to find typical material for illustration in the Lower Lias. BRAND adopts FRANKE's definition but pictures forms both from the Lias Alpha, Beta, Gamma and Delta. The details in his photomicrographs are difficult to make out but only the specimen from the Lias Delta seems to fit the required characters of this subspecies.

The ribs of *M. prima prima* are usually very high and thin and consequently always more or less broken. Distinct lines of growth are usually perceptible on the ribs and are running from the sutures and backwards in a hyperbolic arch marking the joining of the ribs of the last-formed chamber to those of the preceding chamber. Evidently the basal part of the ribs is the strongest, and when exposed to preparation the ribs tend to break in a peculiar way leaving the basal parts projecting as spines or – if treated more crudely – these "spines" break off leaving a test in which the ribs seem to be more or less reduced or interrupted above the sutures. Such maltreated specimens have without doubt been referred to the species *M. spinata, M. incisa* and *M. interrupta* according to their state of preservation. Nevertheless, it seems possible that the character in some cases is natural, and only such forms are in this publication referred to *M. prima spinata.*

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, abundant; 4016′–4024′, common; 4080′–4092′, common; 4143′–4150′, common; 4184′–4194′, common; 4222′–4230′, rare; 4265′–4286′, abundant.

Lias Gamma: Frederikshavn No. 1, 2720′–2727′, rare; Børglum No. 1, 4095′–4105′, rare.

Marginulina prima d'Orbigny
subsp. rugosa Bornemann

Fig. 97.

Marginulina rugosa, BORNEMANN, 1854, p. 39, pl. 3, figs. 26 a, b.
Marginulina raphanus, BRADY, 1867, p. 225, pl. 2, fig. 21.

Description.

The apertural face of this subspecies is smaller than in *M. prima prima* and the apertural face of the preceding chamber is thus more or less covered by the next chamber. Consequently the sutural, transversal ribs are less prominent though usually present, and this character alone is thus insufficient for the discrimination between the subspecies. Actually there is a gradual passage, and the only character which gives a distinct criterion for classification is the position of the aperture in the apertural face. Thus the aperture of *M. prima rugosa* is placed directly on the dorsal edge of the apertural face, while it is well well within the edge in *M. prima prima.*

Remarks.

The position of the aperture is difficult to distinguish in most illustrations. However, BORNEMANN's illustrations seem to show this character sufficiently well to be chosen as the type figure.

Occurrence.

Lias Delta: Gassum No. 1, 4265′–4286′, rare.

Lias Gamma: Gassum No. 1, 4300′–4310′, rare; 4349′–4357′, scarce; 4400′–4417′, abundant; Frederikshavn No. 1, 2787′–2797′, common; 2807′–2817′, common; 2817′–2827′, scarce; Frederikshavn No. 2, 2560′–2568′, common; 2568′–2588′, scarce; 2785′–2805′, scarce; Børglum No. 1, 4294′–4314′, common.

Lias Beta: Gassum No. 1, 4500′–4518′, scarce.

Marginulina prima d'Orbigny
subsp. praerugosa nov. subsp.

Fig. 96.

Dentalina burgundia, TATE & BLAKE, 1876, p. 461, pl. 18, fig. 29.

Description.

The apertural face in this subspecies is not, or only very slightly, thickened and the ribs consequently continue right up or very close to the radiate aperture. The form is connected to *M. prima rugosa* by intermediates, and no distinct limit can be defined between these two forms. For practical reasons all intermediate specimens where a slight thickening of the apertural face can only be observed by careful examination and high magnification are referred to *M. prima praerugosa.*

Remarks.

This subspecies is difficult to discriminate from the very closely related *M. radiata* of which it would undoubtedly be considered a variety were it not for the presence of a gradual passage from *M. prima praerugosa* through *M. prima rugosa* to *M. prima prima. M. prima praerugosa* thus only differs from *M. radiata* in the more rounded section which is a character of little taxonomic value in these very variable forms. Dentaline forms of *M. prima praerugosa* are difficult to discriminate from *D. matutina.*

Occurrence.

Lias Gamma: Gassum No. 1, 4400′–4417′, rare.

Lias Beta: Gassum No. 1, 4500′–4518′, abundant; 4550′–4570′, abundant; 4599′–4616′, rare; Vejrum No. 1, 734′–750′, common.

Lias Alpha: Gassum No. 1, 4649′–4668′, scarce; 4702′–4722′, scarce; Vejrum No. 1, 750′–766′, rare; 766′–776′, common; Vinding No. 1, 4993′–5007′, common.

Marginulina prima d'Orbigny subsp. spinata Terquem

Marginulina spinata, TERQUEM, 1858, p. 55, pl. 3, fig. 8.
Marginulina spinata, TERQUEM & BERTHELIN, 1875, p. 54.
Marginulina interrupta form. spinata, FRANKE, 1936, p. 79, pl. 8, fig. 10.
Marginulina spinata spinata, BARTENSTEIN & BRAND, 1937, p. 161, pl. 4, fig. 61; pl. 5, fig. 47.
Marginulina spinata, MACFADYEN, 1941, p. 39, pl. 2, figs. 33 a, b.

Description.

This subspecies is very similar to *M. prima rugosa* from which it differs in the presence of short spines in continuation of the hyperbolic arches delineating the lines of growth of the longitudinal ribs.

Remarks.

As was mentioned under the remarks to *M. prima prima* it seems somewhat doubtful whether this form is a distinct subspecies or just represents a special state of preservation. Nevertheless, it seems reasonable in a very few cases to consider at least a small number of the specimens, previously referred to *M. spinata*, as a separate subspecies. Due to scarcity of the material and the state of preservation it is at the present moment impossible to judge whether the form is a variant of *M. prima rugosa*, but as it seems to be indicated that the form may have a certain value as a marker it is believed to be most practical to elevate the form to subspecific rank.

Occurrence.

Lias Gamma: Frederikshavn No. 1, 2817′–2827′, scarce.

Distribution.

As far as can be judged from the records this form may be confined to the Lias Gamma.

Vaginulina listi (Bornemann)

Fig. 119.

Cristellaria listi, BORNEMANN, 1854, p. 40, pl. 4, fig. 28 a–c.
Marginulina incurva, TERQUEM, 1863, p. 188, pl. 8, fig. 9.
Marginulina lumbricalis, TERQUEM, 1866, p. 502, pl. 21, fig. 11.
Cristellaria matutina, ISSLER, 1908 (partly), p. 83, pl. 6, fig. 280 (only).
Vaginulina legumen, ISSLER, 1908, p. 69, figs. 187–193.

Vaginulina listi, FRANKE, 1936, p. 82, pl. 8, figs. 21, 22 a, b.
Vaginulina listi, BARTENSTEIN & BRAND, 1937, p. 163; pl. 3, fig. 28; pl. 5, fig. 75.

Description.

Test rectilinear, typically straight or slightly curved towards the dorsal side, with a distinctly curved, though never coiled, initial end, distinctly compressed, egg-shaped in cross-section with an angular dorsal side; number of chambers varying from 7 to 12, twice as broad as high; sutures distinct, only slightly or not deepened, nearly straight; aperture at the dorsal side of the test, radiate, on a nearly cylindrical neck; proloculum spherical. The microspheric form has not been observed in the material; the description above refers only to the megalospheric form.

Occurrence.

Lias Gamma: Frederikshavn No. 2, 2560′–2568′, common.

Lias Beta: Gassum No. 1, 4500′–4518′, common; Vejrum No. 1, 734′–750′, scarce.

SUBFAMILY LENTICULINAE

Marginulinopsis radiata (Franke not Terquem)

Figs. 105, 107.

Cristellaria (Astacolus) radiata, FRANKE, 1936, p. 108, pl. 11, fig. 3.
Cristellaria (Astacolus) radiata, BARTENSTEIN & BRAND, 1937, p. 172, pl. 3, fig. 58.

Description.

Megalospheric form: Test auriculate to elongated oval in outline, typically distinctly compressed, but occasionally rounded, oval in section; initial part coiled with 4 chambers forming less than one whorl; adult part of test uncoiled rectilinear, consisting of 3 to 6 or more chambers; dorsal side of test often with a thin and sharp keel; number of chambers varying from 8 to 12, triangular in the initial part; adult chambers trapezoidal, typically two or three times as broad as high; sutures very indistinct, hardly visible, flush with surface; surface ornamented with several, oblique, in many cases interrupted, ribs; aperture at the peripheral angle, radiate; proloculum large, spherical to ellipsoidal.

Microspheric form: In outline and general appearance similar to the megalospheric form, but with more chambers, especially in the initial, coiled part.

Remarks.

In this publication *Marginulinopsis radiata* is defined as an intermediate form between *Marginulina radiata* and *Marginulinopsis quadricostata*. It differs from the former in the coiled initial end. As the initial end of the microspheric form of *Marginulina radiata* also is coiled this form actually should be referred to the genus *Marginulinopsis*. The size of the initial chamber is believed to decide cases of doubt. The microspheric form of *Marginulinopsis radiata* is easily discriminated from the microspheric form of *Marginulina radiata* in the number of chambers in the coil which is above 4 in the former species. *Marginulinopsis radiata* is discriminated from *Marginulinopsis quadricostata* owing to the carinated, ventral side and the smaller number and greater regularity of the ribs in the latter form.

The nomenclature presented by previous authors shows great confusion. Thus according to FRANKE the specimen pictured and described by TERQUEM should be the holotype of *Cristellaria radiata* and at the same time typical of the species *Vaginulina radiata,* a condition which is very confusing. According to the description by TERQUEM there can hardly be any doubt that the specimens pictured are quite simply varieties of *Marginulina radiata,* and thus the holotype of *Marginulinopsis radiata* must be the specimen pictured by FRANKE. According to the description by FRANKE it is necessary that the initial part of the test is distinctly coiled to allow the material to be referred to *Marginulinopsis radiata,* and only forms with curved initial ends should be included in *Vaginulina radiata.* FRANKE mentions that the species is connected with *Vaginulina radiata* by intermediates, which evidently has been the cause of the inclusion of both *Vaginulina radiata* and *Marginulina radiata* in *Cristellaria* (*Astacolus*) *radiata* by BRAND.

Occurrence.

Lias Delta: Gassum No. 1, 4143′–4150′, rare; 4184′–4194′, rare; 4265′ –4286′, rare.

Lias Gamma: Gassum No. 1, 4349′–4357′, rare; 4400′–4417′, rare; Frederikshavn No. 2, 2568′–2588′, rare.

Lias Beta: Gassum No. 1, 4450′–4466′, rare; 4500′–4518′, scarce; 4550′–4570′, scarce; 4599′–4616′, common; Vejrum No. 1, 734′–750′, rare.

Distribution.

The confusion prevailing as to the definition of this species seems to have caused a similar confusion in the records of distribution. Thus FRANKE records this species from the Lias Alpha and Lias Beta, while BRAND records it from the Lias Beta, Gamma and Delta, but not from the Lias Alpha. The distribution in the Danish Lias seems to be similar to that suggested by BRAND.

Marginulinopsis quadricostata (Terquem)

Figs. 108–113.

Marginulina quadricostata, TERQUEM, 1863, p. 190, pl. 8, figs. 12 a, b.
Cristellaria nexa, TERQUEM & BERTHELIN, 1875, p. 49, pl. 4, figs. 11 a, b.
Cristellaria lacunata, TERQUEM & BERTHELIN, 1875, p. 50, pl. 4, figs. 14 a, b.
Cristellaria (*Astacolus*) *quadricosta,* FRANKE, 1936, p. 109, pl. 11, fig. 4.
Cristellaria (*Astacolus*) *quadricostata,* BARTENSTIEN & BRAND, 1937, p. 173, pl. 3, fig. 47; pl. 4, fig. 71; pl. 5, fig. 57.
Cristellaria quadricostata, MACFADYEN, 1941, p. 33, pl. 2, figs. 25 a, b.

Description.

Megalospheric form: Test auriculate to elongated in outline, compressed, initial part coiled, adult part of test uncoiled, but distinctly curved; periphery with a sharp keel, which generally surrounds the whole test with the exception of the apertural face; with 3 to 4 high and sharp curved ribs on each side, which originate in the coiled part of the test and continue over the whole test up to the last chamber, parallel to the convex periphery of the test; number of chambers very varying from 8 to 12, triangular in the initial part, 5 to 6 chambers forming less than a complete whorl; adult chambers trapezoidal, at least twice as broad as high, somewhat curved toward the direction of the coiled part of the test; sutures very indistinct, hardly visible, flush with surface; aperture at the peripheral angle, radiate; apertural face rounded, indistinct; proloculum large, spherical to ellipsoidal.

Microspheric form: In outline and general appearance similar to the megalospheric form but evidently with a few more chambers, number of chambers 11 to 13; initial part coiled, 6 to 7 chambers forming little more than one complete whorl; proloculum small, spherical.

Remarks.

This species is very closely related to *Marginulinopsis radiata* from which it differs by the extension of the dorsal keel along the ventral concave side of the test and in the smaller number and more regular ribs. It is an intermediate form between *Marginulinopsis radiata* and *Marginulinopsis breoni,* which has no ventral keel and is ornamented with several, fine ribs. These three species are evidently very closely related, and much seems to indicate that all of them may be subspecies of *Marginulinopsis quadricostata* only.

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, rare; 4143′–4150′, rare; 4184′–4194′, common; 4222′–4230′, rare; 4265′–4286′, rare.

Lias Gamma: Frederikshavn No. 2, 2568′–2588′, rare.

Distribution.

Commonly found in the Lias Gamma and Delta in NW Europe.

Marginulinopsis breoni (Terquem)

Fig. 106

Cristellaria breoni, TERQUEM, 1863, p. 210, pl. 10, figs. 4a, b.
Cristellaria (Astacolus) breoni, FRANKE, 1936, p. 109, pl. 10, fig. 26.
Cristellaria (Astacolus) breoni, BARTENSTEIN & BRAND, 1937, p. 173, pl. 4, fig. 75; pl. 5, fig. 56.

Description.

Test auriculate, compressed; initial part coiled, adult part uncoiled, consisting of three triangular to trapezoidal chambers, about 3 times as broad as high; both dorsal and ventral sides convex; whole test flattened and ornamented with several fine more os less parallel ribs; suture indistinct, flush with surface, distinctly curved towards the initial coiled part; aperture radiate. Microspheric form unknown.

Occurrence.

Lias Delta: Gassum No. 1, 3967'–3972', rare.

Marginulinopsis matutina (d'Orbigny)

Figs. 115, 117.

Cristellaria matutina, D'ORBIGNY, 1849, p. 242, No. 264.
Cristellaria antiquata, D'ORBIGNY, 1849, p. 242, No. 265.
Cristellaria vetusta, D'ORBIGNY, 1849, p. 242, No. 267.
Cristellaria protracta, BORNEMANN, 1854, p. 39, pl. 4, fig. 27.
Cristellaria spirolina, BORNEMANN, 1854, p. 40, pl. 4, figs. 30 a, c.
Cristellaria matutina, TERQUEM, 1858, p. 59, pl. 3, figs. 14 a–c.
Cristellaria antiquata, TERQUEM, 1858, p. 60, pl. 3, figs. 15 a, b; pl. 4, fig. 5.
Cristellaria vetusta, TERQUEM, 1858, p. 61, pl. 3, figs. 17 a–d.
Cristellaria recta, TATE & BLAKE (partly), 1876, p. 465, pl. 19, figs. 13, 13 a (only).
Cristellaria matutina, ISSLER, 1908, p. 83, pl. 6, figs. 275–288.
Cristellaria matutina, MACFADYEN, 1936, p. 151, fig. 264 (type figure).
Cristellaria antiquata, MACFADYEN, 1936, p. 151, fig. 265.
Cristellaria vetusta, MACFADYEN, 1936, p. 151, fig. 267.
Cristellaria (Astacolus) matutina, FRANKE, 1936, p. 106, pl. 10, figs. 11, 12.
Cristellaria (Astacolus) vetusta, FRANKE, 1936, p. 105, pl. 10, fig. 13.
Cristellaria (Astacolus) antiquata, FRANKE, 1936, p. 105, pl. 10, fig. 14.
Cristellaria (Astacolus) vetusta, BARTENSTEIN & BRAND, 1937, p. 172, pl. 3, figs. 43 a, b.
Cristellaria (Astacolus) matutina, BARTENSTEIN & BRAND, 1937, p. 172, pl. 2 B, fig. 33; pl. 3, fig. 79; pl. 5, fig. 53.
Cristellaria (Astacolus) rectalonga, BARTENSTEIN & BRAND, 1937, p. 172, pl. 4, fig. 80.
Lenticulina (Astacolus) matutina, PAYARD, 1947, p. 97, pl. 7, fig. 17.
Lenticulina (Astacolus) antiquata, PAYARD, 1947, p. 98, pl. 7, fig. 16.

Description.

Initial part of test closely coiled, consisting of about one whorl, later part uncoiling, curved to rectilinear, compressed; dorsal side subangular; coiled part consisting of 7 to 8 triangular chambers, later chambers triangular to trapezoidal, little more than twice as broad as high; sutures flush with surface in the coiled part, distinctly deepened in the later part of the test; proloculum large, spherical, in or slightly removed from, the angle between the coiled and the uncoiled part of the test; aperture distinctly radiate. Microspheric form unknown.

Remarks.

The reference of the specimens from the Danish Lias to this very ill-defined form is subject to doubt. In the way the species is defined in this publication it appears as a form parallel to *Planularia stilla* from which it largely differs in the uncoiling part of the test. The form is obviously closely related to the forms on the following pages referred to the species *M. lituoides.* This form differs from *M. matutina* in the less compressed test and is supposed to be parallel to *Lenticulina gottingensis.*

The difference between *M. matutina* and *M. lituoides* as here defined, however, is hardly of sufficient importance to be of specific, or even subspecific value. Nevertheless, owing to the parallelism between these two forms on one hand and *Planularia stilla* and *Lenticulina gottingensis* on the other hand it has been considered most practical to keep them apart, at least until it has been possible to decide whether they represent a lineage parallel to that of the *Lenticulina gottingensis* group, or whether they should be considered mere variants of *Planularia stilla* and *Lenticulina gottingensis.* A multitude of widely differing forms have by previous authors been referred to *Cristellaria matutina,* and a revision of the forms referred to this species is thus very necessary.

Occurrence.

Lias Alpha: Gassum No. 1, 4702′–4722′, rare; 4800′–4820′, rare; 4900′–4920′, scarce; 4950′–4970′, common; Vejrum No. 1, 766′–776′, rare.

Marginulinopsis lituoides (Bornemann)

Figs. 118, 120.

Cristellaria lituoides, BORNEMANN, 1854, p. 40, pl. 4, figs. 29 a–c.
Cristellaria (Astacolus) lituoides, FRANKE, 1936, p. 101, pl. 10, figs. 1, 2.

Description.

Initial part of the test coiled, consisting of less than one whorl, later part uncoiling, rectilinear, only slightly compressed, oviform in section; dorsal side subangular; coiled part consisting of 6 to 7 triangular chambers, later chambers trapezoidal, slightly more than twice as broad as high; sutures flush with surface in the coiled part, distinctly deepened in the rectilinear part of the test; proloculum large, spherical at the angle between the coiled and the uncoiled part of the test; aperture protruding, distinctly radiate; microspheric form unknown.

Remarks.

M. lituoides is in all respects similar to *L. gottingensis* from which it differs only in the uncoiling part of the test. It is less compressed than *M. matutina* and *M. prima,* and it further differs from the latter species in the coiled initial part which consists of less than one complete whorl. Nevertheless, the exact definition of these three species is difficult, and it seems doubtful whether the recorded differences may be considered sufficiently distinctive to warrant a specific separation of them. However, they are reported as distinct species in this publication as the occurrence of these forms in the Danish Lias Series shows a striking parallelism to the phylogenetic line af *Planularia stilla, Lenticulina gottingensis* and *Lenticulina acutiangulata.*

Occurrence.

Lias Beta: Gassum No. 1, 4450′–4466′, common; 4500′–4518′, abundant.

Marginulinopsis prima (d'Orbigny)

Figs. 116, 121, 122.

Cristellaria prima, D'ORBIGNY, 1849, p. 242, No. 266.
Cristellaria prima, MACFADYEN, 1936, p. 151, pl. 1, figs. 266 a, b (type figure).
Cristellaria deformis, BORNEMANN, 1854, p. 41, pl. 4, figs. 35 a, b.
Cristellaria prima, TERQUEM, 1866, p. 513, pl. 21, figs. 35 a, b.
Cristellaria (Astacolus) prima, FRANKE, 1936, p. 106, pl. 10, figs. 8, 9.
Cristellaria (Astacolus) prima, BARTENSTEIN & BRAND, 1937, p. 172; pl. 1 A, fig. 25; pl. 2 A, fig. 17; pl. 3, fig. 44; pl. 4, fig. 81; pl. 5, fig. 54.

Description.

Test auriculate, compressed, smooth, angular and often slightly carinated; initial end coiled, consisting of one, or little more than one, whorl, the adult part slightly uncoiled, with a pronounced tendency of the later chambers to extend backwards to the coiled part; coiled part consisting of about 9 triangular chambers, later chambers triangular to trapezoidal, several times broader than high; sutures flush with surface or slightly raised; aperture distinctly radiate; proloculum large, spherical. Microspheric form unknown.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, scarce; 4016′–4024′, rare; 4080′–4092′, scarce; 4143′–4150′, rare; 4184′–4194′, rare; 4222′–4230′, rare; 4265′–4286′, common.

Lias Gamma: Gassum No. 1, 4300′–4310′, rare; Frederikshavn No. 2, 2568′–2588′, scarce; Børglum No. 1, 4294′–4314′, rare.

Remarks.

The specimens from the Danish Lias appear to be similar to the holotype of D'ORBIGNY as pictured by MACFADYEN. Intermediate forms between *M. prima* and *L. acutiangulata* have not been observed, but the two species have many characters in common.

Vaginulinopsis exarata (Terquem)

Fig. 114.

Marginulina exarata, TERQUEM, 1866, p. 507, pl. 21.
Vaginulina exarata, ISSLER, 1908, p. 70, pl. 4, fig. 195.
Cristellaria (Astacolus) exarata, FRANKE, 1936, p. 107, pl. 10, figs. 22 a & b, 23.
Cristellaria (Astacolus) exarata, BARTENSTEIN & BRAND, 1937, p. 173.

Description.

Test straight, compressed, with coiled initial end, composed of approx. 10 chambers, the first four coiled, forming about one whorl; chambers broader than high; sutures slightly oblique, flush with surface, indistinct; ribs high, sharp and distinctly oblique; aperture at the dorsal side of the test, radiate.

Remarks.

The species is intermediate between *Marginulina radiata* and *Marginulinopsis radiata.* It differs from the first-mentioned in the coiled initial end and from the latter in the numerous, distinctly oblique ribs. The figure of *Vaginulina exarata* by ISSLER shows a form which seems to be intermediate between *Marginulina radiata* and this species, and it is thus open to dispute whether the form recorded by ISSLER can be included in *Vaginulinopsis exarata.*

Occurrence.

Lias Beta: Gassum No. 1, 4550′–4568′, rare.

Distribution.

This species is a rather rare form but seems according to the few existing records to be confined to the upper part of the Lias Alpha and the Lias Beta.

Astacolus varians (Bornemann)

Figs. 123–134.

Cristellaria varians, BORNEMANN, 1854, p. 41, pl. 4, figs. 32, 34.
Cristellaria deformis, BORNEMANN, 1854, p. 41, pl. 4, figs. 35 a, b.
Christellaria granulata, BORNEMANN, 1854, p. 41, pl. 4, figs. 36 a, b.
Cristellaria minuta, BORNEMANN, 1854, p. 42, pl. 4, figs. 37 a, b.
Cristellaria convoluta, BORNEMANN, 1854, p. 42, pl. 4, figs. 38 a, b.
Cristellaria major, BORNEMANN, 1854, p. 40, pl. 4, figs. 31 a, b.
Cristellaria cassis, JONES & PARKER, 1860, pl. 20, fig. 41.
Cristellaria acuminata, TERQUEM, 1863, p. 210, pl. 10, fig. 12.
Cristellaria acutauricularis, BRADY, 1867, p. 228, pl. 3, fig. 38.
Cristellaria aargovensis, ZWINGLI & KÜBLER, 1870, p. 6, pl. 1, fig. 15.
Cristellaria studeri, ZWINGLI & KÜBLER, 1870, p. 7, pl. 1, fig. 16.
Cristellaria lunari, ZWINGLI & KÜBLER, 1870, p. 11, pl. 1, fig. 8.
Cristellaria impressa, TERQUEM & BERTHELIN, 1875, p. 46, pl. 4, figs. 3 a, b, 4 a,–d, 5 a, b, 6 a, b, 7 a, b.
Cristellaria impleta, TERQUEM & BERTHELIN, 1875, p. 50, pl. 4, figs. 13 a–f.
Cristellaria major, TATE & BLAKE, 1876, p. 465, pl. 19, fig. 15.
Cristellaria varians, TATE & BLAKE, 1876, p. 466, pl. 17, fig. 27; pl. 19, fig. 16.
Cristellaria communis, HAEUSLER, 1881, p. 24, pl. 2, figs. 10, 14, 31, 34.
Cristellaria sinemuriensis, HAEUSLER, 1881, p. 17, pl. 2, figs. 1, 11.
Cristellaria reniformis, HAEUSLER, 1881, p. 27, pl. 2, fig. 32.
Cristellaria varians, BURBACH & DREYER, 1888, p. 502, pl. 10, figs. 15–21.
Cristellaria subquadrata, BURBACH & DREYER, 1888, p. 505, pl. 10, fig. 22.
Cristellaria acutauricularis, BURBACH & DREYER, 1888, p. 505, pl. 10, figs. 23, 24; pl. 11, figs. 25–27.
Cristellaria acuminata, BURBACH & DREYER, 1888, p. 507, pl. 11, figs. 28, 29.
Cristellaria crepidula, HAEUSLER, 1890, (partly) p. 111, pl. 14, figs. 58, 60 (only).
Cristellaria acutauricularia, CRICK & SHERBORN, 1891, p. 212, pl. 1, fig. 25.
Cristellaria rotulata, CRICK & SHERBORN, 1891, p. 213, pl. 1, fig. 26.
Cristellaria varians, CRICK & SHERBORN, 1891, p. 213, pl. 1, fig. 30.
Cristellaria varians, CRICK & SHERBORN, 1892, p. 70, pl. 2, figs. 15, 16.
Cristellaria semidirecta, SELLHEIM, 1893, p. 19, pl. 1, fig. 11.
Cristellaria gibba, SCHICK, 1903, p. 127, pl. 4, figs. 3, 4.
Cristellaria acutauricularia, SCHICK, 1903, p. 129, pl. 4, fig. 6.
Cristellaria laevigata, SCHICK, 1903, p. 129, pl. 4, fig. 5.

Cristellaria gladius, Schick, 1903, p. 134, pl. 4, fig. 15.
Cristellaria major, Issler, 1908, p. 80, pl. 5, figs. 249, 250.
Cristellaria varians, Issler, 1908, p. 86, pl. 6, figs. 307, 316; pl. 7, figs. 308, 310.
Cristellaria minuta, Issler, 1908, p. 89, pl. 7, figs. 317–320.
Cristellaria (Astacolus) major, Franke, 1936, p. 101, pl. 9, fig. 36.
Cristellaria (Astacolus) adunce, Franke, 1936, p. 103, pl. 10, fig. 16.
Cristellaria (Astacolus) dubia, Franke, 1936, p. 107, pl. 10, fig. 17.
Cristellaria (Lenticulina) subquadrata, Franke, 1936, p. 111, pl. 11, fig. 7.
Cristellaria (Lenticulina) minuta, Franke, 1936, p. 112, pl. 11, fig. 8.
Cristellaria (Lenticulina) varians, Franke, 1936, p. 112, pl. 11, figs. 9–11.
Cristellaria (Lenticulina) varians f. typica, Franke, 1936, p. 112, pl. 11, fig. 9.
Cristellaria (Lenticulina) varians f. recta, Franke, 1936, p. 113, pl. 11, fig. 12.
Cristella (Lenticulina) varians f. granulata, Franke, 1936, p. 113.
Cristellaria (Lenticulina) convoluta, Franke, 1936, p. 113, pl. 11, fig. 14.
Cristellaria (Lenticulina) varians, Bartenstein & Brand, 1937, p. 176, pl. 1 A, fig. 18; pl. 2 A, figs. 16, 20; pl. 2 B, fig. 32; pl. 3, figs. 31, 32; pl. 5, fig. 60.
Cristellaria (Lenticulina) minuta, Bartenstein & Brand, 1937, p. 176, pl. 1 A, figs. 17 a, b; pl. 2 A, fig. 18 a; pl. 2 B, fig. 31; pl. 3, fig. 33; pl. 4, fig. 70; pl. 5, fig. 61.
Cristellaria (Astacolus) major, Bartenstein & Brand, 1937, p. 171.
Cristellaria varians, Macfadyen, 1941, p. 35, pl. 2, figs. 28 a, b.
Lenticulina varians f. recta, Payard, 1947, p. 86, pl. 7, figs. 3–5.

Description.

Test auriculate, consisting of from less than one whorl to somewhat more than one with a strong tendency to uncoiling in the later chambers, which, however, in most cases are extending backwards to the coiled part consisting of up to 12 triangular chambers; sutures flush with surface, between the later chambers usually slightly deepened; periphery angular to carinated; aperture distinctly radiate. Microspheric form similar to the megalospheric form, except for the small proloculum and the presence of somewhat more than one whorl.

Remarks.

It has been impossible for the present author to find sufficient evidence for the discrimination between the following six species *Cristellaria varians*, *C. deformis*, *C. granulata*, *C. minuta*, *C. convoluta* and *C. major*. These species were originally defined by Bornemann, but both the descriptions and the pictures of these forms are so similar that it is difficult to understand what has led Bornemann to consider these six forms as separate species. According to Franke the six forms are discriminated by means of the degree of depression of the sutures between the last chambers, the ratio between the size of the spiral part and the uncoiled part and some other minor criteria which are only differences in degree and usually subject to wide variations. The present author has thus in agreement with Macfadyen included all these and a multitude of evidently very similar species in the single species, *Astacolus varians*. Brand considers *C. minuta* as including immature specimens of other species. As mentioned in the remarks to *Marginulinopsis matutina*, intermediate forms between this species and *Astacolus varians* commonly occur, but it nevertheless seems unlikely that the species *Astacolus varians* should be immature specimens of any other species in the material.

Occurrence.

Lias Delta: Gassum No. 1, 4143′–4150′, rare; 4184′–4194′, abundant; 4222′–4230′, abundant; 4265′–4286′, scarce.

Lias Gamma: Gassum No. 1, 4300′–4310′, scarce; 4349′–4357′, rare; 4400′–4417′, rare; Frederikshavn No. 2, 2560′–2568′, common; 2568′–2588′, scarce; Børglum No. 1, 4294′–4314′, rare.

Lias Beta: Gassum No. 1, 4450′–4466′, scarce; 4500′–4518′, abundant; 4550′–4570′, abundant; 4599′–4616′, rare.

Lias Alpha: Gassum No. 1, 4649′–4668′, common; 4702′–4722′, rare; 4750′–4770′, abundant; 4800′–4820′, rare; 4850′–4870′, scarce; 4900′–4920′, common; 4950′–4970′, scarce.

Distribution.

Evidently widely distributed and often abundant in the Lias and Dogger of NW Europe.

Astacolus varians (Bornemann) var. convolutus (Bornemann)

Fig. 135.

Cristellaria convoluta, Bornemann, 1854, p. 42, pl. 4, figs. 38 a, b.
Cristellaria (Lenticulina) convoluta, Franke, 1936, p. 113, pl. 11, fig. 14.

Description.

This variety differs from the typical form in the tendency of the ventral parts of the later chambers to continue right down to the proloculum.

Remarks.

This form is closely related to *A. varians* and the observed difference is supposed to be of very little significance for the taxonomy and nomenclature. Nevertheless, this form shows a marked difference in distribution if compared to that of the typical form, and it has consequently been considered of some importance to record it as a separate form.

Occurrence.

Lias Delta: Gassum No. 1, 4222′–4230′, rare.

Lias Gamma: Frederikshavn No. 1, 2787′–2797′, rare; 2797′–2807′, rare; 2807′–2817′, rare; 2817′–2827′, rare; Rødby No. 1, 1603′–1623′, rare; 1650′–1670′, rare; 1791′–1802′, rare.

Planularia stilla (Terquem)

Figs. 136–147.

Cristellaria stilla, Terquem, 1866, pl. 517, pl. 22, fig. 7.
Cristellaria (Planularia) stilla, Franke, 1936, p. 96, pl. 9, fig. 26.
Cristellaria (Planularia) stilla, Bartenstein & Brand, 1937, pl. 169, pl. 4, fig. 78.

Remarks.

According to FRANKE *P. stilla* differs from *P. crepidula* in the carinated margin, but this character can hardly be claimed as sufficient for specific separation. Of the specimens from Denmark a few have a pretty high and distinct marginal keel missing only in a few specimens, while the majority have a rather incomplete marginal keel.

Occurrence.

Lias Beta: Gassum No. 1, 4550′–4570′, rare.

Lias Alpha: Gassum No. 1, 4702′–4722′, common; 4750′–4768′, abundant; 4800′–4820′, rare; 4850′4870′, rare.

Planularia inaequistriata (Terquem)

Figs. 148, 149.

Marginulina inaequistriata, TERQUEM, 1863, p. 191, pl. 8, fig. 15.
Marginulina cancellaroides, TERQUEM, 1866, p. 508, pl. 21, figs. 25 a, b.
Marginulina inaequistriata, TATE & BLAKE, 1876, p. 462, pl. 19, fig. 7.
Cristellaria inaequistriata, ISSLER, 1908, p. 80, pl. 5, figs. 251–254.
Cristellaria arietis, ISSLER, 1908 (not TERQUEM, 1866), p. 81, pl. 5, figs. 255, 260.
Cristellaria (Astacolus) inaequistriata, FRANKE, 1936, p. 108, pl. 10, figs. 24, 25.
Cristellaria (Planularia) arietis, FRANKE, 1936, p. 96, pl. 9, fig. 28.
Cristellaria (Astacolus) inaequistriata, BARTENSTEIN & BRAND, 1937, p. 173, pl. 2 A, figs. 21 a–c; pl. 2 B, figs. 36 a, b.
Planularia inaequistriata, BARNARD, 1950, p. 375, figs. 8 c, d, g.

Description.

Little can be added to the previous descriptions of this well-defined and easily identifiable form. According to the specimens from the Danish Lias Series the initial end of the megalospheric form consists of little more than half a whorl. The microspheric form is unknown.

Remarks.

ISSLER considered the broader variants of this form a separate species which he described under the name *Cristellaria arietis.* In the first line this name is preoccupied by *C. arietis* TERQUEM, 1866, and secondly broad and narrow forms may be found together in the same sample; the character is thus hardly sufficient for specific separation. FRANKE (1936) adopted ISSLER's species, while BRAND in BARTENSTEIN & BRAND does not record it from the German Lias. A close relationship of *C. inaequistriata* to *Marginulina radiata* was already assumed by ISSLER (1908).

Occurrence.

Lias Alpha: Gassum No. 1, 4850′–4870′, rare; Vejrum No. 1, 766′–776′, scarce; Vinding No. 1, 4993′–5007′, rare.

Distribution.

Widely distributed and often common in the Lias Alpha of NW Europe.

Planularia eugenii (Terquem)

Fig. 150.

Cristellaria eugenii, TERQUEM, 1863, p. 204, pl. 9, figs. 16 a, b.
Cristellaria pikettyi, TERQUEM, 1866, p. 511, pl. 21, figs. 31, 32.
Cristellaria lata, BURBACH & DREYER, 1888, p. 500, pl. 10, figs. 10, 11.
Cristellaria eugenii, BURBACH & DREYER, 1888, p. 502, pl. 10, fig. 14.
Cristellaria crepidula var. striata, ISSLER, 1908, p. 82, pl. 5, figs. 265?–268.
Cristellaria (Planularia) eugenii, FRANKE, 1936, p. 97, pl. 9, f. 29.
Cristellaria (Planularia) eugenii, BARTENSTEIN & BRAND, 1937, p. 170, pl. 3, fig. 46.

Description.

The two observed specimens differ from *P. inaequistriata* in the reduced number of ribs and in the regularity of these ribs. The form is obviously closely related to *P. inaequistriata.*

Occurrence.

Lias Delta: Gassum No. 1, 4143′–4150′, rare; 4265′–4286′, rare.

Distribution.

The species is a rare form, previously known only from the Lias and Dogger of Germany.

Saracenaria hannoverana Franke

Fig. 152.

Cristellaria (Saracenaria) hannoverans, FRANKE, 1936, p. 98, pl. 9, fig. 33.
Cristellaria (Saracenaria) hannoverana, BARTENSTEIN & BRAND, 1937, p. 170.

Description.

This form is evidently very closely related to *S. sublaevis*, from which it differs in the more rounded section, which may be even ovoid and thus hardly typical of this genus. As intermediate forms seem to occur between these two species, they are probably nothing but varieties of the same species.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, common; 4080′–4092′, scarce.

Saracenaria sublaevis Franke

Fig. 151.

Cristellaria (Saracenaria) sublaevis, FRANKE, 1936, p. 98, pl. 9, figs. 30, 31.
Cristellaria (Saracenaria) sublaevis, BARTENSTEIN & BRAND, 1937, p. 170, pl. 5, figs. 59 a, b.

Description.

Test distinctly triangular in section with a coiled initial part; dorsal margin rounded to subangular; ventral side of uncoiled portion slightly curved, angles between ventral and lateral sides rounded; coiled initial part consisting of less than 5 chambers forming less than one whorl; uncoiling part of up to 6 chambers, broader than high; sutures flush with surface, indistinct, slightly curved; proloculum at the angle between the periphery of the whorl and the ventral side, oblong; aperture *at the dorsal side, distinctly* radiate.

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, common.

Distribution.

Evidently confined to the Lias Delta of Germany and Denmark.

Lenticulina gottingensis (Bornemann)

Figs. 153–170.

Robulina gottingensis, BORNEMANN, 1854, p. 43, pl. 4, figs. 40, 41 a, b.
Cristellaria (Lenticulina) gottingensis, FRANKE, 1936, p. 116, pl. 11, figs. 22 a, b.
Cristellaria (Lenticulina) münsteri, BARTENSTEIN & BRAND, 1937, p. 174, pl. 3, figs. 30 a b; pl. 4, figs. 69 a–c.

Description.

Test lenticular, closely coiled, somewhat inflated; periphery angular to indistinctly keeled; umbilicus wide and with an umbilical plug; chambers triangular, slightly curved, arranged in one to one and a half whorls, 7 to 9 in the last whorl, last chambers slightly embracing; surface smooth; sutures indistinct, flush with surface; apertural face reversely heart-shaped, indistinct, with rounded borders usually not delineated by raised folds, curved, only slightly depressed in the middle, slightly indented by the previous whorl; aperture somewhat protruding, rather distinctly delimited from the apertural face, radiate.

Remarks.

The microspheric form of this species is unknown, which is an obstacle for the understanding of the evolution of this form. The examination shows that the Lias Beta and Lias Gamma form consists of little more than one whorl, and that it has gradually evolved into the Lias Delta form with approximately one and a half whorls and more embracing chambers. A few inequal specimens have been observed; they fit the description well of *Cristellaria* (*Lenticulina*) *gottingensis* (BORNEMANN) form. inaequilatera FRANKE. As a matter of fact a considerable number of the examined specimens shows slight tendencies to trochoid growth, but the inequality is very variable and seems to indicate an accidental, but rather considerable, variability in growth. Owing to this and to the fact that the material is too small for a statistical examination it has not been attempted to base a further subdivision of the species on this character. In the description of the species it was mentioned that the periphery is usually angular. This character may be more or less distinct, and in a few cases the periphery may even be thinly carinated. These characters show that *Lenticulina gottingensis* is very closely related to *L. turbiniformis* and *L. acutiangulata*, and the differences between these three species are not stronger than it seems probable that all of them may be subspecies of a single species.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, common; 4016′–4024′, common; 4080′–4092′, rare; 4265′–4286′, common.

Lias Gamma: Gassum No. 1, 4300′–4310′, scarce; 4349′–4357′, scarce; 4400′–4417′, common; Frederikshavn No. 1, 2757′–2767′, rare; 2767′–2777′, rare; 2787′–2797′, rare; 2797′–2807′, rare; 2817′–2827′, rare; 2827′–2837′, rare; Frederikshavn No. 2, 2560′–2568′, rare; 2785′–2805′ common; Børglum No. 1, 4294′–4314′, rare.

Lias Beta: Gassum No. 1, 4450′–4466′, abundant; 4500′–4518′ abundant.

Distribution.

Occasionally present in the (Lias Alpha ?) Lias Beta, but widely distributed and usually abundant in the Lias Gamma and Delta of NW Europe.

Lenticulina polygonata Franke

Fig. 179.

Cristellaria (Lenticulina) polygonata, Franke, 1936, p. 118, pl. 2, figs. 1a–c, figs. 2a, b.
Cristellaria (Lenticulina) polygonata, Bartenstein & Brand, 1937, p. 175.

Description.

Test lenticular, completely coiled, somewhat higher than broad; last whorl consisting of 9 to 10 chambers, not embracing; sutures distinct, somewhat thickened, which is the cause of the polygonal outline of the test; aperture distinctly radiate, slightly protruding.

Remarks.

The species is an intermediate form between *L. gottingensis* and *L. subalata*, which occurs in the Upper Jurassic and the Dogger. As a matter of fact the difference between these forms is hardly of more than subspecific rank. The species *L. gottingensis*, *L. polygonata*, *L. subalata* and *L. foveolata* thus constitute a line of evolution connected by passage forms. They seem to be of great value as index fossils.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare.

Lenticulina acutiangulata (Terquem)

Figs. 177, 178.

Robulina acutiangulata, Terquem, 1864, p. 220, pl. 10, fig. 20.

Cristellaria (Lenticulina) acutiangulata, FRANKE, 1936, p. 117, pl. 11, fig. 25.
Cristellaria (Lenticulina) acutiangulata, BARTENSTEIN & BRAND, 1937, p. 175, pl. 5, figs. 52 a–d.

Description.

Test lenticular, closely coiled, somewhat inflated, periphery angular and in some specimens distinctly keeled; umbilical plug of translucent, calcareous material; chambers triangular, arranged in one and a half whorls, 8–10 to a whorl, last chambers slightly embracing; surface smooth; sutures indistinct; often slightly raised; apertural face reversely heart-shaped, distinct, usually delineated by raised borders or folds, more or less curved, usually slightly depressed in the middle; more or less indented by the previous whorl; aperture radiate, not distinctly limited from the apertural face, not protruding.

Remarks.

Some of the specimens from the Lias Series in Gassum No. 1 have slightly raised sutures, a fact which indicates relationship to *L. subalata.*

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare; 4016′–4024′, rare; 4080′–4092′, rare; 4143′–4150′, rare; 4184′–4194′, rare.

Lias Gamma: Frederikshavn No. 1, 2720′–2727′, rare; 2737′–2747′, rare; 2747′–2757′, rare.

Distribution.

This species is supposed to be an excellent index fossil for the Lias Delta. The type by TERQUEM is from the capricornu zone of the uppermost Lias Gamma, and BRAND records the form as rare just below the contact, and as common through the whole of the Lias Delta. FRANKE records the species both from the Lias Delta and the Lias Zeta, but according to BARTENSTEIN & BRAND these forms should be referred either to *L. subalata* or *L. gottingensis.*

Darbyella turbiniformis (Terquem)

Figs. 171–176.

Cristellaria turbiniformis, TERQUEM, 1863, p. 422, pl. 10, figs. 9 a–c.
Cristellaria (Lenticulina) turbiniformis, FRANKE, 1936, p. 114, pl. 11, fig. 17.

Description.

Megalospheric form: Test lenticular, generally somewhat higher than broad, distinctly trochoid, closely coiled, with a pronounced, high, thin and sharp keel; composed of approximately 15 chambers arranged in one and a half whorls, 9 to 10 chambers to a whorl, direction of coiling apparently random; chambers embracing on one side and proloculum indistinctly visible on the opposite side; sutures flush to slightly limbate, rather distinct, usually darker colored than the other parts of the test, fairly often pyritized, distinctly curved backwards, final chamber triangular, typically somewhat protruded towards the aperture; apertural face pretty distinct, elongated oval, usually somewhat depressed in the middle, bordered by two blunt ridges, dorsal ridge often more strongly curved than ventral ridge; aperture radiate, lenticuline; proloculum large, spherical.

Microspheric form: The test of this form seems to be only indistinctly or at least less trochoid and differs furthermore from the megalospheric form in having 18–19 chambers arranged in two complete whorls.

Remarks.

The correct identification of this very distinctive form can hardly be doubted as it fits the descriptions and figures given by TERQUEM and FRANKE very well. However, the specimens from Gassum seem slightly smaller than those described by former authors. Thus the height is 0.5–0.6 mm, and the breadth 0.4–0.6 mm, as compared to the corresponding 0.6–1.5 mm and 0.5 –0.9 mm given by FRANKE. The specimen pictured by TERQUEM appears to consist of more chambers arranged in at least 2 whorls, and the specimen pictured by FRANKE seems to show considerably more chambers than observed in the specimens from the Danish Lias Series.

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, common; 4016′–4027′, abundant; 4080′–4092′, common; 4184′–4194′, rare; 4222′–4232′, rare.

Lias Gamma: Frederikshavn No. 1, 2747′–2757′, rare; 2757′–2767′, rare; 2767′–2777′, rare.

Distribution.

Probably widely distributed and common chiefly in the Lias Delta of NW Europe.

FAMILY POLYMORPHINIDAE

Eoguttulina liassica (Strickland)

Figs. 180, 181.

Polymorphina liassica, STRICKLAND, 1846, p. 30, fig. b.
Polymorphina lactea, BRADY, 1867, p. 230, pl. 3, fig. 49.
Polymorphina fusiformis, TATE & BLAKE, 1876, p. 470, pl. 17, fig. 31.
Eoguttulina liassica, CUSHMAN & OZAWA, 1930, p. 17, figs. 2 a–c.
Polymorphina (Eoguttulina) liassica, MACFADYEN, 1941, p. 67, pl. 4, fig. 66.
Polymorphina liassica, FRANKE, 1936, p. 120, pl. 12, figs. 8–10.
Eoguttulina liassica, BARTENSTEIN & BRAND, 1937, p. 178, pl. 1 A, figs. 24 a, b; pl. 2 A, fig. 23; pl. 2 B, fig. 35; pl. 3, fig. 49; pl. 4, figs. 74 a–b; pl. 5, figs. 69 a–b.
Eoguttulina liassica, BARNARD, 1950, p. 376, figs. 8 b, f.

Remarks.

Many of the species described by TERQUEM, 1864 should probably be included in this species.

Occurrence.

Lias Delta: Gassum No. 1, 4016′–4024′, rare.

Lias Gamma: Gassum No. 1, 4300′–4310′, rare; Rødby No. 1, 1791′–1802′, rare; 1802′–1807′, rare; 1807′–1827′, rare; 1827′–1839′, rare.

Lias Beta: Gassum No. 1, 4500′–4518′, rare; 4550′–4570′, rare.

Lias Alpha: Gassum No. 1, 4800′–4820′, scarce; 4950′–4970′, scarce.

Distribution.

Widely distributed and often common in the Lias series of NW Europe.

SUPERFAMILY ROTALIIDEA

FAMILY CERATOBULIMINIDAE

Lamarckina nov. sp.

In the core 1802′–1807′ from Rødby No. 1 occurs a *Lamarckina sp.* in abundance. The material has been delivered to Dr. Johs. Troelsen for further examination and publication, and this species will consequently not be discussed further in this publication.

INCERTAE FAMILIAE

"Frondicularia" nitida Terquem

Frondicularia nitida, Terquem, 1858, p. 32, pl. 1, figs. 9 a–c.
Frondicularia sacculus, Terquem, 1866, p. 482, pl. 9, figs. 20 a, b.
Frondicularia pupiformis, Haeusler, 1881, p. 18, pl. 2, fig. 7.
Frondicularia nitida Burbach, 1886, p. 45, pl. 1, fig. 7.
Frondicularia pupiformis, Issler, 1908, p. 56, pl. 2, figs. 109–114.
Frondicularia nitida, Franke, 1936, p. 68, pl. 7, figs. 1, 3.
Frondicularia sacculus, Franke, 1936, p. 68, pl. 7, fig. 4.
Frondicularia nitida, Bartenstein & Brand, 1937, p. 155, pl. 2 B, fig. 19; pl. 4, fig. 55; pl. 5, fig. 35.
Frondicularia sacculus, Bartenstein & Brand, 1937, p. 154, pl. 4, fig. 46.

Description.

Test elongated, smooth, oval in outline, with nearly parallel sides, distinctly compressed, but with broadly rounded margins which are not carinated, composed of 6 to 9 chambers, inverted chevron-shaped, the adult ones only little or not at all increasing in size; median groove distinct but rather shallow; sutures indistinct, flush with surface, in some cases deepened between the two last chambers; sutural angle close to 90° in the younger chambers, distinctly obtuse in the adult chambers; aperture not preserved in any of the examined specimens; proloculum large, spherical; microspheric form not observed but is evidently described by Issler (1908).

Remarks.

This species is easily discriminated from *Spandelina bicostata terquemi* by the lack of a carinated margin and the broadly rounded sides as well as the much thicker test which is not as flattened as the test of *S. bicostata terquemi.* The species may be related to the genus *Spandelina* owing to the presence of a distinct median groove and the general similarity to the subspecies of the *S. bicostata* group. The differences between the species *F. nitida* and *F. sacculus* are in matters of degrees only, and the latter species is accordingly included in the former as previously suggested by Franke. Brand states that the margins of the specimens in Franke's material are rounded and not keeled as described by Franke. Nevertheless, Brand keeps the two species apart. There may be some reason to believe that *F. sacculus* is a subspecies of *F. nitida,* as the two forms have different stratigraphic ranges. Barnard includes *F. nitida* in *F. brizaeformis.* The pictured specimen differs from the Danish specimens in the presence of a distinct thickening instead of a median groove.

Occurrence.

Lias Beta: Vejrum No. 1, 734′–750′, scarce.

Distribution.

Owing to the general lack of agreement between the various authors as to the definition of this species it is difficult to estimate its stratigraphic range and distribution; it is recorded from both the Lower and the Middle Lias.

"Bolivina" liasica (Terquem)

Fig. 182.

Textilaria liasica, Terquem, 1858, p. 75, pl. 4, figs. 12 a, b.
Textilaria metensis, Terquem, 1858, p. 75, pl. 4, fig. 13 a.
Textilaria breoni, Terquem, 1866, p. 450, p. 18, figs. 10 a, b.
Textilaria pikettyi, Terquem, 1866, p. 527, pl. 122, figs. 23 a–c.
Textilaria angusta, Terquem, 1866, p. 527, pl. 22, figs. 24 a, b.
Bolivina rhumbleri, Franke, 1936, p. 126, pl. 12, fig. 21.
Bolivina rhumbleri, Bartenstein & Brand, 1937, p. 184, pl. 4, figs. 73 a–c; pl. 5, figs. figs. 72 a–d.
Bolivina liasica, Macfadyen, 1941, p. 68, pl. 4, figs. 69 a, b.

Description.

Test triangular, compressed, gradually increasing in breadth from the rounded initial end to the greatest breadth formed by the two last chambers, highest in the middle, composed of about 10 chambers, biserially arranged, periphery subangular; initial end showing no indication of a coiled ancestry; sutures indistinct, flush with surface, straight, very oblique, not indented at the periphery; aperture an elongated slit in the apertural face at a right angle to the suture; the wall of the test at one side of the aperture bends into the chamber and continues downwards through it as an interior septum fastened to the opposite side of the previous aperture of the preceding chamber nearly completely dividing it into two equal parts; wall of the test aragonitic, fibrous; microspheric form unknown.

Remarks.

In all respects, and especially in the apertural characters, this form is a typical *Bolivina* but for the fact that the test consists of aragonite. This circumstance makes the reference to the genus doubtful, as aragonitic tests are typical of the families Robertinidae and Ceratobuliminidae to which the present form shows no similarity. Except for the genera referred to these families only the genera *Colomia* and *Bigenerina* have aragonitic tests. (TROELSEN 1955).

Occurrence.

Lias Delta: Gassum No. 1, 3967′–3972′, rare; 4016′–4024′, rare; 4143′–4150′, abundant; 4184′–4194′, common; 4265′–4286′, abundant.

Lias Gamma: Gassum No. 1, 4300′–4310′, common; Frederikshavn No. 1, 2797′–2807′, rare; 2807′–2817′, rare.

Distribution.

Evidently widely distributed and generally common in the Lias Gamma and Delta of NW Europe.

VIII. Phylogenetic Results

The species and the subspecies in the Danish Lias Series can be subdivided into several supergroups and groups which consist of one or more phylogenetic lines. As previously mentioned the group of subspecies referred to *Geinitzina tenera* and *Spandelina bicostata* are morphologically different from the other species and subspecies in the Lias, and in the trend of development these two groups of subspecies are on the whole fairly similar to each other but fundamentally different from the trend of development within the other groups of species. This is in good agreement with the reference in this publication of these two groups of subspecies to a different family, the Nodosinellidae. The majority of the species and subspecies are referred to the family Nodosariidae and falls in three large supergroups, of which the two following are the most important, namely the *Marginulina radiata* supergroup and the *Marginulinopsis matutina* supergroup, both named after the supposed ancestral form. These two supergroups can be subdivided into smaller groups which correspond to phylogenetic lines. In a way the species referred to the genera *Nodosaria* and *Pseudoglandulina* can be considered a third supergroup, although no phylogenetic lines have been traced in this group of species.

The above-mentioned supergroups comprise the majority of the forms present in abundance, but besides those a few other species are observed which are generally of minor importance. Owing to their scarcity and the occurrence of single species only no phylogenetic lines can be observed and thus their affinities cannot be determined. They belong to the family Polymorphinidae in *Eoguttulina liassica,* and the family Ceratobuliminidae is represented by *Lamarckina* nov. sp. Besides these forms some arenaceous species are observed which occur in abundance in some places and are supposed chiefly to be indicators of facies.

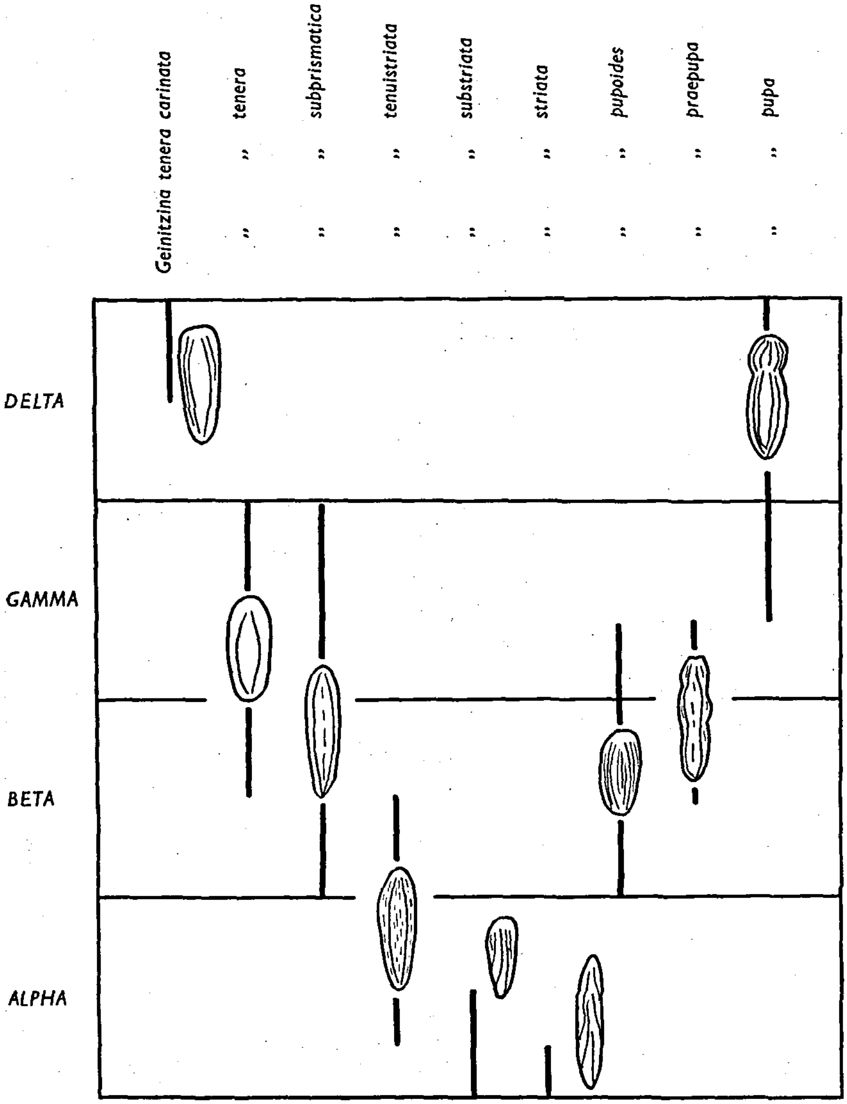
The Geinitzina – Spandelina Supergroup

This group is undoubtedly the most well-defined of all supergroups as it comprises forms belonging to the family Nodosinellidae; consequently it is determined by all the characters pertaining to this family. It consists of several subspecies and naturally falls into two groups, namely the group of subspecies referable to the species *Geinitzina tenera* and the subspecies referred to the species *Spandelina bicostata.*

The *Geinitzina tenera* group appears to consist of two phylogenetic lines or subgroups. The ancestral form of both groups is *G. tenera substriata* and the closely related and evidently more primitive form *G. tenera striata.* The general trend in both phylogenetic lines seems to be a tendency towards a more regular shape which is attained by greater uniformity in the ribs. A parallel effort is the formation of nodosarian straight forms with no trace of a curvature. This result seems to be attained in two different ways forming two different phylogenetic lines. One lines is the *G. tenera tenera* line where the marginal keel and the two median ribs, bordering the median groove, are accentuated at the cost of the additional ribs. This line consists of the subspecies *G. tenera tenuistriata, G. tenera subprismatica, G. tenera tenera* and *G. tenera carinata.* The desired result seems already to have been attained in the subspecies *G. tenera subprismatica* which shows such resemblance to the genus *Nodosaria* that it originally by FRANKE was referred to this genus, but the subspecies appears to have been deficient in other respects and became extinct before the Lias Delta. Contrary to this the more primitive flattened forms seem to be more vigorous, and *G. tenera carinata,* which is very closely related to *G. tenera tenera,* occurs in the Lias Delta, but even this form does not seem to have been sufficiently vigorous to survive the Lias Epsilon.

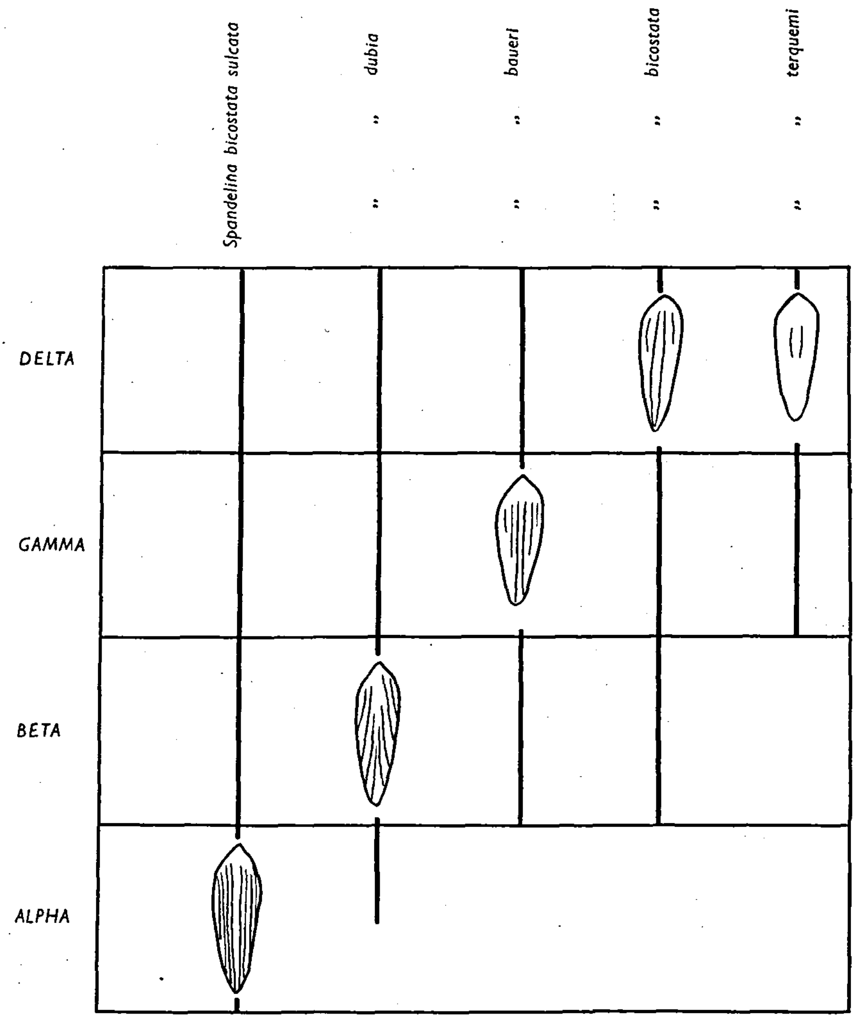
The other phylogenetic line is the *G. tenera pupa* line. In this group the same result is attained in the opposite way, namely by an equal development of all the ribs. The procedure was evidently slow and the result only partly attained in *G. tenera pupa* not very much earlier than the Lias Delta. The ancestral form of this phylogenetic line is supposed to be the same as that of the *G. tenera tenera* line, namely *G. tenera substriata* and the related *G. tenera striata,* and the group consists of the following subspecies, *G. tenera pupoides, G. tenera praepupa* and *G. tenera pupa.* The development of this phylogenetic line seems to be considerably slower than that of the *G. tenera tenera* line. On the other hand this line appears to be more vigorous, and *Lingulina pupa* is recorded both from the Dogger and the Malm; evidently the only subspecies of this supergroup which has been able to survive the whole Jurassic epoch.

According to the above considerations it is to be expected that the subspecies of the *Geinitzina tenera* group may be excellent index fossils; but only the section Gassum No. 1 is available for the evaluation of the vertical distribution of these subspecies in the Danish Lias Series. Various peculiarities in the occurrence of the forms in this section show that some caution



Text-Fig. 2. Evolution of Geinitzina tenera group.

is required for the evaluation. If the distribution of the species and the subspecies in this well is studied it will easily be observed that certain fluctuations occur in the abundance of the subspecies of the two phylogenetic lines. As was to be expected the lower part of the Lias is characterized by the abundance of *G. tenera substriata,* in the lowermost part accompanied by the evidently more primitive *G. tenera striata* and, at a somewhat higher level, of the more advanced *G. tenera tenuistriata.* In the upper part of the Lias Alpha forms of both groups are completely absent and this alone is a serious disadvantage for the tracing of the phylogenetic lines. In the Lias Beta and Gamma *G. tenera tenuistriata* is substituted by *G. tenera subprismatica* and



Text-Fig. 3. Evolution of Spandelina bicostata group.

G. tenera tenera, but the forms of the other phylogenetic line, namely *G. tenera pupoides* and *G. tenera praepupa,* are the predominating forms, and in the lower part of the Lias Delta *G. tenera pupa* occurs exclusively. In the upper part of the Lias Delta this latter subspecies is completely lacking and substituted by *G. tenera carinata.* These fluctuations in abundance thus seem to indicate that the subspecies of the two phylogenetic lines have favored slightly different environments, and that minor differences in facies have caused differences in the occurrence of the various subspecies.

While the *Geinitzina tenera* group, at least superficially, appears as a rather vigorous group the *Spandelina bicostata* group appears as a distinctly regressive series. The trend in the group is a steady reduction of the ribs leading from the many-ribbed *S. bicostata sulcata* through *S. bicostata dubia, S. bicostata baueri* and *S. bicostata bicostata* to the completely smooth form *S. bicostata terquemi.* This latter species seems to occur already in the Lias Gamma and continues, together with most of the other forms, through the Lias Delta. None of these forms seem to have been able to survive the Lias Epsilon.

It has previously been mentioned that the writer considers flattened forms with distinctly chevron-shaped chambers as unities of rather high specialization. For that reason he assumes that the genus *Geinitzina* is the most conservative, i. e. the least specialized form which is either the direct ancestor of the genus *Spandelina* or more closely related to the assumed, but unknown, ancestral form than *Spandelina.* It is thus concluded that the most conservative form also appears to be the most vigorous and long-lived form.

Of special interest is the tendency of the *Geinitzina tenera* group to reproduce nodosarian forms. This is considered a case not of convergence but of parallelism, although *Geinitzina tenera* is phylogenetically sufficiently distant from the genus *Nodosaria* so that the examination of the aperture and the test wall of *G. tenera subprismatica* clearly shows the difference from the similar species of *Nodosaria.*

The Nodosaria – Pseudoglandulina Supergroup

It is generally assumed that the genus *Pseudoglandulina* is derived from the genus *Nodosaria,* and in this publication the latter genus is considered the most primitive form in the family Nodosariidae. Thus it is not surprising that the species referred to these genera seem to be very conservative. Owing to the lack of variation they appear to be of little value as index fossils, but the large variations in abundance may indicate that a closer examination of their occurrence in the Lias may reveal several of them as valuable facies indicators. On the whole the appearance of these forms in the Lias seems to indicate that they are old forms which have been stabilized already before the Lias and have been accustomed to special environments in which they have been able to survive up to this very day.

The Marginulina radiata Supergroup

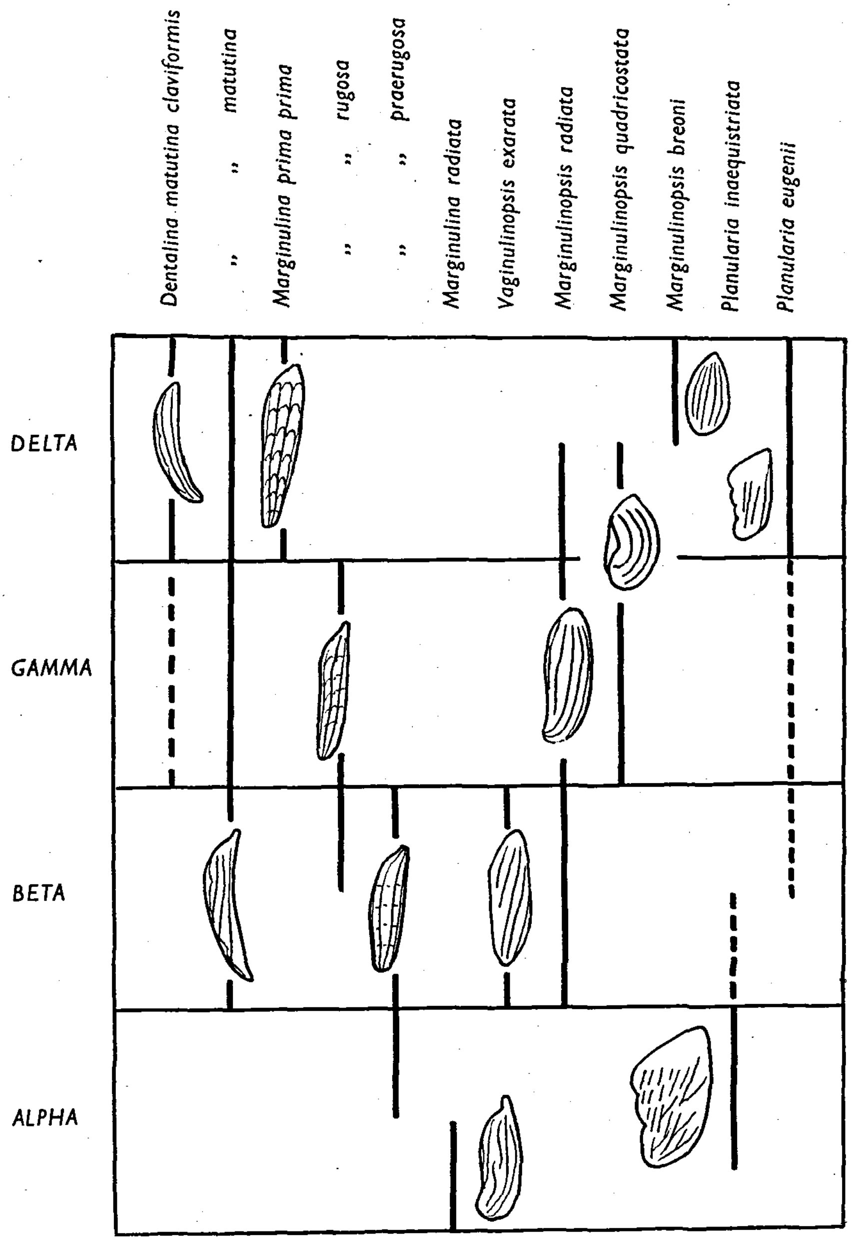
This supergroup falls into three groups or phylogenetic lines, and the two species *Planularia inaequistriata* and *P. eugenii* are assumed to constitute a fourth line probably closely related to the other lines and consequently referred to this supergroup.

The ancestral form of this supergroup is supposed to be *Marginulina radiata* from which three divergent phylogenetic lines are derived, namely the *Dentalina matutina* group, the *Marginulina prima* group and the *Marginulinopsis radiata* group. This supergroup is a very vigorous group showing variation over a wide range that during the Lias epoch resulted not only in the formation of new species, but even in new genera.

The taxonomic position and nomenclature of the ancestral form present great difficulties on account of the immense variation of the species. It has thus been referred to the genera *Vaginulina, Marginulina* and evidently even to *Astacolus* by various authors in conformity with their personal opinions as to which character should be considered most important. The presence of passage forms has been a further obstacle to the discrimination between the ancestral species and the derived species. Typically *Marginulina radiata* is a straight form intermediate between the genera *Marginulina* and *Dentalina;* it is more or less rounded in section, but extreme forms are distinctly flattened and consequently should rather be referred to the genus *Vaginulina.* Nevertheless it seems that the average of the specimens extracted should be referred to the genus *Marginulina,* and although extreme specimens show strong affinities both to the genera *Vaginulina* and *Dentalina* the differences seem to be of less than specific rank; it has consequently been considered incorrect to try to define any subspecies, a thing which would make the classification of the intermediate specimens very difficult as they exceed the number of extreme individuals. Dentaline extremes show affinity to *Dentalina matutina.* Besides these extreme forms another extreme occurs which is more typically marginuline with an initial part distinctly curved to the ventral side, and the microspheric form has definitely transgressed the border zone between the genera *Marginulina* and *Marginulinopsis* as the initial part of the microspheric test is distinctly coiled.

Three phylogenetic lines radiate from the ancestral form, namely a line characterized by the stabilization of the backward curvature of the initial part, the *Dentalina matutina* line, a conservative line, the *Marginulina prima* line, and a progressive line characterized by the steady increase in coiling, the *Marginulinopsis radiata* line. These three phylogenetic lines represent the stabilisation and further development of the three extreme variants in the ancestral form. The affinity of the *Planularia inaequistriata* group to the species *Marginulina radiata* is not sufficiently elucidated by the presence of intermediate forms, and it is consequently assumed that the *Planularia inaequistriata* line branched off from the *Marginulina radiata* stock already before the Lias.

The *Dentalina matutina* group consists of only two subspecies, *D. matutina matutina* and *D. matutina claviformis.* These forms are extremely variable but are referred to the genus *Dentalina* owing to the backwards curved initial part of the test. The shape of the test in section is very variable, rounded to oval, and some specimens may be rather compressed which is a rare occurrence in this genus. Such compressed specimens appear as a peculiar combination of the characters of the two genera *Dentalina* and



Text-Fig. 4. Evolution of Marginulina radiata supergroup.

Vaginulina, but they are referred to the genus *Dentalina* on account of the backward curvature of the initial part of the test. The compression of the test is assumed to be an atavistic feature illustrating the affinity to the ancestral form *Marginulina radiata* which contains similar extreme flattened forms as mentioned above. Most typical for *D. matutina matutina* are the oblique ribs. Evidently the first step in the evolution is the curvature of the initial part of the test while the ornamentation still follows the old pattern. Only at a later stage the apparently more ideal condition is arrived at where the ribs follow the curvature of the test. Such forms are referred to the subspecies *D. matutina claviformis.* However, the evolution is quite gradual and the border-line between the two subspecies is arbitrary, as intermediate forms occur which show the old pattern on one side and the new one on the other.

The *Marginulina prima* group is the most conservative phylogenetic line as this species retains all the characters of the ancestral form *Marginulina radiata* through the whole Lias. It is thus obvious that the two species are difficult to discriminate in the Lias Alpha, and actually the ancestral form *Marginulina radiata* is no more than a subspecies of *Marginulina prima.* Thus the most ancient form *Marginulina prima praerugosa* differs from *Marginulina radiata* in the more rounded section only. Typically both *Marginulina prima* and *Marginulina radiata* are straight forms and thus show great affinity to the genus *Nodosaria* from which they, however, differ in the eccentric position of the aperture.

As in the case of *Marginulina radiata* the various subspecies of *Marginulina prima* contain extreme variants in which the initial part is curved either to the dorsal (apertural) side or to the ventral side of the test. The former variants show affinity to the genus *Dentalina,* and this variant of *Marginulina prima prima* has as a matter of fact been referred to a separate species *Dentalina insignis* by FRANKE. The variant of *Marginulina prima praerugosa* with a dorsal curvature of the test is very difficult to discriminate from *D. matutina matutina* which illustrates the close relationship between the *Marginulina prima* group and the *Dentalina matutina* group.

The *Marginulina prima* group consists of the following subspecies, *M. prima praerugosa, Marginulina prima rugosa, M. prima prima* and *M. prima spinata.* The evolutionary trend within the group is an increase in thickening of the apertural face along which the ribs are joined in arches. The limits of the various subspecies are arbitrary as the evolution takes place quite gradually. The subspecies *M. prima spinata* may possibly be a variant of the subspecies *M. prima rugosa* and *M. prima prima.* The various links in this phylogenetic line are assumed to be of very great value as index fossils.

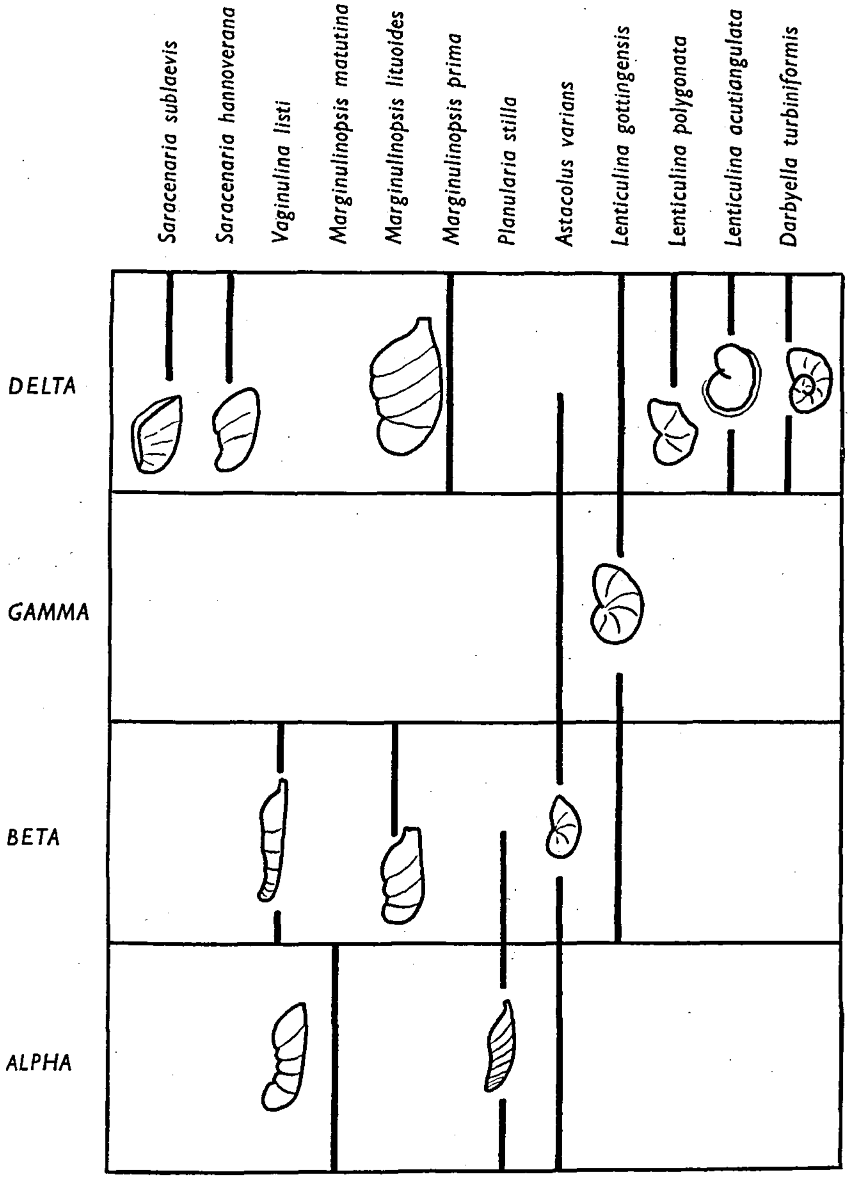
The *Marginulinopsis radiata* group consists of the following species *Vaginulinopsis exarata, Marginulinopsis radiata, Marginulinopsis quadricostata* and *Astacolus breoni.* The ancestral form is *Marginulina radiata,* and the trend of development is a progressive coiling of the initial end combined with a steady reduction of the ribs. The present group is supposed to correspond to the flattened variant of *Marginulina radiata,* which by FRANKE has been referred to a separate species, *Vaginulina curva.* All these species are thus fairly flattened form, and the compression of the test is even more pronounced in *Astacolus breoni* owing to the tendency in the later chambers to extend backwards trying to enclose the initial end. The development of the ornamentation is somewhat similar to the trend in the *Dentalina matutina* group. Thus *Vaginulinopsis exarata* is characterized by the coiled initial end and the obliquity of the ribs; in *Marginulinopsis radiata* and *Marginulinopsis quadricostata* the ribs distinctly tend to follow the curvature of the test, though an indistinct obliquity can still be observed in *Marginulinopsis radiata*. In *Marginulinopsis quadricostata* a certain reduction in the number of ribs is already quite distinct, and it is moreover discriminated from *Marginulinopsis radiata* by the presence of a ventral keel.

The two species *Planularia inaequistriata* and *Planularia eugenii* seem to be parts of a phylogenetic line and show sufficiently great affinities to the *Marginulina radiata* supergroup to be placed in this group, although intermediate forms linking these two species to *Marginulina radiata* are completely missing. Thus this line may have branched off from *Marginulina radiata* already before the Lias. However, it is quite possible that these lines are the sole remnants of a different supergroup, older than, but probably closely related to, the *Marginulina radiata* supergroup.

The Marginulinopsis matutina Supergroup

This supergroup appears less coherent than the *Marginulina radiata* supergroup which to a great extent is due to the lack of ornamentation. This means a considerable reduction in the number of characters easily recognisable and suitable for the classification and definition of the various species and the tracing of their mutual relationships. The arrangement of the species in phylogenetic lines is thus much more dependent on the taste and disposition of the student than in the case of the *Marginulina radiata* supergroup, where the links of the various phylogenetic lines were more easily traced. What further adds to the difficulties is the fact that the ancestral form of this group is unknown, possibly already extinct, before the Lias epoch. Thus this supergroup consists of three separate phylogenetic lines which can only be connected on the assumption of a common ancestral form. Compared to the *Marginulina radiata* supergroup the supergroup in question is more mature, and it is logical that some species in this supergroup before the close of the Lias Delta reaches a higher degree of coiling of the initial part than the most advanced species of the *Marginulina radiata* supergroup. Unfortunately, many things seem to indicate that the higher morphologic specialisation within the *Marginulinopsis matutina* supergroup is accompanied by a tendency in the various species to greater selectivity with regard to environment. This is supposed to account for the fact that the assumed phylogenetic lines are often less complete than in the preceding group. The *Marginulinopsis matutina* supergroup may be subdivided into the following three groups, the *Vaginulina listi* line, the *Marginulinopsis prima* line and the *Lenticulina gottingensis* line.

The *Vaginulina listi* group consists of the species *Vaginulina listi*, *Saracenaria hannoverana* and *Saracenaria sublaevis*. The two latter species are closely related and probably only subspecies of a main species. The relationship between these two species and *Vaginulina listi* is uncertain owing to the lack of passage forms in the available material. However, these species are supposed to belong to a phylogenetic line parallel to the *Marginu-*



Text-Fig. 5. Evolution of Marginulinopsis matutina supergroup.

lina prima group of the *Marginulina radiata* supergroup. The group is assumed to be of greater maturity as illustrated by the fact that some forms in the Lias Delta have reached a higher degree of evolution and are referred to the genus *Saracenaria*. Whether this evolution has been continued, ending in species which should be referred to the genus *Lenticulina* is unfortunately unknown, but it is considered highly probable that this latter species has been derived by parallel evolution both from the *Marginulina – Saracenaria* stages and through the *Vaginulina – Astacolus* or *Planularia* stages.

The Marginulinopsis prima group consists of three species, *Marginulinopsis matutina, Marginulinopsis lituoides* and *Marginulinopsis prima.* The differences between these three forms are rather small and hardly of specific rank. Thus *M. lituoides* seems only to be a more inflated variant of the compressed *M. matutina. M. prima* differs from the two older forms by the greater degree of coiling in the initial end. They are supposed to form a phylogenetic line parallel to the *Marginulinopsis radiata* group in the *Marginulina radiata* supergroup. Moreover the assumed derivation of *M. lituoides* from *M. matutina* constitutes a development parallel to the assumed evolution of *Planularia stilla* and *Astacolus varians* to *Lenticulina gottingensis.*

To the *Lenticulina gottingensis* group have been referred six species, *Planularia stilla, Astacolus varians, Lenticulina gottingensis, Lenticulina polygonata, Lenticulina acutiangulata* and *Darbyella turbiniformis.* The trend of development within this group is a steady increase in coiling combined with a general increase in thickness. The line of evolution is easily traced by means of the numerous intermediate forms which are often difficult to place. The boundaries between the species are thus quite arbitrary. As mentioned above there exists a parallelism between this group and the *Marginulinopsis prima* group which makes it extremely difficult to decide whether some of the specimens of *Planularia stilla, Astacolus varians* and *Lenticulina gottingensis* actually belong to these species or are only immature specimens of *Marginulinopsis matutina* and *Marginulinopsis lituoides.* This observation is evidently similar to the facts described by Barnard (1950). Barnard mentions that "many authors have in the past distinguished young forms of a particular shape as 'Cristellaria' münsteri Roemer and the corresponding adult as 'Cristellaria' matutina d'Orbigny. When, however, a large number of specimens is taken, immediate growth-stages are pieced together and a complete picture of the growth is clearly seen". It is quite evident that this observation led Barnard to consider the *Lenticulina* group as a "plexus". Thus he states that after "a study of 'Cristellaria' from many scattered Liassic horizons and localities, and an attempt to assign them to a particular species, it was realized that the immense variation exhibited by the group, together with convergence towards certain forms, presented more complex problems than were at first anticipated. – – – From a casual glance at the morphologic trends shown at definite horizons it was clear that similar forms arose time and time again throughout the evolution of the group. An analogy may be made with a set of evolving oysters (Swinnerton, 1940), in which at various horizons forms have arisen that are almost identical with specimens from very different levels". According to these comments it is evident that Barnard not only observed the presence of intermediate forms between the various species in the *Marginulinopsis prima* and *Lenticulina gottingensis* groups but also the parallel evolution in these two phylogenetic lines. When only the exterior morphology of the species in these two lines is known it is impossible to decide whether the similarity between the species is due to a rich variation within a single line or parallelism between two very closely related phylogenetic lines, and in that case BARNARD's interpretation appears as the most simple and cautious explanation. Nevertheless, the examination of the interior morphology reveals that the main trend in evolution is a progress in coiling, which was clearly indicated by the evolution of the *Marginulina radiata* supergroup. If, thus, it is assumed that the *Marginulinopsis matutina* supergroup follows the same pattern as the beforementioned supergroup it is undoubtedly most natural to treat the *Marginulinopsis prima* group and the *Lenticulina gottingensis* group as two different phylogenetic lines derived from a common ancestor and showing a considerable amount of parallelism. This point of view is, furthermore, confirmed by the fact that no intermediates are observed between *Marginulinopsis prima* and *Lenticulina gottingensis*. It is thus indicated that the two lines are slightly but distinctly divergent although they seem to be nearly parallel through the Lias Beta and Gamma. It is, however, only fair to admit that BARNARD's view may be as correct as the interpretation in this publication. Actually the two phylogenetic lines are undoubtedly closely related, and it seems highly probable that interbreeding may have occurred to a certain extent through the Lias Beta and Gamma. From this point of view, it is a matter of taste and disposition if the population in the Lias Gamma and Delta is considered two parallel lines or a plexus of highly variable forms which are split into two different lines in the Lias Delta. As BARNARD has not had the material of the Lias Delta at his disposal from the standard profile at the Dorset coast he could not, logically, have arrived at any other interpretation.

In the above paragraphs it was stated that the various lines within the *Marginulina radiata* supergroup and the *Marginulina matutina* supergroup show parallel evolution. Thus the *Marginulina prima* line is supposed to correspond to the *Vaginulina listi* line and the *Marginulinopsis radiata* line to the *Marginulinopsis prima* line; the *Lenticulina gottingensis* line is supposed to represent a stage of development not reached within the *Marginulina radiata* supergroup till the close of the Lias Delta. In the *Marginulinopsis matutina* supergroup no species have been mentioned forming a phylogenetic line which corresponds to the *Dentalina matutina* group in the *Marginulina radiata* supergroup. Nevertheless, smooth specimens of *Dentalina* sp. occur sparsely in the material, but as they are very fragile and only found in a poor state of preservation in the samples, such forms have been completely disregarded. However, the present author is of opinion that at least some of these forms may belong to the *Marginulinopsis matutina* supergroup and form a line parallel to the *Dentalina matutina* group.

IX. Correlation

In the preceding chapter the most important conclusions about the phylogeny of the various species and subspecies in the Danish Lias were outlined, but for the sake of clarity and brevity little was said about the biostratigraphic importance of these forms. As an introduction to the discussion of this question it may be stated that the microfauna in the Danish Lias Series is very similar to the faunas described both from the English and German Lias. Thus a study of the publications af BARTENSTEIN & BRAND (1937), WICHER (1938) and BARNARD (1950) reveals that the various phylogenetic groups described in this publication seem to be present in abundance in the faunas both from Germany and England. This fact is considered of very great importance as changes in phylogenetic lines are supposed to be among the most time-parallel phenomena existing at the present time for regional correlation. It is thus assumed that many of the species and subspecies in these phylogenetic groups are excellent index fossils. However, the divergent views held by previous students about the definition of the various, not distinctly limited, species will prevent any finer subdivision based on the microfaunas of the Lias Series in NW Europe until the question of the nomenclature and classification of these, evidently intergraduated, species and subspecies is solved by agreement between the various students of the Lias Series. It is thus the hope of the present author that this publication will be a small step towards this aim, and in the following pages only the main lines of correlation about the subject will therefore be submitted as they appear after a study of existing literature.

Lias Alpha

To this stage have been referred the following cores: Gassum No. 1, 4649′–4668′, 4702′–4722′, 4750′–4768′, 4800′–4820′, 4850′–4870′, 4900′–4920′, 4950′–4970′; Vinding No. 1, 750′–766′, 766′–776′.

Gassum No. 1: The ancestral forms of the *Geinitzina tenera* group, the *Spandelina bicostata* group and the *Marginulinopsis matutina* supergroup, *Geinitzina tenera striata, Spandelina bicostata sulcata* and *Marginulinopsis matutina* already occur in the lowermost core 4950′–4970′, while the ancestral form of the *Marginulina radiata* supergroup does not occur till the core 4750′–4768′. *Spandelina bicostata sulcata* occurs sparsely in the lower cores; the more advanced form *Spandelina bicostata dubia* appears in the core 4702′–4762′. The difference between these two subspecies is, however, not very distinct in the Lias Alpha where they seem to form a plexus. *Geinitzina tenera striata* is from the very beginning accompanied by the more advanced form *Geinitzina tenera substriata*. In the core 4850′–4870′ *Geinitzina tenera substriata* occurs together with *Geinitzina tenera tenuistriata,* while *Geinitzina tenera striata* already seems to have disappeared. Subspecies of this group are completely missing in the cores from the higher parts of the Lias Alpha.

Marginulinopsis matutina is accompanied by *Astacolus varians* in the lowermost core; the more advanced *Planularia stilla* appears in the core 4850′–4870′, and all three species are fairly common in the Lias Alpha.

Marginulina radiata occurs in the core 4750′–4768′ and the closely related *Marginulina prima praerugosa* appears in the core 4702′–4722′. These two forms are difficult to discriminate and probably form a plexus. In the core 4649′–4668′ at least *Marginulina radiata* has disappeared, and all the specimens in this core are referred to *Marginulina prima praerugosa*. *Planularia inaequistriata* is observed in the core core 4850′–4870′.

Vinding No. 1: Only a few specimens, probably identical with *Astacolus varians,* were observed in the core 5156′–5162′. The core 4993′–5007′ contains a richer fauna with *Marginulina prima praerugosa, Geinitzina tenera tenuistriata* and *Planularia inaequistriata*. The presence of *Marginulina prima praerugosa* and the complete absence of *Geinitzina tenera striata, Geinitzina tenera substriata* and *Marginulina radiata* leaves no doubt that the beds of this core are approximately equivalent to those of the core 4649′–4668′ in Gassum No. 1.

Vejrum No. 1: The microfauna of the core 766′–776′ is very similar to that of 5156′–5162′ in Vinding No. 1. Thus the very atypical fauna of the core 750′–766′ is transitional between the Lias Alpha and Beta.

General Correlation: BRAND records a poor fauna only from the psilonoten shale in Germany and has been unable to designate any index fossil for this zone. *Marginulina radiata* and *Frondicularia tenera tenera* are the most common forms, but unfortunately it is impossible to determine whether the form recorded as *F. tenera* is identical with *Geinitzina tenera substriata*. BARNARD reports that only doubtful casts were extracted from the Pteria contorta shales and the succeeding Ostrea and planorbis zones and that the lack of foraminifera probably is due to subsequent alterations with destruction of the calcareous shells. Nevertheless, if the microfauna of the cores 4950′–4970′ and 4900′–4920′ in Gassum No. 1 is compared with the fauna plates by BRAND it appears to be very similar to that of the psilonoten stufe in Germany. *Geinitzina tenera striata* has previously only been recorded from the planorbis zone of the Yorkshire Lias. It thus seems reasonable to believe that the beds in the cores 4950′–4970′ and 4900′–4920′ are equivalent to the psilonoten stufe in Germany. The presence of *Psiloceras* sp. in the core 4950′–4970′ in Gassum No. 1 is thus in close agreement with this statement. BRAND states that the uppermost part of the psilonoten stufe in North Germany is characterized by the abundance of *Reophax dentaliniformis*. It is in this connection worth while to direct the attention to the occurrence of *Reophax* sp. in the core 4900′–4920′ of Gassum No. 1, although it is considered insufficient evidence for the purpose of correlation.

The vertical distribution of *Planularia inaequistriata* both in the German Lias outside Germany has been very thoroughly examined by BRAND, who considers this form a very reliable index fossil for the Schlotheimia and Arieten stufen in Germany and the corresponding zones outside Germany. This observation is confirmed by BARNARD who records this form from the angulatum, bucklandi and semicostatum zones of the Dorset coast. The presence of this species in the core 4850′–4870′ of Gassum No. 1 is thus in very good agreement with the occurrence of *Schlotheimia angulata* in the same core. A discrimination of the Schlotheimia stufe and the Arieten stufe is according to BRAND only rarely possible, and the differences in the fauna of the various beds described by BARNARD from the angulatum, bucklandi and semicostatum zones are thus mostly of importance for local correlation.

Lias Beta

The following cores have been referred to this stage: Gassum No. 1, 4450′–4466′, 4500′–4518′, 4599′–4616′; Vejrum No. 1, 734′–750′.

Gassum No. 1: In this stage the *Geinitzina tenera* group is distinctly split up into two subgroups. The primitive forms *G. tenera striata* and *G. tenera substriata* have completely disappeared, and of the Lias Alpha forms only *G. tenera tenuistriata* continues up into at least the lower part of the Lias Beta. The Lias Beta is further characterized by the appearance of two new forms, *Geinitzina tenera subprismatica* and *G. tenera tenera* of which the latter, at least, occurs in the upper part of the Lias Beta. *Spandelina bicostata sulcata* continues up into the Lias Beta, and is here accompanied by *S. bicostata dubia, S. bicostata baueri* and *S. bicostata bicostata.*

The *Marginulina radiata* supergroup has been split up into several divergent branches. The ancestral form *Marginulina radiata* has completely disappeared, but *Dentalina matutina matutina* occurs in great abundance. The rather primitive *Marginulina prima praerugosa* continues through the whole Lias Beta, but in the upper part of the stage is observed *Marginulina prima rugosa* which forms a plexus with the first-mentioned subspecies in the upper part of the Lias Beta and the lower part of the Lias Gamma. A very important event in the Lias Beta is the first appearance of the coiled form, *Marginulinopsis radiata* which is present in nearly all samples from the base of the Lias Beta and high up in the Lias Delta.

The *Marginulinopsis matutina* supergroup keeps the lead through the Lias Beta. Thus while a branch of the *Marginulina radiata* supergroup reaches the *Marginulinopsis* stage at the beginning of the Lias Beta the *Lenticulina* stage is already attained in *Lenticulina gottingensis* which at least occurs in the upper part of the Lias Beta. A very remarkable species is *Vaginulina listi* which seems to have its main occurrence in the Lias Beta.

Vejrum No. 1: The presence of *Vaginulina listi* together with the abundant occurrence of *Dentalina matutina matutina* and *Marginulina prima praerugosa* in the core 734′–750′ makes it possible to refer the beds to the Lias Beta stage. According to the general appearance the fauna is most similar to that from the core 4500′–4518′ of Gassum No. 1, but owing to the absence of *Marginulina prima rugosa* the beds are assumed to be equivalent to the beds above the core 4550′–4570′ and below the core 4500′–4518′ in Gassum No. 1.

General Correlation: BRAND designates *Nodosaria issleri* as the index fossil of the Lias Beta. According to this author *Vaginulina listi* is found chiefly in this stage which is further characterized by the abundant occurrence of *Dentalina matutina* and the presence of *Frondicularia tenera prismatica* and *F. tenera octocosta.* BARNARD reports that the microfauna of the corresponding semicostatum, obtusum, oxynotum and raricostatum zones is similar in general appearance to the fauna of the German Lias Beta. As BARNARD has not observed *Nodosaria issleri* he mentions the disappearance of *Planularia inaequistriata* and the occurrence of *Dentalina matutina* as typical of the fauna of these zones. The disappearance of *Frondicularia sulcata* before the Lias Beta seems particularly characteristic of the Lias of the Dorset coast as this species is found higher up in the Lias in Germany as well as in Denmark. It may thus be stated that the microfauna in the Danish beds, referred to the Lias Beta, is very similar to the microfauna of the equivalent beds in England and Germany. The occurrence of *Aegoceras planicosta* in the core 4500′–4518′ from Gassum No. 1 is in very good agreement with this correlation.

Lias Gamma

The following cores have been referred to this stage. Gassum No. 1, 4300′–4310′, 4349′–4357′, 4400′–4417′; Børglum No. 1, 4095′–4105′, 4294′–4314′; Frederikshavn No. 1, 2720′–2727′; 2727′–2737′; 2737′–2747′; 2747′–2757′; 2757′–2767′; 2767′–2777′; 2787′–2797′; 2797′–2807′; 2807′–2817′; 2817′–2827′; 2817′–2837′; Frederikshavn No. 2, 2560′–2568′; 2568′–2588′; 2785′–2805′; Haldager No. 1, 4980′–5000′.

Gassum No. 1: The fauna of the beds referred to the Lias Gamma is surprisingly similar to that of the Lias Beta. Thus only the occurrence of *Marginulina prima rugosa* unaccompanied by *Marginulina prima praerugosa* makes it possible to discriminate the Lias Beta and the Lias Gamma in this well. Surprising in this respect is the lack of *"Bolivina" liasica* which is generally found in the Lias Gamma and Delta.

Børglum No. 1: It is questionable whether the core 4095′–4105′ belongs to the Lias Gamma stage. Thus the occurrence of both *Dentalina matutina claviformis* and *Marginulina prima prima* shows affinity to the Lias Delta. The presence of *Geinitzina tenera tenera, Geinitzina tenera pupoides, Geinitzina tenera praepupa* and *Marginulina prima rugosa* in the core 4294′–4314′ is a definite indication of the Lias Gamma age of these beds. It is considered natural to believe that this core should be referred to the lower Lias Gamma and the former to the upper part of this stage.

Frederikshavn No. 1 and No. 2: The beds from the depth 2782′ and 2697′, respectively, show great affinity to the Lias Delta, while the beds below this depth undoubtedly belong to the Lias Gamma.

Haldager No. 1: The microfauna in the core 4980′–5000′ contains *"Bolivina" liasica, Lenticulina gottingensis* and *Geinitzina tenera praepupa;* the beds are consequently referred to the Lias Gamma.

General Correlation: BRAND records *Bolivina rhumbleri* as the index fossil for both the Lias Delta and the Lias Gamma and *Flabellina paradoxa* as confined to the Lias Gamma. BARNARD does not mention these forms from the jamesoni, ibex and davoei zones of the Lias of the Dorset coast but reports that the beds, corresponding to the German Lias Gamma, contain only long-ranging species. Thus BARNARD is unable to denote any good index fossils for the zones. The fauna of the Danish Lias Gamma seems to be more similar to that of the equivalent beds in South England, and the markers given by BRAND are consequently of little more than local importance. It is believed by the present author that future research may reveal *Marginulina prima rugosa* as a reliable index fossil for the Lias Gamma. *Aegoceras capricornu* is observed in the core 4300′–4310′ of Gassum No. 1.

Lias Delta

To this stage have been referred the following cores: Gassum No. 1, 3967′–3972′; 4016′–4024′; 4080′–4092′; 4143′–4150′; 4184′–4194′; 4222′–4230′; 4265′–4286′.

Gassum No. 1: The microfauna in the cores referred to this stage is distinguished from the Lias Gamma by the appearance of quite a considerable number of new forms. Thus *Geinitzina tenera pupa* and *Geinitzina tenera carinata* appear for the first time in the section and the same applies to *Spandelina bicostata terquemi*. The differentiation in the two other supergroups continues through the Lias Delta age. Thus *Dentalina matutina claviformis* branches off the *Dentalina matutina* group evidently just before the Lias Delta, and the evolution in the *Marginulina prima* group leads to the subspecies *Marginulina prima prima*. In the *Marginulinopsis radiata* group *Marginulinopsis quadricostata* probably branched off already in the Lias Gamma. In the *Marginulinopsis matutina* supergroup the two species *Saracenaria hannoverana* and *Saraceneria sublaevis* have probably been derived from the *Vaginulina listi* group, and in the *Marginulinopsis prima* group the coiling has progressed as illustrated in *Marginulinopsis prima*. However, the most important feature of this group is probably the events in the *Lenticulina gottingensis* group which produces the two distinctive forms, *Lenticulina acutiangulata* and *Darbyella turbiniformis*. Evidently intermediates between the *Lenticulina gottingensis* lineage and the *Marginulinopsis prima* lineage do not occur any longer.

General Correlation: Very little is known from England about the microfauna of the beds equivalent to the Lias Delta. Thus the microfauna from the Danish Lias can only be compared with the results published from Germany by BARTENSTEIN & BRAND (1937). According to their work the great difference between the Lias Delta and the Lias Gamma in the standard profile of Gassum No. 1 is due to local conditions as several of the forms – confined to the Lias Delta in this standard profile – appear to have much longer ranges in Germany. This is especially the case as regards the following species and subspecies, *Spandelina bicostata terquemi*, *Geinitzina tenera pupa*, *Marginulinopsis quadricostata* and *"Bolivina" liasica* which all are recorded from the Lias Gamma of Germany. Besides, several of these forms are observed in beds referred to the Lias Gamma from various other wells in Denmark.

As the most important index fossils for the Lias Delta BRAND notes *Lenticulina acutiangulata* and *Saracenaria sublaevis*. The ranges of these two forms are not, however, completely confined to the Lias Delta stage as the former seems to appear already in the capricornu zone of the Lias Gamma while the latter occurs before the upper part of the margaritatus zone of the Lias Delta. While the Lias Gamma in the standard profile of Gassum No. 1 thus appears to be much poorer in species than the corresponding beds in Germany the general appearance of the microfauna – referred to the Lias Delta – is very similar to the fauna recorded by BRAND from Germany. The presence of *Amaltheus margitatus* in the cores 4080′–4092′, 4143′–4150′, 4222′–4230′ and 4265′–4286′ further confirms the correlation.

X. Conclusions

1. The Danish Lias Series contains a prolific microfauna of foraminifera which permits biostratigraphic correlation with the Lias Series in Germany and England.

2. Several phylogenetic lines have been discovered which are supposed to contain exellent index fossils owing to the fact that correlation lines drawn in accordance with the distribution of the various stages in such a phylogenetic line are assumed to be more parallel with time than other sets of correlation lines.

3. The family Nodosariidae did not reach its climax in the Jurassic but appears in the Lias mainly as a primitive family in the state of rapid evolution.

4. The presumably highly developed forms – previously referred to the genera *Frondicularia* and *Lingulina* – do not belong to the family Nodosariidae and are referred to the genera *Spandelina* and *Geinitzina* of the ancient family Nodosinellidae.

5. A close examination of the various species in the material, has revealed that all species, referred to the family Nodosariidae, have well-preserved radiate apertures in contradistinction to the forms referred to the family Nodosinellidae which all have simple, rounded or oval apertures. The two families are pretty similar in the structure of the wall, which is calcareous and fibrous, but the Nodosinellidae differ from the Nodosariidae in having an imperforate wall, which in this connection means that pores – if present at all – are smaller or of the same size as the calcite needles and thus can not be discerned in thin-section. The similarity of the nodosinellid genera *Spandelina* and *Geinitzina* to the much younger nodosariid genera *Frondicularia* and *Lingulina* is supposed to be due to convergence.

6. The name Lagenidae is considered illegal, and the genus *Nodosaria* must be considered the type genus of this family as originally indicated by RHUMBLER (1895). The correct name of the family will then be Family Nodosariidae (SCHULTZE, 1854) RHUMBLER, 1895.

7. In accordance with HOWCHIN, CHAPMAN & PARR (1934) the present

author assumes that the genus *Lenticula* has developed from a straight, ancestral form. The evolution of this genus from the genus *Marginulina* can be traced through the Lias Series, and the records of this genus from previous systems are thus considered doubtful.

8. The genus *Nodosaria* was by RHUMBLER considered as derived from the genus *Nodosinella*. The present author agrees in the assumption of the Nodosinellidae as the ancestral family of the Nodosariidae and finds that the tendency of *Geinitzina* and *Spandelinoides* to produce nodosarian forms confirms this assumption.

XI. Dansk Resumé

FORAMINIFERERNE I LIAS SERIEN I JYLLAND

I den foreliggende Afhandling er beskrevet Foraminiferfaunaen i den danske Lias Serie. Denne Serie er hovedsagelig aflejret i et stort Bassin mellem Fyn-Falster Aksen af det Skandinaviske Grundfjeldsomraade. Aflejringerne langs Sydkanten er ukendte, men langs Bassinets Nordrand blev aflejret de Lag, der gaar under Betegnelsen, Höganäs Formationen. De tre Boringer Gassum No. 1, Vinding No. 1 og Vejrum No. 1 er placeret i den midterste Del af Bassinet, og her bestaar Lias Serien af en Lagfølge af Havaflejringer, som i det mindste omfatter Etagerne Lias Alpha, Beta, Gamma og Delta. Mikrofaunaen i disse Lag ligner meget de Mikrofaunaer, som er beskrevet fra de tilsvarende Lag i Tyskland, Frankrig og England, og skønt en relativ Hævning af Fyn-Falster Aksen maa antages, har det danske Bassin formodentlig været forbundet med de engelske og tyske Bassiner.

Mikrofaunaen i disse Lag kan inddeles i følgende Overgrupper, *Geinitzina tenera* Gruppen, *Spandelina bicostata* Gruppen, *Nodosaria-Pseudoglandulina* Overgruppen, *Marginulina radiata* Overgruppen og *Marginulinopsis matutina* Overgruppen. Foruden de forskellige Arter og Underarter af disse Overgrupper er følgende Arter observeret, *Eoguttulina liassica*, *»Frondicularia« nitida*, *»Bolivina« liasica* og *Lamarckina nov. sp.* Med Undtagelse af *Nodosaria-Pseudoglandulina* Overgruppen bestaar de øvrige Overgrupper af een eller flere fylogenetiske Linjer. Tidligere Forfattere har bemærket, at de forskellige Arter, ja selv Slægter, inden for hver af disse Overgrupper ikke er tydeligt afgrænsede. Faktisk optræder disse Overgrupper som fylogenetiske Enheder, inden for hvilke Populationen i Tidens Løb viser en gradvis Udvikling langs een eller flere fylogenetiske Linjer, som kan forfølges ved Hjælp af Overgangsformer.

Geinitzina tenera Gruppen. Arterne og Underarterne inden for denne Gruppe er tidligere af nogle Forfattere blevet henført til Slægten *Frondicularia* og af andre til Slægten *Lingulina*. Liasformernes Lighed med disse to Slægter synes imidlertid at skyldes Konvergens, og paa Grund af Manglen af Porer i Skalvæggen og af en radiat Apertur er disse Former blevet henført til Slægten *Geinitzina* af Familien Nodosinellidae. Denne Slægt er kun kendt fra Palæozoikum, men nogle Former synes at have overlevet og forekommer saaledes i Jura Systemet. Gruppen bestaar af to fylogenetiske Linjer, *Geinitzina tenera tenera* Linjen og *Geinitzina tenera pupa*

Linjen. I begge disse Undergrupper synes Udviklingslinjen at gaa mod nodosaria-agtige Typer. Dette Maal naas i den førstnævnte Undergruppe med *G. tenera subprismatica* ved Accentuering af den ydre Køl og de to mellemste Ribber paa Bekostning af de intermediære, svagere Ribber og ved en Afrunding af den oprindeligt sammentrykte Form. *G. tenera subprismatica* er imidlertid en Form med en kort geologisk Levetid og følgelig en begrænset vertikal Udbredelse. Den er derfor et udmærket Ledefossil for Lias Beta og Gamma. Et lignende Resultat er opnaaet i *G. tenera pupa* Linjen, men paa modsat Maade, nemlig ved en ligelig Udvikling af alle Ribberne.

Spandelina bicostata Gruppen. Underarterne og Arterne inden for denne Gruppe er tidligere blevet henført til Slægten *Frondicularia.* Som det var Tilfældet med *Geinitzina tenera*, skyldes Ligheden ogsaa her Konvergens, og disse Arter og Underarter er derfor af lignende Grunde henført til Slægten *Spandelina* tilhørende Familien Nodosinellidae. Tendensen i Udviklingen er en gradvis Reduktion af Ribberne og fører fra den stærkt ribbede *S. bicostata sulcata* i Lias Alpha til den glatte *S. bicostata terquemi* i Lias Gamma og Delta.

Nodosaria-Pseudoglandulina Overgruppen. Denne Gruppe viser ingen tydelig Udvikling igennem Lias Epoken. Disse Arter er aabenbart stabiliserede og konservative og derfor af ringe Værdi som Ledefossiler. Derimod tyder meget paa, at de er vigtige Facies-Indikatorer.

Marginulina radiata Overgruppen. Stamformen er *Marginulina radiata,* fra hvilken *Dentalina matutina, Marginulina prima, Marginulinopsis radiata* og *Planularia inaequistriata* Linjerne formentlig er afspaltede. Udviklingslinjen er hovedsagelig en gradvis Oprulning af den ældste Del af Skallen og er parallel med Udviklingslinjen i *Marginulinopsis matutina* Overgruppen. Udviklingen af *Marginulina radiata* Overgruppen er imidlertid forsinket i Sammenligning med *Marginulinopsis matutina* Overgruppen. Saaledes naar den sidstnævnte Gruppe allerede *Lenticulina*-Stadiet i Lias Gamma.

Marginulinopsis matutina Overgruppen. Denne Overgruppe synes at have naaet en højere Udviklingsform end den forudnævnte Overgruppe, og Tilstedeværelsen af færre Overgangsformer i denne Overgruppe er i god Samklang med denne Antagelse. *Marginulinopsis matutina* Overgruppen formodes at bestaa af tre fylogenetiske Grupper, *Vaginulina listi, Marginulinopsis prima* og *Lenticulina gottingensis* Linjerne. Formodentlig har alle tre Linjer en fælles Stamform, men denne er ukendt og uddøde formodentlig før Lias Epoken.

Det synes at være en almindelig Regel, at den mikrosfære Form er stærkere oprullet end den tilsvarende megalosfære. Paa den Maade staar de Slutninger, man vilde være tilbøjelig til at drage ved Anvendelse af den biogenetiske Lov om Rekapitulationen, i tydelig Modstrid med den iagttagne Udvikling.

Undersøgelsen af Liasformerne afslører, at alle Nodosariidae synes at have radiate Aperturer. Da en saadan Apertur mangler og paa Grund af Skalvæggens Struktur er de Arter, som tidligere har været henført til Slægterne *Frondicularia* og *Lingulina,* i denne Afhandling henført til Slægterne *Geinitzina* og *Spandelina* under Familien Nodosinellidae.

I Modsætning til den almindelige Anskuelse er Nodosariiderne i Lias Serien betragtet som en primitiv Gruppe i hurtig Udvikling. Dette gælder i særlig Grad *Marginulina radiata* og *Marginulinopsis matutina* Overgruppgerne, mens de forskellige *Nodosaria-* og *Pseudoglandulina*-Arter allerede synes at være stabiliserede i Begyndelsen af Lias Epoken. Herudfra kan drages den Slutning, at Slægten *Nodosaria* er udviklet fra en Art inden for Familien Nodosinellidae, og at den er den ældste Slægt i Familien Nodosariidae. Udviklingslinjen i Familien Nodosariidae er saaledes en Ændring af Aperturens Stilling fra central til ekcentrisk, og den derpaa følgende Oprulning af Skallerne. I Overensstemmelse med disse Karakterer er Familien derfor opdelt i de følgende Underfamilier, Nodosariinae med de to Slægter *Nodosaria* og *Pseudoglandulina,* Marginulinae med de nært forbundne Slægter *Dentalina, Marginulina* og *Vaginulina* og Lenticulinae med Slægterne *Vaginulinopsis, Marginulinopsis, Saracenaria* og *Lenticulina.* Slægten *Robulus* forekommer ikke i Lias, og det er derfor endnu usikkert, om denne og beslægtede Former bør betragtes som en selvstændig Underfamilie. Arter af Familien Enantiomorphinidae er ikke iagttaget, men Familien Polymorphinidae er repræsenteret af Arten, *Eoguttulina liassica.* Det anses derfor som tvivlsomt, om Familien Enantiomorphinidae bør betragtes som et Overgangsled mellem Familien Nodosariidae og Familien Polymorphinidae.

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Fig. 1. *Geinitzina tenera striata,* megalospheric specimen, Gassum No. 1, 4950′–4970′, a) and b) side views, c) aperture, 50 X.

Fig. 2. *Geinitzina tenera striata,* microspheric specimen showing curvature of test, Gassum No. 1, 4950′–4970′, 50 X.

Fig. 3. *Geinitzina tenera substriata,* Gassum No. 1, 4850′–4870′, 50 X, Type.

Fig. 4. *Geinitzina tenera substriata,* Gassum No. 1, 4950′–4970′, a) and b) side views, 50 X.

Fig. 5. *Geinitzina tenera substriata,* Gassum No. 1, 4950′–4970′, 50 X.

Fig. 6. *Geinitzina tenera substriata,* Gassum No. 1, 4950′–4970′, showing slight indication of original curvature, 50 X.

Fig. 7. *Geinitzina tenera substriata,* microspheric specimen with slight indication of original curvature, Gassum No. 1, 4950′–4970′, 50 X.

Fig. 8. *Geinitzina tenera substriata,* as above, Gassum No. 1, 4950′–4970′ 50 X.

Fig. 9. *Geinitzina tenera substriata,* Gassum No. 1, 4950′–4970′, 50 X.

Fig. 10. *Geinitzina tenera substriata,* Gassum No. 1, 4950′–4970′, 50 X.

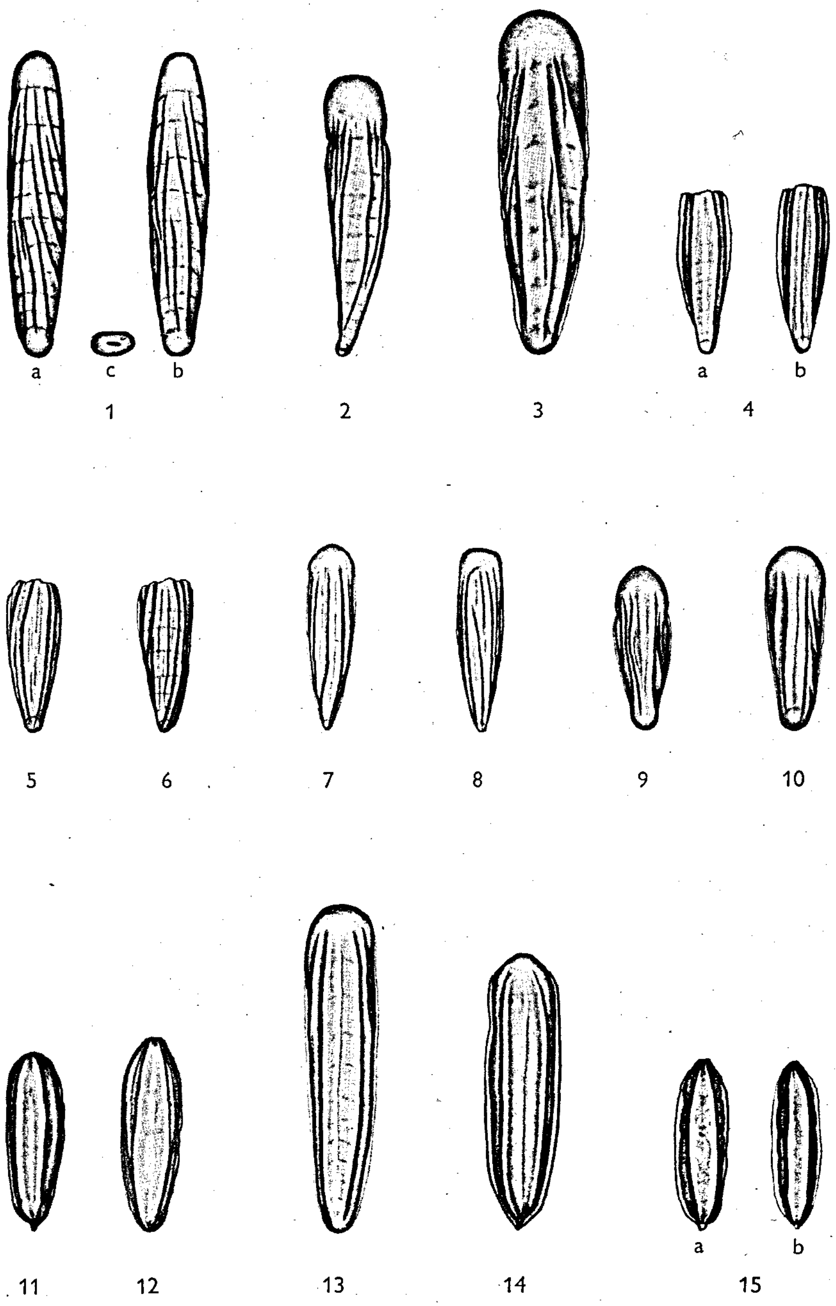
Fig. 11. *Geinitzina tenera subprismatica,* Gassum No. 1, 4349′–4357′, 50 X.

Fig. 12. *Geinitzina tenera subprismatica,* Gassum No. 1, 4349′–4357′, 50 X.

Fig. 13. *Geinitzina tenera tenuistriata,* megalospheric specimen, elongated, No. 1, 4850′–4870′, 50 X.

Fig. 14. *Geinitzina tenera subprismatica,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 15. *Geinitzina tenera subprismatica,* Gassum No. 1, 4349′–4357′, a) and b) side views, 50 X.



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A. N. del.

Fig. 16. *Geinitzina tenera tenuistriata,* megalospheric specimen, Gassum No. 1, 4850′–4870′, 50 X. Type.

Fig. 17. *Geinitzina tenera tenuistriata,* megalospheric specimen, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 18. *Geinitzina tenera tenera,* megalospheric specimen, Gassum No. 1, 4349′–4357′, 50 X.

Fig. 19. *Geinitzina tenera tenera,* megalospheric specimen, Gassum No. 1, 4349′–4357′, 50 X.

Fig. 20. *Geinitzina tenera tenera,* megalospheric specimen, Gassum No. 1, 4300′–4310′, 50 X.

Fig. 21. *Geinitzina tenera tenera,* megalospheric specimen, Gassum No. 1, 4300′–4310′, 50 X.

Fig. 22. *Geinitzina tenera tenera,* microspheric specimen, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 23. *Geinitzina tenera tenera,* microspheric specimen, Gassum No. 1, 4349′–4357′, a) marginal view, b) side view, 50 X.

Fig. 24. *Geinitzina tenera tenuistriata,* megalospheric specimen showing transition to *G. tenera pupoides,* Gassum No. 1, 4850′–4870′, 50 X.

Fig. 25. *Geinitzina tenera pupoides,* megalospheric specimen, Gassum No. 1, 4550′–4570′, 50 X.

Gig. 26. *Geinitzina tenera pupoides,* megalospheric specimen, Gassum No. 1, 4400′–4417′, 50 X.

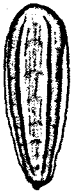
Fig. 27. *Geinitzina tenera pupoides,* megalospheric specimen, Gassum No. 1, 4349′–4350′, 50 X. Type.

Fig. 28. *Geinitzina tenera pupoides,* microspheric specimen showing slight indication of original curvature, Gassum No. 1, 4550′–4570′ 50 X.

Fig. 29. *Geinitzina tenera pupoides,* microspheric specimen, no indication of original curvature, Gassum No. 1, 4400′–4417′ 50 X.

Fig. 30. *Geinitzina tenera praepupa,* megalospheric specimen, Gassum No. 1, 4450′–4466′, 50 X. Type.

Fig. 31. *Geinitzina tenera praepupa,* megalospheric specimen, Gassum No. 1, 4400′–4417′, 50 X.



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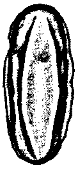

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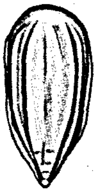

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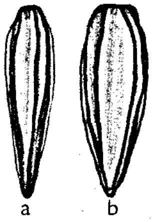

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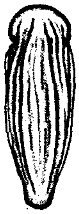

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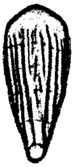

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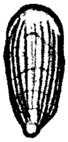

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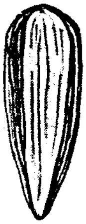

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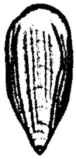

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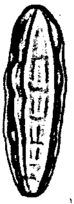

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Fig. 32. *Geinitzina tenera pupa*, megalospheric specimen, Gassum No. 1, 4265′–4286′, 50 X.

Fig. 33. *Geinitzina tenera pupa*, megalospheric specimen, Gassum No. 1, 4265′–4286′, 50 X.

Fig. 34. *Geinitzina tenera pupa*, megalospheric specimen, Gassum No. 1, 4222′–4230′, 50 X.

Fig. 35. *Geinitzina tenera pupa*, megalospheric specimen, Gassum No. 1, 4222′–4230′, 50 X.

Fig. 36. *Geinitzina tenera pupa*, megalospheric specimen, Gassum No. 1, 4222′–4230′, 50 X.

Fig. 37. *Geinitzina tenera pupa*, megalospheric specimen, Gassum No. 1, 4143′–4150′, 50 X.

Fig. 38. *Geinitzina tenera pupa*, megalospheric specimen, Gassum No. 1, 4184′–4190′, a) and b) side views, 50 X.

Fig. 39. *Geinitzina tenera pupa*, megalospheric specimen, Gassum No. 1, 4143′–4150′, a) and b) side views, 50 X.

Fig. 40. *Geinitzina tenera pupa*, microspheric specimen, Gassum No. 1, 4265′–4286′, 50 X.

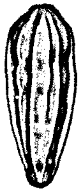
Fig. 41. *Geinitzina tenera pupa*, microspheric specimen, Gassum No. 1, 4222′–4230′, 50 X.

Fig. 42. *Geinitzina tenera pupa*, microspheric specimen, Gassum No. 1, 4184′–4194′, a) and b) side views, c) aperture, 50 X.

Fig. 43. *Geinitzina tenera pupa*, microspheric specimen, Gassum No. 1, 4143′–4150′, 50 X.

Fig. 44. *Geinitzina tenera pupa*, microspheric specimen, Gassum No. 1, 4143′–4150′, 50 X.

Fig. 45. *Geinitzina tenera pupa*, microspheric specimen, Gassum No. 1, 4143′–4150′, 50 X.



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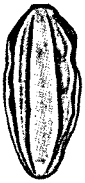

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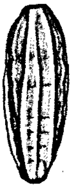

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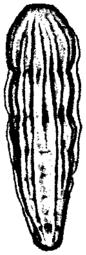

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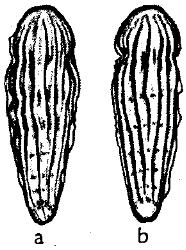

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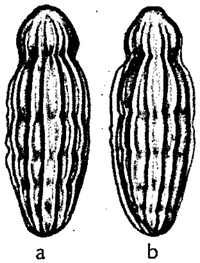

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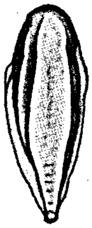

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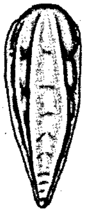

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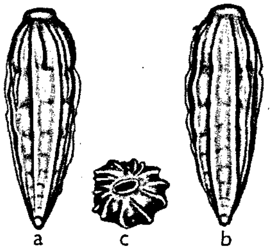

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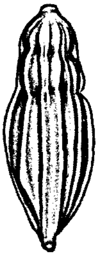

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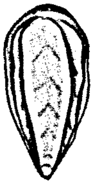

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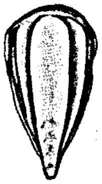

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Fig. 46. *Geinitzina tenera carinata,* megalospheric specimen, Gassum No. 1, 4016′–4024′, 50 X. Type.

Fig. 47. *Geinitzina tenera carinata,* megalospheric specimen, Gassum No. 1, 4016′–4024′ 50 X.

Fig. 48. *Geinitzina tenera carinata,* megalospheric specimen, Gassum No. 1, 4016′–4024′ 50 X.

Fig. 49. *Geinitzina tenera carinata,* megalospheric specimen, Gassum No. 1, 4016′–4024′, a) and b) side views, 50 X.

Fig. 50. *Geinitzina tenera carinata,* megalospheric specimen, Gassum No. 1, 3967′–3972′, a) side view, b) aperture, 50 X.

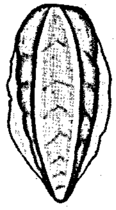
Fig. 51. *Geinitzina tenera carinata,* megalospheric specimen, Gassum No. 1, 3967′–3972′, a) and b) side views, 50 X.

Fig. 52. *Geinitzina tenera carinata,* megalospheric specimen, Gassum No. 1, 4016′–4024′ 50 X.

Fig. 53. *Geinitzina tenera carinata,* megalospheric specimen, Gassum No. 1, 3967′–3972′, a) and b) side views, c) and d) marginal views, 50 X.

Fig. 54. *Geinitzina tenera carinata,* microspheric specimen, Gassum No. 1, 4080′–4092′, a) and b) side views, 50 X.

Fig. 55. *Geinitzina tenera carinata,* microspheric specimen, Gassum No. 1, 3967′–3972′, 50 X.



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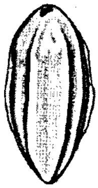

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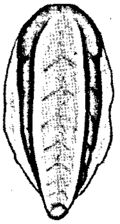

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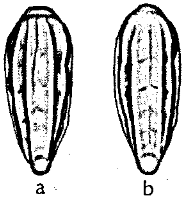

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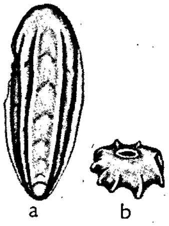

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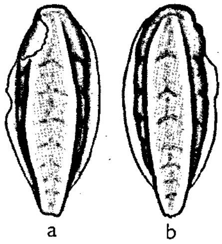

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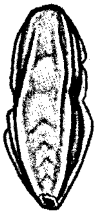

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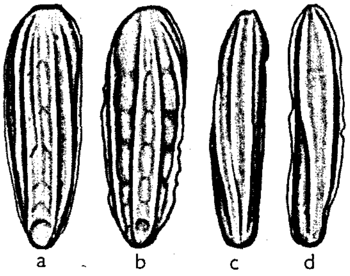

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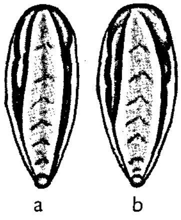

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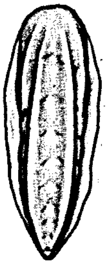

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Fig. 56. *Spandelina bicostata sulcata,* microspheric specimen, Gassum No. 1, 4950′–4970′, 50 X.

Fig. 57. *Spandelina bicostata sulcata,* megalospheric specimen, Gassum No. 1, 4950′–4970′, 50 X.

Fig. 58. *Spandelina bicostata sulcata,* megalospheric specimen, passage to *S. bicostata dubia,* Gassum No. 1, 4950′–4970′, 50 X.

Fig. 59. *Spandelina bicostata sulcata,* megalospheric specimen, spined variety, Gassum No. 1, 4850′–4870′, 50 X.

Fig. 60. *Spandelina bicostata dubia,* megalospheric specimen, spined variety, Gassum No. 1, 4850′–4870′, 50 X.

Fig. 61. *Spandelina bicostata dubia,* megalospheric specimen, Gassum No. 1, 4702′–4722′, 50 X.

Fig. 62. *Spandelina bicostata bicostata,* megalospheric specimen, Gassum No. 1, 4500′–4518′, a) and b) side views, c) aperture, 50 X.

Fig. 63. *Spandelina bicostata bicostata,* immature megalospheric specimen, Gassum No. 1, 4500′–4518′ 50 X.

Fig. 64. *Spandelina bicostata bicostata,* immature megalospheric specimen, Gassum No. 1, 4500′–4518′ 50 X.

Fig. 65. *Spandelina bicostata dubia,* megalospheric specimen, Gassum No. 1, 4550′–4570′, 50 X.

Fig. 66. *Spandelina bicostata baueri,* microspheric specimen, Gassum No. 1, 4016′–4024′, 50 X.

Fig. 67. *Spandelina bicostata bicostata,* spined megalospheric specimen, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 68. *Spandelina bicostata bicostata,* megalospheric specimen, Gassum No. 1, 4016′–4024′, 50 X.

Fig. 69. *Spandelina bicostata terquemi,* megalospheric specimen, Gassum No. 1, 4080′–4092′, 50 X.


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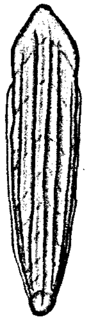
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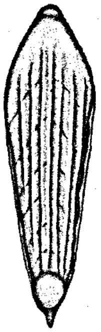
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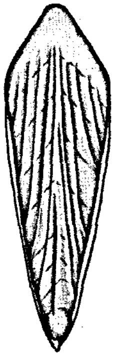
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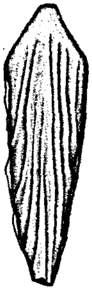
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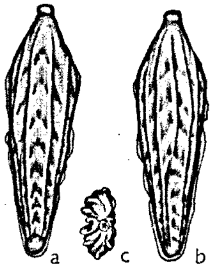

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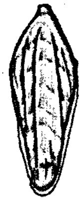
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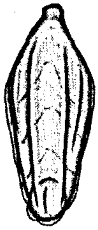
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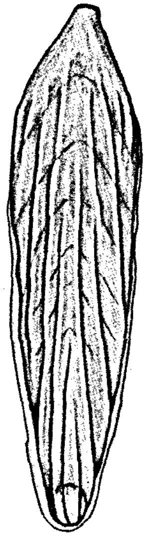
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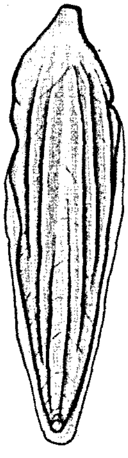
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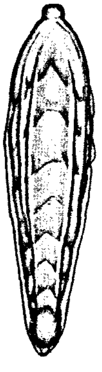
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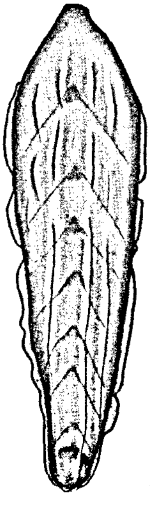
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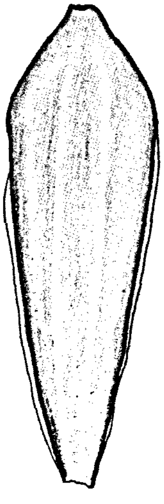
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A. N. del.

Fig. 70. *Nodosaria simoniana*, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 71. *Nodosaria radiata*, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 72. *Nodosaria metensis*, Gassum No. 1, 4950′–4970′, 50 X.

Fig. 73. *Nodosaria hortensis*, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 74. *Nodosaria mitis*, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 75. *Nodosaria columnaris*, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 76. *Nodosaria columnaris*, Gassum No. 1, 4016′–4024′, 50 X.

Fig. 77. *Nodosaria oculina*, Gassum No. 1, 4500′–4518′, 50 X.

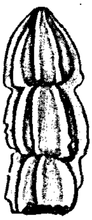
Fig. 78. *Nodosaria costata*, Gassum No. 1, 4016′–4024′, 50 X.

Fig. 79. *Nodosaria fontinensis*, Gassum No. 1, 4184′–4194′, 50 X.

Fig. 80. *Nodosaria dispar*, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 81. *Nodosaria dispar*, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 82. *Nodosaria issleri*, Gassum No. 1, 4500′–4518′, 50 X.



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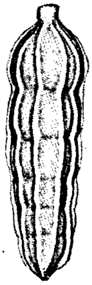

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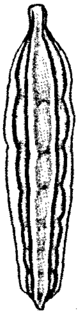

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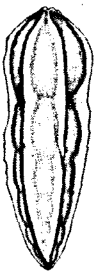

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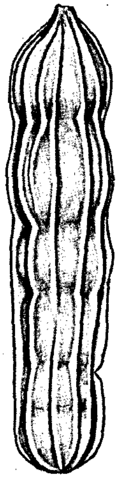

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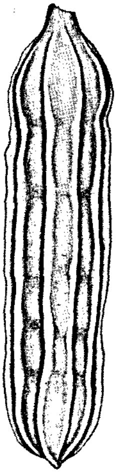

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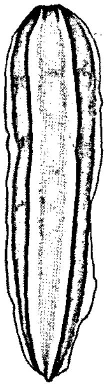

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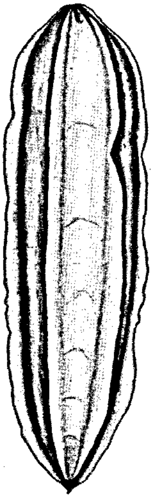

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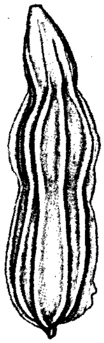

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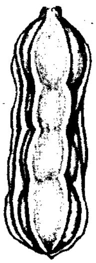

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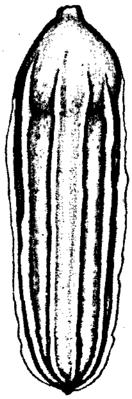

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A. N. del.

Fig. 83. *Pseudoglandulina vulgata* var. pupoides, megalospheric specimen, Gassum No. 1, 4016′–4024′, 50 X.

Fig. 84. *Pseudoglandulina vulgata* var. pupoides, microspheric specimen, Gassum No. 1, 4016′–4024′, 50 X.

Fig. 85. *Pseudoglandulina vulgata,* Gassum No. 1, 3967′–3972′, 50 X.

Fig. 86. *Pseudoglandulina vulgata* var. irregularis, Gassum No. 1, 3967′–3972′, 50 X.

Fig. 87. *Pseudoglandulina multicostata,* Gassum No. 1, 3967′–3972′, 50 X.

Fig. 88. *Dentalina matutina matutina,* microspheric specimen, differs from the typical form by having fewer ribs, the irregularities indicate variation towards *D. matutina claviformis,* Gassum No. 1, 4500′–4518′, a) and b) side views, c) front view, 50 X.

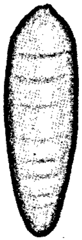
Fig. 89. *Dentalina matutina claviformis,* Gassum No. 1, 3967′–3972′, a) side view, b) front view, 50 X.

Fig. 90. *Dentalina matutina matutina,* megalospheric specimen, Gassum No. 1, 4500′–4518′, a) side view, b) front view, 50 X.

Fig. 91. *Dentalina matutina matutina,* megalospheric specimen, short and compressed variety, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 92. *Dentalina matutina matutina,* extreme specimen with small apertural chamber, aperture broken, very similar to d'ORBIGNY's type as figured by MACFADYEN, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 93. *Dentalina matutina matutina,* extreme specimen very similar to d'ORBIGNY's type of *D. primaeva* as figured by MACFADYEN, Gassum No. 1, 4550′–4570′, 50 X.



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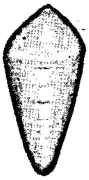

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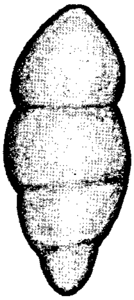

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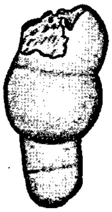

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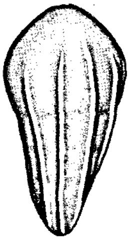

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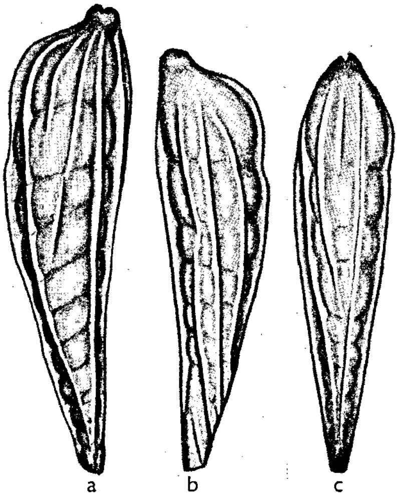

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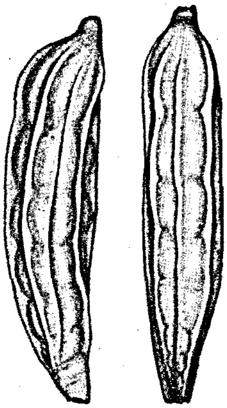

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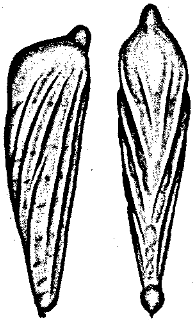

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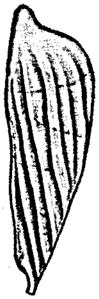

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A. N. del.

Fig. 94. *Marginulina radiata,* megalospheric specimen, Gassum No. 1, 4750′–4768′, a) side view, b) section, 50 X.

Fig. 95. *Marginulina radiata,* microspheric specimen, Gassum No. 1, 4750′–4768′, a) and b) 50 X, c) 240 X.

Fig. 96. *Marginulina prima praerugosa,* megalospheric specimen, Gassum No. 1, 4500′–4518′, a) side view, b) aperture, 50 X. Type.

Fig. 97. *Marginulina prima rugosa,* megalospheric specimen, Gassum No. 1, 4500′–4518′, a) side view, b) aperture, 50 X.

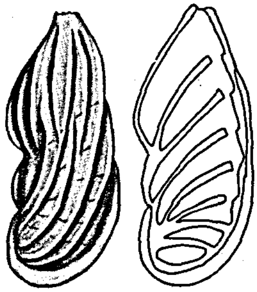
Fig. 98. *Marginulina prima prima,* megalospheric specimen, Gassum No. 1, 4265′–4285′, a) side view, b) aperture, 50 X.

Fig. 99. *Marginulina prima prima,* fragment with very distinct transversal ribs, Gassum No. 1, 3967′–3972′, a) side view, b) aperture, 50 X.

Fig. 100. *Marginulina prima praerugosa* form. burgundiae, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 101. *Marginulina prima praerugosa* form. burgundiae, showing proloculum and arrangement of chambers, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 102. *Marginulina prima prima* form. burgundiae, Gassum No. 1, 4184′–4194′, 50 X.



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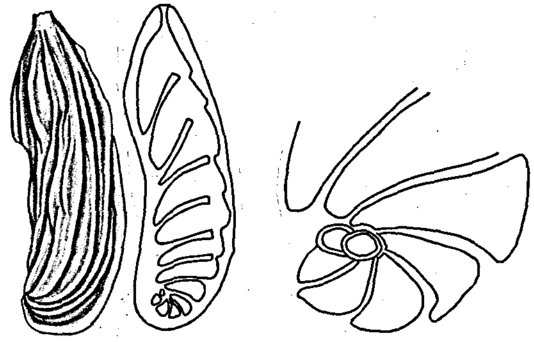

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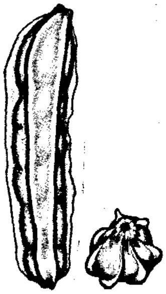

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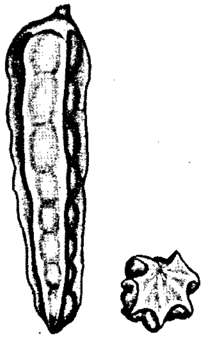

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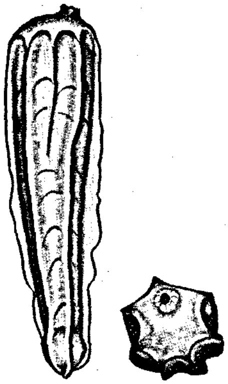

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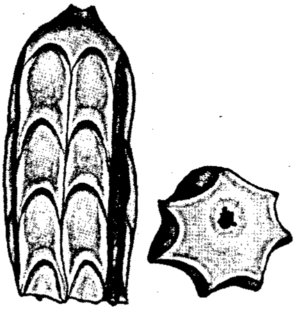

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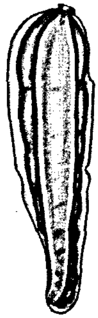

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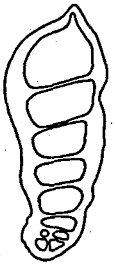

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A. N. del.

Fig. 103. *Marginulina prima prima* var. insignis, Gassum No. 1, 4265′–4286′, 50 X.

Fig. 104. *Marginulina prima prima,* probably megalospheric, but with small proloculum, Gassum No. 1, 4265′–4286′, 50 X.

Fig. 105. *Marginulinopsis radiata,* megalospheric specimen, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 106. *Marginulinopsis breoni,* Gassum No. 1, 3967′–3972′, 50 X.

Fig. 107. *Marginulinopsis radiata,* megalospheric specimen, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 108. *Marginulinopsis quadricostata,* microspheric specimen, Gassum No. 1, 4184′–4194′, 50 X.

Fig. 109. *Marginulinopsis quadricostata,* megalospheric specimen, Gassum No. 1, 4184′–4194′, 50 X.

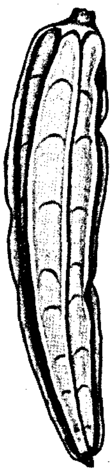
Fig. 110. *Marginuliopsis quadricostata,* megalospheric specimen, Gassum No. 1, 4184′–4194′, 50 X.

Fag. 111. *Marginulinopsis quadricostata,* megalospheric specimen, Gassum No. 1, 4184′–4194′, 50 X.

Fig. 112. *Marginulinopsis quadricostata,* megalospheric specimen, Gassum No. 1, 4143′–4150′, 50 X.

Fig. 113. *Marginulinopsis quadricostata,* microspheric specimen, Gassum No. 1, 4143′–4150′, 50 X.

Fig. 114. *Vaginulinopsis exarata,* Gassum No. 1, 4550′–4570′, 50 X.



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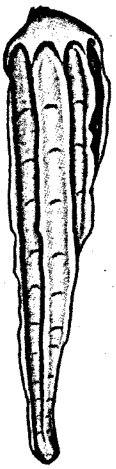

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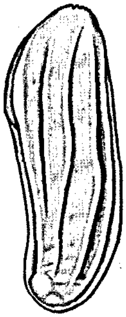

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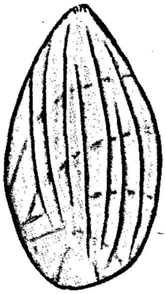

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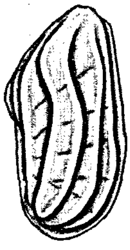

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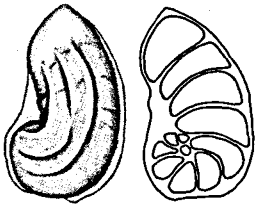

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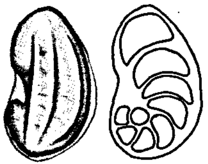

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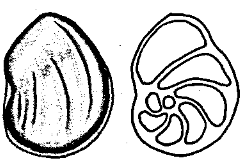

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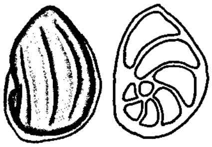

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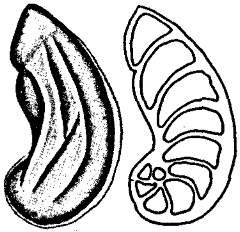

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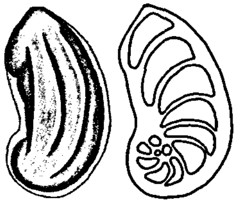

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A. N. del.

Fig. 115. *Marginulinopsis matutina,* Gassum No. 1, 4950′–4970′, 50 X.

Fig. 116. *Marginulinopsis prima,* showing relationship to *Lenticulina polygonata,* Gassum No. 1, 4300′–4310′, 50 X.

Fig. 117. *Marginulinopsis matutina,* Gassum No. 1, 4950′–4970′, 50 X.

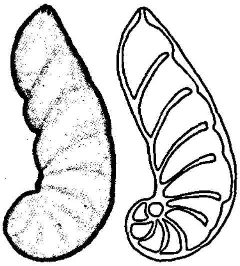
Fig. 118. *Marginulinopsis lituoides,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 119. *Vaginulina listi,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 120. *Marginulinopsis lituoides,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 121. *Marginulinopsis prima,* Gassum No. 1, 4016′–4024′, 50 X.

Fig. 122. *Marginulinopsis prima,* Gassum No. 1, 4143′–4150′, 50 X.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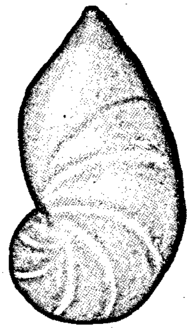

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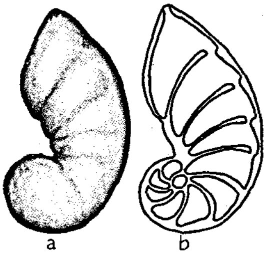
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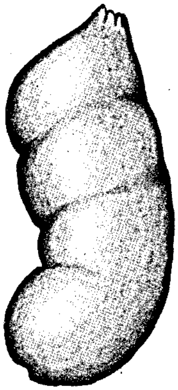

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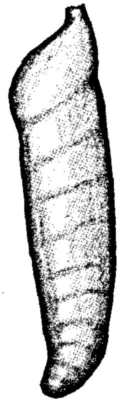

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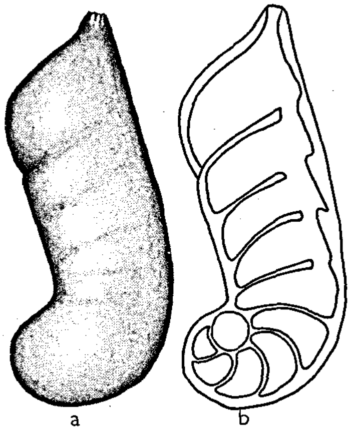
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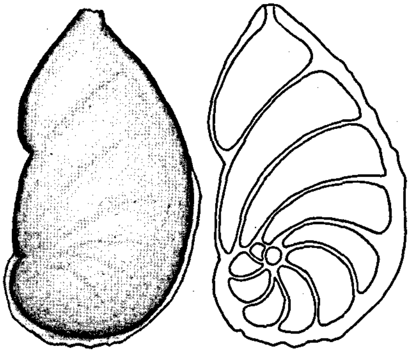
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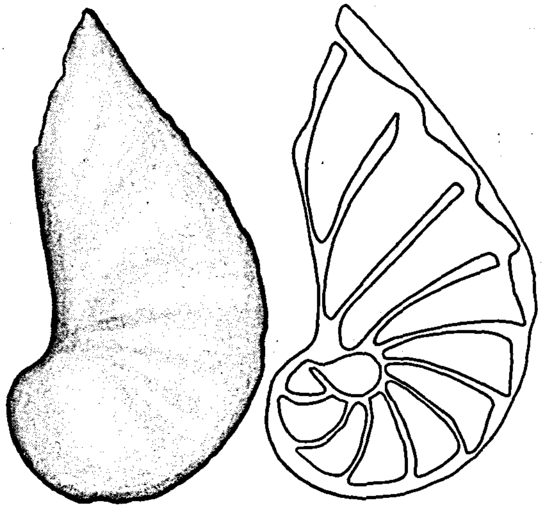

a b

122

A. N. del.

Fig. 123. *Astacolus varians*, Gassum No. 1, 4850′–4870′, 50 X.

Fig. 124. *Astacolus varians*, Gassum No. 1, 4649′–4668′, 50 X.

Fig. 125. *Astacolus varians*, Gassum No. 1, 4649′–4668′, 50 X.

Fig. 126. *Astacolus varians*, Gassum No. 1, 4649′–4668′, 50 X.

Fig. 127. *Astacolus varians*, Gassum No. 1, 4649′–4668′, 50 X.

Fig. 128. *Astacolus varians*, Gassum No. 1, 4500′–4518′, 50 X.

Fig. 129. *Astacolus varians*, Gassum No. 1, 4300′–4310′, 50 X.

Fig. 130. *Astacolus varians*, microspheric specimen, Gassum No. 1, 4184′–4194′, 50 X.

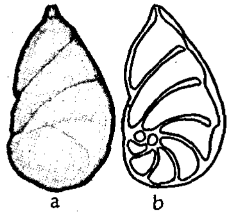
Fig. 131. *Astacolus varians*, microspheric specimen, Gassum No. 1, 4184′–4194′, 50 X.

Fig. 132. *Astacolus varians*, Gassum No. 1, 4184′–4194′, 50 X.

Fig. 133. *Astacolus varians*, Gassum No. 1, 4184′–4194′, 50 X.

Fig. 134. *Astacolus varians*, Gassum No. 1, 4184′–4194′, 50 X.

Fig. 135. *Astacolus varians* var. convolutus, Gassum No. 1, 4222′–4230′, 50 X.



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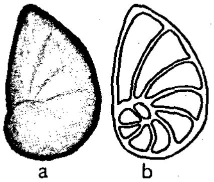

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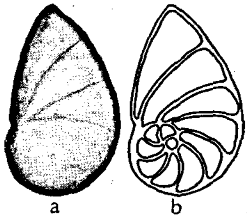

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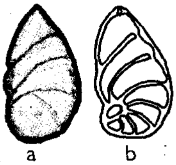

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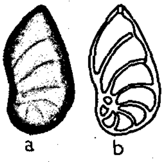

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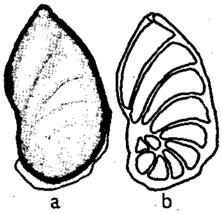

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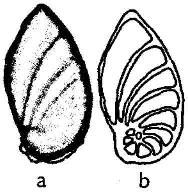

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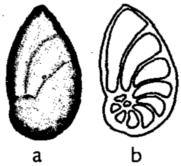

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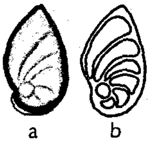

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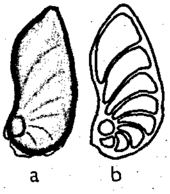

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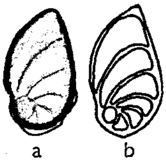

134

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A. N. del.

Fig. 136. *Planularia stilla,* Gassum No. 1, 4702′–4722′, 50 X.

Fig. 137. *Planularia stilla,* microspheric specimen, Gassum No. 1, 4750′–4770′, 50 X.

Fig. 138. *Planularia stilla,* Gassum No. 1, 4702′–4722′, 50 X.

Fig. 139. *Planularia stilla,* Gassum No. 1, 4750′–4770′, 50 X.

Fig. 140. *Planularia stilla,* Gassum No. 1, 4750′–4770′, 50 X.

Fig. 141. *Planuloria stilla,* Gassum No. 1, 4750′–4770′, 50 X.

Fig. 142. *Planularia stilla,* Gassum No. 1, 4750′–4770′, 50 X.

Fig. 143. *Planularia stilla,* Gassum No. 1, 4750′–4770′, 50 X.

Fig. 144. *Planularia stilla,* Gassum No. 1, 4750′–4770′, 50 X.

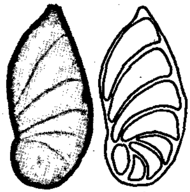
Fig. 145. *Planularia stilla,* Gassum No. 1, 4750′–4770′, 50 X.

Fig. 146. *Planularia stilla,* Gassum No. 1, 4750′–4770′, 50 X.

Fig. 147. *Planularia stilla,* Gassum No. 1, 4702′–4722′, 50 X.

Fig. 148. *Planularia inaequistriata,* Gassum No. 1, 4850′–4870′, 50 X.

Fig. 149. *Planularia inaequistriata,* Gassum No. 1, 4850′–4870′, 50 X.



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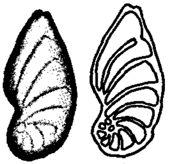

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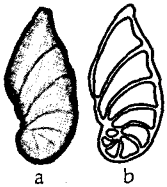

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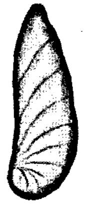

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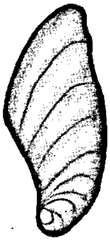

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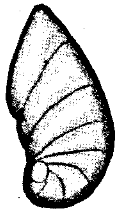

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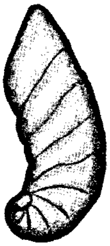

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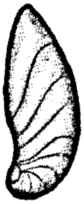

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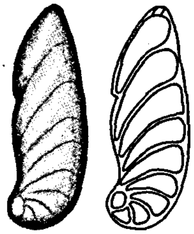

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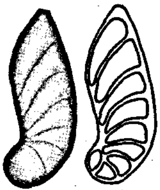

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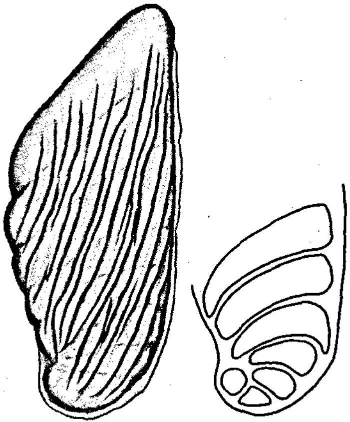

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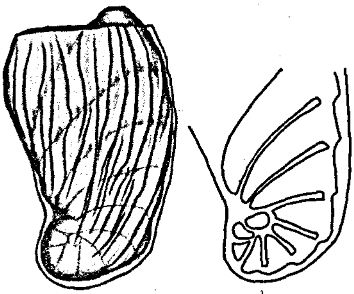


149

A. N. del.

Fig. 150. *Planularia eugenii,* Gassum No. 1, 4265′–4286′, 50 X.

Fig. 151. *Saracenaria sublaevis,* Gassum No. 1, 4016′–4024′, 50 X.

Fig. 152. *Saracenaria hannoverana,* Gassum No. 1, 3967′–3972′, 50 X.

Fig. 153. *Lenticulina gottingensis,* Gassum No. 1, 4500′–4518′, a) side view, b) front view, c) section, 50 X.

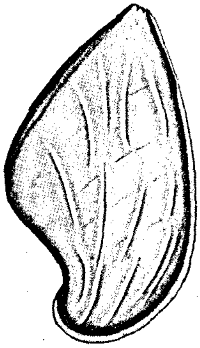
Fig. 154. *Lenticulina gottingensis,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 155. *Lenticulina gottingensis,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 156. *Lenticulina gottingensis,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 157. *Lenticulina gottingensis,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 158. *Lenticulina gottingensis,* Gassum No. 1, 4500′–4518′, 50 X.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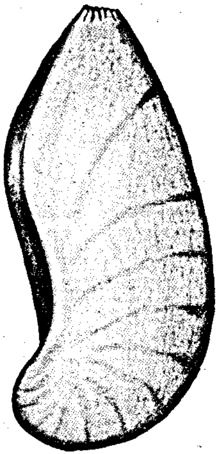
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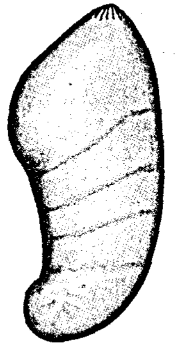
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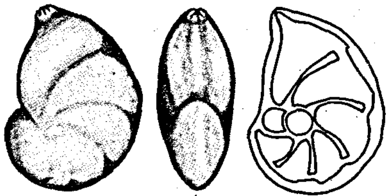
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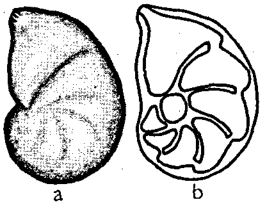
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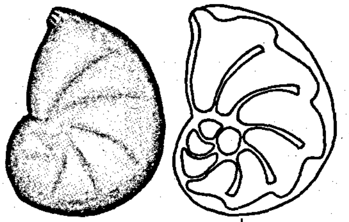
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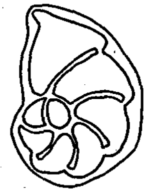
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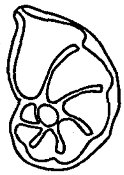
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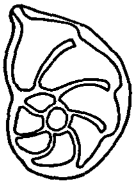

158

A. N. del.

Fig. 159. *Lenticulina gottingensis,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 160. *Lenticulina gottingensis,* Gassum No. 1, 4500′–4518′, 50 X.

Fig. 161. *Lenticulina gottingensis,* Gassum No. 1, 4300′–4310′, a) side view, b) front view, c) transmitted light, 50 X.

Fig. 162. *Lenticulina gottingensis,* Gassum No. 1, 4300′–4310′, a) side view, b) front view, c) transmitted light, 50 X.

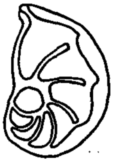
Fig. 163. *Lenticulina gottingensis,* passage to *L. polygonata,* Gassum No. 1, 4300′–4310′, 50 X.

Fig. 164. *Lenticulina gottingensis,* slightly inequal specimen showing relationship to *Darbyella turbiniformis,* Gassum No. 1, 4265′–4286′, a) side view, b) front view, c) transmitted light, 50 X.

Fig. 165. *Lenticulina gottingensis,* Gassum No. 1, 4265′–4286′, 50 X.

Fig. 166. *Lenticulina gottingensis,* Gassum No. 1, 4265′–4286′, a) side view, b) transmitted light, 50 X.

Fig. 167. *Lenticulina gottingensis,* slightly carinated specimen showing relationship to *L. acutiangulata,* Gassum No. 1, 4265′–4286′, a) side view, b) front view, c) transmitted light, 50 X.



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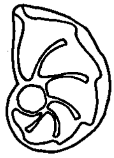

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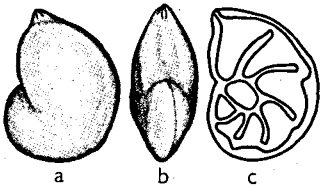

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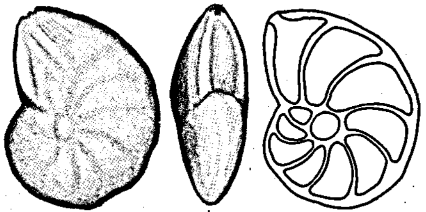

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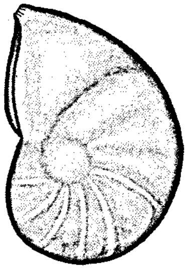

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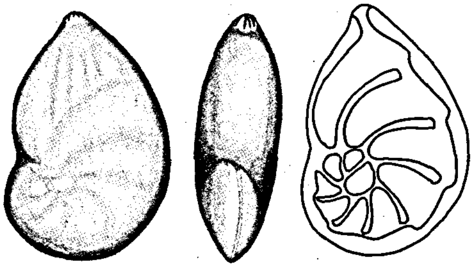

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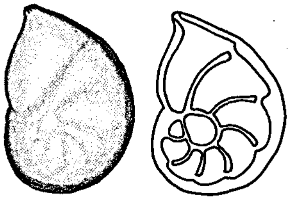

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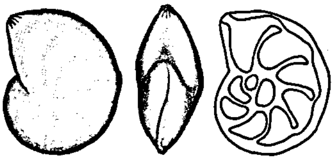


167

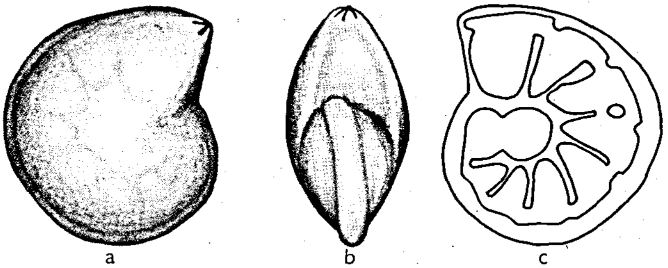
A. N. del.

Fig. 168. *Lenticulina gottingensis,* showing relationship to *L. acutiangulata,* Gassum No. 1, 4184′–4194′, a) side view, b) front view, c) transmitted light, 50 X.

Fig. 169. *Lenticulina gottingensis,* showing relationship to *L. polygonata,* Gassum No. 1, 4016′–4024′, a) side view, b) front view, c) transmitted light, 50 X.

Fig. 170. *Lenticulina gottingensis,* Gassum No. 1, 3967′–3972′.

Fig. 171. *Darbyella turbiniformis,* microspheric specimen, Gassum No. 1, 4016′–4024′, a) and c) side views, b) front view, d) transmitted light, 50 X.



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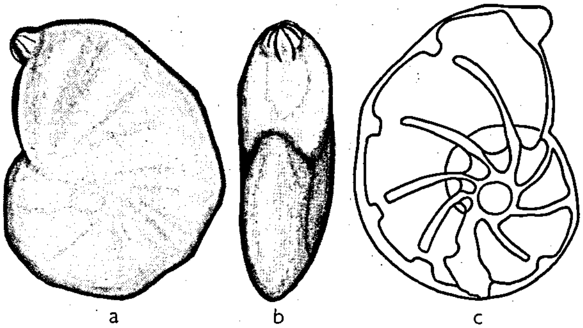

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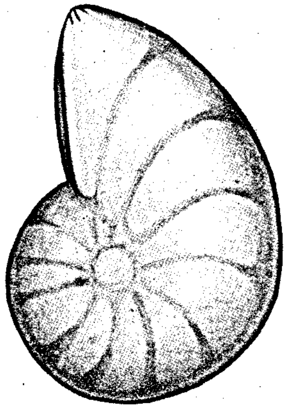

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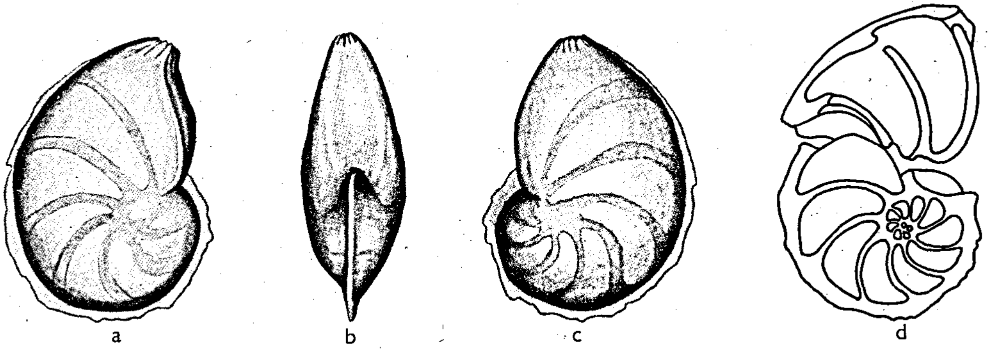


171

A. N. del.

Fig. 172. *Darbyella turbiniformis,* megalospheric specimen, Gassum No. 1, 4016′–4024′, a) and c) side views, b) front view, 50 X.

Fig. 173. *Darbyella turbiniformis,* microspheric specimen, Gassum No. 1, 4016′–4024′, a) front view, b) transmitted light, 50 X.

Fig. 174. *Darbyella turbiniformis,* megalospheric specimen, Gassum No. 1, 4016′–4024′, transmitted light, 50 X.

Fig. 175. *Darbyella turbiniformis,* megalospheric specimen, Gassum No. 1, 4016′–4024′, transmitted light, 50 X.

Fig. 176. *Darbyella turbiniformis,* megalospheric specimen, Gassum No. 1, 4016′–4024′, transmitted light, 50 X.

Fig. 177. *Lenticulina acutiangulata,* Gassum No. 1, 3967′–3972′, 50 X.

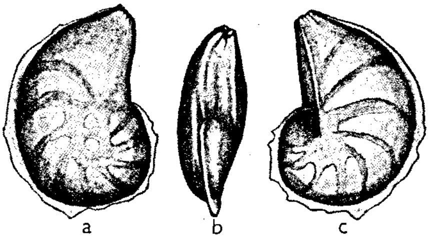
Fig. 178. *Lenticulina acutiangulata,* Gassum No. 1, 4016′–2024′, transmitted light, 50 X.

Fig. 179. *Lenticulina polygonata,* Gassum No. 1, 3967′–3972′, 50 X.

Fig. 180. *Eoguttulina liassica,* Gassum No. 1, 4950′–4970′, 50 X.

Fig. 181. *Eoguttulina liassica,* Gassum No. 1, 4950′–4970′, 50 X.

Fig. 182. “*Bolivina*« *liasica,* Gassum No. 1, 4143′–4150′, a) side view, b) end view of broken final chamber, trace of interior wall on side of preceding aperture.



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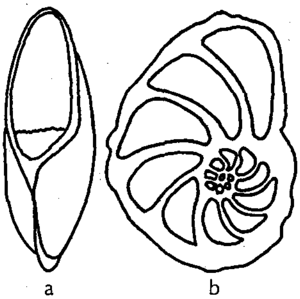

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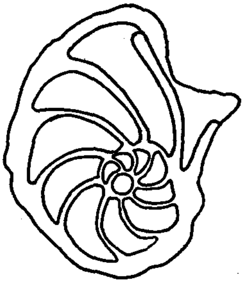

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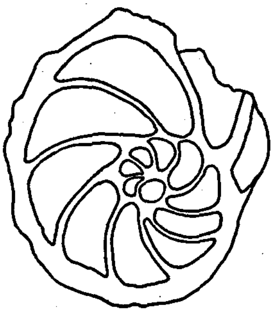

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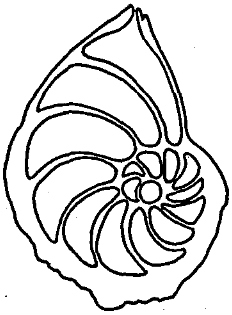

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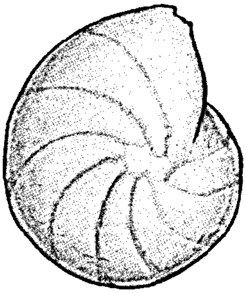

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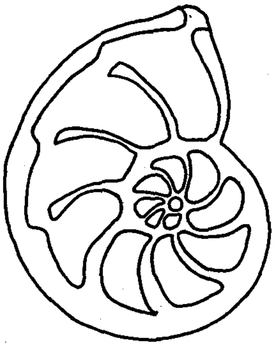

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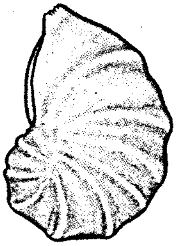
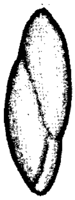


179



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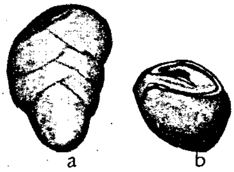
181



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