8. FORAMINIFERS FROM THE UPPER JURASSIC AND LOWER CRETACEOUS OF THE EASTERN ATLANTIC (DSDP LEG 41, SITES 367 AND 370)

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INTRODUCTION

At Sites 367 and 370 (for locations see Figure 1) the oldest recovered sediments above the cored basalt are Upper Jurassic and Lower Cretaceous. For study of the foraminifers, 144 samples (62 from the Upper Jurassic, 25 from the Lower Cretaceous of Site 367, the rest from the Lower Cretaceous of Site 370), were taken and partly washed by V. Krasheninnikov and U. Pflaumann during the cruise. These authors worked on samples corresponding to ours (see sample intervals in Tables 1, 2, and 4); we thus had a valuable opportunity for cooperation and comparison of results. They reached conclusions similar to ours about the general distribution, the age, and the depth of the sediments, and agreed with most of the determinations of species. Our results are marked K (Kuznetsova) or S (Seibold).

Seibold gave special consideration to the Jurassic material; Kuznetsova studied the Lower Cretaceous material, in addition to her Jurassic samples.

JURASSIC

Lithological Remarks

The Jurassic section of Site 367 is about 64 meters thick (at western Atlantic Site 100 it is 71 m thick; at Site 105 it is 54 m). The sequence starts with a thin layer (about 80 cm thick) of greenish gray clays above the basalt, overlain by pale red to red argillaceous limestones, which alternate with grey and green limestones. Light gray limestones continue into the Lower Cretaceous. The lithology is, in general, very similar to lithology of the sites in the western Atlantic (Luterbacher, 1972), and to the Alpine and Mediterranean Jurassic (Bernoulli and Jenkyns, 1974).

According to Renz (this volume), the content of calcium carbonate in his samples from Sections 367-36-2, 367-35-4, and 367-34-4 ranges from 30% (where radiolarians are abundant) to 42 to 65%. This is low in comparison with values from the European Upper Jurassic (Seibold and Seibold, 1960), where 60 to 80% is not unusual, at least in the Kimmeridge.

Methods

All samples and the residues were weighed for quantitative studies. Most of the samples were hard material. They were cautiously pressed and then boiled and frozen several times (after addition of sodium sulfate for better crystallization). Softer material was treated with H_2O_2 and then washed.

The grain-size fractions of 40-63 μm and >63 μm were kept separately. Checking of some 40-63 μm

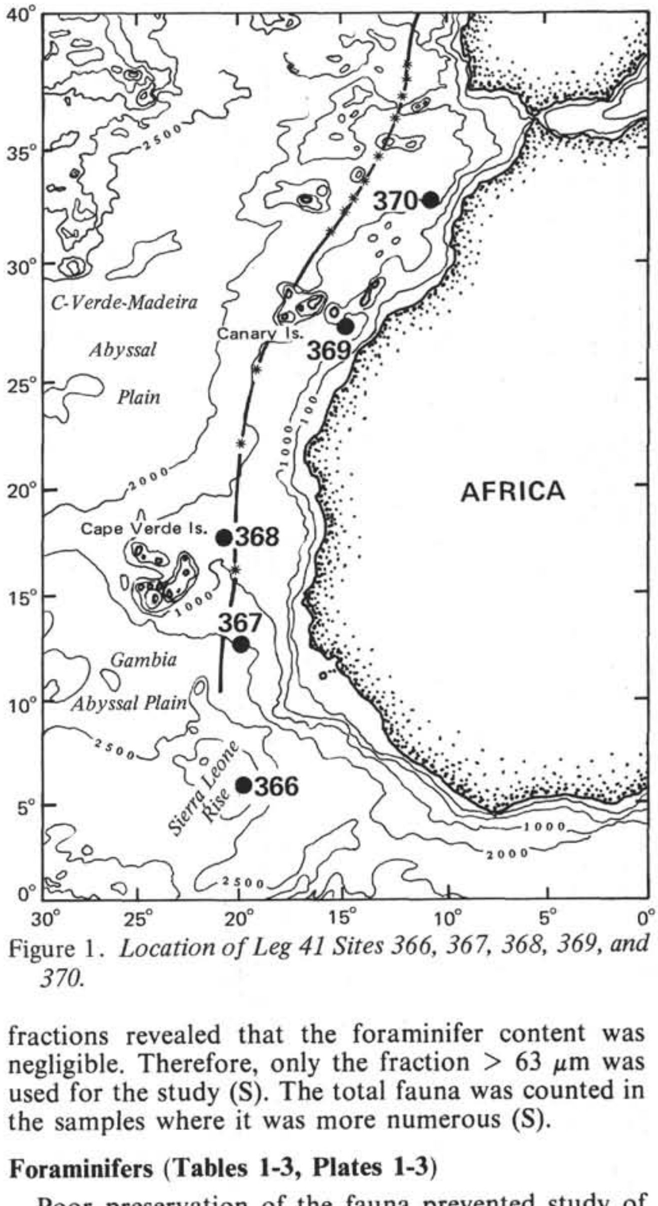

Figure 1. *Location of Leg 41 Sites 366, 367, 368, 369, and 370.*

fractions revealed that the foraminifer content was negligible. Therefore, only the fraction > 63 μm was used for the study (S). The total fauna was counted in the samples where it was more numerous (S).

Foraminifers (Tables 1-3, Plates 1-3)

Poor preservation of the fauna prevented study of systematic details, but exchange of material between the authors and comparison with results from better preserved material of the western Atlantic (Luterbacher, 1972) helped in species identification.

Quantitative data are given for the samples that contain numerous foraminifers and allow more detailed comparisons (Table 3).

The systematic composition of the assemblages includes 30 genera and about 50 species. The distribu-

TABLE 1
Distribution Chart of Foraminifers and Other Microfossils of the Upper Jurassic, Site 367

Sample (Interval in cm)	38-1, 38	37, CC	37-1, 86-88	37-1, 28	36, CC	36-3, 42-44	36-3, 52	36-2, 24-26	36-2, 110-112	35, CC	35-5, 28-30	35-4, 14-16	35-3, 111-113	35-2, 40-42	35-1, 21-22	35-1, 134-136	34, CC	34-4, 87-89	34-3, 22-24	34-3, 94-96	34-2, 100-102	34-1, 63-64	33, CC	33-3, 124-125	33-2, 85-86	33-1, 114-116	32, CC	32-5, 114-116	32-4, 132-134	32-3, 54-56	32-2, 10-12
Preservation	G	P	M	M	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P			P	P	P				
Rhizammina? spp.	F	F	F	A	R	R	C				F	F	A	F	F			F	F	R	R	R					F				
Saccorhiza sp.															R																
Lagenammina sp.	F				R	R	R							R?	R			R			R										
Glomospira sp.			R	C		R	F				C		F		F			F	R	R	R				R						
Glomospira variabilis K. & Z.	R		R	F							F				R?			R		R											
Tolypammina sp.	R			R		R?												R													
Lituotuba sp.							R								R																
Reophax helveticus Haeusl.	A		R	R?									R		R																
Reophax sp.					R													R							R?						
Haplophragmoides pygmaeus? Haeusl.	R																														
Ammobaculites sp.				R		R					R	R?																			
Texularia cf. *jurassica* Gumb.	R		R	F			R				R	R			R					R											
Trochammina? sp.			R	F			R							R?				R													
Bigenerina jurassica Haeusl.				F																											
Ophthalmidium? sp.			R																												
Nodosaria nitidana Gumb.	R		R															R													
Nodosaria sp.	R																		R												
Astacolus fraasi (Schw.)	R			R																											
Astacolus matutinus Orb.		R?																													
Astacolus primus Orb.	R			R									R							R											
Astacolus rectalongus Brand	R		R										R	R			R	R													
Astacolus sp.					R																										
Dentalina-group	A	R	C	A	F	F	F					R	R	R				F	R	R							R				
Lagena sp.	R			R																											
Lenticulina munsteri Roem.	F	R	F	C	F	R	R	R?			R		F			R		F		F					R	R					
Lenticulina sp.			R																												
Marginulina cf. *megalocephala* Schw.	R		R															R													
Marginulina minuta Terq.			R																												
Falsopalmula deslongchampsi Terq.	R																														
Pseudonodosaria sp.			R																												
Vaginulina jurassica Gumb.	F		R	R		R												R	R												
Lingulina franconica Gumb.	F				R													R													
Guttulina cf. *bilocularis* (Terq.)	A		F	C	R							R				R		F		R							F				
Guttulina cf. *pygmaea* Schw.	R		R	R														R													
Ramulina spandeli Paalz.	R			R																											
Oolina sp.			R																												
"*Spirillina*" spp.	A	R	A	A	C	A	A	F	F	R	C	F	A				R	A	F	A	R	R			F		F				
Patellina? sp.	C	R		F	R		R					R						A		R											
Trocholina sp.				R?	R																										
Conorbina? aff. *scutuliformis* Seib.	C	R	R	R			R					F						A	R	F											
Number of species	25	7	21	22	11	9	11	2	1	1	7	8	8	5	8	2	2	19	7	11	4	2	0	0	4	1	4	0	0	0	0
Ostracodes	C		R	R	R									R				R		R							4?				
Radiolarians	○	●	●	○	●	○	○	★					●	★	○	○	○	○	●	○	○	○			○	○	○	○	●	●	●

Note: The occurrence of radiolarians is marked with different signs, since they were not counted but only estimated. Their abundance is so much greater in many samples that the same symbols seemed not to be useful. ○ = rare; ● = numerous; ★ = very abundant.

tion Tables 1-3 show the prevalence of calcareous forms and give the characteristic picture of a relatively rich fauna at the base of the site (samples from Cores 367-38 and 367-37). The assemblages are characterized as follows: (1) dominance of the "*Spirillina*" group (S); (2) few agglutinated species (about fifteen, of which only simple tubular forms like *Rhizammina* spp., *Glomospira*, and *Glomospirella* are numerous; (3) among *Nodosariidae* (about a third of the fauna), the *Dentalinae* and *Lenticulinae* are more abundant, whereas the representatives of other genera are rare; (4) *Guttulinae*, mostly *Guttulina* cf. *bilocularis* Terquem, are always present in the richer samples. Above these basal samples, the fauna decreases in species and individuals, yielding mostly poor assemblages. Only the "*Spirillinae*" remain common or abundant. In the upper part of the profile, some samples are completely barren (Cores 367-31, 367-30). Kuznetsova's material does not have dominant "*Spirillinae*," and the number of species and individuals per sample is lower. There-

TABLE 2
Distribution Chart of Foraminifers and Other Microfossils From the Upper Jurassic of Site 367 (Kuznetsova)

Sample (Interval in cm)	38-1, 28-30 cm	37, CC	37-1, 84-86 cm	37-1, 26-28 cm	36, CC	36-3, 40-42 cm	36-2, 22-24 cm	36-1, 108-110 cm	36-1, 124-126 cm	35, CC	35-5, 26-28 cm	35-4, 14-16 cm	35-4, 78-80 cm	35-3, 109-111 cm	35-3, 24-26 cm	35-2, 38-40 cm	35-1, 132-134 cm	34, CC	34-4, 85-87 cm	34-3, 92-94 cm	34-2, 102-104 cm	34-1, 62-63 cm	33, CC	33-3, 132-134 cm	33-2, 84-86 cm	33-1, 112-114 cm	32, CC	32-5, 112-114 cm	32-4, 130-132 cm	32-3, 52-54 cm	32-2, 8-10 cm
Rhizammina sp.	R																														
Lagenammina sp.								R																		R					
Hyperammina sp.	R																										R				
Glomospira variabilis											R															R					
Glomospira sp.																		R	R												
Glomospirella gaultina (Beth.)																								R							
Glomospirella gordialis (P. et J.)											R																				
Tolypammina sp.			R																			R									
Reophax chrysalis (Haeusl.)	R																														
Reophax helveticus (Haeusl.)					R																										
Haplophragmoides sp.																										R					
Haplophragmium aff. *canariensis* Orb.																										R					
Textularia jurassica Gimb.			R			R																									
Trochammina suprajurassica n.n. Seib.																										R					
Bigenerina (?) *jurassica* Haeusl.				R?																											
Nodosaria nitidana Gumb.			R	R																											
Dentalina soluta Reuss				R																											
Dentalina laevigata Schw.			R	R																							R				
Dentalina cylindrica Schw.			R	R																							F				
Dentalina turgida Schw.				R							U																				
Lenticulina quenstedti Gumb.				R										R																	
Lenticulina uhligi Wisn.				R										R																	
Lenticulina ex gr. *uhligi* (sp. nov.)				R									R	R																	
Lenticulina munsteri Roem.			R				R	R																						R	R
Lenticulina semiexpleta (Schw.)	R						R				R																				
Lenticulina ex gr. *subgaultina* Bart.							R				R																				
Lenticulina multangulosa (Schw.)																											R				
Astacolus primus Orb.						R																									
Astacolus sp.			R																												
Astacolus exiguus (Schw.)	R																														
Marginulina sp.			R?								R																				
Falsopalmula deslongchampsi (Terq.)	R		R																								R				
Vaginulina sp.			R										R																		
Lingulina franconica Gumb.					R																										
Pseudonodosaria sp.			R																												
Ramulina spandeli Paalz.			F									R															F				
Guttulina bilocularis (Terq.)			R																R												
Guttulina pygmea (Schw.)	R		R	R																											
Guttulina sp.			R				R																								
Globulina laevis (M.)	R																														
Spirillina sp.			F																												
Trocholina aff. *nodulosa* Seib.								R																							
Trocholina aff. *infragranulata*			R				R																								
Cornuspira (?) *eichenbergi*																											R				
Conorbina sp.			R																R												
Hoeglundina (?) sp.			R																												
Paalzovella? sp.																											R				
Number of species	8	0	19	10	2	2	5	3	0	0	5	2	4	0	0	0	0	1	3	0	0	1	0	1	0	5	8	0	0	1	1
Ostracoda											R															R	R				
Radiolaria											R			A										A			R				

fore, her faunal chart (Table 2) shows an even more scattered distribution.

An interesting exception of this picture is Core 367-34, especially Sample 367-34-4, 87-89 cm (S), which contains a local abundance of two species—small *Patellina*) sp. and the even smaller "*Conorbina*" aff. *scutuliformis* Seibold (Plate 3, Figure 15)—both very rare in the rest of the profile. A few tiny and doubtful casts, resembling perhaps the "*Globigerinae*" recorded in the European Upper Jurassic, are poorly preserved

TABLE 3
Quantitative Distribution Chart of Foraminifers and Ostracodes in Some Samples of the Upper Jurassic of Site 367 (Seibold)

Sample	34-4	34-3	34-3	35-5	35-4	35-3	36, CC	36-3	36-3	37-1	37-1	38-1
Rhizammina spp.	3	7	3	2	9	26	2	2	10	38	4	14
Lagenammina sp.	1						1	3	1			
Glomospira sp.	8	1	1	12		8		1	6	18	3	5
Glomospira variabilis	2		3	7						6	1	
Tolypammina sp.	2							2		1		1
Reophax helveticus						1?			2	1?	1	11
Reophax sp.	3				3							2
Haplophragmoides pygmaeus?							2					
Ammobaculites sp.										1		
Textularia cf. *jurassica*				2	1?				3	6	2	1
Trochammina? sp.	1		1	1	3				1	5	2	3
Bigenerina jurassica											4	
Ophthalmidium? sp.											2	
Nodosaria nitidana	1										1	1
Nodosaria sp.												1
Astacolus fraasi										1		1
Astacolus matutinus		1										2
Astacolus rectalongus			1			1					1	1
Astacolus primus	1					2				2		
Astacolus sp.							1					
Dentalina spp.	4	1	1		1	1	5	4	4	33	21	38
Lagena sp.										1		1
Lenticulina cf. *munsteri*	4		7	3		5	7	2	3	19	4	4
Lenticulina spp.											2	
Marginulina cf. *megalocephala*	1										1	1
Marginulina minuta											1	
Falsopalmula deslongchampsi												1
Pseudonodosaria sp.											1	
Vaginulina jurassica	1	2						1		1	3	5
Lingulina franconica	1						1					9
Guttulina cf. *bilocularis*	5		3		1		3			11	4	31
Guttulina cf. *pygmaea*	1									3	2	2
Ramulina spandeli										1		1
Oolina											1	
Spirillina spp.	85	7	49	75	10	27	21	133	39	199	92	124
Patellina? sp.	220		2		1		2		1	5		13
Trocholina sp.							1			1?		
Conorbina? aff. *scutuliformis*	61	1	5					4	3	2	2	11
"*Globigerina*"-casts	6											
Spec. indet.	1			7	6	5	2			12	4	9
total number of counted individuals	408	20	76	102	32	76	48	151	75	369	158	292
Weight grainsize >63 y g	0.25	2.02	1.0	0.009	0.09	0.65	7.9	1.1	0.45	0.25	0.09	0.08
Counted	•	0.69	•	•	•	•	2.0	1.0	0.08	•	•	•
Number of species	19	7	11	7	8	8	11	9	11	21	21	25
Number of individuals per 10g/Sed.	143	62	87	120	40	81	105	222	334	220	85	313
Ostracodes												
Polycope sp.							1?			2	2	34
Bairdia? sp. or others	1		1				2					26

Note: • = total fraction counted.

and cannot be positively identified (Plate 3, Figure 13). It may be interesting that Renz assumes a rich ammonite assemblage in his Sample 367-34-4.

Table 3 lists the numbers of specimens counted in the richer samples. In order to obtain comparable values, the number of individuals per 10 g of sediment is calculated. It must be emphasized, however, that these numbers are only an approach to quantitative comparisons, and are not as exact as those obtained in studies of recent material. Table 3 shows more distinctly the dominance of "*Spirillinae*" and the variability within the given range of symbols (R - A), especially for the abundant forms. Besides, the calculations show that the difference between "rich" and "poor" samples is not as great as could be assumed from the qualitative picture alone. In Figure 2, species numbers and numbers of counted individuals are plotted on a Fisher α graph for diversity values (Murray, 1973). Several samples, especially those of Core 367-34, are grouped around the same value, though at first glance, Sample 367-34-4 seems to have more species than the others.

Other Faunal Components

Ostracodes: Sample 367-38-1, 38 cm, is the only sample with a higher number of small ostracodes of at least two different smooth-walled types. One group, belonging to the *Polycopidae*, contains a larger specimen which shows traces of sculpture under the Stereoscan microscope (Plate 3, Figures 17, 18). According to the figures of Oertli (1972), the other forms may belong to the genus *Bairdia*?, but the assignment is tentative, owing to inadequate preservation. Ostracodes, except for 10 samples where ostracodes are rare, are absent throughout the profile.

Radiolarians: Normally siliceous and sometimes calcified radiolarians are abundant in many samples, mostly where the foraminifers are rare or absent. An

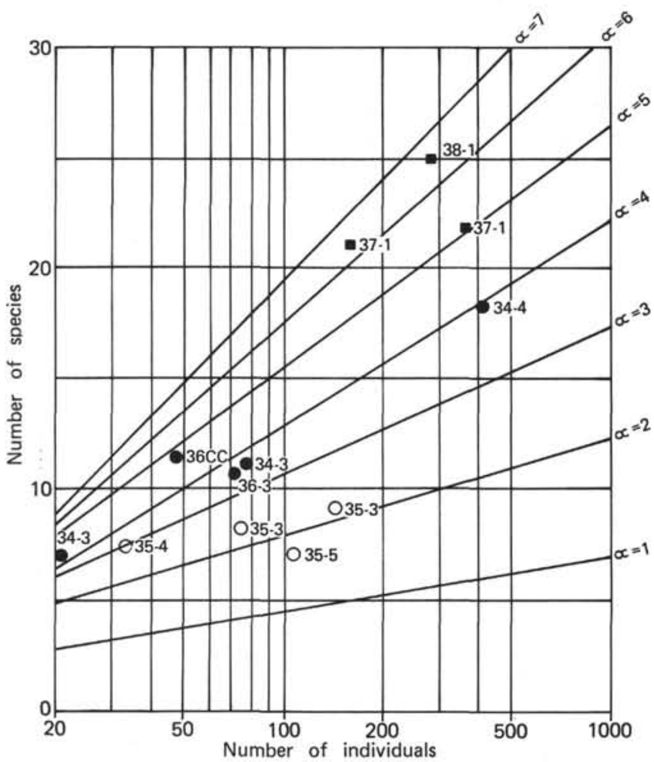

Figure 2. *Fisher α diversity values of some samples from the Upper Jurassic of Site 367.*

exception is Sample 367-37-1, 86-88 cm, where more radiolarians and foraminifers occur together. The occurrence of ostracodes and radiolarians is marked on the distribution charts.

Particles of *Saccocoma* spp. are frequent, aptychi are sometimes present, sponge spicules and fish remains are rare.

Taxonomy Remarks

Preservation is poor, except in the lowermost samples. The agglutinated forms are mostly compressed; the calcareous species are recrystallized and sutures or apertures are normally not visible. The presentation of stereoscan-microphotographs is therefore not very useful. The specimens show little more than their recrystallization (Plate 3, Figure 13). The added normal microphotographs give a better impression. The poor state of the material and its scarcity (some species are represented by only a single specimen, e.g., *Falsopalmula deslongchamsi* [Terquem], *Marginulina minuta* [Terquem] make the identification difficult and a detailed study impossible. Therefore, often only an open nomenclature can be used. We tried to adapt the identifications to those of Luterbacher (1972), in order to facilitate comparison.

In the genus *Rhizammina* spp. (S), many pieces of straight or curved tubular specimens, which probably do not belong to one species, are included. Two types, one more smooth-walled and another coarser agglutined form, occur together.

Seibold treated the *Dentalinae* as a group because the variability in the genus is insufficient and the specimens too few for separation. In the basal samples, however, where they are more numerous, the following species can be distinguished: *Dentalina* cf. *bicornis* Terquem, *Dentalina* cf. *bullata* Schwager, *Dentalina jurensis* (Gümbel), *Dentalina sinemuriensis* Terquem, and *Dentalina turgida* Schwager. Some broken specimens could not be identified, but may belong to *Dentalina aequabilis* Schwager. These determinations are in harmony with those of Kuznetsova (Table 2).

The "*Spirallina*" group includes the very thin forms which some authors refer to as *Cornuspira* or *Spirillina eichbergensis* Kubler and Zwingli (K), *Spirillina kubleri* Myatliuk, *Spirillina tenuissima* Gümbel, and elongate specimens which may belong to *Spirillina elongata* Bielecka and Pozaryski.

In *Conorbina* aff. *scutuliformis* Seibold, the chambers of the first whorl are only sometimes visible as tiny nodules on top of the dorsal side. The strongly concave ventral side with relatively distinct borders (Plate 3, Figure 15) indicates the affinity with the European form (Seibold and Seibold, 1960); Oesterle, 1968; Wernli, 1971; Bizon [Discorbis, 1958]). "*Conorboides paravelendisensis*" Reiss nom. nud. (Maync, 1966) is also very similar, but more rounded in its periphery. The isolated abundant occurrence in Core 367-34 cannot be explained, because ecological information is lacking.

The assignment of *Patellina*? sp. is also difficult. Only the two semi-circles of the last formed chambers are visible on the ventral side, and the dorsal side is only a structureless flat cone or hemisphere. A few better preserved specimens show slight traces of apertural figures or spiral sutures on the dorsal side.

Size

Many specimens of the same species are only about half the size of specimens from the western Atlantic and from the faunas from Jurassic shelf sediments. A few measurements were taken to illustrate this and listed together with measurements from the figures of Luterbacher (western Atlantic) and from material of the south German Oxford faunas.

	W. Atlantic	S. Germany	Site 367
Glomospira variabilis	0.25	0.15-0.27	0.14-0.15
Bigenerina jurassica	0.5	0.5-0.69	0.45
Falsopalmula deslongch.	1.1	0.61-0.74	0.64
Lenticulina munsteri	0.9	0.52-1.0	0.35-0.62
Lingulina franconica	0.7	0.45-0.87	0.28-0.30
Vaginulina jurassica	–	0.61-0.74	0.36
Conorbina? aff. *scut.*	–	0.20-0.27	0.15-0.17
(measurements in mm)			

Farinacci's (1965) figures from Italy also show larger forms (*Lenticulinae* from 0.7 to 1.4 mm). It must be considered that large specimens are normally taken for photographs, and the values thus obtained exceed the normal size. But the largest forms of our fauna never reach these lengths. From 30 randomly selected individuals from Section 367-38-1 (S), only one reaches a length of 0.64 mm; the length of all other forms ranges between 0.10 and 0.38 mm.

Comparisons

The comparison with the material of the western Atlantic shows the same picture of rich basal faunas

TABLE 4
Distribution Chart of Foraminifers and Ostracodes From the Lower Cretaceous (Valanginian) of Site 370 (Kuznetsova)

	38, CC	38-5, 55-57 cm	38-4, 31-33 cm	38-3, 68-70 cm	38-2, 96-98 cm	38-1, 92-94 cm	39, CC	39-4, 63-65 cm	39-3, 49-51 cm	39-2, 45-47 cm	39-2, 56-58 cm	40, CC	40-4, 36-38 cm	40-3, 51-53 cm	40-2, 98-100 cm	40-1, 37-39 cm	41-5, 26-28 cm	41-4, 77-79 cm	41-3, 108-110 cm	41-2, 53-55 cm	41-1, 55-57 cm	42, CC	42-4, 71-73 cm	42-3, 48-50 cm	42-2, 70-72 cm	43, CC	43-4, 61-63 cm	43-3, 105-107 cm	43-2, 43-45 cm	44, CC	44-3, 23-25 cm	44-2, 33-35 cm	44-1, 69-71 cm	45, CC	45-4, 15-17 cm	45-3, 41-43 cm	45-2, 70-72 cm	45-1, 94-96 cm	46, CC	46-5, 32-34 cm
Rhizammina sp.																																								
Lagenammina sp.																														R										
Ammolagena sp.																										R														
Glomospira variabilis		R																														R	F							
Glomospirella gaultina	R	R		R																												R	F						R	
Reophax scorpiurus																																								
R. guttifer																																R								
Haplophragmoides chapmani																																R	C			R				
H. excavatus umbilicatula																																								
Ammobaculites eocretaceous																																								
Dorothia hechti	R		R		R							C													F	F				F		R	F				C		C	R
D. praehauteriviana	C		F	C	A		R			F		A		C		R		R							A	F			C	A	R		A			C	C		C	
Gaudryina sp.																																								
Lenticulina ouaschensis																										R													R	
L. nodosa	R																																							R
L. insularis	R		R				R																			R	R			R			R				C			R
L. subgaultina														R																R		R								
L. schreiteri														R																										
L. eichenbergi																										R				R										
L. nimbifera					R																					R				R			R							
L. mutabilis												R														R				R										
L. subalata																										R				F									R	
L. ambanjabensis												R																									R			
L. espitaliei																														R										
L. saxonica	R		R				R																																	
L. guttata			R																																					
Astacolus calliopsis	R	R		F							R															R				R			R				F			R
A. colligoni	R											R														R				R		R							R	
A. matutinus		R	R	R	R							R		R																									R	
A. planiuscula												R				R									F					F		R								
A. explicatus				R																					R															
A. primus																		R																						
A. schloenbachi mediterranea																																								
Planularia madagascariensis	R											R				R																							R	
P. tricarinella	R		R							R	R															F				F									R	
Saracenaria inflata												R														R				R										
S. compacta			R		R			R				R														R				R										
S. tsaramandrosoensis	R			R								R																												
Marginulina pseudodebilis	R																																						R	
Tristix acutangulatus																																							R	
Vaginulinopsis enodis																																								R
V. sp.																																								
Vaginulina geinitzi	R																																							
V. incurvata																														R										
V. exilis																																R								
Citharina strombecki																														R										
C. recta				R																																				
Nodosaria sceptrum				R				R		R																														
Dentalina bullata	R																																							
D. soluta	R	R			R			R										R								R				R			R				F			
D. communis	R		R	R	R		R	R								R										R			R	F	R		R							
D. xiphioides				R						R																R				R										
D. legumen														R											R														R	
Lingulina trilobitomorpha																													R								R			
L. loryi														R																										
Frondicularia frankei	R																																							
Geinitzinita lingulaeformis														R				R																					R	
Eoguttulina polygona			R																						R													R	R	
Guttulina ichnusae												R																		R									R	
G. nuorensis																														R										
Globulina prisca		R		R						F		F				F													F	R							C			
Pseudonodosaria mutabilis	R																								R	R				R							F		F	
P. vulgata																									R														R	
Ramulina oculeata	R			R	R							R														R				R										
R. tappanae																					R					R													R	
Oolina sp.				R								R													R					R										
Spirillina italica																																							R	
S. minima																																								
S. kubleri sardoa	R																																					R		
Gavelinella bettenstedti	F	F		R	C			R			C																										R	R		
Siphoninella sp.?																										R				R										
Hedbergella sp.					*R*																								R?	R?										R
Number of species	21		10	14	10	0	4	5	0	5	3	15	0	7	0	5	0	4	0	0	1	0	0	0	9	21	0	0	5	29	2	9	10	0	0	2	10	3	19	6
Ostracodes			R									R																	R	R										

Note: R - rare - 1-3 specimens; F - few - 4-10 specimens; C - common - 11-25 specimens; A - abundant - more than 25 specimens.

TABLE 4 – *Continued*

46-4, 71-73 cm	46-3, 100-102 cm	46-2, 86-88 cm	47, CC	47-3, 53-55 cm	47-2, 51-53 cm	47-1, 96-98 cm	48, CC	48-2, 35-37 cm	48-1, 63-65 cm	49, CC	49-2, 69-71 cm	49-1, 29-31 cm	50, CC	50-2, 12-14 cm	50-1, 95-97 cm	51-2, 69-71 cm
											R					
								R								
							C	R			C	C				
							R				R					
				R												
						R										
						R										
							R									
				C			F									
				A			A	R	R							
								R	R							
							R				R					
							F									
							R				R					
							R	R								
				F				R								
											R	R				
							R	R								
							R									
				F												
				F				R								
							R									
												R				
				R		R?	R	R								
							R									
								R								
											R					
				R			R									
		R														
				R				R								
		R														
							R									
		F														
		C		C			R									
		R									R					
		R					R									
		F														
		R		F												
0	0	8	0	11	0	3	18	11	2	0	9	2	0	0	0	0

declining upward in the section. However, the western Atlantic sequence, with richer faunas, has a greater thickness: 41 and 36 meters, compared with 2 meters at Site 367. All three profiles have many species in common, and "*Spirillinae*" is commonly abundant. The number of species is smaller in the eastern Atlantic: 46 (K), 40 or 50 (when "*Spirillinae*" and *Dentalinae* are separated) (S), to 71 in the western Atlantic. Farinacci counted 46 species in the Italian deep-water Oxfordian. Although a greater quantity of sediment might provide more species, the difference between the eastern and western Atlantic samples seems too great to be explained only be the study of more material. The number of species per sample is also interesting: the greatest numbers in the west Atlantic are 34 and 32, and many samples have between 20 and 30 species. At Site 367 only one sample has 24 species. Data from the European Jurassic range between 60 and 80 species, with an average of about 30 per sample. Though this number is somewhat variable, according to the personal preference of the author to split or to combine species, these deviations seem small enough to make such a comparison possible. The numbers indicate that the values from the western Atlantic are closer to those from the shelf areas. Several forms which occur commonly in the western Atlantic—for example *Ophthalmidium* and *Brotzenia*—do not occur in Site 367 sediments. In addition to the rare *Lenticulina quenstedti* (Gümbel), some sculptured *Nodosariae* and *Frondicularia nikitini* Uhlig are also rarely present in the western Atlantic samples, whereas sculptured forms are extremely rare in Site 367 sediments.

Kuznetsova's (1974) material from the Jurassic/Lower Cretaceous of the eastern Indian Ocean, Leg 27, has some species in common with Site 367: *Lenticulina quenstedti* (Gümbel) (rare), *Dentalina communis* d'Orbigny, *Ramulina spandeli* Paalzow, etc. But her material is in abundance, diversity, and preservation considerably poorer.

It is astonishing that in spite of their rarity, many species were found by all authors (Farinacci, Luterbacher, Kuznetsova, Seibold), e.g., *Falsopalmula deslongchamsi* (Terquem), *Nodosaria nitidana* Gümbel, *Linguilina franconica* Gümbel. This indicates that these rare species are nevertheless significant in the deeper water facies.

Gordon (1970) mentions, in his review about the biogeography of Jurassic foraminifers, the lack of sculptured forms in a Sinai Kimmeridge profile (thought to be of moderate depth), described by Said and Barakat (1958). The smooth-walled nodosariids are abundant, as on the European shelf, but the sculptured species, although present, are not as common. Our results tend to indicate that a considerable dimunition of sculptured species is connected with greater depth. The study of such profiles south of the tethyan border facies will offer interesting comparative data for eastern Atlantic faunas.

Conclusions

Age

Many of the listed species occur throughout the European and North American Upper Jurassic. Their association (numerous *Dentalinae*, *Lenticulina quenstedti* [Gümbel], *L. uhligi* [Wisniowski], *L. semiexpleta* [Schwager]—all rare but characteristic [K]—and the "*Spirillinae*") indicates an Oxfordian age. The boundary between the Oxford and Kimmeridge cannot be stated from our material. Renz (this volume) assigns Section 376-34-4 to the Kimmeridge. It is the section with the local abundance of *Patellinae* and *Conorbina*? aff. *scutuliformis* Seibold. The latter occurs abundantly in one profile near the upper boundary of the Oxford in South Germany, and is rarely recorded in the Oxford of Switzerland (Oesterle, 1968). A similar form was found in the Oxford of Israel, but extends into the Tithonian.

The poor assemblages in the upper part of the profile prevent a statement of age. Regarding the thickness of the Oxfordian layers in the western Atlantic and the coincidence in the faunal trend, one is tempted to think that only the upper part of the Oxfordian was cored at Site 367.

Depth/Environment

Luterbacher assumes for the Upper Jurassic of the western Atlantic sites a bathyal depth, with shallowing toward the base (indicated by the richer faunas). The arguments for this assumption (similarly with the deep-water assemblages from Italy, absence of ornamented ostracodes, abundance of radiolarians and of *Saccocoma* spp.) can also be used for the samples of Site 367. In addition, in our material dominant foraminifer genera of the shelf species (e.g., *Lenticulina*, *Dentalina*, agglutinated genera like *Reophax* and *Ammobaculites*) were scarce. Also sculptured foraminifer species were remarkably reduced, the number of species decreased, the specimens were smaller, and the ostracodes were small and scarce.

All of this could perhaps indicate an even greater depth than in the Oxford of the western Atlantic, or may have been caused by other less favorable environmental conditions.

LOWER CRETACEOUS

Valanginian Stage

A foraminifer assemblage typical for the south European and Mediterranean Lower Cretaceous was found in Holes 367 (Cores 26-29) and 370 (Cores 38-49) in pale gray limestones and compact marls. Several species, known from deposits of the Valanginian of Italy, the Crimea, Germany, and Madagascar have been observed here (Table 4, Plates 4-7).

In the composition of the assemblages, benthic foraminifers predominate; in some samples, however, single representatives of planktonic foraminifers were found. The agglutinated forms, mainly representatives of the genus *Dorothia*, are dominant. The associations surpass the Jurassic material in diversity and abundance.

The systematic composition of the fauna (its relative abundances and diversity—35 genera and 72 species (Table 4, Plates 4-7), and especially the presence of forms with a narrow stratigraphic range, enable age determination of the deposits up to a substage, the upper Valanginian (no more detailed zonal subdivision by foraminifers has been suggested). The most representative species are: *Ammobaculites eocretaceus* Bartenstein and Brand, *Dorothia praehauteriviana* Dieni and Massari, *Lenticulina eichenbergi* Bartenstein and Brand, *Lenticulina nodosa* (Reuss), *Lenticulina nimbifera* Espitalié and Sigal, *Lenticulina insularis* Dieni and Massari, *Astocolus colligoni* Espitalié and Sigal, *Astocolus calliopsis* (Reuss), *Guttulina ichnusae* Deine and Massari, *Gavelinella bettenstedti* Dieni and Massari, and *Ichusella trocholinaeformis* Dieni and Massari.

Most of these species are frequent, although never abundant, except *Dorothia praehauteriviana* Dieni and Massari, which reaches 40 to 50 tests in some samples.

Most of the characteristic species were described from the upper Valanginian of Italy (Dieni and Massari, 1966), Germany (Bartenstein and Brand, 1951), and Madagascar (Espitalié and Sigal, 1963). Many species, such as *Ammobaculites erocretaceus* Bartenstein and Brand, *Lenticulina nodosa* (Reuss), *Astacocolus calliopsis* (Reuss), *Planularia madagascariensis* Espitalie and Sigal, *Tristix acutangulatux* Reuss, and *Pseudonodosaria mutabilis* (Reuss), were observed in upper Valanginian deposits of the Crimea (Gorbachik, 1969).

Conclusions

Lower Cretaceous foraminifer faunas from Holes 367 and 370 are similar in composition. But in Hole 370, the assemblages are considerably richer and more diverse.

Comparison of the Cretaceous foraminifers in Holes 367 and 370 with the European and Mediterranean forms shows their great similarity and enables the determination of their age: Valanginian (Hole 367, Cores 26-29; Hole 370, Cores 38-49). Hole 370, which contains a richer fauna in the given interval is upper Valanginian.

The similarity between the Lower Cretaceous (Valanginian) faunas from the northwestern Pacific Ocean (Douglas, 1971; Douglas and Moullade, 1972) and those from the eastern Atlantic is evident. Several species are common to both faunal assemblages. The species list, which do not suggest common species at first glance, conceal the close relationship of some species which belong to a single genetic group. Therefore, the lists certainly contain more common species (*Lenticulina ouaschensis* [Sigal], *Lenticulina muensteri* [Roemer], *Lenticulina eichenbergi* Bartenstein and Brand, *Tristix acutangulatus* Reuss, etc.), there are some genetically closely related forms (*Dorothia ouaschensis* [Sigal], *Dorothia praehauteriviana* Dieni and Massari and *Dorothia hauteriviana* [Moullade]; *Dorothia praeoxycona* Moullade, and *Dorothia hechti* Dieni and Massari), which started their development in the Valanginian or at the end of the Berriasian and continued it into the Hauterivian and Barremian.

The composition of the fauna in Holes 367 and 370, their characteristic features, dimensions, sculpture of the test, presence of various generations, predominance of adult tests, and other features, indicate that the fauna developed in a warm water basin and, of course, at a level above the carbonate compensation depth.

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PLATE 1

(All figures approximately ×100)

Figure 1	*Rhizammina* sp. Sample 367-38-1, 28-30 cm.
Figure 2	*Haplophragmium* ex gr. *canariensis* d'Orb. Sample 367-33-1, 10-12 cm.
Figures 3a, b	*Trochammina suprajurassica* (n. n. for *Tr. concava* Seibold). Sample 367-33-1, 10-12 cm.
Figures 4a, b	*Haplophragmoides* sp. Sample 367-33-1, 10-12 cm.
Figures 5, 6a, b	*Lagenammina* sp. 5. Sample 367-31-1, 84-86 cm. 6. Sample 367-33-1, 10-12 cm.
Figure 7	*Reophax* cf. *helveticus* Haeusler. Sample 367-36, CC.
Figure 8	*Glomospirella gaultina* (Berthelin). Sample 367-33-3, 132-134 cm.
Figures 9, 10	*Ramulina spandeli* Paalzon. 9. Sample 367-37-1, 84-86 cm. 10. Sample 367-38-1, 28-30 cm.
Figures 11-13	*Glomospira variabilis* Kübler and Zwingli. Sample 367-35-5, 26-28 cm.
Figure 14	*Trocholina* sp. Sample 367-36, CC.
Figures 15a, b, c	*Spirillina* sp. Sample 367-38-1, 28-30 cm.
Figures 16a, b	*Spirillina* sp. Sample 367-37-1, 84-86 cm.
Figures 17a, b	*Falsopalmula* cf. *deslongchampsi* (Terq.). Sample 367-38-1, 28-30 cm, and 38 cm.

PLATE 1

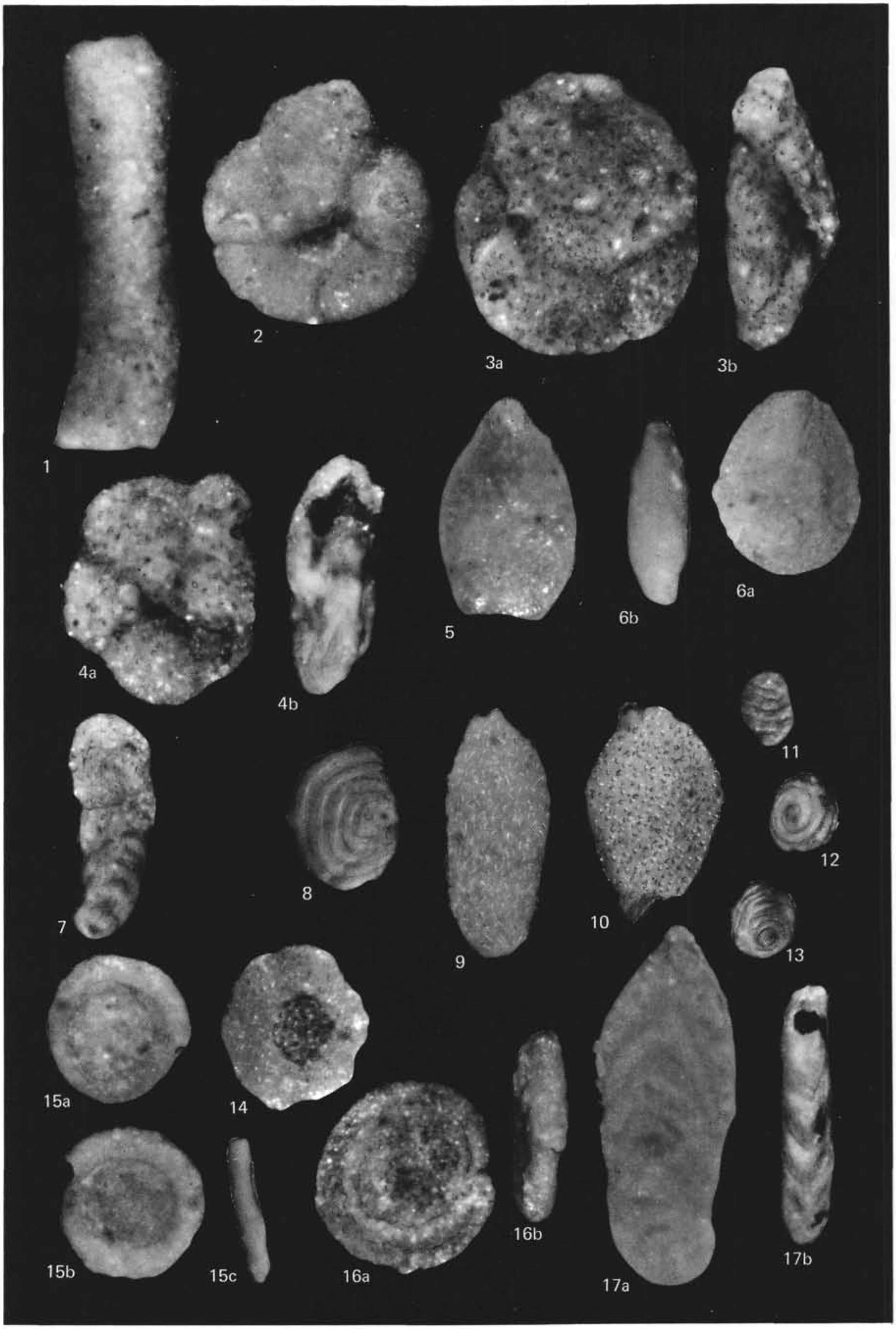


PLATE 2

(All figures approximately ×100)

Upper Jurassic

Figures 1a, b	*Lenticulina uhligi* (Wisniowskii). Sample 367-35, CC.
Figures 2a, b	*Lenticulina* ex gr. *uhiligi* (Wisniowskii) sp. nov.). Sample 367-37-1, 84-86 cm.
Figures 3a, b	*Lenticulina* ex gr. *uhligi* (Wisniowskii). Sample 367-37-1, 84-86 cm.
Figures 4a, b	*Astacolus* sp. Sample 367-37-1, 84-86 cm.
Figures 5a, c	*Nodosaria nitidana* Gümbel. Sample 367-37-1, 84-86 cm.
Figures 6a, b	*Lenticulina tumida* Mjatliuk. Sample 367-37-1, 84-86 cm.
Figures 7a, b	*Astacolus exiguus* (Schwager). Sample 367-38-1, 28-30 cm.
Figures 8a, b, 9	*Lenticulina münsteri* (Roem.). 8. Sample 367-32-2, 16-18 cm. 9. Sample 367-35-5, 26-28 cm.
Figures 10a, b	*Lenticulina quenstedti* (Gümbel). Sample 367-37-1, 84-86 cm.

PLATE 2

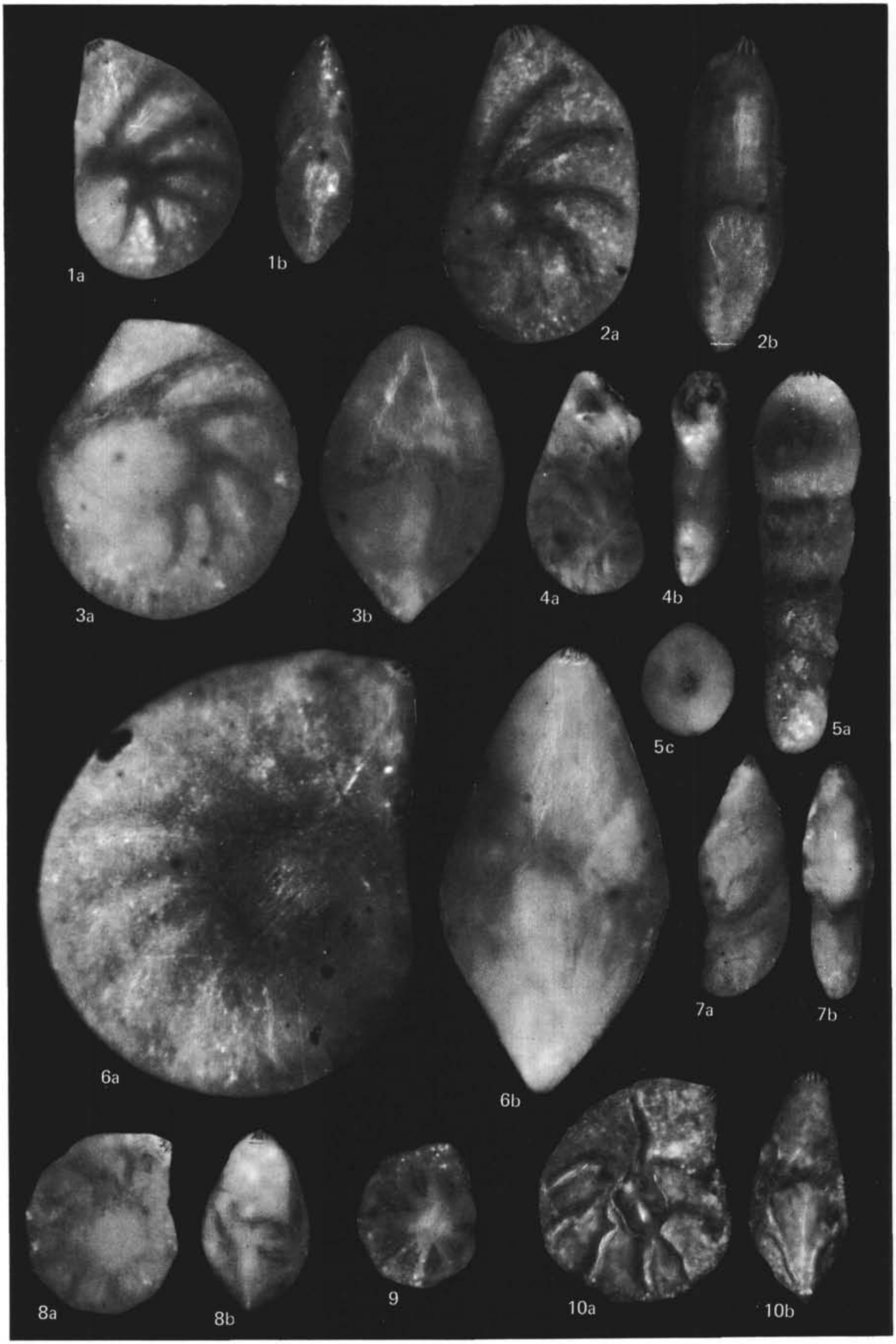


PLATE 3

Upper Jurassic

Figure 1	*Bigenerina jurassica* (Haeusler). Sample 367-38-1, 38 cm; ×100.
Figure 2	*Reophax helveticus* (Haeusler). Sample 367-38-1, 38 cm; ×100.
Figure 3	*Textularia* cf. *jurassica* Gümbel. Sample 367-37-1, 28 cm; ×100.
Figure 4	*Marginulina minuta* Terquem. Sample 367-37-1, 86-88 cm; ×100.
Figure 5	*Lingulina franconica* (Gümbel). Sample 367-38-1, 38 cm; ×100.
Figure 6	*Astacolus* cf. *fraasi* (Schwager). Sample 367-38-1, 38 cm; ×100.
Figure 7	"*Spirillina*" sp. Sample 367-37-1, 86-88 cm; ×100.
Figure 8	*Dentalina* cf. *bicornis* Terquem. Sample 367-38-1, 38 cm; ×100.
Figure 9	*Vaginulina jurassica* (Gümbel). Sample 367-38-1, 38 cm; ×100.
Figure 10	*Astacolus rectalongus* Brand. Sample 367-38-1, 38 cm; ×100.
Figure 11	*Guttulina* cf. *bilocularia* (Terquem). Sample 367-38-1, 38 cm; ×100.
Figure 12	*Glomospira variabilis* (Kubler and Zwingli). Sample 367-35-5, 28-30 cm; ×250.
Figure 13	*Globigerina*?-casts. Sample 367-34-1, 87-89 cm; ×500.
Figure 14	*Astacolus primus* (Orbigny). Sample 367-37-1, 28 cm; ×100.
Figure 15	*Conorbina?* aff. *scutuliformis* Seibold, Ventralseite. Sample 367-34-4, 87-89 cm; ×250.
Figures 16-19	Ostracodes, gen. et spec. indet. Sample 367-38-1, 38 cm; ×250.

PLATE 3

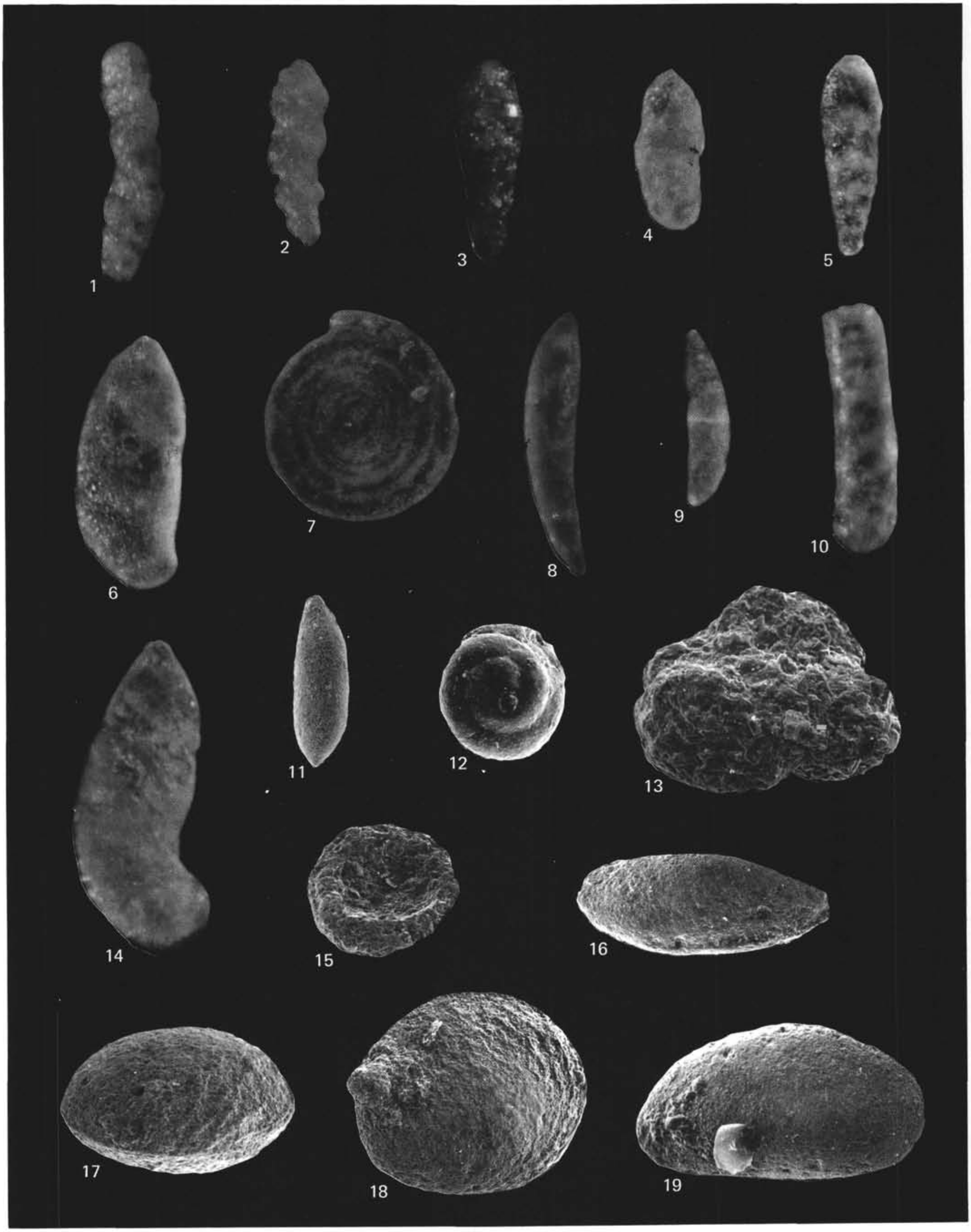


PLATE 4

(All figures approximately ×100)

Lower Cretaceous

(a—lateral view; b—peripheral view
c—apertural view; d—initial view)

Figure 1	*Haplophragmoides champmani* Crespin. Sample 370-47-1, 96-98 cm.
Figure 2	*Ammobaculites erocretaceous* Bartenstein and Brand. Sample 370-48, CC.
Figures 3, 4	*Dorothia hechti* Dieni and Massari. Sample 370-43, CC.
Figures 5, 6	*Dorothia praehauteriviana* Dieni and Massari. 5. Sample 370-38-3, 68-70 cm. 6. Sample 367-28-3, 64-66 cm.
Figure 7	*Glomospirella gaultina* (Berth.). Sample 370-45-2, 70-72 cm.
Figure 8	*Ammolagena* sp. Sample 370-43, CC.

PLATE 4

PLATE 5

(All figures approximately × 100, except Figure 1 × 75)

Lower Cretaceous

Figure 1	*Lenticulina eichenbergi* Bartenstein and Brand Sample 370-43, CC. a. lateral view. b. peripheral view.
Figure 2	*Lenticulina subalata* (Reuss). Sample 370-43, CC.
Figure 3	*Lenticulina ouaschensis* (Sigal). Sample 367-26, CC; a. lateral view. b. peripheral view.
Figure 4	*Lenticulina insularis* Dieni and Massari. Sample 370-43, CC; a. lateral view. b. peripheral view.
Figure 5	*Lenticulina ambanjabensis* Espitalié and Sigal. Sample 370-40, CC; a. lateral view. b. peripheral view.
Figure 6	*Lenticulina nodosa* (Reuss). Sample 370-48, CC; a. lateral view. b. peripheral view.
Figure 7	*Lenticulina nimbifera* Espitalié and Sigal. Sample 367-26, CC, a—lateral view, b—peripheral view.
Figures 8, 9	*Gavelinella bettenstedti* Dieni and Massari. 8. Sample 370-38, CC. 9. Sample 370-46-2, 86-88 cm; a. dorsal view. b. ventral view. c. peripheral view.
Figure 10	*Ichnusella trocholinaeformis* Dieni and Massari. Sample 370-38-4, 3l-33 cm; a. dorsal view. b. ventral view c. peripheral view.
Figure 11	*Guttulina ichnusae* Dieni and Massari. Sample 370-38-4, 31-33 cm.
Figures 12, 13	*Globulina prisca* Reuss. Sample 370-47-3, 53-55 cm.
Figure 14	*Hedbergella* sp. Sample 370-38-2, 96-98 cm. a. dorsal view. b. ventral view. c. peripheral view.

PLATE 5

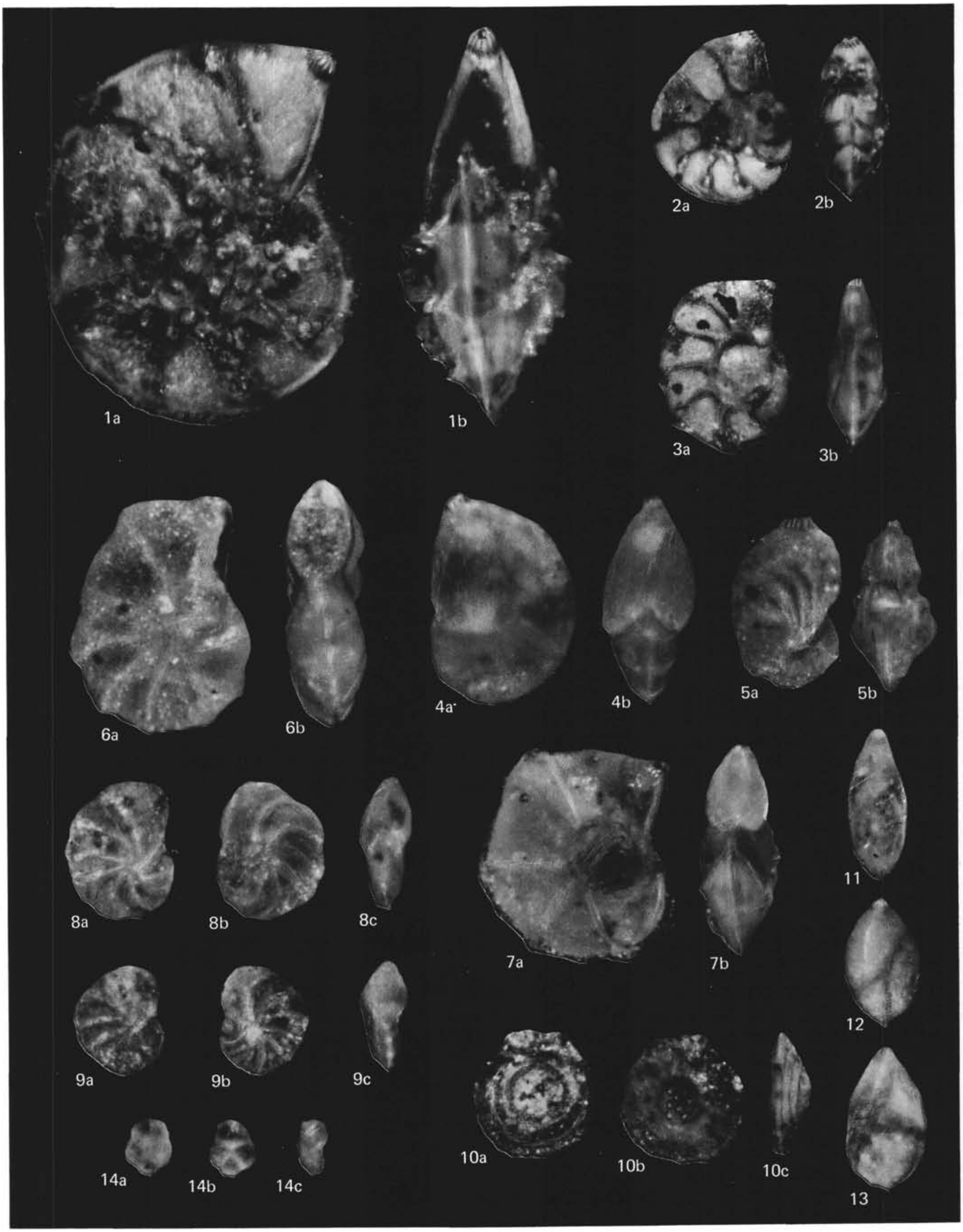

1a
1b
2a
2b
3a
3b
6a
6b
4a
4b
5a
5b
8a
8b
8c
7a
7b
11
12
9a
9b
9c
10a
10b
10c
13
14a
14b
14c

PLATE 6

(All figures approximately × 100)

Lower Cretaceous

(a—lateral view; b—peripheral view)

Figure 1	*Vaginulinopsis* sp. Sample 370-49-2, 69-71 cm.
Figure 2	*Astacolus calliopsis* (Reuss). Sample 370-46, CC.
Figure 3	*Astacolus primus* d'Orb. Sample 370-48, CC.
Figures 4, 5	*Vaginulinopsis enodis* Loeblich and Tappan. Sample 367-28-3, 64-66 cm.
Figures 6, 7	*Astacolus* sp. 6. Sample 370-38, CC. 7. Sample 370-43, CC.
Figure 8	*Vaginulina* sp. Sample 367-28-3, 64-66 cm.
Figure 9	*Astacolus* aff. *schloenbachi mediterranea* Dieni and Massari. Sample 367-28-3, 64-66 cm.
Figure 10	*Astacolus explicatus* Espitalié and Sigal. Sample 370-43, CC.

PLATE 6

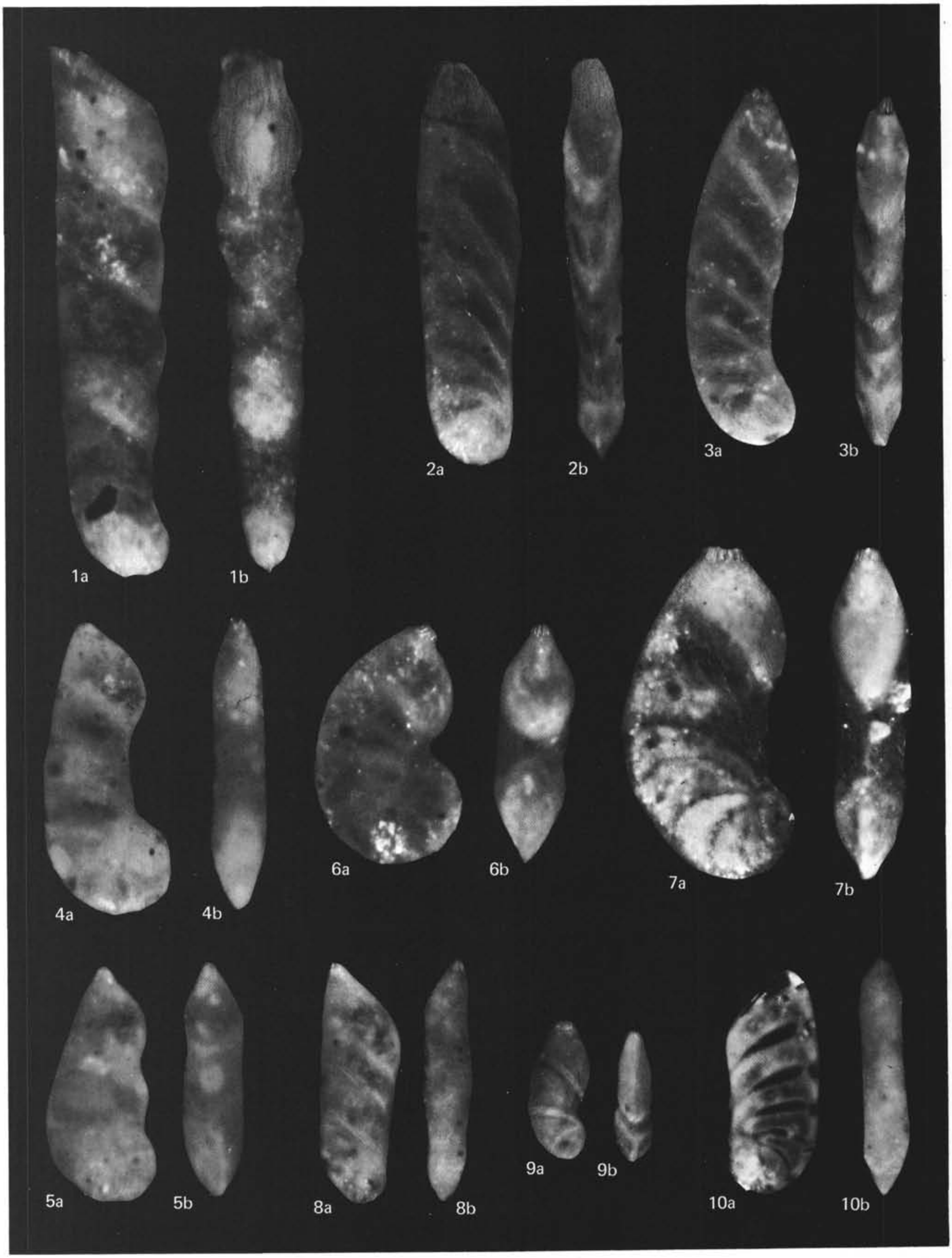


PLATE 7

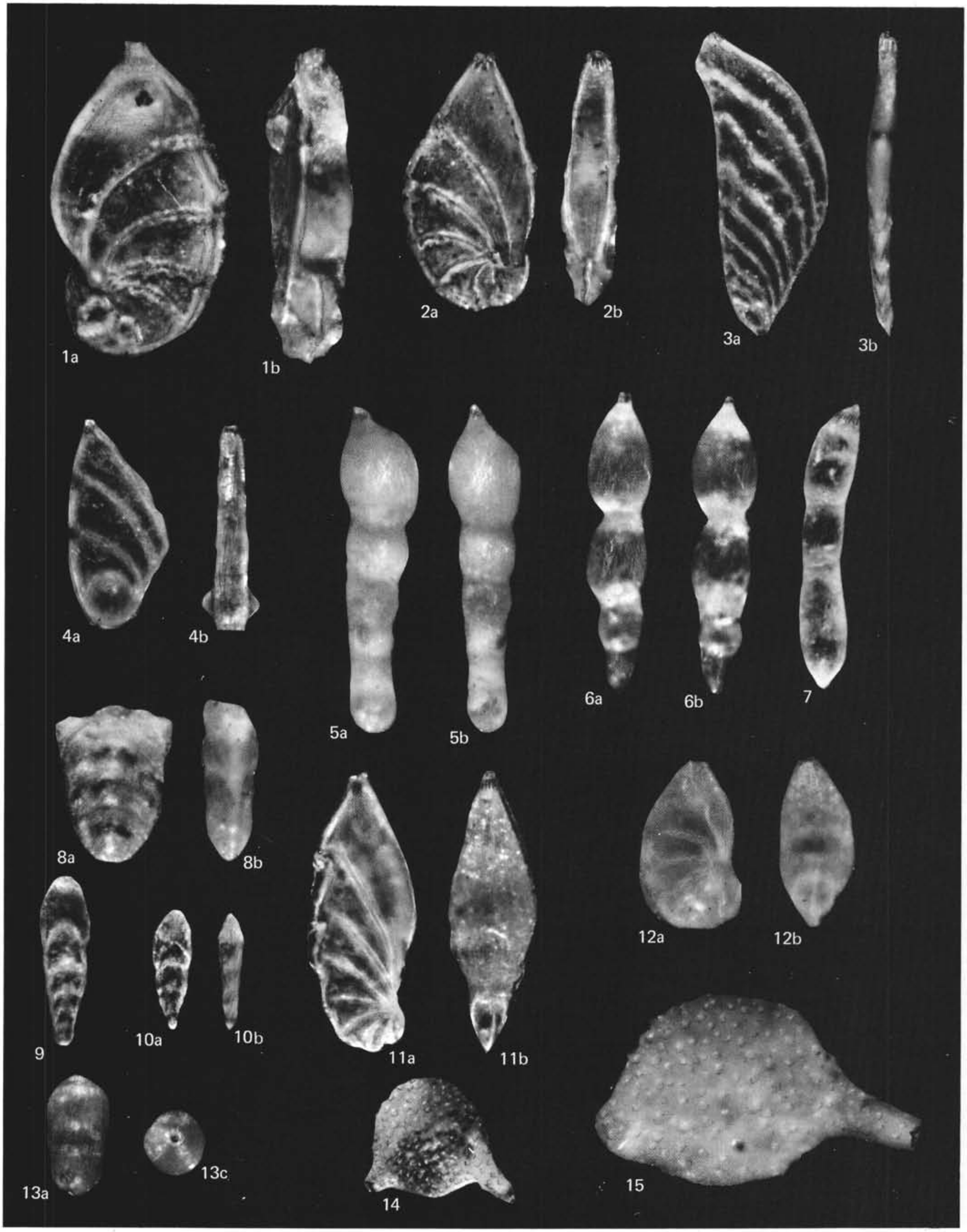
(All figures approximately × 100)

Lower Cretaceous

(a—lateral view, b—peripheral view, c—apertural view)

Figures 1, 2	*Planularia tricarinella* (Reuss). 1. Sample 370-44, CC. 2. Sample 370-43, CC.
Figure 3	*Planularia madagascariensis* Espitalié and Sigal. Sample 370-47-3, 53-55 cm.
Figure 4	*Citharina* aff. *strombecki* (Reuss). Sample 370-44, CC.
Figure 5	*Marginulina* sp. Sample 367-28-3, 64-66 cm.
Figure 6	*Dentalina bullata* Schwager. Sample 370-38, CC.
Figure 7	*Dentalina communis* d'Orbigny. Sample 370-43, CC.
Figure 8	*Lingulina trilobitomorpha* Pathy. Sample 370-43-2, 43-45 cm.
Figures 9, 10	*Lingulina* aff. *loryi* (Berthelin). 9. Sample 367-28-3, 104-106 cm. 10. Sample 370-46-2, 86-88 cm.
Figure 11	*Saracenaria tsaramandrosoensis* Epitalié and Sigal. Sample 370-40, CC.
Figure 12	*Saracenaria compacta* Espitalié and Sigal. Sample 370-38-4, 31-33 cm.
Figure 13	*Pseudonodosaria mutabilis* (Reuss). Sample 370-46, CC.
Figures 14, 15	*Ramulina tappanae* Bartenstein and Brand. 14. Sample 370-41-1, 55-57 cm. 15. Sample 370-43, CC.

PLATE 7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