VERHANDELINGEN DER KONINKLIJKE NEDERLANDSE
AKADEMIE VAN WETENSCHAPPEN, AFD. NATUURKUNDE
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FORAMINIFERAL ASSEMBLAGES FROM THE LIAS OF NORTH-WESTERN EUROPE

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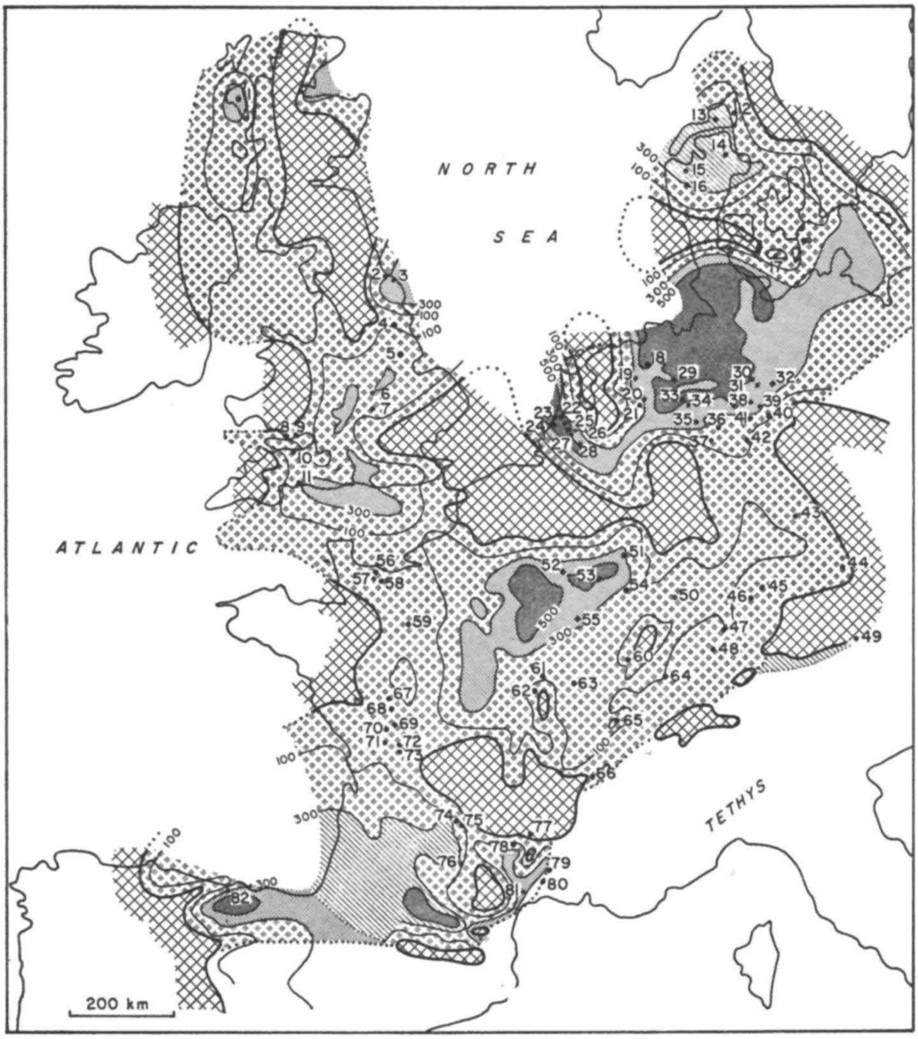
CONTENTS

ABSTRACT

The lateral and vertical distribution of benthonic foraminiferal assemblages in the north-western European Lias is statistically evaluated in a semiquantitative analysis of a large number of fossiliferous samples.

The presence of a series of assemblages, related to differences in environment of deposition, rather than to an evolutionary succession of faunas, is demonstrated.

An overall deepening of the Lias sea in this part of Europe is postulated.



1. Portree
2. Sandsend
3. Robin Hood's Bay
4. Scunthorpe
5. Bracebridge
6. Rugby
7. Byfield
8. Nash Point
9. Lavernock
10. Watchet-Kilve
11. Lyme Regis
12. Frederikshavn
13. Börglum
14. Gassum
15. Vejrum
16. Vinding
17. Rödby
18. Vlagtwedde
19. Zweelo
20. Rammelbeek
21. Oldenzaal
22. Zoetermeer
23. Den Haag
24. Rijswijk
25. Moerkapelle
26. Bleskensgraaf
27. Werkendam
28. Loon op Zand
29. Hemmelte W.
30. Hambühren
31. Ölheim
32. Reislingen
33. Osnabrück
34. Vehrte
Enger
Diebrock
35. Bethel
36. Kollerbeck
37. Borlinghausen
Bonenburg
38. Hildesheim
39. Haverlahwiese
Baddeckenstedt
Salzgitter
40. Grube Friederike
Goslar
41. Winzenburg
42. Göttingen
43. Trimeusel
44. Irlbach
45. Reichenbach
46. Holzmaden
47. Schömberg
48. Aubächle
49. Sachrang
50. Hochfelden
51. Bettembourg
52. Dontrien
53. Belleville
54. Mécleuves
55. Montier en Der
56. Vieux Pont
57. Tilly-sur-Seules
58. Maltot
59. Le Fourneau
60. Creveney
61. Ste. Colombe
62. Corbigny
63. Sombernon
64. Mt. Terri
65. Blois
66. Corbeyssieu
67. Vrines
68. Airvault
69. Sanxay
70. St. Maixent
71. Melle
72. Sauzé
73. Montalembert
74. Rignac
75. Lavergne
76. Penne
77. Mende
78. Fontaneilles
79. Fressac
80. St. Loup
81. Valmascle
82. Parbayon

RECONSTRUCTED LIAS THICKNESS (After BITTERLI, 1963)

0 - 300 m
300 - 500 m
500 m
Areas with strong change in thickness
Lias absent

Fig. 1. Locality map.

I. INTRODUCTION

During the years 1958–1961 the Koninklijke/Shell Exploratie en Produktie Laboratorium (Rijswijk) carried out an investigation of bituminous rock sequences in north-western Europe (BITTERLI, 1960, 1962, 1962a, 1963, 1963a).

This investigation included the selected sampling of bituminous and non-bituminous beds as preserved in some seventy Lias sections in Great Britain, France, Spain, Germany, The Netherlands, Luxemburg, Switzerland and Austria (see locality map, fig. 1).

From this material 1205 samples – mainly clay, shale and marl – were chosen at random, washed over a set of sieves, and semiquantitatively studied to determine their foraminiferal content.

The geographical and stratigraphical distribution of these samples is listed in Table I, together with localities or stages on which quantitative data are available from the literature.

The present publication deals with the results of this investigation, attention being paid to the sample preparation technique, the distribution of the foraminiferal species found, their grouping into assemblages and their palaeoecological significance.

An annotated check list of species is added to facilitate comparison with earlier publications on Lias Foraminifera.

The geological stages used are those defined by the First Colloquium on the Jurassic (Luxemburg, 1962), except that the boundary between Middle and Upper Toarcian is taken at the top of the *Hildoceras bifrons* zone. Material from the Lower Aalenian younger than the *Leioceras opalinum* zone is not included in the present study.

The age of the samples is based on ammonite determinations (BITTERLI, 1962).

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II. SAMPLE PREPARATION

The sediment samples have been subjected to the following procedure:

1. between 100 and 150 grammes of dry sediment was washed after crushing and/or soaking through a set of sieves (20–40–100–200 mesh);
2. the material left on the 40, 100 and 200 mesh screens was retained and dried on a hot plate;
3. these three fractions of sediment, respectively representing material $>420\ \mu$, between 420 and 150 μ, and between 150 and 75 μ, were stored in bottles after drying;

TABLE I

List of sample localities, Lias N.W. Europe (with number of wash residues studied per stage).

		Hett.	L. Sin.	U. Sin.	L. Plie	U. Plie	L.+M. Toarc.	U. Toarc. L. Aal.	Total
I.	SCOTLAND								
	Portree	–	–	–	–	–	3	–	3
II.	YORKSHIRE-MIDLANDS								
	Sandsend	–	–	–	–	–	5	–	5
	Robin Hood's Bay	–	–	7	7	4	14	–	32
	Scunthorpe	–	2	4	–	–	–	–	6
	Bracebridge	–	–	–	2	4	3	–	9
	Rugby	1	6	–	–	–	–	–	7
	Byfield	–	–	–	–	–	2	1	3
III.	W. NETHERLANDS								
	Zoetermeer 1	–	–	–	–	–	5———		5
	Den Haag 2	———	1	–	1	–	–	–	2
	Rijswijk 1	–	–	–	–	2	5	–	7
	Moerkappelle 1	–	–	–	–	1	–	–	1
	Bleskensgraaf 1	–	–	–	–	1	–	–	1
	Werkendam 1	–	–	–	–	–	5———		5
	Loon op Zand 1	–	–	–	–	6	13	3	22
IV.	DENMARK								
	Frederikshavn 1	–	–	–	x	x	–	–	x
	Børglum 1	–	–	–	x	–	–	–	x
	Gassum 1	———	x	x	x	x	–	–	x
	Vejrum 1	———	x	x	–	–	–	–	x
	Vinding 1	———	x	x	–	–	–	–	x
	Rödby 1	———	x	–	x	–	–	–	x
V.	N.W. GERMANY-E. NETHERLANDS								
	Vlagtwedde 1	–	–	–	–	1	5	–	6
	Zweelo 1	–	–	–	–	–	7———		7
	Rammelbeek D. 1	–	–	–	–	1	–	–	1
	Oldenzaal 4	2	1	2	2	2	–	–	9
	Hemmelte West 17	———	13	3	5	4	21	2	48
	Hambühren WA 2	x	x	x	x	x	–	–	x
	Ölheim 4	–	–	–	–	–	x	–	x
	Reislingen	–	–	–	–	x	–	–	x
	Osnabrück	–	x	–	x	–	–	–	x
	Vehrte-Enger-Diebrock	–	–	x	x	–	13	2	15
	Bethel-Bielefeld	x	x	–	–	4	39	x	43
	Kollerbeck	–	–	–	x	–	–	–	x
	Borlinghausen-Bonenburg	x	–	–	x	x	–	–	x
	Hildesheim-Lechstedt	–	–	–	–	x	–	–	x
	Haverlahwiese	–	x	x	x	3	11	3	17
	Grube Friederike-Goslar	9	14	24	2	23	28	11	111
	Winzenburg	–	–	–	–	x	–	–	x
	Göttingen	22	–	–	–	–	–	–	22
VI.	S. GERMANY-AUSTRIA-SWISS JURA								
	Trimeusel	–	–	–	–	1	5	3	9
	Irlbach	–	–	–	–	–	4	11	15
	Reichenbach	———	3	2———		8	4	–	17
	Holzmaden	–	–	–	–	–	19	–	19
	Schömberg	–	–	–	–	1	33	4	38

		Hett.	L. Sin.	U. Sin.	L. Plie	U. Plie	L.+M. Toarc.	U. Toarc. L. Aal.	Total
	Aubächle	9	1	18	6	13	28	5	80
	Sachrang	–	–	–	–	–	31	–	31
	Hochfelden	20	–	–	–	–	–	–	20
	Mt Terri	–	–	–	–	–	38	–	38
VII.	PARIS BASIN								
	Bettembourg	–	–	–	–	14	22	–	36
	Mécleuves	5	–	–	–	–	–	–	5
	Creveney	–	–	–	–	–	4	–	4
	Blois	–	–	–	–	–	6	–	6
	Corbeyssieu	–	–	–	–	–	3	–	3
	Dontrien 1	–	–	–	–	2	1	–	3
	Belleville well	–	–	–	–	–	23	6	29
	Montier en Der 101	–	–	–	–	1	1	–	2
	Ste Colombe	–	–	–	–	–	11	–	11
	Corbigny	–	–	–	–	–	2	–	2
	Sombernon	–	–	–	–	–	3	2	5
VIII.	N.E. AQUITAINE								
	Rignac	–	–	–	–	–	3	–	3
	Lavergne	–	–	–	–	–	3	–	3
	Penne	–	–	–	–	–	9	–	9
IX.	LOWER RHONE VALLEY								
	Mende	–	–	–	–	———	6	–	6
	Fontaneilles	–	–	–	14	19	59	40	132
	Fressac	–	–	–	–	1	6	8	15
	St. Loup	–	–	–	–	4	15	3	22
	Valmascle	–	–	–	–	–	3	–	3
X.	POITEVIN								
	Vrines	–	–	–	–	–	–	1	1
	Airvault	–	–	–	–	–	1	4	5
	Sanxay	–	–	–	–	–	–	3	3
	St. Maixent	–	–	–	–	–	–	6	6
	Melle	–	–	–	–	–	–	6	6
	Sauzé	–	–	–	–	–	3	2	5
	Montalembert	–	–	–	–	–	–	2	2
XI.	CANTABRIA								
	Parbayon	–	–	–	28	–	–	–	28
XII.	NORMANDY								
	Vieux Pont	–	–	–	–	–	5	–	5
	Tilly-sur-Seulles	–	–	–	2	–	4	–	6
	Maltot	–	–	–	–	–	3	–	3
	Le Fourneau	–	–	–	–	–	5	–	5
XIII.	WESSEX								
	Nash Point	6	6	–	–	–	–	–	12
	Lavernock	38	–	–	–	–	–	–	38
	Watchet-Kilve	52	16	–	–	–	–	–	68
	Lyme Regis	12	13	24	17	5	–	2	73
		176	76	84	86	125	542	130	1219

x=Locality and/or stage from which quantitative foraminiferal data are available from the literature, and not from the present sample material.

4. the coarse and medium fractions were investigated microscopically in such a way as to enable a reasonable estimate of the abundance of each foraminiferal species;
5. the fine fraction (75–150 μ) was investigated only as a control to see if it contained considerable numbers of species not present in the coarser fractions.

III. DISTRIBUTION OF FORAMINIFERAL SPECIES

A check-list of the species of Foraminifera found in the samples studied is given in Chapter VI.

The distribution of these species in time and space is summarised on a range chart (table II), giving their occurrences in the six Lias stages each subdivided according to the area into which the sample localities have been grouped on table I.

On this chart single occurrences have been given the same value as common occurrences.

Moreover the chart has been completed with additional data from the following literature sources:

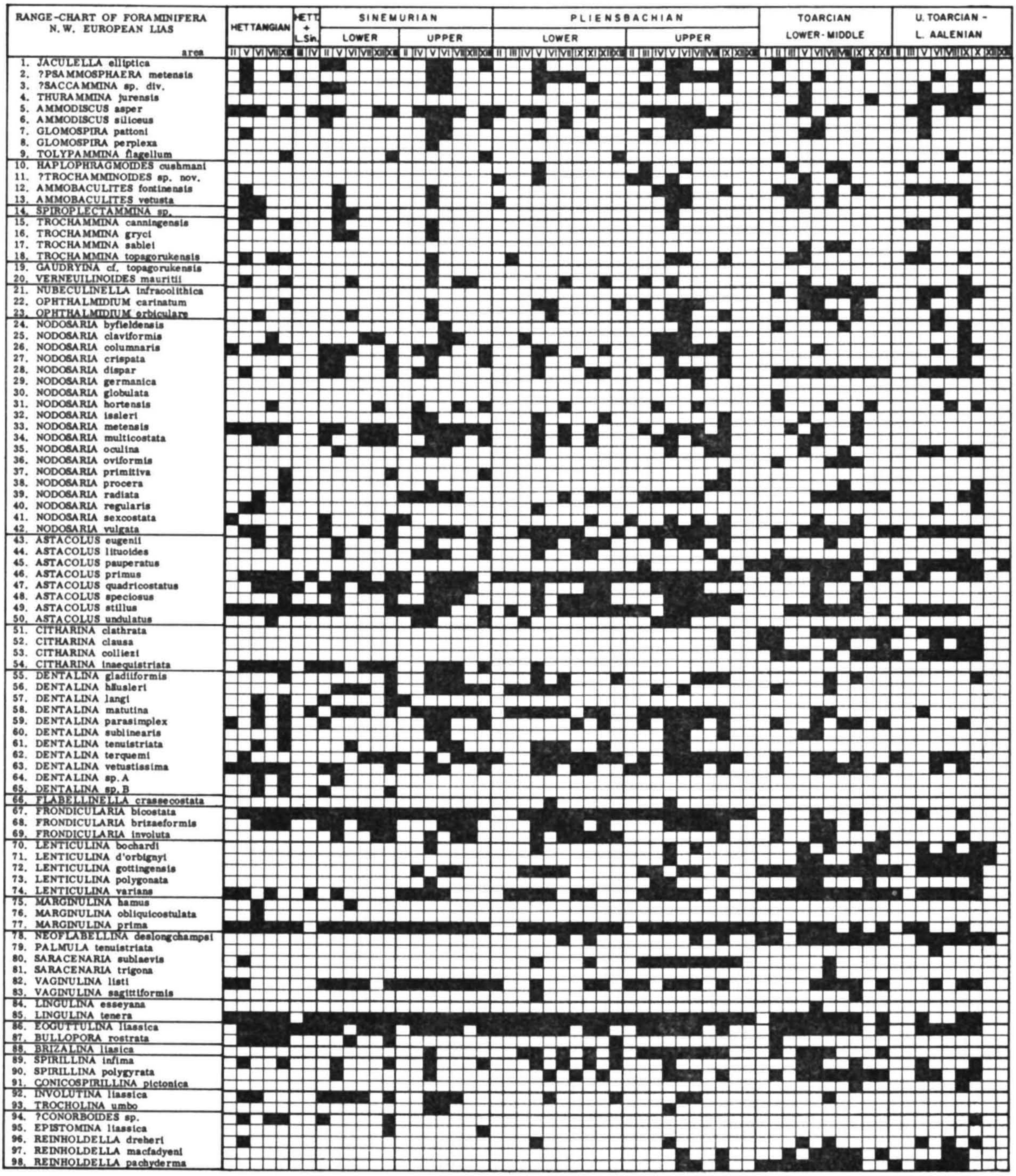
Denmark: NØRVANG, 1957;
Yorkshire-Midland: BARNARD, 1950a, 1959;
N.W. Germany: BARTENSTEIN & BRAND, 1937; KLINGLER, 1962; RABITZ, 1963;
Paris Basin: BIZON, 1961; BIZON & OERTLI, 1961; CHAMPEAU, 1961; COUSIN, ESPITALIE, SIGAL & APOSTOLESCU, 1961; LE CALVEZ & LEFAVRAIS-RAYMOND, 1961a;
N.E. Aquitaine: LE CALVEZ & LEFAVRAIS-RAYMOND, 1961;
Poitevin: MAGNÉ, SÉRONIE-VIVIEN & MALMOUSTIER, 1961; PAYARD, 1947;
Normandy: RIOULT & BIZON, 1961;
Wessex: BARNARD, 1950, 1959.

The following conclusions regarding the species distribution can be drawn from this range chart:

a. Twelve species, viz.

Ammodiscus asper (TERQUEM)
Nodosaria vulgata (BORNEMANN)
Astacolus primus (D'ORBIGNY)
Astacolus stillus (TERQUEM)
Dentalina matutina D'ORBIGNY
Dentalina terquemi D'ORBIGNY
Frondicularia bicostata D'ORBIGNY
Lenticulina varians (BORNEMANN)
Marginulina prima D'ORBIGNY)
Vaginulina listi (BORNEMANN)

TABLE II


RANGE-CHART OF FORAMINIFERA N.W. EUROPEAN LIAS
area
HETTANGIAN
HETT + L.Sin.
SINEMURIAN
LOWER
UPPER
PLIENSBACHIAN
LOWER
UPPER
TOARCIAN
LOWER-MIDDLE
U. TOARCIAN - L. AALENIAN
1. JACULELLA elliptica
2. ?PSAMMOSPHAERA metensis
3. ?SACCAMMINA sp. div.
4. THURAMMINA jurensis
5. AMMODISCUS asper
6. AMMODISCUS siliceus
7. GLOMOSPIRA pattoni
8. GLOMOSPIRA perplexa
9. TOLYPAMMINA flagellum
10. HAPLOPHRAGMOIDES cushmani
11. ?TROCHAMMINOIDES sp. nov.
12. AMMOBACULITES fontinensis
13. AMMOBACULITES vetusta
14. SPIROPLECTAMMINA sp.
15. TROCHAMMINA canningensis
16. TROCHAMMINA gryci
17. TROCHAMMINA sablei
18. TROCHAMMINA topagorukensis
19. GAUDRYINA cf. topagorukensis
20. VERNEUILINOIDES mauritii
21. NUBECULINELLA infraoolithica
22. OPHTHALMIDIUM carinatum
23. OPHTHALMIDIUM orbiculare
24. NODOSARIA byfieldensis
25. NODOSARIA claviformis
26. NODOSARIA columnaris
27. NODOSARIA crispata
28. NODOSARIA dispar
29. NODOSARIA germanica
30. NODOSARIA globulata
31. NODOSARIA hortensis
32. NODOSARIA issleri
33. NODOSARIA metensis
34. NODOSARIA multicostata
35. NODOSARIA oculina
36. NODOSARIA oviformis
37. NODOSARIA primitiva
38. NODOSARIA procera
39. NODOSARIA radiata
40. NODOSARIA regularis
41. NODOSARIA sexcostata
42. NODOSARIA vulgata
43. ASTACOLUS eugenii
44. ASTACOLUS lituoides
45. ASTACOLUS pauperatus
46. ASTACOLUS primus
47. ASTACOLUS quadricostatus
48. ASTACOLUS speciosus
49. ASTACOLUS stilus
50. ASTACOLUS undulatus
51. CITHARINA clathrata
52. CITHARINA clausa
53. CITHARINA colliezi
54. CITHARINA inaequistriata
55. DENTALINA gladiiformis
56. DENTALINA häusleri
57. DENTALINA langi
58. DENTALINA matutina
59. DENTALINA parasimplex
60. DENTALINA sublinearis
61. DENTALINA tenuistriata
62. DENTALINA terquemi
63. DENTALINA vetustissima
64. DENTALINA sp. A
65. DENTALINA sp. B
66. FLABELLINELLA crassecostata
67. FRONDICULARIA bicostata
68. FRONDICULARIA brizaeformis
69. FRONDICULARIA involuta
70. LENTICULINA bochardi
71. LENTICULINA d'orbignyi
72. LENTICULINA gottingensis
73. LENTICULINA polygonata
74. LENTICULINA varians
75. MARGINULINA hamus
76. MARGINULINA obliquicostulata
77. MARGINULINA prima
78. NEOFLABELLINA deslongchampsi
79. PALMULA tenuistriata
80. SARACENARIA sublaevis
81. SARACENARIA trigona
82. VAGINULINA listi
83. VAGINULINA sagittiformis
84. LINGULINA esseyana
85. LINGULINA tenera
86. EOGUTTULINA liassica
87. BULLOPORA rostrata
88. BRIZALINA liasica
89. SPIRILLINA infima
90. SPIRILLINA polygyrata
91. CONICOSPIRILLINA pictonica
92. INVOLUTINA liassica
93. TROCHOLINA umbo
94. ?CONORBOIDES sp.
95. EPISTOMINA liassica
96. REINHOLDELLA dreheri
97. REINHOLDELLA macfadyeni
98. REINHOLDELLA pachyderma

Lingulina tenera BORNEMANN
Eoguttulina liassica (STRICKLAND)

appear in more than half of the columns. Apart from having a wide geographical distribution they occur throughout the Lias.

b. The following twenty-five species seem less widespread (in 25–50 % of the columns):

?*Psammosphaera metensis* (TERQUEM)
Ammobaculites fontinensis (TERQUEM)
Nodosaria columnaris FRANKE
Nodosaria dispar FRANKE
Nodosaria metensis TERQUEM
Nodosaria multicostata (BORNEMANN)
Nodosaria radiata (TERQUEM)
Astacolus eugenii (TERQUEM)
Astacolus pauperatus JONES & PARKER
Astacolus quadricostatus (TERQUEM)
Astacolus speciosus (TERQUEM)
Citharina clathrata (TERQUEM)
Citharina inaequistriata (TERQUEM)
Dentalina häusleri SCHICK
Dentalina parasimplex (HAGENMEYER)
Dentalina vetustissima D'ORBIGNY
Frondicularia brizaeformis BORNEMANN
Frondicularia involuta TERQUEM
Lenticulina gottingensis (BORNEMANN)
Neoflabellina deslongchampsi (TERQUEM)
Brizalina liasica (TERQUEM)
Spirillina infima (STRICKLAND)
Spirillina polygyrata GÜMBEL
Involutina liassica (JONES)
Reinholdella pachyderma HOFKER

Most of these species have been found in all Lias stages, except for *C. inaequistriata* (apparently not younger than L. Pliensbachian), *N. deslongchampsi* (appearing in Pliensbachian), *A. pauperatus*, *C. clathrata* and *R. pachyderma* (first appearances in Upper Pliensbachian), whereas *B. liasica* seems to be restricted to Upper Sinemurian-Middle Toarcian.

c. Of even less widespread occurrence (in 10–25 % of the columns) are thirty-seven species:

Jaculella elliptica (DEECKE)
Thurammina jurensis FRANKE
Ammodiscus siliceus (TERQUEM)
Glomospira pattoni TAPPAN

Tolypammina flagellum (TERQUEM)
Haplophragmoides cushmani LOEBLICH & TAPPAN
?*Trochamminoides* sp. nov.
Ammobaculites vetustus (TERQUEM & BERTHELIN)
Trochammina canningensis TAPPAN
Trochammina topagorukensis TAPPAN
Verneuilinoides mauritii (TERQUEM)
Nubeculinella infraoolithica (TERQUEM)
Ophthalmidium carinatum (KÜBLER & ZWINGLI)
Ophthalmidium orbiculare BURBACH
Nodosaria byfieldensis BARNARD
Nodosaria claviformis TERQUEM
Nodosaria crispata TERQUEM
Nodosaria hortensis TERQUEM
Nodosaria issleri FRANKE
Nodosaria oculina (TERQUEM & BERTHELIN)
Nodosaria procera FRANKE
Nodosaria sexcostata TERQUEM
Astacolus lituoides (BORNEMANN)
Astacolus undulatus (TERQUEM)
Citharina clausa (TERQUEM)
Citharina colliezi (TERQUEM)
Dentalina gladiiformis FRANKE
Dentalina sublinearis FRANKE
Dentalina tenuistriata TERQUEM
Lenticulina bochardi (TERQUEM)
Lenticulina d'orbignyi (ROEMER)
Lenticulina polygonata FRANKE
Saracenaria sublaevis FRANKE
Bullopora rostrata QUENSTEDT
?*Conorboides sp.*
Reinholdella dreheri (BARTENSTEIN)
Reinholdella macfadyeni (TEN DAM)

In a time-stratigraphic sense most species occur throughout the Lias, but some of them, e.g. *T. jurensis*, *N. infraoolithica*, *C. clausa*, *C. colliezi* and *L. d'orbignyi* appear for the first time in the Uppermost Middle Lias or Upper Lias.

d. the remaining twenty-six species have been found too infrequently to allow a conclusion to be drawn regarding their stratigraphic and geographic range.

IV. FORAMINIFERAL ASSEMBLAGES

Recent foraminiferal assemblages are characterised by combinations of a restricted number of species which constitute the bulk of the fauna.

We might call these species the main components of the assemblages.

In the passage from one environment into another, one or more of the main components [1]) are usually replaced by others, thus leading to other combinations. Hence, in general, different environments of deposition result in different combinations of main components.

Statistical data gathered from Recent foraminiferal faunas indicate that in a succession of environments the combinations of the main components in the assemblages change in a similar order. Making use of this observation, we tried to investigate the presence of a similar order in Lias faunas. At first glance, our impression was that the Lias faunas were rather monotonous in composition, because of the predominance of lagenid species, but as the investigation progressed, it became apparent that certain combinations of faunal main components seemed to appear repeatedly, with the exclusion of main components from other combinations.

To check this observation, it was necessary to express the mutual affinity or disaffinity of the faunal components in the form of a numerical value, in order to arrive at a sound statistical base for the composition of the various foraminiferal assemblages and their interrelationships. This was achieved in the following way. Of the 1219 samples studied 662 proved to be barren or poor in Foraminifera. The remaining 557 samples yielded foraminiferal faunas in which between one and seven species occurred abundantly or commonly.

For all foraminiferal samples combined it was found that only 44 species (considering the three species of *Reinholdella* as one and splitting *Lenticulina varians* into the form with elevated sutures and the one with flush sutures, (see page 38)) occur as a main component in two or more samples.

The total number of samples in which these species occur as a main component is listed in table III, together with the number of samples in which they co-occur with another main component (table III, below diagonal).

From these figures the affinities between the species have been calculated by applying a corrected version of the chi² test, as mentioned by KENDALL & STUART (1961, p. 555), which identifies pairs of species based on the occurrence or non-occurrence in all samples, and moreover applies a correction because of the discontinuity of the distribution.

This corrected version is expressed in the following equation:

$$\chi_c^2 = \frac{n\{|ad-bc|-\frac{1}{2}n\}^2}{(a+c)(b+d)(a+b)(c+d)}$$

in which

χ_c^2 = chi², corrected version

n = total number of samples,
a = total number of samples in which two given species co-occur,

[1]) i.e. those components constituting 5 % or more of the total benthonic fauna.

b = total number of samples in which the first species occurs alone,
c = total number of samples in which the second species occurs alone,
d = total number of samples in which none of the two species occur.

The resulting chi^2 values are given in table III, above diagonal.

TABLE III

number of samples in which main-component	n = 557	PSAMMOSPHAERA metensis	?SACCAMMINA sp. div.	THURAMMINA jurensis	AMMODISCUS asper	" siliceus	HAPLOPHRAGMOIDES cushmani	?TROCHAMMINOIDES sp. nov.	AMMOBACULITES fontinensis	TROCHAMMINA topagorukensis	VERNEUILINOIDES mauritii	NUBECULINELLA infraoolithica	OPHTHALMIDIUM carinatum	" orbiculare	NODOSARIA dispar	" metensis	" multicostata	" radiata	ASTACOLUS eugenii	" lituoides	" pauperatus	" primus	" quadricostatus	" stillus	CITHARINA clathrata	" colliezi	" inaequistriata	DENTALINA matutina	" sublinearis	" terquemi	" vetustissima	FRONDICULARIA bicostata	LENTICULINA d'orbignyi	" gottingensis	" varians (fl.)	" varians (elev.)	MARGINULINA prima	NEOFLABELLINA deslongchampsi	LINGULINA tenera	EOGUTTULINA liassica	BRIZALINA liassica	SPIRILLINA polygyrata	CONICOSPIRILLINA pictonica	?CONORBOIDES sp.	REINHOLDELLA sp.
14	PSAMMOSPHAERA metensis	X			9		94	1	4	+																							+	-	56	-	-			-	14				+
6	?SACCAMMINA sp. div.		X		28			4	+		3																				1	+					2		+						
3	THURAMMINA jurensis			X					11																								2	+		4						6	82		-
35	AMMODISCUS asper	4	4		X	45		+	7	17	4			1				1				-		-				2			+	7			4		4		2		1				
4	" siliceus				4	X				3																									22		-				1				
5	HAPLOPHRAGMOIDES cushmani	4					X	137		2																								-		-									-
5	?TROCHAMMINOIDES sp. nov.	1	1		1		3	X														+													1		+				+				
33	AMMOBACULITES fontinensis	3	1	2	2				X												+					+							-	4		3						+	5		7
9	TROCHAMMINA topagorukensis	1			4	1	1			X										7				+				1				3					+		2						
6	VERNEUILINOIDES mauritii		1		2						X											+		1							1						+		+	2					
5	NUBECULINELLA infraoolithica											X	12	2											1									+		4		13				3			
17	OPHTHALMIDIUM carinatum											2	X	119							+			-	-			6			9	-		-		-	4		1	-	11	8			-
11	" orbiculare				2							1	7	X								-						10			58	2		-		-	16	5	4		20				-
9	NODOSARIA dispar														X										5					1			+	7		4	-				+				+
3	" metensis															X						1	7	5			2				2			+					-	5					
4	" multicostata																X							+			17										1		-						
2	" radiata				1													X				1		+				7			37	2			5		4								
2	ASTACOLUS eugenii																		X			17	11				37												4						
2	" lituoides									1										X								7				2					+		+						
8	" pauperatus								1				1								X												8	6		+						20			-
33	" primus				1			1			1			1		1		1	2			X	14	8			36	18			+	20		-		-	3		32	-	3				-
6	" quadricostatus															1			1			3	X	-			33				11						-		2	-					
60	" stillus				3					2	2		2			2	1	1				9	1	X			5	+	+		5	7		-	1	-	13		71	28	-			+	
18	CITHARINA clathrata											1	1		2										X	6								16		23						+			-
8	" colliezi								1																2	X								1		10				-					3
16	" inaequistriata															1	2		2			7	3	5			X				2	5					7		18					0	
9	DENTALINA matutina				2					1			2	2				1		1		4		2				X			6	12			+		10		6		25				-
2	" sublinearis																							1					X										+	10					
9	" terquemi														1															X	+			7			23		-		+				9
16	" vetustissima		1		2						1		3	5		1		2				2	2	5			2	2		1	X	1		-	+	-	7		18	3	1				-
24	FRONDICULARIA bicostata		1		5					2			1	2				1		1		7		7			3	3			2	X		-	-		51		41		2				
15	LENTICULINA d'orbignyi	1		1					1						1						2												X	12		21						9	1		-
223	" gottingensis	4		2			1		19			3	3	3	8	2					7	3		1	16	5				8	3	3	13	X	-	100	-	1	-	-	-	7	-		23
13	" varians (fl.)	5			3	2		1										1						3				1			1	1		2	X		2		2		16				
166	" varians (elev.)	3		3			1		15			4	3	1	6						3	2		1	15	7					1		13	120		X	-	-	-	-		1			19
112	MARGINULINA prima	3	3		12	1		2		3	2		7	8	2		2	2		1		11	1	23			8	6		8	8	19		26	5	1	X		55	-	15			-	-
2	NEOFLABELLINA deslongchampsi											1		1																				2		1		X	+						+
105	LINGULINA tenera		2		10					4	2		5	5		1	1		2	1		19	3	36			10	5	1	2	10	17		13	5	5	49	1	X	14	-			-	-
55	EOGUTTULINA liassica	1									2		1			2						2	1	16		1	1		2		4			1		1	5		21	X	-			-	-
25	BRIZALINA liassica	4			3	1		1					4	4	1							4		3				4		1	2	3		5	4		13		3	1	X				23
7	SPIRILLINA polygyrata			1					1			1	2								2				1								2	5		4						X	34		
5	CONICOSPIRILLINA pictonica			2					2																								1	2		1						2	X		
17	?CONORBOIDES sp.																							3			1										1		1	1				X	
113	REINHOLDELLA sp.	4		1			1		13				2	1	3						2	1			4	4		1		6	2		1	68		53	10	1	5	1	15				X

number of samples in which main-components are co-occurring

chi^2 values (+ = positive < 1; - = negative)

Restricting our attention to those species that occur as a main component in at least 25 samples, we find that the following eleven species qualify as such:

Ammodiscus asper
Ammobaculites fontinensis
Astacolus primus
Astacolus stillus
Lenticulina gottingensis
Lenticulina varians (elev.)
Marginulina prima

Lingulina tenera
Eoguttulina liassica
Brizalina liasica
Reinholdella

The number of samples in which they co-occur and the chi² values derived from these co-occurrences are (extracted from table III) recapitulated on figure 2.

	AMMODISCUS asper	AMMOBAC. fontinensis	ASTACOLUS primus	ASTACOLUS stillus	LENTICULINA gottingensis	LENTICULINA varians (elev.)	MARGINULINA prima	LINGULINA tenera	EOGUTTULINA liassica	BRIZALINA liasica	REINHOLDELLA
AMMODISCUS asper		*7*	-	-	*0*	*0*	*4*	*2*	*0*	*1*	*0*
AMMOBAC. fontinensis	2		*0*	*0*	*4*	*3*	*0*	*0*	*0*	*0*	*7*
ASTACOLUS primus	1	0		*8*	-	-	*3*	*32*	-	*3*	-
ASTACOLUS stillus	3	0	9		-	-	*13*	*71*	*28*	-	*0*
LENTICULINA gottingensis	0	19	3	1		*100*	-	-	-	-	*23*
LENTICULINA varians (elev.)	0	15	2	1	120		-	-	-	*0*	*19*
MARGINULINA prima	12	0	11	23	26	1		*55*	-	*15*	-
LINGULINA tenera	10	0	19	36	13	5	49		*14*	-	-
EOGUTTULINA liassica	0	0	2	18	1	1	5	21		-	-
BRIZALINA liasica	3	0	4	3	5	0	13	3	1		*23*
REINHOLDELLA	0	13	1	0	68	53	10	5	1	15	

chi² values

Co-occurrences.

Fig. 2.

If re-arranged as much as possible in the order of magnitude of the chi² values, the arrangement becomes as given in figure 3.

Taking a chi² value of 10, indicated in figure 3 by a shaded background, as the lowest level of significant affiliation, we can expect basic assemblages characterised by the following single, pairs or clusters of main components to occur:

Ammodiscus asper
Ammobaculites fontinensis
Lenticulina gottingensis (including *Lenticulina varians*, because of high co-occurrence and high chi² value)
Lenticulina gottingensis + *Reinholdella*
Reinholdella
Reinholdella + *Brizalina liasica*
Brizalina liasica

Brizalina liasica + *Marginulina prima*
Marginulina prima
Marginulina prima + *Lingulina tenera*
Marginulina prima + *Lingulina tenera* + *Astacolus stillus*
Marginulina prima + *Astacolus stillus*
Lingulina tenera
Lingulina tenera + *Astacolus primus*
Astacolus primus
Lingulina tenera + *Astacolus stillus*
Lingulina tenera + *Eoguttulina liassica*
Lingulina tenera + *Astacolus stillus* + *Eoguttulina liassica*
Astacolus stillus + *Eoguttulina liassica*
Astacolus stillus
Eoguttulina liassica

These basic assemblages are indeed present in about 75 % of the foraminiferal samples investigated, sometimes accompanied by one or more of the less commonly occurring main components. In the majority of the remaining 25 % samples, combinations of these basic assemblages have been found. The occurrence of the assemblages at the various localities is indicated per stage in table IV.

From the information collected in this table it appears that faunas with common *Ammodiscus asper*, *Ammobaculites fontinensis*, *Marginulina*

	AMMODISCUS asper	AMMOBAC. fontinensis	LENTICULINA gottingensis	LENTICULINA varians (elev.)	REINHOLDELLA	BRIZALINA liasica	MARGINULINA prima	LINGULINA tenera	ASTACOLUS stillus	ASTACOLUS primus	EOGUTTULINA liassica
AMMODISCUS asper		*7*	*0*	*0*	*0*	*1*	*4*	*2*	-	-	*0*
AMMOBAC. fontinensis	2		*4*	*3*	*7*	*0*	*0*	*0*	*0*	*0*	*0*
LENTICULINA gottingensis	0	19		*100*	*23*	-	-	-	-	-	-
LENTICULINA varians (elev.)	0	15	120		*19*	*0*	-	-	-	-	-
REINHOLDELLA	0	13	68	53		*23*	-	-	*0*	-	-
BRIZALINA liasica	3	0	5	0	15		*15*	-	-	*3*	-
MARGINULINA prima	12	0	26	1	10	13		*55*	*13*	*3*	-
LINGULINA tenera	10	0	13	5	5	3	49		*71*	*32*	*14*
ASTACOLUS stillus	3	0	1	1	0	3	23	36		*8*	*28*
ASTACOLUS primus	1	0	3	2	1	4	19	19	9		-
EOGUTTULINA liassica	0	0	1	1	1	1	5	21	18	2	

chi2 values

Co-occurrences.

Fig. 3.

prima, *Lingulina tenera*, *Astacolus stillus*, *Astacolus primus* and *Eoguttulina liassica* occur more or less throughout the whole Lias, or can be expected to do so considering their range given on table II.

Their occurrence therefore should be explained as being dependent on environmental changes.

Brizalina liasica becomes a main component during the Lower Pliensbachian; *Reinholdella* and *Lenticulina gottingensis* during the Upper Pliensbachian. According to the literature, the first-mentioned species already appears in the Upper Sinemurian, while, moreover, the genus *Brizalina* is quoted by LOEBLICH & TAPPAN (1964, p. c552) from the Upper Triassic. The latter two forms are mentioned in the literature from Upper Sinemurian and Hettangian, respectively. In view of their vertical range, the occurrence of the three forms as main components could thus also very well be dependent on environmental factors. The conclusion that the presence or absence of the ten main components just mentioned

TABLE IV

BASIC ASSEMBLAGE	HETTANGIAN	SINEMURIAN		PLIENSBACHIAN		TOARCIAN LOWER-MIDDLE	U. TOARCIAN-L. AALENIAN
		LOWER	UPPER	LOWER	UPPER		
Ammodiscus asper		40	**40** 45 **48**		20 **21** 25 **26** **28** **29** **35** **40** 45	28	
Ammobaculites fontinensis		40				**22** 53 65 **81**	**28** 40 **78**
Lenticulina gottingensis					48 51 **80**	22 **28** **40** **45** **47** **48** 51 **53** **56** 57 **58** **59** **60** **61** **63** **64** **66** **72** **74** **76** 77 **78** 79 **80** **81**	**7** **29** **39** **40** **44** **47** **48** **53** **67** **68** **69** **70** **71** **72** **73** **78** **79** **80**
Lenticulina gottingensis-Reinholdella					47 51	**1** **7** **40** **43** **51** 53 **55** **61** **62** **65** **74** 76 **77** **78** **79** **80**	**40** **43** **78** **79** **80**
Reinholdella					51	**5** **22** **24** **28** **40** **51** **53** **60** **61** **65** **66** **75** **77** **78**	**40** **44** **78**
Reinholdella-Brizalina liasica					**51**	**5** **51** **57**	
Brizalina liasica				**11** 82	**40** **78**	**47**	
Brizalina liasica-Marginulina prima				**21**	**40** **45** 78	51	
Marginulina prima	**21** 50	**6** **11**	40	**11** **40** **48** **78**	**21** **24** 25 29 **40** 45 47 **48** 51 78 80	45 **47** 48 51 77 78	40
Marginulina prima-Lingulina tenera	**6** **8** 9 **50**		21 **40** 45	**11**	20 **28** 48 51 **78** 80	45 47 48 57 **64** 77	
M. prima - L. tenera-Astacolus stillus	**50**	**10**	40	**21** **57** **82**	48 51 **78**		
Marginulina prima-Astacolus stillus	9 ·11	**6** **11** **21**		**57**	45 78		
Lingulina tenera	**8** **10** **11** **50**	**3** **10** **11**	**11** **40** 45 **48**		**18** **42** **45** **52**	47 **49** 75 76 79	
Lingulina tenera-Astacolus primus	11 **50**	10 11	21 45	82	**5** 48 51 **78**		
Astacolus primus	50				48 **51** **78**	45 56	
Lingulina tenera-Astacolus stillus	**9** **10** 11	**10** **11** **40**		**82**			
Lingulina tenera-Eoguttulina liassica	**8** **9** **10**						
L. tenera-Astacolus stillus Eoguttulina liassica	**9**	**10**		82			
Astacolus stillus Eoguttulina liassica	**9** **11**	**10**					
Astacolus stillus	**9** **10** **11**			**78** **82**		**22** 56	
Eoguttulina liassica	**9** **10** **11** **48** **54**	**10**		**23**		**49** **53** **56** **64** 80	

6 basic assemblage only   6 combination of basic assemblages

Occurrence of basic assemblages at the various localities investigated (the numbers correspond to the localities shown in fig. 1).

is facies controlled seems to be corroborated by lithological and additional palaeontological evidence presented in figure 4. This figure shows that there exist marked differences in lithology and rock-colour for each of the basic assemblages. Moreover, the number of samples with co-occurring ostracods and pelagic belemnites and ammonites is expressed as a percentage of the total number of samples in which a foraminiferal main component is present alone or in combination with others. These percentages seem to indicate a gradual decrease of ostracods and increase of ammonites/belemnites in the succession *Eoguttulina liassica* – *Astacolus stillus* – *Lingulina tenera* – *Marginulina prima* – *Brizalina liasica* –

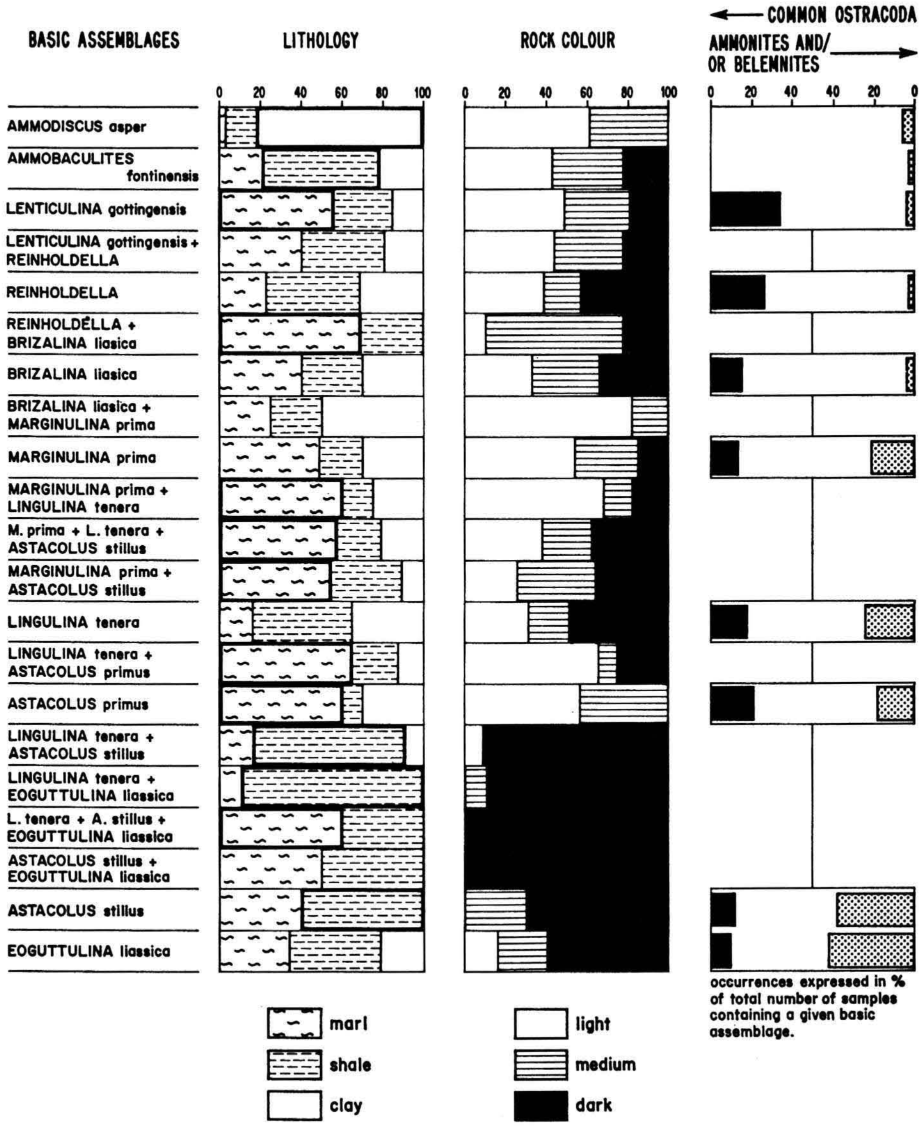


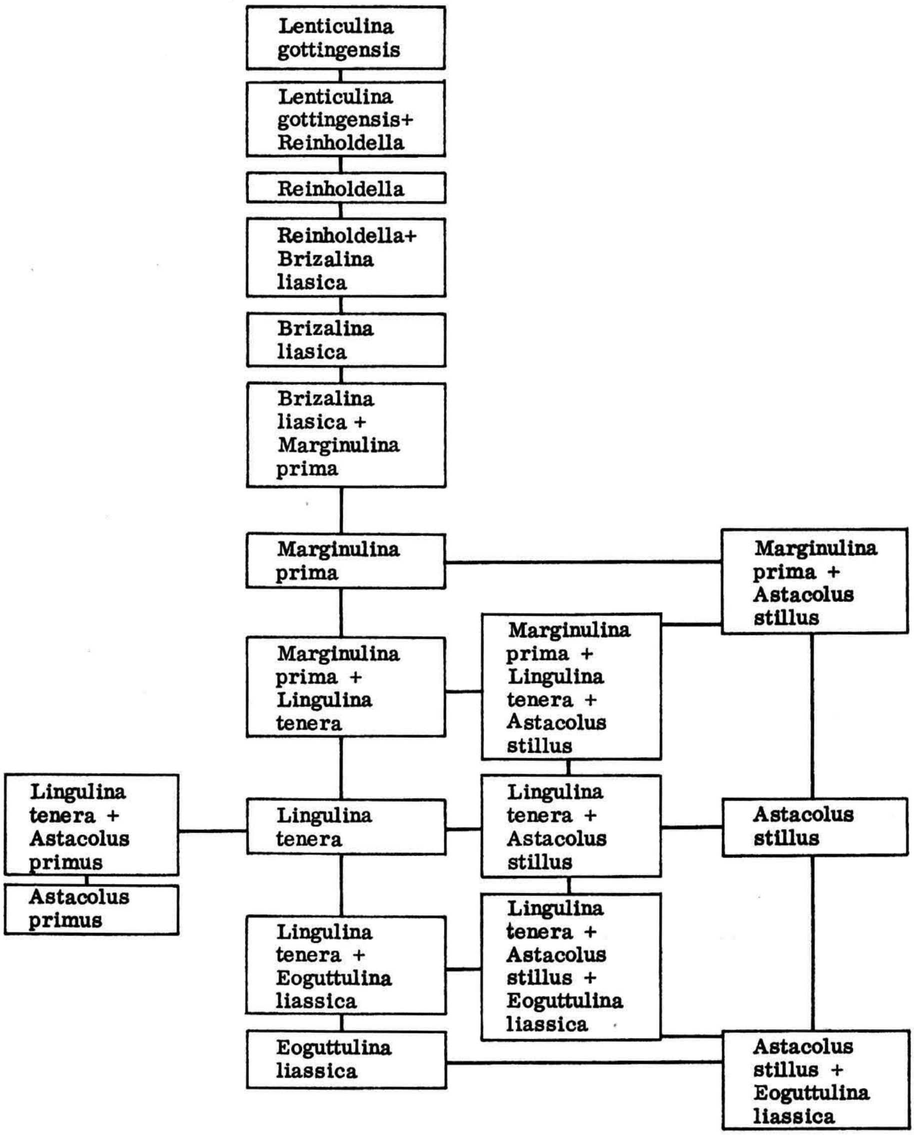
Fig. 4. Relation of basic assemblage to lithology and other organisms.

Reinholdella – Lenticulina gottingensis. This trend could very well represent a gradual change towards open and/or deeper marine conditions.

Amongst the less common main components there are some that apparently make their first appearance during the Lias, e.g. *Citharina clathrata*, *C. clausa* and *C. colliezi*, occurring for the first time during the Upper Pliensbachian, and whose origin is obscure.

V. ENVIRONMENT OF DEPOSITION

If the conclusion regarding the environmental dependence is correct, the chi^2 values of the ten commonly occurring main components permit the recognition of the following succession of foraminiferal assemblages:



One end of this succession is formed by *Lenticulina gottingensis*, occurring in light to dark marls, shales and clays, rich in ammonites and belemnites, but poor in ostracods. This part probably represents the deepest and/or most open marine condition.

Towards the other end of the succession passing on to *Eoguttulina liassica*, dark-coloured and black shales and marls are predominant, while the ammonite and belemnite content seems to decrease, and the ostracods become more common. This end could very well represent the shallowest marine, or even brackish-water environments.

The branch ending with *Astacolus primus*, on the other hand, is again characterised by predominantly light to dark marls, richer in ammonites and belemnites, and possibly represents open-marine, nearshore conditions.

Assemblages with *Ammodiscus asper* and *Ammobaculites fontinensis* do not fit into this succession. The former species seems to prefer predominantly light-coloured clays, the latter light to dark shales. Ammonites and belemnites are conspicuously absent in both. These environmental interpretations are admittedly vague, mainly because unfortunately none of the assemblages, nor even any of the species, has persisted till the present, thus making a direct faunistic comparison with Recent conditions impossible. Nevertheless some indirect evidence tends to support the above interpretation.

Unornamented *Lenticulina*, similar to *L. gottingensis*, if occurring as a main component, and always co-occurring with a variable number of other benthonic species, occurs in Recent seas between 60 and 1500 m depth. In Recent deposits the genus *Lenticulina* is a rather rare element, whereas in Mesozoic and Tertiary deposits it occurs often, even in monospecific faunas. However that may be, the Recent distribution of *Lenticulina* does not run counter to the conclusion that *L. gottingensis* could very well represent the deepest marine part of the sequence, though the depth range covered by the genus during Lias times remains an unanswered question.

Regarding *Eoguttulina liassica*, thought of as representing the shallower end of the sequence, it is quite feasible that its Recent counterpart has to be looked for in forms like *Guttulina yabei* CUSHMAN & OZAWA and *G. australis* (D'ORBIGNY).

Guttulina yabei has been recorded as a main component, but together with other species at 8 m depth in Oyster Harbour, a lagoon with an open outlet to the King George Sound, Western Australia (McKENZIE, 1962).

Guttulina australis is mentioned as a main component from shallow inner-neritic deposits, together with other benthonic forms, in the Gulf of Mexico near Horn Island, between 2 and 3 m depth (WALTON, 1960) and in the Atlantic offshore North Carolina at 9 and 12 m sea depth (HADLEY, 1936).

This could mean that the depositional environment indicated by

Eoguttulina liassica should be placed somewhere in lagoonal or shallow inner neritic.

As the material studied for the present paper has been taken from washable shales, clays and marls only, a complete picture of all faunal assemblages occurring in the Lias cannot be given.

For example, *Involutina*, which according to WICHER (1952) is characteristic of reef environments in the widest sense, is to be expected in hard limestones, and consequently has only been found occasionally as a main component in the Lowermost Lias of Rugby, Hochfelden and Göttingen, where it occurs in combination with *Lingulina tenera* and/or *Marginulina prima*.

This selective sampling, combined with the fact that the outcrops have been sampled with a variable density, does not provide a good basis for the construction of dependable palaeogeographic maps.

Broadly speaking, however, it seems, in view of the distribution of the basic assemblages as presented on table IV, that during the Lias a general deepening of the sea took place in large parts of northwestern Europe.

VI. ANNOTATED CHECK-LIST OF SPECIES

Up till 1964, about 850 Liassic species, subspecies, varieties and forms had been recorded in ELLIS & MESSINA's Catalogue of Foraminifera. With the exception of 27 Alaskan species, they all originated from the western European Lias (mainly France, Germany, England and Denmark).

Slightly more than half of the names were created in the second half of the nineteenth century by TERQUEM and BERTHELIN, who like others of the "Continental school" gave "a new specific name to every form which slightly differed from the original type (often without consulting previous literature)" (BARNARD, 1950).

The "British school", on the other hand, had the general "tendency to regard all foraminifera (since they belonged to such a lowly group of animals) as variants of even one species" (BARNARD, 1950). For this reason, various British Liassic Foraminifera bear the names of forms originally described from older or younger, even Recent, deposits.

In modern literature, there is a tendency to group similar-looking species into larger units (group, supergroup, NØRVANG; plexus, BARNARD; gens, HOFKER). Such a larger unit, whatever it is called, could be imagined as an aggregate of all species that have a larger number of essential characters in common and that are continuously related to each other in time and space. They probably represent different stages in a micro-evolutionary development or geographical and environmental variation. A morphological study on a statistical basis of such a larger unit shows how the various stages intergrade (VAN DER VLERK with *Lepidocyclina*; HOFKER, and others, with Mesozoic and Lower Tertiary benthonic smaller Foraminifera; BLOW, and others, with planktonic Foraminifera, to mention just a few).

Data obtained from such studies are often used for a time-stratigraphical zonation.

This approach to the study of morphological variation and development has also been applied to some groups of Liassic Foraminifera, coincidentally by different authors at about the same time on partly the same groups (NØRVANG, 1957; BARNARD, 1956, 1957), viz. *Lingulina tenera*, *Frondicularia bicostata* and *Marginulina prima*. Earlier work has been done by WICHER (1952) on *Involutina-Trocholina* and by HOFKER (1952) on *Reinholdella*.

The possibility of applying the results of these studies to zonation seems to be restricted thus far to the main stages of the Lias, which seems to imply that the micro-evolution has probably taken place at a much slower pace than had been the case with the ammonites.

Other students have actually re-investigated topotype material, and have often come to the conclusion that various species had been described more than once, sometimes by the same author. It also appeared that "les espèces récoltées correspondaient peu, en général, aux figurations et descriptions de Terquem" as BIZON (1960) remarks in connection with a restudy of TERQUEM's species from the Lias of Lorraine.

From all these observations it seems reasonable to assume that in many cases the names used for Liassic Foraminifera are actually synonyms, or refer to minor variants or aberrant forms that can be incorporated in well-established and readily recognisable species, or species-groups, of which more is known about the variation width and morphological development.

As the main object of the present study has been to try to interpret the gross environment of deposition, rather than to establish a more detailed zonation, a statistical study of certain groups has not been undertaken.

Because in most cases the composition of the assemblages remains the same, notwithstanding a morphological evolution in time, it is assumed that very probably these evolutions have not been induced by major variations in the environmental conditions of the sea floor (see also remarks under *Lingulina tenera*).

In the following list we have tried to give the latest taxonomical name for each species or recognised group of species with a reference to:

a. the original name, as given in the Catalogue of Foraminifera, by ELLIS & MESSINA;

b. established synonyms;

c. one or more references to modern literature in which a representative figure of the species in question can be found. The literature referred to is to be found in the Bibliography.

In this way a total of about 250 names of Liassic species, subspecies and varieties out of the 850 mentioned in the literature could be classified in these taxonomical notes. The remaining 600 have not been found in the present investigation.

As much as possible the taxonomic subdivision given by LOEBLICH & TAPPAN (1964) has been followed.

Almost all species are figured on Plates I-VIII.

Family: ASTRORHIZIDAE BRADY, 1881.

Jaculella elliptica (DEECKE, 1884).

Rhabdammina elliptica DEECKE, 1884, p. 23, i. 1a, b.

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

Jaculella elliptica (DEECKE) – TAPPAN, 1955, p. 35, pl. 7, figs. 4–6.

Family: SACCAMMINIDAE BRADY, 1884.

?Psammosphaera metensis (TERQUEM, 1862) (Pl. I, figs. 12, 13).

Annulina metensis TERQUEM, 1862, p. 433, pl. 5, figs. 6a, b.

Annulina metensis TERQUEM – BARTENSTEIN & BRAND, 1937, p. 129, pl. 4, figs. 11a, b, pl. 5, fig. 3.

This species probably is a flattened *Psammosphaera*.

?Saccammina spec. div. (Pl. I, figs. 20, 21).

The specimens are badly preserved, but can sometimes be identified with *Proteonina difflugiformis* and *P. ampullacea* as figured by BARTENSTEIN & BRAND (1937). Both species have originally been described from Recent deposits. The preservation of the Liassic material does not allow a reliable identification.

Thurammina jurensis FRANKE, 1936 (Pl. I, fig. 23).

Thyrammina jurensis FRANKE, 1936, p. 13, pl. 1, fig. 8.

Thurammina jurensis FRANKE – BARTENSTEIN & BRAND, 1937, p. 129, pl. 6, fig. 4.

Family: AMMODISCIDAE REUSS, 1862.

Ammodiscus asper (TERQUEM, 1863) (Pl. I, figs. 6–9).

Involutina aspera TERQUEM, 1863, p. 431, pl. 10, figs. 21a, b.

Ammodiscus incertus (D'ORBIGNY) – BARTENSTEIN & BRAND, 1937, p. 130, pl. 3, figs. 5a-c, pl. 4, fig. 4, etc.

Ammodiscus asper (TERQUEM) – BARNARD, 1950, p. 351, fig. 1a, i, ii.

Involutina aspera TERQUEM – BIZON, 1960, p. 4, pl. 1, fig. 1.

Specimens assigned by some authors to *Glomospira gordialis* have been compared by BARNARD with the type specimens of that species, but proved to be abnormal forms of *Ammodiscus*. HAGENMEYER (1954) observed that in the L. Sinemurian, this species seems to be more common in clayey than in marly sediments (compare p. 19, fig. 4).

Ammodiscus siliceus (TERQUEM, 1862) (Pl. I, figs. 10, 11).

Involutina silicea TERQUEM, 1862, p. 450, pl. 6, figs. 11a, b.

Involutina silicea TERQUEM – BIZON, 1960, p. 4, pl. 1, figs. 2a, b. pl. 4, fig. 1.

Glomospira pattoni TAPPAN, 1955 (Pl. I, figs. 14, 15).

Glomospira gordialis (JONES & PARKER) – BARTENSTEIN & BRAND, 1937, p. 133, pl. 4, fig. 5, pl. 10, fig. 7.

Glomospira pattoni TAPPAN, 1955, p. 40, pl. 8, figs. 15–17.

We compared the specimens from the Lias with alleged *Glomospira gordialis* from the Barremian of Haverlahwiese, the Oxfordian of Kandern and the Gurnigel Flysch of Zollhaus, but could not detect any appreciable difference.

Glomospira perplexa FRANKE, 1936 (Pl. I, figs. 16, 17).

Glomospira perplexa FRANKE, 1936, p. 18, pl. 1, fig. 12.

Some of our specimens show affinities with the genus *Thalmannina* MAJZON 1943.

Tolypammina flagellum (TERQUEM, 1870) (Pl. I, fig. 22).

Webbina flagellum TERQUEM, 1870, p. 375, pl. 29, fig. 30.

Tolypammina flagellum (TERQUEM) – BARNARD, 1950, p. 354, fig. 1b.

Family: LITUOLIDAE LAMARCK, 1809.

Haplophragmoides cushmani LOEBLICH & TAPPAN, 1946. (Pl. I, figs. 18, 19).

Haplophragmoides canariensis (D'ORBIGNY) – BARTENSTEIN & BRAND, 1937, p. 189, pl. 10, fig. 46, etc.

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

?Trochamminoides sp. nov. (Pl. II, fig. 1).

Haplopragmoides emaciatum (BRADY) – BARTENSTEIN & BRAND, 1937, p. 188, pl. 5, fig. 73.

This species is not the same as the Recent *Alveolophragmium emaciatum*, as it is not alveolar; it is very probably streptospirally coiled with elongated tubuliform chambers.

Ammobaculites fontinensis (TERQUEM, 1870) (Pl. I, figs. 1–3).

Haplophragmium fontinense TERQUEM, 1870, p. 235, pl. 24, figs. 29, 30a, b.

Haplophragmium infrajurensis TERQUEM, 1870, p. 235, pl. 24, figs. 27, 28a, b.

Ammobaculites fontinensis (TERQUEM) – BARNARD, 1950a, p. 4, pl. 1, figs. 1, 2.

Ammobaculites vetustus (TERQUEM & BERTHELIN, 1875) (Pl. I, figs. 4, 5).

Haplophragmium vetustum TERQUEM & BERTHELIN, 1875, p. 53, pl. 4, figs. 16a-d.

Ammobaculites agglutinans (D'ORBIGNY) – BARTENSTEIN & BRAND, 1937, p. 186, pl. 4, fig. 14, etc.

Ammobaculites vetusta (TERQUEM & BERTHELIN) – TAPPAN, 1955, p. 45, pl. 13, figs. 1–3.

Family: TEXTULARIIDAE EHRENBERG, 1839.

Spiroplectammina sp. (Pl. II, fig. 5).
Spiroplectammina sp. TAPPAN, 1955, p. 46, pl. 13, fig. 12.

Family: TROCHAMMINIDAE SCHWAGER, 1877.

Trochammina canningensis TAPPAN, 1955.
Trochammina globigeriniformis (PARKER & JONES) – BARTENSTEIN & BRAND, 1937, p. 189, pl. 1A, fig. 21, pl. 4, fig. 13, pl. 5, fig. 76.
Trochammina canningensis TAPPAN, 1955, p. 49, pl. 14, figs. 15–19.

Trochammina gryci TAPPAN, 1955 (Pl. I, figs. 24, 25).
Trochammina nana forma a, BARTENSTEIN & BRAND, 1937, p. 190, text fig. 20, pl. 2B, figs. 40a, b.
Trochammina gryci TAPPAN, 1955, p. 50, pl. 14, figs. 12–14.
Our specimens fit rather well the description given by BARTENSTEIN & BRAND, as they have a practically flat spire.

Trochammina sablei TAPPAN, 1955 (Pl. I, figs. 26, 27).
Trochammina sablei TAPPAN, 1955, p. 50, pl. 14, figs. 6–9.

Trochammina topagorukensis TAPPAN, 1955 (Pl. I, figs. 28–30).
Trochammina topagorukensis TAPPAN, 1955, p. 51, pl. 14, figs. 10, 11.

Family: ATAXOPHRAGMIIDAE SCHWAGER, 1877.

Gaudryina cf. topagorukensis TAPPAN, 1955 (Pl. II, fig. 6).
Only a few specimens have been found in the U. Sinemurian of Grube Friederike and are probably identical with *Gaudryina topagorukensis* TAPPAN (1955, p. 48, pl. 14, fig. 4).

Verneuilinoides mauritii (TERQUEM, 1866) (Pl. II, figs. 2–4).
Verneuilina mauritii TERQUEM, 1866, p. 448, pl. 18, figs. 18a, b.
Verneuilina georgiae TERQUEM, 1866, p. 448, pl. 18, figs. 19a, b.
Verneuilinoides mauritii (TERQUEM) – BIZON, 1960, p. 4, pl. 1, figs. 3a, b, pl. 4, fig. 10.
In our material a number of specimens are flattened.

Family: NUBECULARIIDAE JONES, 1875.

Nubeculinella infraoolithica (TERQUEM, 1870).
Webbina infraoolithica TERQUEM, 1870, p. 373, pl. 29, figs. 19–26.
Tolypammina jurensis FRANKE, 1936, p. 15, pl. 1, fig. 11.
Nubeculinella infraoolithica (TERQUEM) – BARTENSTEIN & BRAND, 1937, BRAND, 1937, p. 180, pl. 6, figs. 38a-c, pl. 8, figs. 35a-f, etc.

Ophthalmidium carinatum (KÜBLER & ZWINGLI, 1866) (Pl. II, fig. 8).
Oculina carinata KÜBLER & ZWINGLI, 1866, p. 14, pl. 2, fig. 19.
Oculina nucleus KÜBLER & ZWINGLI, 1866, p. 14, pl. 2, fig. 20.
Ophthalmidium okeni ZWINGLI & KÜBLER, 1870, p. 18, pl. 2, figs. 10, 11.
Ophthalmidium birmenstorfensis ZWINGLI & KÜBLER, 1870.

Spiroloculina concentrica TERQUEM & BERTHELIN, 1875, p. 80, pl. 7, figs. 1a-g, 2a-h, 3a-d, 4a-o.
Spirophthalmidium tenuissimum PAALZOW, 1932, p. 100, pl. 5, figs. 11–13.
Spirophthalmidium concentricum (TERQUEM & BERTHELIN) – FRANKE, 1936, p. 123, pl. 12, figs. 15, 17.

Ophthalmidium orbiculare BURBACH, 1886 (Pl. II, figs. 9, 10).
Ophthalmidium orbiculare BURBACH, 1886, p. 490, pl. 5, figs. 3–6.
Ophthalmidium ovale BURBACH, 1886, p. 499, pl. 5, figs. 7–12.
Praeophthalmidum orbiculare (BURBACH) – KNAUFF, 1966, p. 101, pl. 6, fig. 35–75.

Family: NODOSARIIDAE EHRENBERG, 1839.

Nodosaria byfieldensis BARNARD, 1950 (Pl. III, fig. 4).
Nodosaria byfieldensis BARNARD, 1950a, p. 17, pl. 3, fig. 2.

Nodosaria claviformis TERQUEM, 1866 (Pl. III, fig. 5).
Nodosaria claviformis TERQUEM, 1866, p. 477, pl. 19, figs. 17, 18a, b.
Nodosaria claviformis TERQUEM – BIZON, 1960, p. 9, pl. 3, fig. 5, pl. 4, fig. 12.
Our specimens, also from the lower part of the Upper Pliensbachian, have fine striae, which are more neatly arranged than BIZON's pl. 3, fig. 5 would suggest.

Nodosaria columnaris FRANKE, 1936 (Pl. III, figs. 6, 7)
Nodosaria columnaris FRANKE, 1936, p. 48, pl. 4, figs. 19a, b.
Nodosaria columnaris FRANKE – BARNARD, 1950, p. 356, fig. 4e.

Nodosaria crispata TERQUEM, 1866 (Pl. II, fig. 31).
Nodosaria crispata TERQUEM, 1866, p. 476, pl. figs. 9, 10a-c, 11a, b.
Nodosaria crispata TERQUEM – BARTENSTEIN & BRAND, 1937, p. 145, pl. 3, fig. 13, etc.

Nodosaria dispar FRANKE, 1936 (Pl. III, figs. 8, 9).
Nodosaria mutabilis TERQUEM, 1870, p. 353, pl. 26, figs. 6–12. (not COSTA 1855).
Nodosaria variabilis TERQUEM & BERTHELIN, 1875, p. 20, pl. 1, figs. 19a-f (not NEUGEBOREN 1852).
Nodosaria dispar FRANKE, 1936, p. 47, pl. 4, figs. 18a-d.
Nodosaria mutabilis TERQUEM forma *collaris* FRANKE, 1936, p. 51, pl. 5, fig. 2c.
Nodosaria reinecki HAGENMEYER, 1959 (new name for: *Nodosaria mutabilis* TERQUEM 1870).

Nodosaria germanica FRANKE, 1936 (Pl. III, fig. 10).
Nodosaria germanica FRANKE, 1936, p. 41, pl. 3, figs. 18a, b.
Nodosaria germanica FRANKE – BARTENSTEIN & BRAND, 1937, p. 143, pl. 5, fig. 66.

Nodosaria globulata BARNARD, 1950 (Pl. III, fig. 11).
Nodosaria globulata BARNARD, 1950a, p. 17, pl. 3, fig. 8, text fig. 9.

Nodosaria hortensis TERQUEM, 1866.
Nodosaria hortensis TERQUEM, 1866, p. 476, pl. 19, fig. 13.
Nodosaria hortensis TERQUEM – BARNARD, 1950, p. 356, fig. 4d.
This species probably is only a more regular form of *N. dispar*. Our specimens are rather small.

Nodosaria issleri FRANKE, 1936.
Nodosaria issleri FRANKE, 1936, p. 53, pl. 5, fig. 6.

Nodosaria metensis TERQUEM, 1863 (Pl. III, fig. 12).
Nodosaria metensis TERQUEM, 1863, p. 377, pl. 7, figs. 5a, b.
Nodosaria metensis TERQUEM – BARNARD, 1950, p. 355, figs. 2, 4f.
Nodosaria metensis TERQUEM var. *robusta* BARNARD, 1950, p. 356, fig. 3.

Nodosaria multicostata (BORNEMANN, 1854) (Pl. IV, fig. 2).
Orthocerina multicostata BORNEMANN, 1854, p. 35, pl. 3, figs. 14a, b, 15a, b.
Pseudoglandulina multicostata (BORNEMANN) – BARNARD, 1950, p. 364, fig. 4a.
Pseudoglandulina multicostata (BORNEMANN) var. *semicostata* BARNARD, 1950, p. 364, fig. 4b.
Pseudoglandulina multicostata (BORNEMANN) – DREXLER, 1958, p. 498, pl. 20, fig. 25.

Nodosaria oculina (TERQUEM & BERTHELIN, 1875) (Pl. III, fig. 13).
Dentalina oculina TERQUEM & BERTHELIN, 1875, p. 31, pl. 2, figs. 20a-c.
Nodosaria oculina (TERQUEM & BERTHELIN) – FRANKE, 1936, p. 49, pl. 4, fig. 21.
Nodosaria oculina (TERQUEM & BERTHELIN) – NØRVANG, 1957, p. 355, fig. 77.

Nodosaria oviformis (TERQUEM, 1863) (Pl. IV, fig. 3).
Glandulina oviformis TERQUEM, 1863, p. 378, pl. 7, figs. 4a, b.
Glandulina oviformis TERQUEM – FRANKE, 1936, p. 55, pl. 5, fig. 11.
Pseudoglandulina oviformis (TERQUEM) – BARTENSTEIN & BRAND, 1937, p. 149, pl. 4, fig. 40.

Nodosaria primitiva ZWINGLI & KÜBLER, 1870 (Pl. III, figs. 14, 15).
Nodosaria primitiva ZWINGLI & KÜBLER, 1870, pl. 5, fig. 1.
Nodosaria primitiva ZWINGLI & KÜBLER – FRANKE, 1936, p. 43, pl. 4, fig. 4.

Nodosaria procera FRANKE, 1936 (Pl. III, fig. 16).
Nodosaria procera FRANKE, 1936, p. 51, pl. 5, fig. 3.
Nodosaria procera FRANKE – BARTENSTEIN & BRAND, 1937, p. 146, pl. 3, figs. 17a-c.

Nodosaria radiata (TERQUEM, 1886) (Pl. III, fig. 17).
Dentalina radiata TERQUEM, 1866, p. 490, pl. 20, figs. 5a, b.
Nodosaria radiata (TERQUEM) – FRANKE, 1936, p. 49, pl. 4, fig. 20.

Nodosaria regularis TERQUEM, 1862.
Nodosaria regularis TERQUEM, 1862, p. 436, pl. 5, fig. 12.
Nodosaria simplex TERQUEM & BERTHELIN, 1875, p. 19, pl. 1, figs. 16a-c.
Nodosaria regularis TERQUEM – FRANKE, 1936, p. 41, pl. 3, figs. 19a, b.

Nodosaria sexcostata TERQUEM, 1858 (Pl. III, fig. 18).
Nodosaria sexcostata TERQUEM, 1858, p. 588, pl. 1, figs. 5a, b.
Nodosaria sexcostata TERQUEM – FRANKE, 1936, p. 46, pl. 4, figs. 12a, b.

Nodosaria vulgata (BORNEMANN, 1854) (Pl. IV, figs. 4, 5).
Glandulina vulgata BORNEMANN, 1854, p. 31, pl. 2, figs. 1a, b, 2 (corrected name for *G. rotundata* in text).
Glandulina major BORNEMANN, 1854, p. 31, pl. 2, figs. 4a, b.
Orthocerina pupoides BORNEMANN, 1854, p. 35, pl. 3, figs. 16a, b.
Glandulina tenuis BORNEMANN, 1854, p. 31, pl. 2, figs. 3a, b.
Glandulina hybrida TERQUEM & BERTHELIN, 1875, p. 22, pl. 1, fig. 26.
Glandulina irregularis FRANKE, 1936, p. 57, pl. 5, figs. 15a, b.
Pseudoglandulina vulgata (BORNEMANN) – BARNARD, 1950a, p. 24, pl. 5, fig. 7, text fig. 15.
Pseudoglandulina pupoides (BORNEMANN) – DREXLER, 1958, p. 498, pl. 20, fig. 27.

Astacolus eugenii (TERQUEM, 1863) (Pl. VII, fig. 3).
Cristellaria eugenii TERQUEM, 1863, p. 414, pl. 9, figs. 16a, b.
Planularia eugenii (TERQUEM) – NØRVANG, 1957, p. 381, fig. 150.

Closely related to *Citharina inaequistriata* (TERQUEM) according to NØRVANG, who also included *Cristellaria pikettyi* TERQUEM 1866 under its synonymy.

Astacolus lituoides (BORNEMANN, 1854) (Pl. VI, fig. 5).
Cristellaria lituoides BORNEMANN, 1854, p. 40, pl. 4, figs. 29a-c.
Marginulinopsis lituoides (BORNEMANN) – NØRVANG, 1957, p. 375, figs. 118, 120.

Astacolus pauperatus (JONES & PARKER, 1860) (Pl. VI, figs. 22–25).
Planularia pauperata JONES & PARKER, 1860, p. 454, pl. 20, fig. 39.
Cristellaria simplex TERQUEM, 1863, p. 413, pl. 9, figs. 15a, b.
Planularia pauperata JONES & PARKER – BARNARD, 1950a, p. 10, pl. 2, fig. 7, text figs. 3, 4.
Planularia pseudocrepidula ADAMS, 1957, p. 208, text figs. 1–5 (part).
Planularia pseudocrepidula ADAMS, var. *robusta* ADAMS, 1957, p. 213, text figs. 2–4 (part).

ADAMS (1957) made a differential diagnosis of *Planularia pseudocrepidula* which is identical with *A. pauperatus*.

Astacolus primus (D'ORBIGNY, 1850, 1849 MS) (Pl. VI, figs. 6–8).

Cristellaria prima D'ORBIGNY, 1849, p. 242, no. 266.
Cristellaria antiquata D'ORBIGNY, 1849, p. 242, no. 265.
Cristellaria matutina D'ORBIGNY, 1849, p. 242, no. 264.
Cristellaria vetusta D'ORBIGNY, 1849, p. 242, no. 267.
Cristellaria protracta BORNEMANN, 1854, p. 39, pl. 4, figs. 27a, b.
Cristellaria spirolina BORNEMANN, 1854, p. 40, pl. 4, figs. 30a-c.
Marginulinopsis prima (D'ORBIGNY) – NØRVANG, 1957, p. 376, figs. 116, 121, 122.
Marginulinopsis matutina (D'ORBIGNY) – NØRVANG, 1957, p. 374, figs. 115, 117.

We included in this species, or rather in this group of closely related forms, which needs further study (see BARNARD, 1949, 1960), *A. primus* as well as *A. matutinus* as figured by NØRVANG. This group is one of the most exasperating ones to unravel. We may well consider that it has caused a considerable number of "new species" in the past. MACFADYEN (1936) investigated and figured the original topotype material and states as one of the differences of otherwise similar-looking forms that *A. primus* has an outer margin varying from slightly keeled to sharp-edged, while *A. matutinus* shows an acute peripheral margin but a well-rounded inner margin. *Cristellaria antiquata*, considered by some authors as synonymous with one of the two or both, has, according to MACFADYEN, well-rounded inner and outer margins. One becomes completely mystified when comparing the figure given by BARNARD (1950) of *Lenticulina matutina*, which looks like *Astacolus lituoides*, being "drum-shaped" in the straight portion of the test according to his description.

Astacolus quadricostatus (TERQUEM, 1863) (Pl. VI, figs. 9, 10).

Marginulina quadricostata TERQUEM, 1863, p. 400, pl. 8, figs. 12a, b.
Cristellaria nexa TERQUEM & BERTHELIN, 1875, p. 49, pl. 4, figs. 11a, b.
Cristellaria lacunata TERQUEM & BERTHELIN, 1875, p. 50, pl. 4, figs. 14a-b.
Lenticulina (Astacolus) neoradiata NEUWEILER, 1959, p. 430, pl. 1, figs. 1–5.
Marginulinopsis quadricostata (TERQUEM) – BIZON, 1960, p. 7, pl. 2, figs. 4a, b. pl. 4, fig. 18.

Some of the specimens determined as *A. quadricostatus* in our material belong to *Astacolus pulchrus* (TERQUEM 1866) as figured and described by BIZON (1960, p. 6, pl. 2, figs. 1a, b, pl. 4, fig. 3). However, the two species are difficult to separate.

Astacolus speciosus (TERQUEM, 1858).

Cristellaria speciosa TERQUEM, 1858, p. 624, pl. 4, figs. 2a-d.
Marginulina speciosa (TERQUEM) – BIZON, 1960, p. 8, pl. 2, figs. 2a, b, pl. 4, fig. 11.

FRANKE, BARTENSTEIN & BRAND, MACFADYEN, and others, mentioned this species under the name *quadricostata*, according to BIZON.

Astacolus stillus (TERQUEM, 1866) (Pl. VI. fig. 26, Pl. VII, figs. 1, 2).
Cristellaria stilla TERQUEM, 1866, p. 517, pl. 22, fig. 7.
Planularia stilla (TERQUEM) – NØRVANG, 1957, p. 379, figs. 136–147.

Astacolus undulatus (TERQUEM, 1858) (Pl. VI, fig. 11).
Marginulina undulata TERQUEM, 1858, p. 610, pl. 3, figs. 2a, b.
Marginulina radiata TERQUEM, 1863, p. 410, pl. 9, figs. 10a, b.
Marginulina undulata TERQUEM – BARNARD, 1950, p. 372, fig. 5f.
Marginulina radiata (TERQUEM) – BIZON, 1960, p. 7, pl. 2, figs. 3a, b, pl. 4, figs. 17a, b.

Citharina clathrata (TERQUEM, 1863) (Pl. II, figs. 11–14).
Marginulina longuemari var. *clathrata* TERQUEM, 1863, p. 192, pl. 8, figs. 16, 19a, b.
Vaginulina clathrata (TERQUEM) – BARNARD, 1950a, p. 29, pl. 5, figs. 8–10, text fig. 17.

This species belongs to a large group of strongly ribbed *Citharina* species, which appeared for the first time in the Toarcian, and probably disappeared in the Lower Cretaceous. PAYARD (1947) set up a number of new species and varieties, but the criteria for distinguishing them have not been put on a statistical basis, which makes a determination very difficult. The variability of the morphological forms even within one alleged species, is already exasperating, as is shown by a comparison of the original figure given by TERQUEM of *Marginulina longuemari* var. *clathrata* with those of *Vaginulina clathrata* by BARNARD and *Pseudocitharina longuemari* var. *clathrata* by PAYARD (1947, pl. 4, fig. 1).

Until the morphological differences are investigated statistically, we would therefore prefer to consider the following species to belong to this group:

Marginulina longuemari TERQUEM 1863.
Marginulina longuemari var. *angusta* TERQUEM 1866.
Marginulina longuemari var. *gradata* TERQUEM 1863.
Marginulina longuemari var. *vagina* TERQUEM 1863.
Pseudocitharina dorso ventrocarinata PAYARD 1947.
Pseudocitharina enigmatica PAYARD 1947.
Pseudocitharina fallax PAYARD 1947.
Pseudocitharina fasciata PAYARD 1947.
Pseudocitharina fasciata subsp. *pictavensis* PAYARD 1950. (new name for: var. *aalense* PAYARD 1947).
Pseudocitharina gillardi PAYARD 1947.
Pseudocitharina gradata PAYARD 1947.
Pseudocitharina inversa PAYARD 1947.
Pseudocitharina longuemari var. *aalense* PAYARD 1947.
Pseudocitharina longuemari var. *cordata* PAYARD 1947.
Pseudocitharina mariei PAYARD 1947.
Pseudocitharina proxima var. *compressa* PAYARD 1947.

Pseudocitharina proxima var. *conica* PAYARD 1947.
Pseudocitharina proxima var. *cylindrica* PAYARD 1947.
Pseudocitharina proxima var. *dorsocarinata* PAYARD 1947.
Pseudocitharina proxima var. *intercostata* PAYARD 1947.
Pseudocitharina subaequilateralis var. *asymetrica* PAYARD 1947.
Pseudocitharina subaequilateralis var. *typica* PAYARD 1947.
Pseudocitharina toarcense PAYARD 1947.
Pseudocitharina tricosta PAYARD 1947.
Pseudocitharina welschi PAYARD 1947.

Citharina clausa (TERQUEM, 1868) (Pl. II, fig. 15).
Marginulina clausa TERQUEM, 1868, p. 91, pl. 5, figs. 1a, b, 2.
Citharina clausa (TERQUEM) – BARNARD, 1950a, p. 15.

Citharina colliezi (TERQUEM, 1866) (Pl. II, fig. 16).
Marginulina colliezi TERQUEM, 1866, p. 430, pl. 17, figs. 10a-c.
Marginulina flabelloides TERQUEM, 1868, p. 102, pl. 6, figs. 1a-b.
Marginulina condita TERQUEM, 1868, p. 92, pl. 5, figs. 5a, b.
Vaginulina flabelloides (TERQUEM) – BARTENSTEIN & BRAND, 1937, p. 164, pl. 6, fig. 27, etc.
Pseudocitharina colliezi (TERQUEM) – PAYARD, 1947, pl. 3, figs. 1–7.
Citharina colliezi (TERQUEM) – BARNARD, 1950a, p. 14, pl. 3, fig. 1.

This species, which occurs regularly in the Toarcian-L. Aalenian, belongs to a group of species with a variable ornamentation, though all have the same morphological outline. This group occurred from the Upper Lias to the Lower Cretaceous, and perhaps even in more recent times. A quantitative statistical investigation would be of interest for time-stratigraphical purposes.

Citharina inaequistriata (TERQUEM, 1863) (Pl. VI, figs. 20, 21).
Marginulina inaequistriata TERQUEM, 1863, p. 401, pl. 8, figs. 15a-f.
Marginulina cancellaroides TERQUEM, 1866, p. 508, pl. 21, figs. 8c, d, g.
Cristellaria pikettyi TERQUEM, 1866, p. 511, pl. 21, figs. 31, 32.
Planularia inaequistriata (TERQUEM) – BARNARD, 1950, p. 375, figs. 8c, d, g.
Planularia inaequistriata (TERQUEM) – BIZON, 1960, p. 5, pl. 1, fig. 5, pl. 4, fig. 4.

Closely related to this species is *Citharina ornata* (TERQUEM, 1858) which, according to BIZON (1960), is a younger form with regular fine striae, developed from *C. inaequistriata*, which has well-developed irregular striae, as the name indicates. In our material *C. inaequistriata* is well-represented in Hettangian and Sinemurian. The younger *C. ornata* has been found only occasionally in the Upper Pliensbachian.

However, the specific differentiation of these citharinids has not yet been settled, as is demonstrated by the species placed by BIZON in synonying with *P. ornata*:

Cristellaria cordiformis TERQUEM 1863.
Cristellaria eugenii TERQUEM 1863.
Cristellaria intermedia TERQUEM 1862.
Cristellaria ligata TERQUEM 1866.
Cristellaria nucleata TERQUEM 1863.
Cristellaria ornata TERQUEM 1858.
Cristellaria plebeia TERQUEM 1866.
Cristellaria securiformis TERQUEM 1866.
Cristellaria striatula TERQUEM 1866, while *Cristellaria suturalis* TERQUEM 1866 is considered by BIZON as an intermediate between *C. inaequistriata* and *C. ornata*.

Dentalina gladiiformis FRANKE, 1936 (Pl. II, fig. 17).
Dentalina gladiiformis FRANKE, 1936, p. 30, pl. 2, figs. 22a-b.

Dentalina häusleri SCHICK, 1903 (Pl. II, fig. 18).
Dentalina varians TERQUEM 1866, p. 411, pl. 15, fig. 19a (only).
Dentalina häusleri SCHICK – BARTENSTEIN & BRAND, 1937, p. 141, pl. 3, fig. 12.
Dentalina häusleri SCHICK – BARNARD, 1950, p. 362, fig. 5j.
BIZON (1960) investigated the type specimens and came to the conclusion that the ribbed form should be named *Dentalina varians* TERQUEM 1866; BARNARD assigned the name *varians* only to the smooth forms. TERQUEM'S original figures represent both the smooth and ribbed forms. In our material this species is practically restricted to the U. Sinemurian.

Dentalina langi BARNARD, 1950 (Pl. II, fig. 19).
Dentalina langi BARNARD, 1950, p. 361, fig. 5e.

Dentalina matutina D'ORBIGNY, 1850, (1849 MS) (Pl. II, figs. 20–24).
Dentalina matutina D'ORBIGNY, 1849, p. 242, no. 259.
Dentalina primaeva D'ORBIGNY, 1849, p. 242, no. 260.
Dentalina claviformis TERQUEM, 1866, p. 490, pl. 20, figs. 4a, b.
Dentalina matutina D'ORBIGNY – BARNARD, 1950, p. 359, fig. 5d.
Dentalina matutina D'ORBIGNY – DREXLER, 1958, p. 493, pl. 20, fig. 10.
Dentalina primaeva D'ORBIGNY – DREXLER, 1958, p. 493, pl. 20, fig. 11.
The figure given by BARNARD is different from those by NØRVANG (1957), but approaches D'ORBIGNY'S figure better. Probably this species belongs to a group of closely related the following species to which also belong:

Dentalina fasciata TERQUEM 1866.
Dentalina gyrosa TERQUEM 1866.
Dentalina lamellosa TERQUEM 1866.
Dentalina multicostata TERQUEM 1866.
Dentalina octoplicata TERQUEM 1866.
Dentalina paucicosta TERQUEM 1866.
Dentalina renati TERQUEM 1866.

Dentalina sculpta TERQUEM 1866.
Dentalina virgata TERQUEM 1866.
Dentalina matutina multicostata NEUWEILER 1959 (new name for *D. multicostata* TERQUEM 1866, not D'ORBIGNY 1840).
Dentalina matutina waaseri HAGENMEYER 1959 (new name for *D. fasciata* TERQUEM 1866, not SEGUENZA 1862).

Forms belonging to this group show in the present material a maximum occurrence in the U. Sinemurian.

Dentalina parasimplex (HAGENMEYER, 1959) (Pl. II, figs. 25, 26).
Vaginulina simplex TERQUEM, 1863, p. 394, pl. 8, figs. 1a, b (not *Marginulina* simplex KARRER 1862).
Marginulina parasimplex HAGENMEYER, in BACH, HAGENMEYER & NEUWEILER, 1959, p. 434.
We would prefer to put this species in the genus *Dentalina*.

Dentalina sublinearis FRANKE, 1936.
Dentalina sublinearis FRANKE, 1936, p. 31, pl. 2, fig. 24.

Dentalina tenuistriata TERQUEM, 1866 (Pl. II, fig. 27).
Dentalina tenuistriata TERQUEM, 1866, p. 405, pl. 15, figs. 5a-c.
Dentalina tenuistriata TERQUEM – BIZON, 1960, p. 9, pl. 3, fig. 2, pl. 4. fig. 14.

Dentalina terquemi D'ORBIGNY, 1850 (1849 MS) (Pl. III, figs. 1–3).
Dentalina terquemi D'ORBIGNY, 1849, p. 242, no. 257.
Vaginulina hausmanni BORNEMANN, 1854, p. 38, pl. 3, figs. 25a, b.
Dentalina terquemi D'ORBIGNY – BARNARD, 1950, p. 363, fig. 1f.
This peculiar species is characterised by an initial end of drum-shaped chambers, later followed by elongated constricted chambers (BARNARD, 1950). Occurs regularly in the Sinemurian-Aalenian, a maximum in the Upper Pliensbachian. Specimens of *Dentalina obscura* TERQUEM 1858 (BIZON, 1960, p. 8, pl. 2, fig. 7, pl. 4, fig. 5), which is very close to the present species, are included.

Dentalina vetustissima D'ORBIGNY, 1850 (1849 MS) (Pl. II, fig. 28).
Dentalina vetustissima D'ORBIGNY, 1849, p. 242, no. 261.
Dentalina vetustissima D'ORBIGNY – MACFADYEN, 1936, p. 150, pl. 1, fig. 261.

Dentalina sp. A (Pl. II, fig. 29).

Dentalina sp. B (Pl. II, fig. 30).

Flabellinella crassecostata BACH, 1959 (Pl. VI, fig. 17).
Flabellinella crassecostata BACH, in BACH, HAGENMEYER & NEUWEILER, 1959, p. 446, text pl. 1, figs. 8a, b, pl. 21, figs. 11a, b.

Frondicularia bicostata D'ORBIGNY, 1850 (1849 MS) (Pl. V, figs. 2–23, pl. VI, figs. 1, 2).

Frondicularia bicostata D'ORBIGNY, 1849, p. 242, no. 256.
Frondicularia terquemi D'ORBIGNY, 1849, p. 241, no. 255.
Frondicularia sulcata BORNEMANN, 1854, p. 37, pl. 3, figs. 22a-c.
Frondicularia dubia BORNEMANN, 1854, p. 37, pl. 3, figs. 23a-c.
Frondicularia pulchra TERQUEM, 1858, p. 32, pl. 1, figs. 10a-c.
Frondicularia quadricosta TERQUEM, 1863, p. 379, pl. 7.
Frondicularia mesoliassica BRAND, in BARTENSTEIN & BRAND, 1937, p. 158, text fig. 16, pl. 4, fig. 66.
Frondicularia sulcata plexus, BARNARD, 1957, pl. 174, pl. 1.
Spandelina bicostata subsp. *sulcata* BORNEMANN – NØRVANG, 1957, p. 341, figs. 56–59.
Spandelina bicostata subsp. *dubia* BORNEMANN – NØRVANG, 1957, p. 344, figs. 60, 61, 65.
Spandelina bicostata subsp. *baueri* BURBACH – NØRVANG, 1937, p. 346, fig. 66.
Spandelina bicostata subsp. *bicostata* D'ORBIGNY – NØRVANG, 1937, p. 347, figs. 62–64, 67, 68.
Spandelina bicostata subsp. *terquemi* D'ORBIGNY – NØRVANG, 1937, p. 349, fig. 69.
Frondicularia baueri BURBACH, 1886, p. 52, pl. 2, figs. 48–52.
Frondicularia delirata CRICK & SHERBORN, 1891, p. 214, pl. 6, fig. 37.

NØRVANG considered the majority of the above-mentioned species to belong to one group, the *Spandelina bicostata* group, with the subspecies *sulcata*, *dubia*, *baueri*, *bicostata* and *terquemi*. BARNARD at the same time studied the same group, and distinguished forms A-K within what he refers to as the *Frondicularia sulcata* plexus. In a later publication, RABITZ (1963) more or less follows the division in subspecies given by NØRVANG, thereby combining *baueri* with the subspecies *dubia* and separating a subspecies *pulchra*. The stratigraphical ranges given by NØRVANG and BARNARD for the various subspecies do not cover each other in all details.

The figures given on Plates V and VI may give an impression of the complexity of this group. The subspecies *sulcata* can be found on Pl. V, fig. 10, *dubia* on Pl. V, fig. 22, *baueri* on Pl. VI, fig. 2, *bicostata* on Pl. V, fig. 2 and *terquemi* on Pl. VI, fig. 1. *Frondicularia mesoliassica*, probably belonging to form K of BARNARD, is given on Pl. V, fig. 7.

Frondicularia brizaeformis BORNEMANN, 1854 (Pl. IV, fig. 42, V, 1).

Frondicularia brizaeformis BORNEMANN, 1854, p. 36, pl. 3. figs. 17a-d, 18a-c, 20a, b.
Frondicularia intumescens BORNEMANN, 1854, p. 36, pl. 3, figs. 19a-c.
Frondicularia major BORNEMANN, 1854, p. 36, pl. 3, figs. 21a-c.
Frondicularia nitida TERQUEM, 1858, p. 32, pl. 1, figs. 9a-c.

Frondicularia impressa TERQUEM, 1863, p. 379, pl. 7, figs. 21a-d.
Frondicularia sacculus TERQUEM, 1866, p. 482, pl. 19, figs. 20a, b.
Frondicularia elliptica BURBACH, 1886, p. 48, pl. 1, fig. 21–26; pl. 2, fig. 37.
Frondicularia lata BURBACH, 1886, p. 48, pl. 1, fig. 27, 28, 30–32.
Frondicularia carinata BURBACH, 1886, p. 47, pl. 1, fig. 17–20, 29.
Frondicularia securiformis BURBACH, 1886, p. 56, pl. 1, fig. 10, 11.
Frondicularia intumescens BORNEMANN – BARTENSTEIN & BRAND, 1937, p. 153, pl. 4, fig. 45.
Frondicularia nitida TERQUEM – BARTENSTEIN & BRAND, 1937, p. 153, pl. 4, fig. 45.
Frondicularia major BORNEMANN – BARTENSTEIN & BRAND, 1937, p. 155, pl. 5, fig. 68.
Frondicularia brizaeformis BORNEMANN – BARNARD, 1957, p. 171, text. figs. 1A-F, 2A-F.
Plectofrondicularia brizaeformis (BORNEMANN) – RABITZ, 1963, p. 215, pl. 17, fig. 26–27.
Frondicularia intumescens BORNEMANN – RABITZ, 1963, p. 207, pl. 17, fig. 21.
Frondicularia major elliptica BURBACH – RABITZ, 1963, p. 208, pl. 17, fig. 19.
Frondicularia major lata BURBACH – RABITZ, 1963, p. 209, pl. 17, fig. 20.
Frondicularia major major BORNEMANN – RABITZ, 1963, p. 209, pl. 17, fig. 18.
Frondicularia nitida TERQUEM – RABITZ, 1963, p. 210.
Frondicularia securiformis BURBACH – RABITZ, 1963, p. 210.

According to BARNARD (1957) the morphological varieties of this species seem to have no stratigraphical significance in the Lower Lias. In our material the species is present throughout the Lias.

Frondicularia involuta TERQUEM, 1866 (Pl. VI, figs. 3, 4).
Frondicularia involuta TERQUEM, 1866, p. 403, pl. 15, figs. 3a, b.
Frondicularia lignaria TERQUEM, 1866, p. 480, pl. 19, fig. 14.
Frondicularia varians TERQUEM, 1866, p. 480, pl. 19, fig. 15a, b.
Frondicularia involuta TERQUEM – BARNARD, 1950, p. 13, pl. 2, figs. 8, 9.
"*Frondicularia*" *involuta* TERQUEM – BIZON, 1960, p. 12, pl. 3, figs. 6a-c, pl. 4, fig. 16.

Lagena aphela TAPPAN, 1955 (Pl. IV, figs. 16, 17).
Lagena globosa (MONTAGU) – BARTENSTEIN & BRAND, 1937, p. 165, pl. 4, fig. 68, etc.
Lagena aphela TAPPAN, 1955, p. 82, pl. 28, figs. 13, 14.

A few specimens have been found in the Upper Pliensbachian of Grube Friederike; the species is not mentioned on the range chart.

Lagena ovata (TERQUEM, 1858) (Pl. IV, figs. 18, 19).
Oolina ovata TERQUEM, 1858, p. 586, pl. 1, figs. 2a-c.
Lagena ovata (TERQUEM) – FRANKE, 1936, p. 90, pl. 9, fig. 5.
A few specimens have been found in the Upper Pliensbachian of Grube Friederike. Not mentioned on the range chart.

Lenticulina bochardi (TERQUEM, 1863) (Pl. VII, fig. 4).
Cristellaria bochardi TERQUEM, 1863, p. 419, pl. 10, figs. 3a-c.
Lenticulina bochardi (TERQUEM) – BIZON, 1960, p. 5, pl. 1, figs. 4a, b.
Forms assigned to *Lenticulina muensteri* by authors are included in our material (see also *Lenticulina varians*).

Lenticulina d'orbignyi (ROEMER, 1839) (Pl. VII, figs. 5, 6).
Peneroplis d'Orbignii ROEMER, 1839.
Cristellaria (*Astacolus*) *d'orbignyi* var. *elongata* FRANKE, 1936, p. 110, pl. 11, fig. 6.
Cristellaria (*Lenticulina*) *d'orbignyi* (ROEMER) – BARTENSTEIN & BRAND, 1937, p. 178, pl. 6, figs. 37a-c, pl. 9, figs. 56a-d.

Lenticulina gottingensis (BORNEMANN, 1854) (Pl. VII, figs. 7, 8).
Robulina gottingensis BORNEMANN, 1854, p. 43, pl. 4, figs. 40, 41a, b.
Lenticulina gottingensis (BORNEMANN) – NØRVANG, 1957, p. 382, figs. 153–170.

Lenticulina polygonata FRANKE, 1936 (Pl. VII, fig. 9).
Cristellaria (*Lenticulina*) *polygonata* FRANKE, 1936, p. 118, pl. 12, figs. 1a, b, 2a, b.
Lenticulina polygonata FRANKE – NØRVANG, 1957, p. 383, fig. 179.

Lenticulina varians (BORNEMANN, 1854) (Pl. VII, figs. 10–17).
Cristellaria varians BORNEMANN, 1854, p. 41, pl. 4, figs. 32–34.
Cristellaria minuta BORNEMANN, 1854, p. 42, pl. 4, figs. 37a, b.
Cristellaria major BORNEMANN, 1854, p. 40, pl. 4, figs. 31a, b.
Cristellaria convoluta BORNEMANN, 1854, p. 42, pl. 4, figs. 38a, b.
Cristellaria deformis BORNEMANN, 1854, p. 41, pl. 4, figs. 35a, b. (not KARRER, 1867).
Cristellaria granulata BORNEMANN, 1854, p. 41, pl. 4, figs. 36a, b.
Cristellaria impleta TERQUEM & BERTHELIN, 1875, p. 50, pl. 4, figs. 13a-f (not SCHWAGER, 1865).
Cristellaria impressa TERQUEM & BERTHELIN, 1875, p. 46, pl. 4, figs. 3a, b, 4a-d, 5a, b, 6a, b, 7a, b (not REUSS, 1862).
Cristellaria acuminata TERQUEM, 1863, p. 420, pl. 10, figs. 5a, b.
Cristellaria (*Astacolus*) *adunca* FRANKE, 1936, p. 103, pl. 10, fig. 16.
Cristellaria (*Astacolus*) *dubia* FRANKE, 1936, p. 107, pl. 10, fig. 17.
Cristellaria (*Lenticulina*) *varians* BORNEMANN var. *recta* FRANKE, 1936, p. 113, pl. 11, fig. 12.
Astacolus varians (BORNEMANN) – NØRVANG, 1957, p. 3 7 figs. 123–134.
NØRVANG's figures closely resemble those of *C. varians* of BORNEMANN.

This probably is the true *varians*, the more so as it is described from Lower Liassic deposits of Göttingen. The species has flush sutures, which is confirmed by RABITZ (1963), who investigated BORNEMANN's types. However, *Lenticulina varians* of authors also includes a species with elevated sutures (see Pl. VII, figs. 12–17), occurring abundantly in the Toarcian-Aalenian. The following literature references apply to this species:

Cristellaria (Lenticulina) varians (BORNEMANN) – BARTENSTEIN & BRAND, 1937, p. 176, pl. 9, figs. 53a-b (only).

Lenticulina varians (BORNEMANN) – BARNARD, 1950a, p. 8, pl. 2, figs. 3–6, text fig. 2.

Our specimens comply with the extensive description given by BARNARD, and include the flabelline growth-forms. Thus the species figured by NØRVANG (1957) as *Astacolus varians* (=*Cristellaria varians* BORNEMANN 1854) is clearly different from the forms described as *Lenticulina varians* (=*Cristellaria varians* BORNEMANN 1854) by BARNARD (1950a), although the latter species may have evolved from the former.

Cristellaria subalata REUSS 1854 (originally described from the Turonian-Senonian of Gosau (Salzburg), as figured by BARTENSTEIN & BRAND (1937), is included in this species. Probably this species with elevated sutures is identical to *Lenticulina bochardi* of French authors.

Marginulina hamus TERQUEM, 1866 (Pl. IV, fig. 6).

Marginulina hamus TERQUEM, 1866, p. 501, pl. 21, figs. 8a, b.

Marginulina (Saracenaria) hamus TERQUEM – BARNARD, 1950, p. 372, fig. 5h.

Marginulina (Saracenaria) hamus TERQUEM – DREXLER, 1958, p. 492, pl. 20, fig. 7.

This species has thus far been found only in the Hettangian-L. Sinemurian.

Marginulina obliquecostulata HAGENMEYER, 1959, (Pl. IV, fig. 7).

Marginulina obliquecostulata HAGENMEYER, in BACH, HAGENMEYER & NEUWEILER, 1959, p. 434, pl. 21, figs. 9a, b.

This species too has only been found in the Hettangian-L. Sinemurian.

Marginulina prima D'ORBIGNY, 1850 (1849 MS) (Pl. IV, figs. 8–15).

Marginulina prima D'ORBIGNY, 1849, p. 242, no. 262.

Marginulina rugosa BORNEMANN, 1854, p. 39, pl. 3, figs. 26a, b.

Marginulina alata TERQUEM, 1858, p. 615, pl. 3, figs. 9a, b.

Marginulina ornata TERQUEM, 1858, p. 616, pl. 3, figs. 10a-c.

Marginulina prima var. *acuta* TERQUEM, 1858, p. 614, pl. 3, fig. 7.

Marginulina prima var. *recta* TERQUEM, 1858, p. 613, pl. 3, fig. 6.

Marginulina prima var. *gibbosa* TERQUEM, 1858, p. 612, pl. 3, figs. 5a, b.

Marginulina spinata TERQUEM, 1858, p. 615, pl. 3, fig. 8.

Marginulina burgundiae TERQUEM, 1863, p. 406, pl. 9, figs. 3a-d.

Marginulina interrupta TERQUEM, 1866, p. 426, pl. 17, figs. 4a-c. (not STACHE, 1864).

Marginulina prima var. *praelonga* TERQUEM & BERTHELIN, 1875, p. 54, pl. 4, fig. 18.
Marginulina gibberula TERQUEM & BERTHELIN, 1875, p. 55, pl. 4, figs. 21a, b.
Marginulina crassiuscula TERQUEM & BERTHELIN, 1875, p. 56, pl. 4, figs. 23a-c.
Marginulina burgundiae TERQUEM var. *psilonoti* ISSLER, 1908, p. 68, figs. 175, 176.
Dentalina insignis FRANKE, 1936, p. 36, pl. 3, figs. 11a, b.
Marginulina incisa FRANKE, 1936, p. 78, pl. 8, figs. 11, 12.
Marginulina prima D'ORBIGNY – NØRVANG, 1957, p. 365.
Marginulina prima form *burgundiae* TERQUEM – NØRVANG, 1957, p. 366, figs. 100–102.
Marginulina prima subsp. *prima* D'ORBIGNY – NØRVANG, 1957, p. 367, figs. 98, 99, 103, 104.
Marginulina prima subsp. *praerugosa* NØRVANG, 1957, p. 369, fig. 96.
Marginulina prima subsp. *spinata* TERQUEM – NØRVANG, 1957, p. 370.

A detailed description of this species is given by NØRVANG, who considers it as a part of his *Marginulina radiata* supergroup. In the most primitive forms the costae continue towards the aperture (*prima praerugosa*, see Pl. IV, fig. 8); in the most advanced forms the costae end up against a sort of roof, in which the aperture is present (*prima*, see Pl. IV, fig. 14). This trend was confirmed in the material studied. Some sort of differential diagnosis of *Marginulina prima* from the Upper Lias has been published by ADAMS (1957).

Neoflabellina deslongchampsi (TERQUEM, 1863) (Pl. VI, fig. 18).
Flabellina deslongchampsi TERQUEM, 1863, p. 426, pl. 10, fig. 13.
Flabellina jurensis FRANKE, 1936, p. 92, pl. 9, fig. 13.
Flabellina deslongchampsi TERQUEM – BARTENSTEIN & BRAND, 1937, p. 168, pl. 6, figs. 28a-d, etc.
Neoflabellina deslongchampsi (TERQUEM) – BARNARD, 1951, fig. B 1.

Palmula tenuistriata (FRANKE, 1936) (Pl. VI, fig. 19).
Flabellina tenuistriata FRANKE, 1936, p. 93, pl. 9, fig. 17.
Falsopalmula tenuistriata (FRANKE) – BARTENSTEIN, 1947, p. pl. 1, fig. 1–5.

The specimens show a pitted surface like *Planularia dictyodes* (DEECKE 1884) as figured by BARTENSTEIN & BRAND (1937, text fig. 17).

Saracenaria sublaevis FRANKE, 1936 (Pl. VI, fig. 16).
Cristellaria (Saracenaria) sublaevis FRANKE, 1936, p. 98, pl. 9, figs. 30, 31.
Saracenaria sublaevis FRANKE – NØRVANG, 1957, p. 381, fig. 151.

Saracenaria trigona (TERQUEM, 1866) (Pl. VI, figs. 12–15).
Marginulina trigona TERQUEM, 1866, p. 435, pl. 18, figs. 1a-d.
Saracenella trigona (TERQUEM) – FRANKE, 1936, p. 87, pl. 7, fig. 14.

Vaginulina listi (BORNEMANN, 1854) (Pl. III, figs. 19–24).
Cristellaria listi BORNEMANN, 1854, p. 40, pl. 4, figs. 28a-c.
Marginulina incurva TERQUEM, 1863, p. 398, pl. 8, figs. 9a-d.
Vaginulina listi (BORNEMANN) – NØRVANG, 1957, p. 370, fig. 119.
Some specimens come very close to *Marginulina trilobata* D'ORBIGNY 1840, described from the Cretaceous of France.

Vaginulina sagittiformis (TERQUEM, 1868) (Pl. IV, fig. 1).
Marginulina sagittiformis TERQUEM, 1868, p. 76, pl. 3, figs. 1a-c.
Vaginulina sagittiformis (TERQUEM) – FRANKE, 1936, p. 86, pl. 8, figs. 37, 38.

Lingulina esseyana DEECKE, 1886.
Lingulina esseyana DEECKE, 1886.
Lingulina ovalis TERQUEM & BERTHELIN, 1875, p. 23, pl. 1, figs. 27a, b (not SCHWAGER, 1865).
Lingulina ovalis TERQUEM & BERTHELIN – BARNARD, 1950, p. 28, pl. 1, fig. 5.
Lingulina esseyana DEECKE – BARNARD, 1956, p. 271, pl. 1, figs. 3a, b, 4.

Lingulina tenera BORNEMANN, 1854 (Pl. IV, figs. 20–41).
Lingulina tenera BORNEMANN, 1854, p. 38, pl. 3, figs. 24a-c.
Marginulina interlineata TERQUEM, 1858, p. 617, pl. 3, figs. 11a, b.
Frondicularia hexagona TERQUEM, 1858, p. 594, pl. 1, figs. 13a-c.
Marginulina collenoti TERQUEM, 1866, p. 424, pl. 17, figs. 1a-d.
Marginulina pupa TERQUEM, 1866, p. 429, pl. 17, figs. 7a-f.
Lingulina striata TATE & BLAKE, 1876, p. 455, pl. 18, figs. 16, 16a.
Frondicularia occidentalis BERTHELIN, 1879, p. 34, pl. 1, figs. 9–11.
Frondicularia pygmaea FRANKE, 1936, p. 70, pl. 7, fig. 5.
Nodosaria subprismatica FRANKE, 1936, p. 48, pl. 4, fig. 17.
Frondicularia tenera var. *octocosta* BRAND, in BARTENSTEIN & BRAND, 1937, p. 157, text fig. 15c, pl. 3, fig. 27.
Frondicularia tenera var. *prismatica* BRAND, in BARTENSTEIN & BRAND, 1937, p. 156, text fig. 15a, pl. 3, figs. 34a-c.
Lingulina tenera plexus, BARNARD, 1956, p. 274, pl. 1, figs. 1–2, 9a-b, 10a-b, pl. 2, pl. 3.
Geinitzina tenera subsp. *striata* (TATE & BLAKE) – NØRVANG, 1957, p. 332, figs. 1, 2.
Geinitzina tenera subsp. *substriata* NØRVANG, 1957, p. 333, figs. 3–10.
Geinitzina tenera subsp. *tenuistriata* NØRVANG, 1957, p. 334, figs. 13, 16, 17, 24.
Geinitzina tenera subsp. *subprismatica* (FRANKE) – NØRVANG, 1957, p. 335, figs. 11, 12, 14, 15.
Geinitzina tenera subsp. *tenera* (BORNEMANN) – NØRVANG, 1957, p. 336, figs. 18–23.
Geinitzina tenera subsp. *pupoides* NØRVANG, 1957, p. 338, figs. 25–29.

Geinitzina tenera subsp. *praepupa* NØRVANG, 1957, p. 338, figs. 30–31.
Geinitzina tenera subsp. *pupa* (TERQUEM) – NØRVANG, 1957, p. 339, figs. 32–45.
Geinitzina tenera subsp. *carinata* NØRVANG, 1957, p. 340, figs. 46–55.

BARNARD and NØRVANG studied this species in some detail, although not on a quantitative basis, and arrived at certain conclusions regarding the vertical distribution of the morphological forms. We tried to apply these results but met with difficulties in distinguishing the varieties and subspecies used by the two authors for the simple reason that all forms appear to intergrade. Generally speaking, however, there are two extreme forms, the smooth *tenera tenera* (Pl. IV, figs. 29, 30) and the costate *tenera pupa* (Pl. IV, figs. 40, 41). BARNARD arrives at the conclusion "that the root stock went through the full time-range of the plexus almost unchanged, and that the variant neither persisted for long nor apparently gave rise to any new, persistent, well-established species" and supports the suggestion made by MACFADYEN (1941) that the various forms might prove of value for zonal purposes, thereby rejecting his former idea (BARNARD, 1950) that the differences in range for the varieties arise from the fact that the variation is due to different environments. In our material, *tenera tenera* is the major element in Hettangian and Sinemurian faunas, *tenera prismatica* (Pl. IV, figs. 26–28) practically restricted to the U. Sinemurian, while *tenera pupa* seems to have had its major distribution in the Lower Pliensbachian.

Family: POLYMORPHINIDAE D'ORBIGNY, 1839.

Eoguttulina liassica (STRICKLAND 1846) (Pl. VII, figs. 18, 19).
Polymorphina liassica STRICKLAND, 1846, p. 30, fig. b.

This species is very common in the Hettangian-L. Sinemurian, some of the specimens may belong to *Eoguttulina metensis* (TERQUEM 1864).

Bullopora rostrata QUENSTEDT 1858 (Pl. II, fig. 7).
Bullopora rostrata QUENSTEDT, 1858, p. 580, pl. 73, fig. 28.
Bullopora rostrata QUENSTEDT – ADAMS, 1962, p. 157, pl. 24, fig. 4.

Family: BOLIVINITIDAE CUSHMAN 1927.

Brizalina liasica (TERQUEM 1858) (Pl. VII, figs. 20–27).
Textilaria liasica TERQUEM, 1858, p. 634, pl. 4, figs. 12a, b.
Textilaria metensis TERQUEM, 1858, p. 635, pl. 4, figs. 13a, b.
Textilaria angusta TERQUEM, 1866, p. 527, pl. 22, figs. 24a, b.
Textilaria breoni TERQUEM, 1866, p. 450, pl. 18, figs. 10a, b.
Textilaria pikettyi TERQUEM, 1866, p. 527, pl. 22, figs. 23a-c.
Bolivina rhumbleri FRANKE, 1936, p. 126, pl. 12, fig. 21.
Bolivina rhumbleri FRANKE, var. *amalthea* BRAND, in BARTENSTEIN & BRAND, 1937, p. 185, pl. 7, figs. 1a-i, text fig. 2 (part).
"*Bolivina*" *liasica* (TERQUEM) – NØRVANG, 1957, p. 387, fig. 182.
Bolivina liasica (TERQUEM) – BIZON, 1960, p. 14, pl. 4, fig. 6.

According to HOFKER (1957) this species belongs to an evolutionary sequence comprising the Cretaceous *Brizalina textularioides* and *incrassata*, which splits into *Brizalina decurrens* and *B. plaita* var. *limbosa*, and continues into the Tertiary *B. beyrichi* and B. *semistriata*.

Family: SPIRILLINIDAE REUSS, 1862.

Spirillina infima (STRICKLAND, 1846).
Orbis infimus STRICKLAND, 1846, p. 30, fig. a.
Spirillina orbicula TERQUEM & BERTHELIN, 1875, p. 17, pl. 1, figs. 12a-c.
Spirillina infima (STRICKLAND) - BARNARD, 1950, p. 376, fig. 1g.

Spirillina polygyrata GÜMBEL, 1862 (Pl. VII, fig. 28).
Spirillina polygyrata GÜMBEL, 1862, p. 214, pl. 6, figs. 11a-c.
Spirillina polygyrata GÜMBEL - BARTENSTEIN & BRAND, 1937, p. 131, pl. 4, fig. 10, etc.

Conicospirillina pictonica (BERTHELIN, 1879) (Pl. VII, figs. 29, 30).
Placentula pictonica BERTHELIN, 1879, p. 36, pl. 1, figs. 23–25.

Family: INVOLUTINIDAE BÜTSCHLI, 1880.

Involutina liassica (JONES 1853) (Pl. VIII, figs. 8–10).
Nummulites? liassicus JONES, 1853, p. 275.
Involutina jonesi TERQUEM & PIETTE, 1862, p. 461, pl. 6, figs. 22a-c.
Involutina deslongchampsi TERQUEM, 1863, p. 432, pl. 10, figs. 22a-b.
Involutina nodosa TERQUEM, 1886, p. 523, pl. 22, figs. 25a, b.
Involutina petrea TERQUEM, 1866, p. 466, pl. 18, figs. 17a-c.
Problematina cf. *liassica* (JONES) - BARNARD, 1950, p. 378, figs. 10a-c.
Involutina liasina (JONES) - WICHER, 1952, text pl. 4, fig. 2.
This species belongs, according to WICHER (1952) and KRISTAN-TOLLMANN (1963), to an evolutionary line comprising the genera *Involutina* and *Trocholina*, and others. WICHER states: "Trocholinen (bilden) das gemeinsame Element von Bryozoenrasen und Korallenriff und sind für einen ganz bestimmten Biotop charakteristisch, den ich als 'Riffbereich im weitesten Sinne' bezeichnen möchte".

Trocholina umbo FRENTZEN, 1941 (Pl. VIII, figs. 11, 12).
Trocholina umbo FRENTZEN, 1941, p. 306, pl. 1, figs. 12a-c.
Trocholina umbo FRENTZEN - WICHER, 1952, p. 262, text pl. 4, fig. 3.
See also under foregoing species.

Family: CERATOBULIMINIDAE CUSHMAN, 1927.

?Conorboides sp. p. (Pl. VII, figs. 31, 32).
The taxonomic place of this species, which occurs abundantly in the Hettangian-L. Sinemurian, is as yet uncertain. It is badly preserved, has a glassy appearance, and could possibly belong to the genus *Conorboides* HOFKER.

Epistomina liassica BARNARD, 1950 (Pl. VII, figs. 33, 34).
Epistomina liassica BARNARD, 1950, p. 377, figs. 9a-c.

Reinholdella dreheri (BARTENSTEIN 1937) (Pl. VII, figs. 35, 36).
Discorbis dreheri BARTENSTEIN, in BARTENSTEIN & BRAND, 1937, p. 192, pl. 6, figs. 45a, b, pl. 8, figs. 42a-d, pl. 10, figs. 47a-d.

Reinholdella macfadyeni (TEN DAM 1947) emend. HOFKER 1952 (Pl. VIII, figs. 3–7).
Asterigerina macfadyeni TEN DAM, 1947, p. 396, text figs. 1a-c.
Reinholdella macfadyeni (TEN DAM) – HOFKER, 1952, p. 17, text figs. 3–6.

Reinholdella pachyderma HOFKER 1952 (Pl. VII, figs. 1, 2).
Reinholdella pachyderma HOFKER, 1952, pp. 15, 16, text figs. 1, 2.
HOFKER (1954) puts the genus *Reinholdella* in a phylogenetic line comprising, among others, *Reinholdella* (Lias, Dogger) – *Voorthuysenia* (Dogger, Malm, Lower Cretaceous) – *Hoeglundina* (Lower Cretaceous to Recent). *Hoeglundina* occurs at present in sediments of bathyal and abyssal environments, if found in larger quantities. *Reinholdella* might possibly also be indicative of deeper environments, unless the genera migrated from shallower to deeper realms in the course of their development. Possibly "*Epistomina*" *liassica* is one of the earliest members of this sequence. At present HOFKER's classification is subject to extensive discussion by various authors.

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PLATES 1—8

All figures $\times 100$, unless otherwise mentioned.

Plate I

Figs. 1–3 *Ammobaculites fontinensis* (Terquem).
(1) Grube Friederike, U. Pliensbachian, Amaltheenton; (2) idem, U. Sinemurian; (3) Paris Basin, U. Toarcian-L. Aalenian.

4–5 *Ammobaculites vetustus* (Terquem & Berthelin).
(4) Grube Friederike, Aalenian, Opalinuston; (5) Oldenzaal 4, Pliensbachian.

6–9 *Ammodiscus asper* (Terquem).
(6) Grube Friederike, L. Pliensbachian; (7) Paris Basin, U. Toarcian-L-Aalenian; (8, 9) Grube Friederike, U. Pliensbachian, Amaltheenton.

10–11 *Ammodiscus siliceus* (Terquem).
Grube Friederike, U. Pliensbachian, Amaltheenton.

12–13 ?*Psammosphaera metensis* (Terquem).
Grube Friederike, U. Pliensbachian, Amaltheenton.

14–15 *Glomospira pattoni* Tappan
Grube Friederike, U. Pliensbachian, Amaltheenton.

16–17 *Glomospira perplexa* Franke.
Grube Friederike, U. Sinemurian.

18–19 *Haplophragmoides cushmani* Loeblich & Tappan.
Grube Friederike, Aalenian, Opalinuston.

20–21 ?*Saccammina* sp. div.
Paris Basin, U. Pliensbachian.

22 *Tolypammina flagellum* (Terquem).
Paris Basin, U. Toarcian-L. Aalenian.

23 *Thurammina jurensis* Franke.
Grube Friederike, U. Toarcian-L. Aalenian.

24–25 *Trochammina gryci* Tappan.
Grube Friederike, U. Sinemurian.

26–27 *Trochammina sablei* Tappan.
Grube Friederike, Aalenian, Opalinuston. (26) dorsal; (27) ventral.

28–30 *Trochammina topagorukensis* Tappan.
(28) Grube Friederike, U. Sinemurian, dorsal; (29) same specimen, ventral; (30) Grube Friederike, U. Pliensbachian, Amaltheenton.

PLATE I

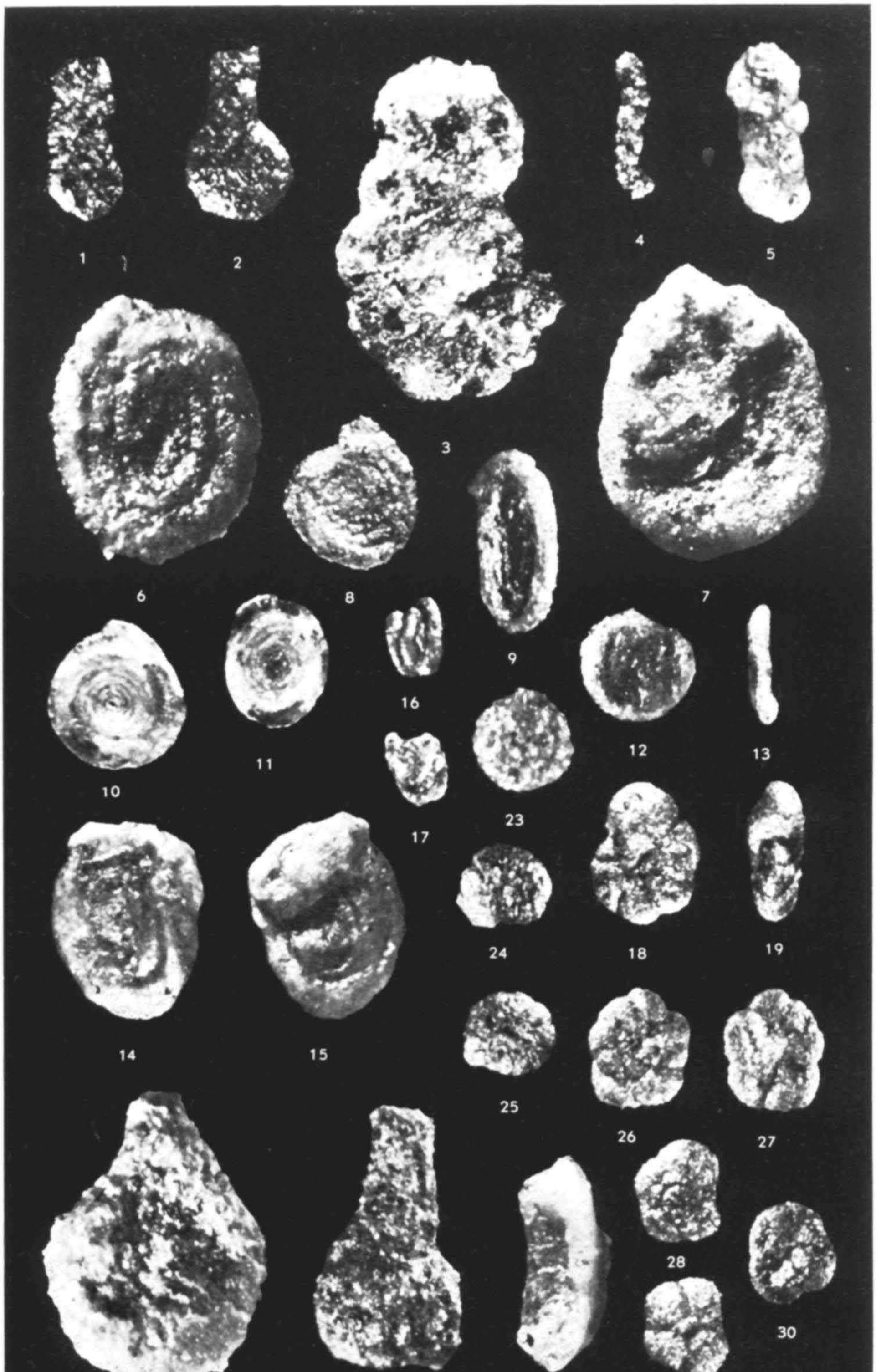
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PLATE II

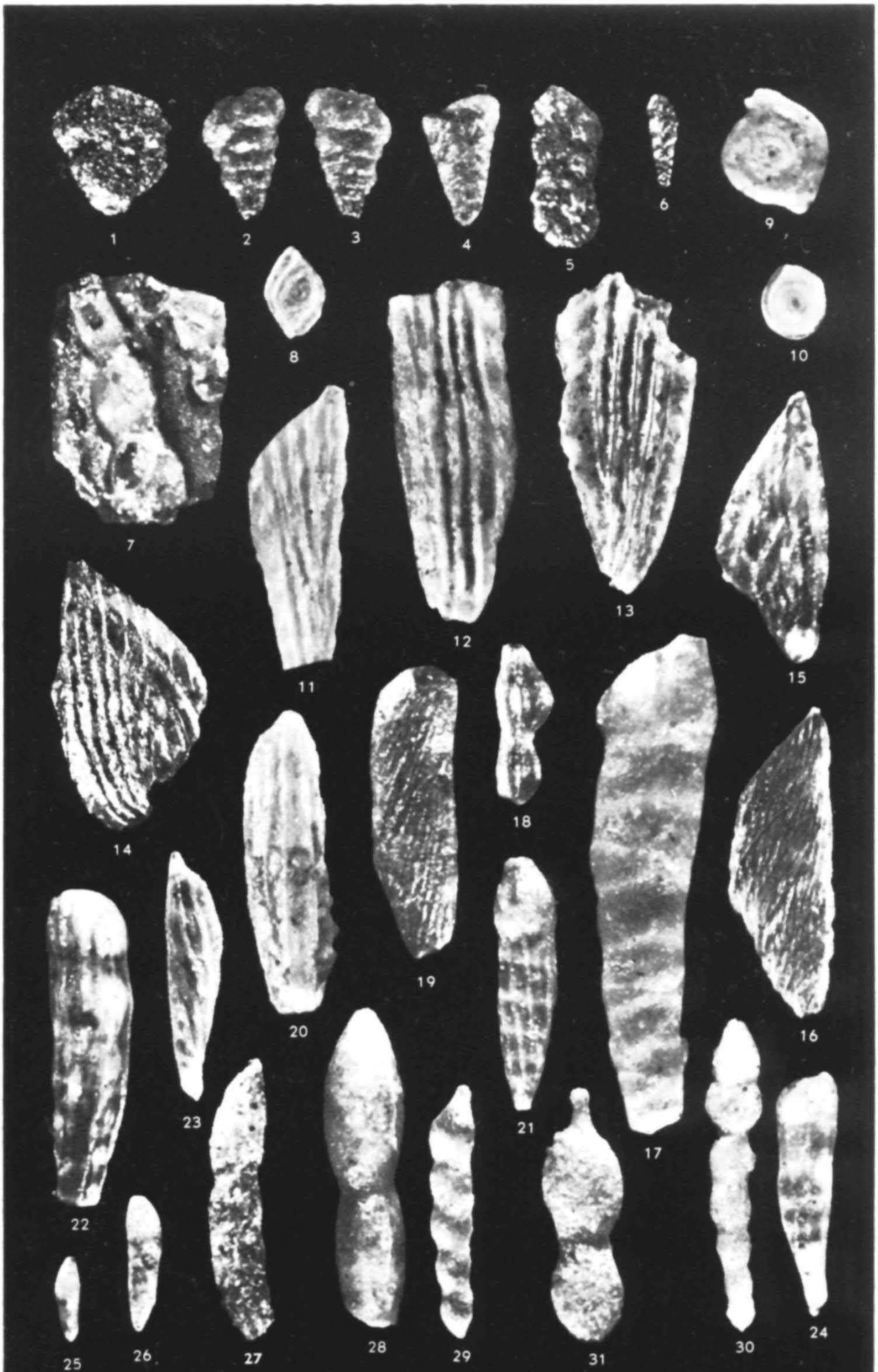
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Plate II

Figs. 1 *?Trochamminoides* sp. nov.
Grube Friederike, U. Pliensbachian, Amaltheenton.

2–4 *Verneuilinoides mauritii* (Terquem).
(2, 3) Grube Friederike, U. Pliensbachian, Amaltheenton; (4) Fontaneilles, L. Pliensbachian, davoei zone.

5 *Spiroplectammina* sp.
Grube Friederike, L. Sinemurian.

6 *Gaudryina* cf. *topagorukensis* Tappan.
Grube Friederike, U. Sinemurian.

7 *Bullopora rostrata* Quenstedt.
Lyme Regis, Hettangian, angulata zone.

8 *Ophthalmidium carinatum* (Kübler & Zwingli).
Oldenzaal 4, L. Pliensbachian.

9–10 *Ophthalmidium orbiculare* Burbach
(9) Schömberg, U. Toarcian-L. Aalenian, Jurensismergel; (10) Grube Friederike, U. Pliensbachian, Amaltheenton.

11–14 *Citharina clathrata* (Terquem).
(11, 12) Paris Basin, M. Toarcian; (13) Lorraine, U. Toarcian, ×56; (14) Grube Friederike, Aalenian, Opalinuston, ×56.

15 *Citharina clausa* (Terquem).
Aubächle, U. Toarcian-L. Aalenian, Jurensismergel.

16 *Citharina colliezi* (Terquem).
Lorraine, U. Toarcian, ×56.

17 *Dentalina gladiiformis* Franke.
Grube Friederike, U. Sinemurian.

18 *Dentalina häusleri* Schick.
Grube Friederike, U. Sinemurian.

19 *Dentalina langi* Barnard.
Aubächle, L. Sinemurian, Arietenschichten.

20–24 *Dentalina matutina* D'Orbigny.
(20, 21) Aubächle. U. Sinemurian, Fossilarme Tone; (22, 24) Grube Friederike, U. Pliensbachian, Amaltheenton; (23) Paris Basin, U. Pliensbachian, ×56.

25–26 *Dentalina parasimplex* (Hagenmeyer).
Grube Friederike, U. Pliensbachian, Amaltheenton.

27 *Dentalina tenuistriata* Terquem.
Paris Basin, U. Pliensbachian.

28 *Dentalina vetustissima* D'Orbigny.
Grube Friederike, U. Pliensbachian, Amaltheenton.

29 *Dentalina* sp. A.
Grube Friederike, L. Sinemurian.

30 *Dentalina* sp. B.
Paris Basin, U. Pliensbachian, ×56.

31 *Nodosaria crispata* Terquem.
Paris Basin, U. Pliensbachian.

Plate III

Figs. 1–3 *Dentalina terquemi* D'Orbigny.
(1) Grube Friederike, U. Pliensbachian, Amaltheenton, ×56; (2) Aubächle, L. Pliensbachian, Numismalismergel, ×56; (3) Aubächle, U. Pliensbachian, Amaltheenton, ×56.

4 *Nodosaria byfieldensis* Barnard.
Fressac, U. Toarcian-L. Aalenian, jurense zone.

5 *Nodosaria claviformis* Terquem.
Grube Friederike, U. Pliensbachian, Amaltheenton.

6–7 *Nodosaria columnaris* Franke.
(6) Paris Basin, U. Pliensbachian; (7) Grube Friederike, U. Sinemurian.

8–9 *Nodosaria dispar* Franke.
(8) Grube Friederike, Aalenian, Opalinuston; (9) idem, L. Sinemurian.

10 *Nodosaria germanica* Franke.
Bettembourg, U. Pliensbachian, spinatus zone, ×56.

11 *Nodosaria globulata* Barnard.
Aubächle, U. Toarcian-L. Aalenian, Jurensismergel.

12 *Nodosaria metensis* Terquem.
Grube Friederike, L. Sinemurian.

13 *Nodosaria oculina* (Terquem & Berthelin).
Grube Friederike, U. Toarcian-L. Aalenian.

14–15 *Nodosaria primitiva* Kübler & Zwingli.
(14) Fontaneilles, U. Pliensbachian, margaritatus zone; (15) Grube Friederike, Aalenian, Opalinuston.

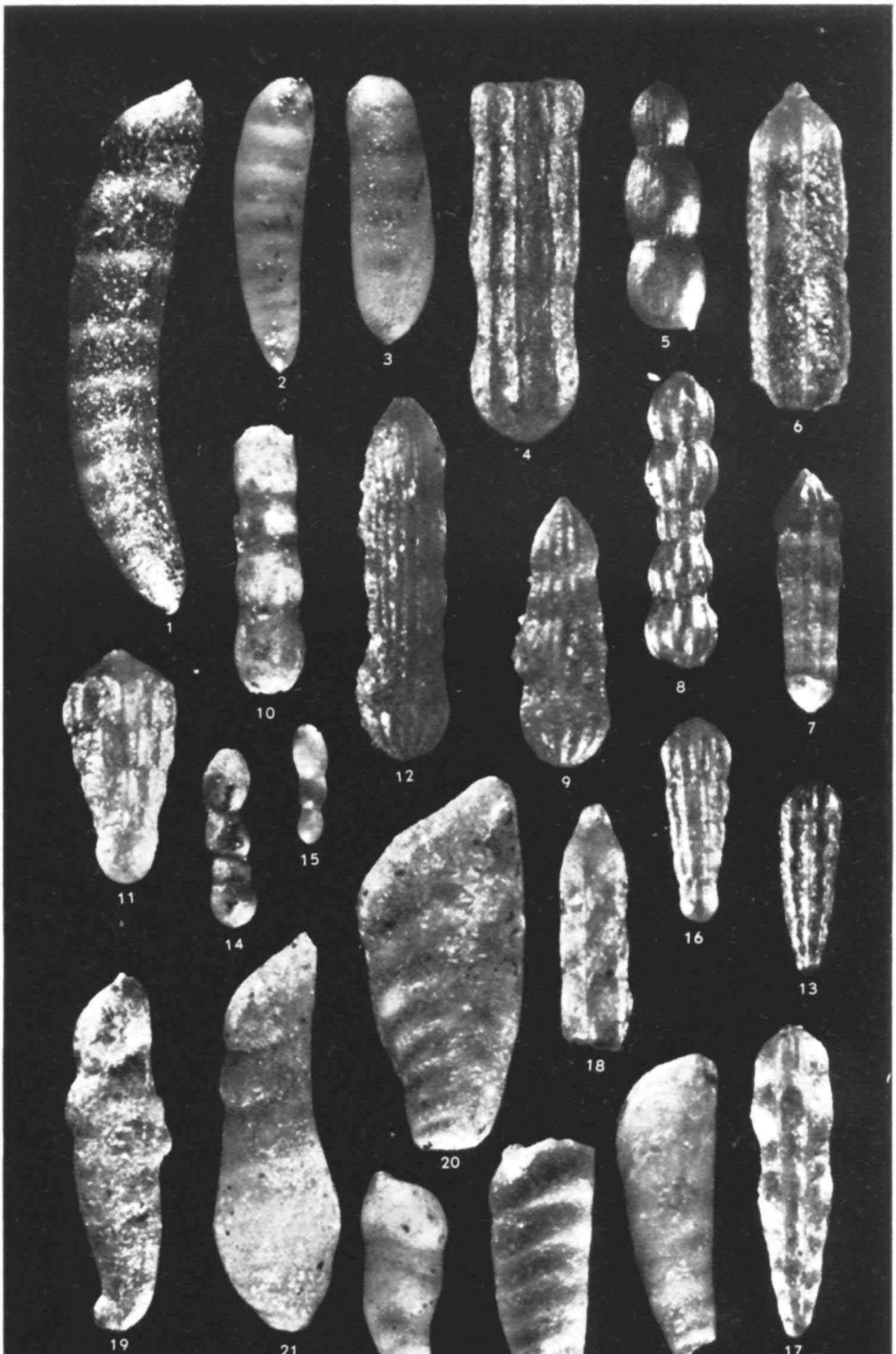
16 *Nodosaria procera* Franke.
Grube Friederike, U. Sinemurian.

17 *Nodosaria radiata* (Terquem).
Grube Friederike, U. Sinemurian.

18 *Nodosaria sexcostata* Terquem.
Paris Basin, L. Pliensbachian.

19–24 *Vaginulina listi* (Bornemann).
(19, 22, 23) Grube Friederike, U. Sinemurian; (20) Fontaneilles, L. Pliensbachian, ibex zone; (21) Idem, Aalenian; (24) Grube Friederike, U. Pliensbachian, Amaltheenton.

PLATE III



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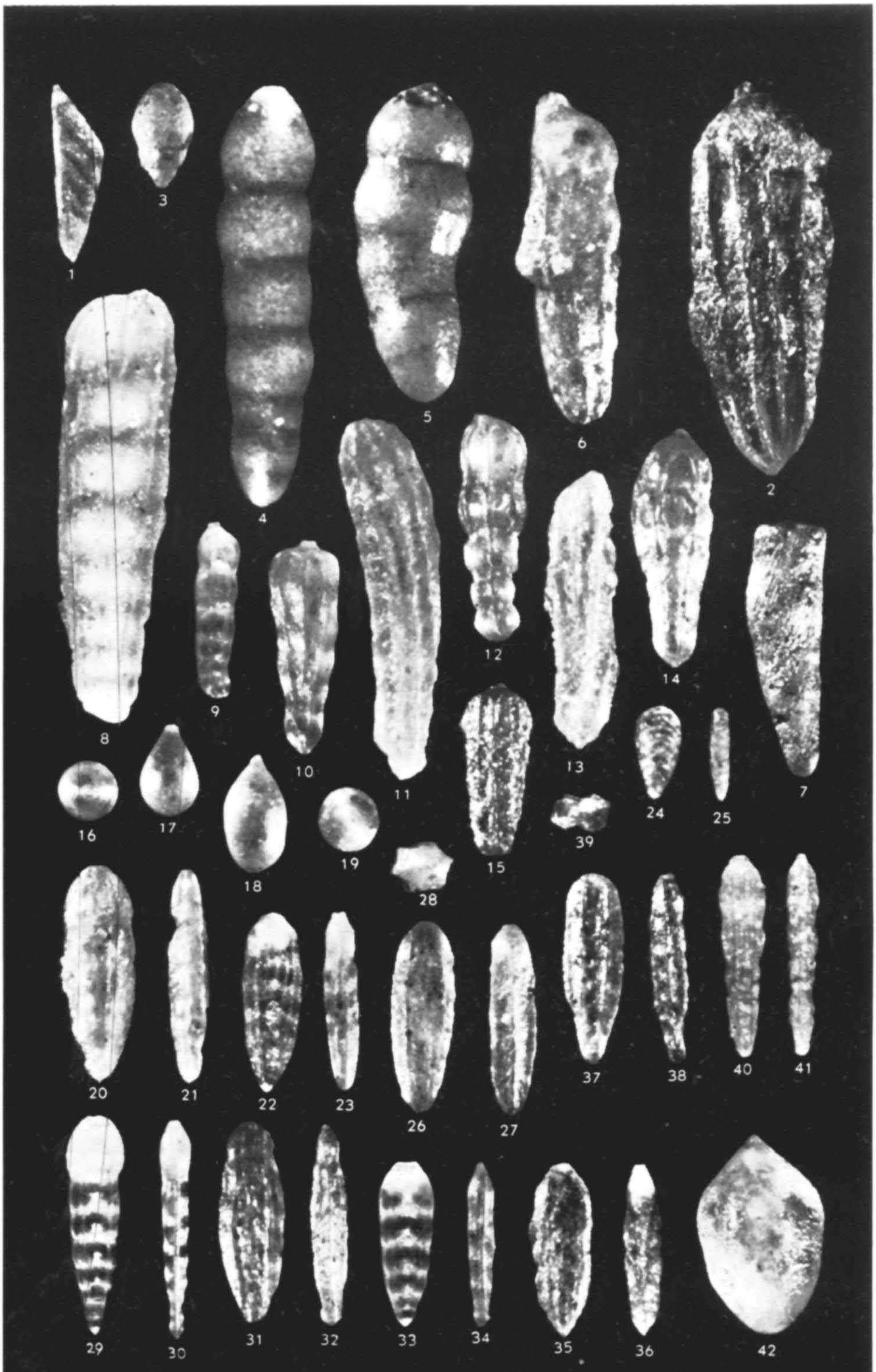
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PLATE IV

Figs. 1 *Vaginulina sagittiformis* (TERQUEM).
Paris Basin, L. Toarcian.

2 *Nodosaria multicostata* (BORNEMANN).
Aubächle, U. Sinemurian, Fossilarme Tone, ×56.

3 *Nodosaria oviformis* (TERQUEM).
Grube Friederike, U. Pliensbachian, Amaltheenton.

4–5 *Nodosaria vulgata* (BORNEMANN).
Grube Friederike, U. Pliensbachian, Amaltheenton.

6 *Marginulina hamus* TERQUEM.
Hochfelden, Hettangian.

7 *Marginulina obliquecostulata* HAGENMEYER.
Hochfelden, Hettangian.

8–15 *Marginulina prima* D'ORBIGNY.
(8) Aubächle, U. Sinemurian, Fossilarme Tone; (9) Grube Friederike, L. Pliensbachian; (10, 12, 14) Idem, U. Pliensbachian, Amaltheenton; (11) Idem, Aalenian, Opalinuston; (13) Lyme Regis, L. Sinemurian; semicostatum zone; (15) Ostercappeln, Lias.

16–17 *Lagena aphela* TAPPAN.
Grube Friederike, U. Pliensbachian, Amaltheenton.

18–19 *Lagena ovata* (TERQUEM).
Grube Friederike, U. Pliensbachian, Amaltheenton.

20–41 *Lingulina tenera* BORNEMANN.
(20, 21) Lorraine, L. Sinemurian; (22, 23, 26–28, 31, 32, 37–39) Grube Friederike, U. Sinemurian; (24, 25) Paris Basin, U. Pliensbachian; (29, 30, 33–36) Grube Friederike, U. Pliensbachian, Amaltheenton; (40, 41) Paris Basin, L. Pliensbachian.

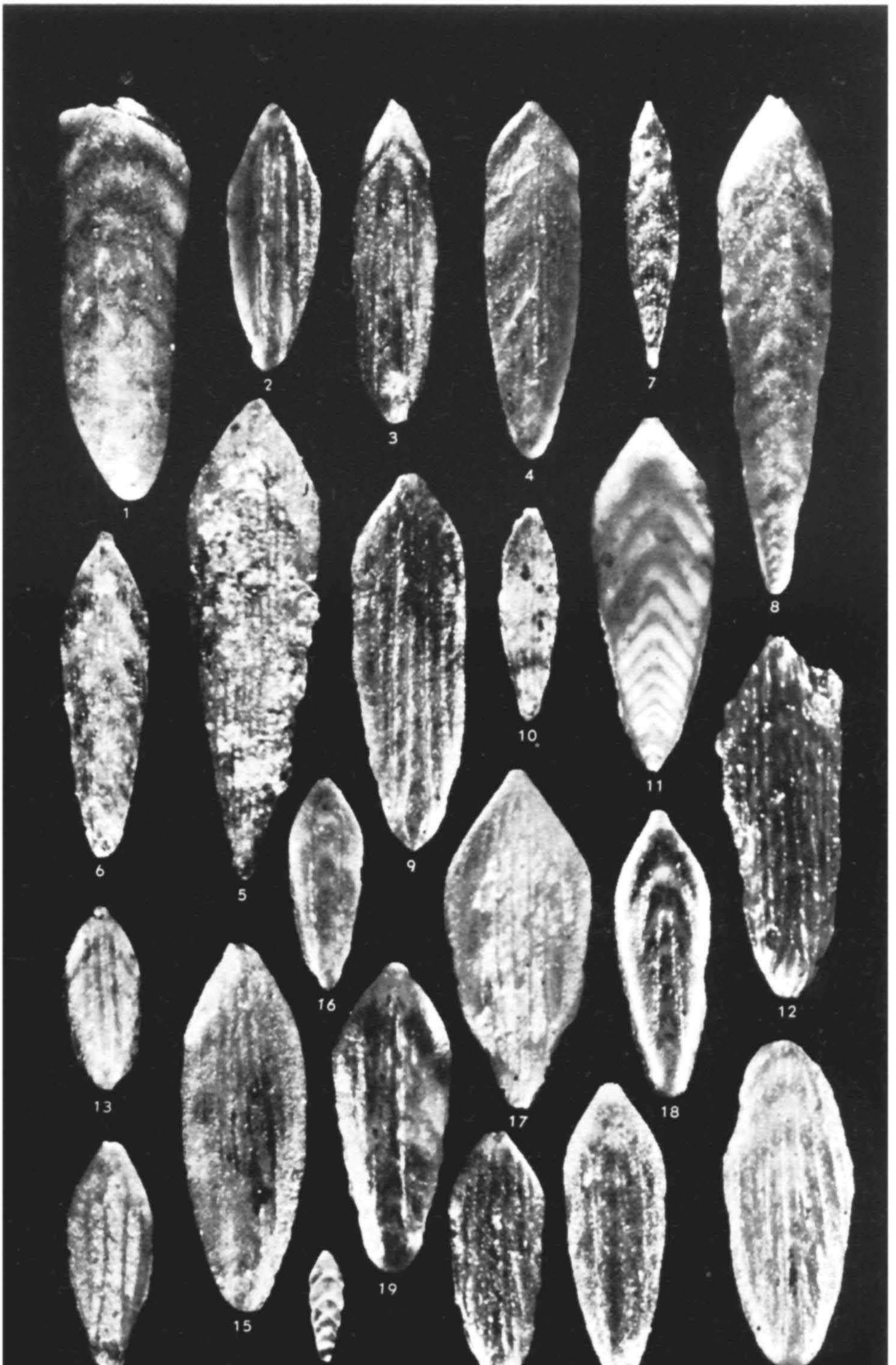
42 *Frondicularia brizaeformis* BORNEMANN.
Grube Friederike, U. Toarcian-L. Aalenian, ×56.

PLATE V

Figs. 1 *Frondicularia brizaeformis* BORNEMANN.
Grube Friederike, U. Pliensbachian, Amaltheenton, ×56.

2–23 *Frondicularia bicostata* D'ORBIGNY.
(2, 3, 13, 15, 16, 18, 21, 23) Aubächle, U. Pliensbachian, Amaltheenton; (4) Paris Basin, ?U. Pliensbachian, ×56; (5–7) Paris Basin, U. Pliensbachian; (8, 19) Grube Friederike, U. Pliensbachian, Amaltheenton; (9, 12, 22) Grube Friederike, U. Sinemurian (12: ×56); (10) Aubächle, Hettangian, Psilonotenschichten; (11) Aubächle, U. Sinemurian, Fossilarme Tone, in glycerine; (14) Aubächle, U. Pliensbachian, Zwischenkalke; (17) Aubächle, U. Pliensbachian, Costatenkalke; (20) Grube Friederike, U. Toarcian-L. Aalenian.

PLATE V



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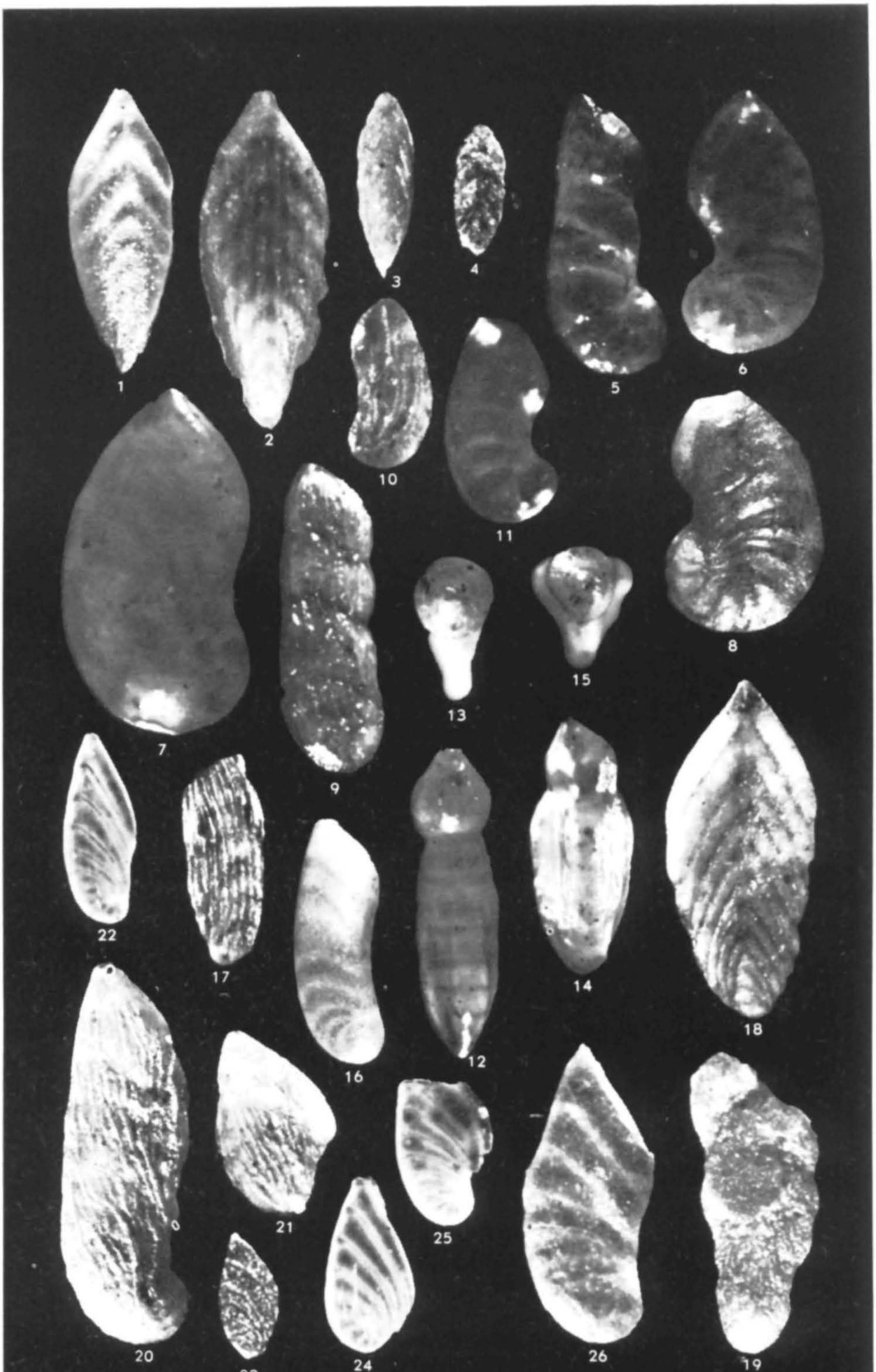


PLATE VI

Figs. 1–2 *Frondicularia biocostata* D'ORBIGNY.
(1) Aubächle, U. Pliensbachian, Amaltheenton; (2) Idem, U. Sinemurian, Fossilarme Tone.

3–4 *Frondicularia involuta* TERQUEM.
(3) Lorraine, U. Sinemurian; (4) Lyme Regis, U. Pliensbachian, margaritatus zone.

5 *Astacolus lituoides* (BORNEMANN).
Grube Friederike, U. Sinemurian.

6–8 *Astacolus primus* (D'ORBIGNY).
(6) Aubächle, L. Pliensbachian, Davoei Schichten, ×56; (7) Idem, U. Pliensbachian, Zwischenkalke; (8) Grube Friederike, U. Pliensbachian, Amaltheenton, ×56.

9–10 *Astacolus quadricostatus* (TERQUEM).
(9) Lorraine, U. Sinemurian; (10) Grube Friederike, U. Sinemurian.

11 *Astacolus undulatus* (TERQUEM).
Grube Friederike, U. Pliensbachian, Amaltheenton.

12–15 *Saracenaria trigona* (TERQUEM).
Bettembourg, Toarcian, tenuicostatum-falcifer zones (13, 15: apertural face).

16 *Saracenaria sublaevis* FRANKE.
Grube Friederike, U. Pliensbachian, Amaltheenton, ×56.

17 *Flabellinella crassecostata* BACH.
Grube Friederike, U. Pliensbachian, Amaltheenton.

18 *Neoflabellina deslongchampsi* (TERQUEM).
Lorraine, U. Toarcian.

19 *Palmula tenuistriata* (FRANKE).
Schömberg, Jurensismergel.

20–21 *Citharina inaequistriata* (TERQUEM).
Lorraine, L. Sinemurian, ×56.

22–25 *Astacolus pauperatus* (JONES & PARKER).
(22, 24, 25) Stewartby, M. Callovian; (23) Grube Friederike, U. Toarcian-L. Aalenian.

26 *Astacolus stillus* (TERQUEM).
Grube Friederike, U. Sinemurian.

PLATE VII

Figs. 1–2 *Astacolus stillus* (TERQUEM).
(1) Grube Friederike, U. Sinemurian; (2) Idem, U. Pliensbachian, Amaltheenton.

3 *Astacolus eugenii* (TERQUEM).
Paris Basin, L. Pliensbachian.

4 *Lenticulina bochardi* (TERQUEM).
Lorraine, M. Toarcian.

5–6 *Lenticulina d'orbignyi* (ROEMER).
(5) Grube Friederike, U. Toarcian-L. Aalenian; (6) Schömberg, U. Toarcian-L. Aalenian, Jurensismergel, flabelline form.

7–8 *Lenticulina gottingensis* (BORNEMANN).
Grube Friederike, U. Toarcian-L. Aalenian.

9 *Lenticulina polygonata* FRANKE.
Paris Basin, U. Pliensbachian, ×56.

10–17 *Lenticulina varians* (BORNEMANN).
(10) Grube Friederike, U. Sinemurian; (11) Idem, U. Pliensbachian, Amaltheenton; (12) Idem, U. Toarcian-L. Aalenian; (13) Paris Basin, L. Toarcian; (14) Mécleuves, Hettangian; (15) Lorraine, M. Toarcian; (16, 17) Byfield, Toarcian, bifrons zone.

18–19 *Eoguttulina liassica* (STRICKLAND).
(18) Grube Friederike, Aalenian, Opalinuston; (19) Idem, U. Pliensbachian, Amaltheenton.

20–27 *Brizalina liasica* (TERQUEM).
(20) Bracebridge, Toarcian, tenuicostatum zone; (21, 22) Paris Basin, U. Pliensbachian; (23, 24) Aubächle, Toarcian, Posidonienschiefer; (25, 26) Grube Friederike, U. Pliensbachian, Amaltheenton; (27) Parbayon, L. Pliensbachian, davoei zone.

28 *Spirillina polygyrata* GÜMBEL.
Grube Friederike, U. Toarcian-L. Aalenian.

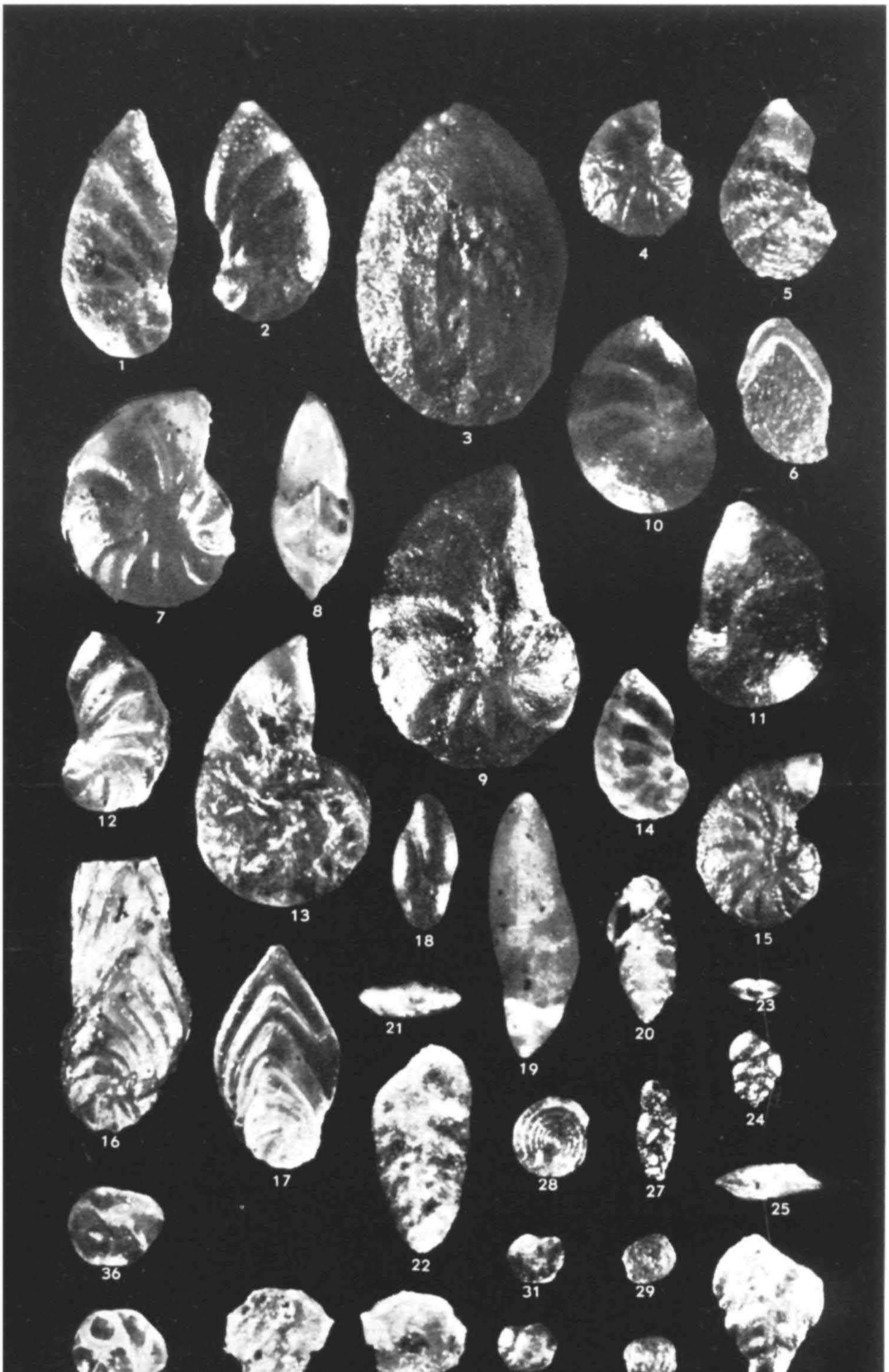
29–30 *Conicospirillina pictonica* (BERTHELIN).
Fontaneilles, Aalenian (29) ventral; (30) dorsal.

31–32 ?*Conorboides* sp.
Watchet-Kilve, Hettangian, angulata zone.

33–34 *Epistomina liassica* BARNARD.
Lyme Regis, L. Sinemurian, semicostatum zone.

35–36 *Reinholdella dreheri* (BARTENSTEIN).
Grube Friederike, Amaltheenton.

PLATE VII



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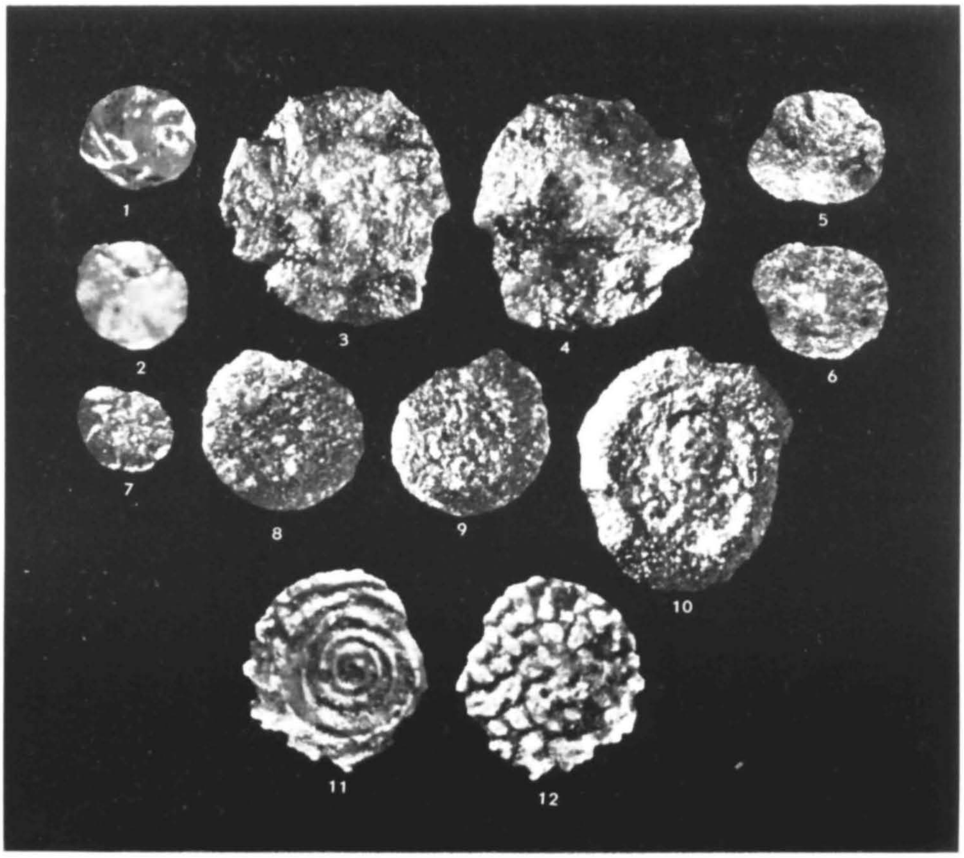

PLATE VIII

Figs. 1–2 *Reinholdella pachyderma* HOFKER.
Lorraine, M. Toarcian (1) dorsal; (2) ventral.

3–7 *Reinholdella macfadyeni* (TEN DAM).
(3, 4) Fontaneilles, Aalenian; (5, 6) Idem, U. Pliensbachian, margaritatus zone, ×56; (7) Idem, Toarcian, bifrons zone.

8–10 *Involutina liassica* (JONES).
(8, 9) Göttingen, Hettangian, Angulatenschichten, ×56; (10) Aubächle, Psilonotenschichten.

11–12 *Trocholina umbo* FRENTZEN.
Paris Basin, L. Sinemurian.