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A Standard Late Cenozoic Microbiostratigraphy in Southern Okinawa-jima, Japan
Part 2. Details on the Occurrence of Planktonic Foraminifera with Some Taxonomic Annotations

By

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Abstract As revealed in the previous article (Part 1), the Upper Miocene to lowermost Pleistocene sequence developed in the southern area of Okinawa-jima, Ryukyu Islands, was successfully divided into nine calcareous nannofossil zones and nine planktonic foraminiferal ones based upon the same rock materials. In this paper, the stratigraphic occurrences of planktonic foraminifera are shown in detail using an occurrence chart of 90 taxa, a range chart of the selected 49 taxa, and the illustration of scanning electron micrographs of almost all taxa. Some of the results statistically confirm the validity of some inter-regional datum planes, while the others offer us a few locally valid datum planes. New stratigraphic and taxonomic informations on certain taxa are noticed.

Preface

The Shimajiri Group well developed in the southern Okinawa-jima region was divided into nine planktonic foraminiferal zones from Zone N16 to N22 in BLOW's (1969) scheme and, at the same time, into nine calcareous nannofossil zones from Zone CN9a to CN13a in OKADA and BUKRY's (1980) scheme. As discussed in Part 1 (TANAKA and UJIIÉ, 1984) and summarized in Figure 1, an inconsistent correlation could be recognized between both kinds of microfossil zones, partly because the same rock samples were utilized.

Actual working for such a zonation as summarized in Part 1 was based upon a quantitative analysis of the planktonic foraminiferal assemblages obtained from 72 samples. The results of such an analysis and their interpretation will be indicated in the following paragraphs. Taxonomic annotations on some taxa are also added.

On the Occurrence Range Chart

Each a completely dried rock sample was soaked in a 3% solution of hydrogen peroxide for about one day and then washed through a 200 mesh screen. Sometimes this procedure was repeated thrice. For the case of the Shimajiri Group and the Chinen

Formation treated here, almost all samples were thus macerated in leaving many well preserved specimens on the screen. From the residue after 100 mesh sieving in dry condition, 250-odd specimens of planktonic foraminifera per a sample were picked out, classified into more than 90 taxa, and counted individually per respective taxa (Table 1a-c).

Among 90 taxa shown in Table 1, stratigraphically important taxa and their related ones were chosen for drawing a range chart (Fig. 1), where their relative abundances are also indicated by a logarithmic expression just like the previous trial to one of the Philippine Sea piston cores (UJIIÉ and MIURA, 1971). This type of range chart offers us more clear image of the occurrence mode through a stratigraphic sequence than such a simple range chart as shown in Figure 6 of Part 1.

Internationally valid datum levels of the first appearance are necessarily accompanied with rather abundant occurrence from the initial stage; these cases are of *Globorotalia* (s.s) *plesiotumida* BLOW and BANNER at the base of Zone N17, *Pulleniatina primalis* BANNER and BLOW at the N17B base, *Globorotalia* (s.s.) *tumida* (BRADY) at the N18 base, *Globorotalia* (*Turborotalia*) *tosaensis* TAKAYANAGI and SAITO at the N21 base, and *Globorotalia* (s.s.) *truncatulinoides* (D'ORBIGNY) at the N22 base, as seen in Figure 1. That of *Sphaeroidinella dehiscens* (PARKER and JONES) including its subspecies, *immatura*, which defines the boundary between Zones N18 and N19, seems to be located in the upper part of N19. In a somewhat different section of the Shimajiri Group, NATORI (1976) recognized the initial appearance datum level of *S. dehiscens*, s.s. nearly at the same horizon as this study and, at the same time, that of *S. dehiscens immatura* (CUSHMAN) at a horizon far below the former. Since BLOW (1969) pointed out almost simultaneous first appearance of both subspecies, the first occurrence of *S. dehiscens*, s.s in the Shimajiri sequence may be of local one. For detecting such an initial appearance of *S. dehiscens immatura* as expressed by rare occurrence, it is necessary to treat so much amount of each a sample that its geographical tracing based upon hundreds of samples may become practically impossible. On the other hand, the first though local appearance datum plane of *Globorotalia* (s.s.) *margaritae* BOLLI and BERMÚDEZ can easily be traced throughout the southern Okinawa-jima region due to its peculiar morphology and its common occurrence from the initial stage of restricted stratigraphic range.

In general, it is difficult to designate the phylogenetical extinction-level of planktonic foraminiferal taxa because of gradual diminishing of occurrence or because of reworking that extend the last occurrence beyond the true extinction-level Concerning three taxa proposed by BERGGREN (1973) for subdividing the Pliocene, however, their abrupt disappearances after common and continuous occurrence are evidently presented as seen in Figure 1. The bases of Zones PL2, PL3, and PL5 are thus defined by the last appearance datum planes of *Globigerina nepenthes* TODD, *Globorotalia* (s.s.) *margaritae*, and *Globoquadrina altispira* (CUSHMAN and JARVIS), respectively.

Table 1a. Occurrence chart of planktonic foraminifera in the Shimajiri Group and Chinen Formation.

	N16							N17A						N17B										
	R2 831m	812	772	739	693	669	525	586	545	515	485	445	405	369	273	224	185	143	104	s-22	s-18	s-26	R1-5m	s-127
Globigerina bulloides																				?1				
G. praebulloides		1				1	2		1		4		3	2			1		3		?1		1	2
G. foliata	13	21	18	15	21	28	5	10	31	20	21	20	21	27	14	20	15	15	9	14	10	25	33	11
G. foliata, var. A																			1	1	1	6	1	1
G. falconensis	5	30	41	18	12	23	5	6	25	26	26	25	7	9	11	37	34	21	3	6	4	23	12	15
G. praecalida																								1
G. calida																								
G. nepenthes	40	13	8	43	16	12	33	20	32	19	43	29	5	6	8	10	14	22	12	32	13	10	18	12
G. decoraperta	13	17	12	6	12	22	37	12	44	14	25	19	7	12		18	18		7	4	33	7	8	11
G. rubescens																								
G. cf. *apertura*																								
G. cf. *woodi*			2	1	1	3	1	5	17								1	3	3		4	3	2	
G. aff. *angustiumbilicata*																								
G. sp. A																								
G. sp. B																								
G. spp.	1								2															1
Globigerinoides bollii	3	3	1	1	1		1	5	3	4	1		2	4	3		5		1		8	1		
G. cf. *kennetti*																								
G. canimarensis																					1			
G. conglobatus							1	1		1		3	2		1			1	8	5	6	4		5
G. bulloideus	3	4	1	1	1	1	1						1	2		2		?1	2					
G. quadrilobatus	8	13	12	12	29	22	44	30	6	17	19	8	31	24	33	22	24	16	19	12	29	9	19	21
G. quadrilobatus sacculifer	8	4	4	8	4	5	10	11	4	4	8	3	10	10	8	9	18	8	8	1	5	4	11	7
G. fistulosus																								
G. obliquus	48	50	31	24	36	38	54	43	20	22	47	47	55	31	18	36	44	35	14	38	44	22	34	23
G. extremus		1		1	4	2	2	7	4	4	1		7			3	3	3	4	3	4	2	2	8
G. elongatus																								
G. pyramidalis																								
G. ruber	2	?1				?2							2						?1					
G. aff. *tenellus*																								
G. spp.							1								?1	2								
Globigerinita glutinata	18	18	43	18	23	42	17	19	7	17	12	18	12	14	17	19	20	14	8	9	11	7	7	16
G. uvula	1		1	1	1			1		1	3	1	1					1						
G. iota																								
G. parkerae																								
Candeina nitida																			1					
Orbulina bilobata			1	1	2	1	1	1					1				1	2						
O. suturalis	1	1		1			2	1			1	1		1	1	1	2	2					5	
O. universa	6	7	9	12	8	8	4	11	3	11	9	9	14	9	2	12	3	14	3	11	8	5	3	8
Sphaeroidinellopsis kochi					1				1								1							
S. seminulina seminulina	3	4	10	6	11	5	3	8	2	7	5	8	8	9		4	6	4	6	7	3	1	4	5
S. seminulina subdehiscens	4	5	15	18	9	8	9	7	16	16	3	8	12	14	5	8	3	5	3	17	1	3	3	4
S. paenedehiscens																								
Sphaeroidinella dehiscens																								
Prosphaeroidinella parkerae	1		1				3	4	?2				8	1		2						1		1
Globoquadrina altispira			3	1	6	6	6	12	8	6	6	6	5	3	4	1	4	1		5				4
G. altispira, var.			1	2																				
G. globosa	2				?1		1		2	5	2	1		1		1	2	1						1
G. venezuelana	2	2	3	4	5	4	4	4	3		5		6						1	3				4
G. cf. *baroemoensis*			1																					
G. sp. A																								
Globorotaloides variabilis var. A		?1																		2		7	4	
G. variabilis, var.B							1	1															1	
Globorotalia (Turborotalia) anfracta																		?1						
G. (T.) acostaensis	5	22	14	20	28	6	9	8	7	18	?1	18	12	23	20	30	49	71	93	75	25	86	61	30
G. (T.) acostaensis, var. A	3		5		3		1			?3		2	3	8	2	2	4	6	4	10	1	25	22	4
G. (T.) acostaensis, var. B						?1	?1											2		3	1			1
G. (T.) acostaensis humerosa										4		5						2		3		1		
G. (T.) cf. *paralenguaensis*				1	4	3		2	1		3	1												
G. (T.) scitula		2				2	5		1						1						4	1		
G. (T.) cf. *subscitula*		1							1						1	2			2	1				
G. (T.) crassaformis																								
G. (T.) crassaformis, vars.																								
G. (T.) viola																								
G. (T.) tosaensis																								
G. (T.) sp. A																								
G. (T.) sp. B																								
G. (T.) spp.				1		1																		
Globorotalia (s.s.) *truncatulinoides*																								
G. (s.s.) aff. *pliozea*															?1					?3				
G. (Turborotalia) sp.						?1			?1				?1											
G. (s.s.) *margaritae*																								
G. (s.s.) *ungulata*																					1			
G. (s.s.) *cultrata*	9	2	1	7	1	9	2	13	7	7	10	2	?3	2	1		?2	2	6	2	2			8
G. (s.s.) *limbata*																								
G. (s.s.) *merotumida*	16	5	5	5		9	6	2	2	2	3	2	2	2	5	9	1	2	1		7	2		
G. (s.s.) *plesiotumida*								2	3	3	3	3	12	7	4	5	3	1	4	?1	3	?2	2	2
G. (s.s.) *tumida*																								13
G. (s.s.) *tumida flexuosa*																								
G. (s.s.) sp. A																								
G. (s.s.) spp.																								
Globigerinella obesa			1				1					1				2							1	
G. pseudobesa									2	?1			2						?3			1		
G. siphonifera														1		2	1	1						2
Hastigerina cf. *pelagica*																								
Pulleniatina primalis							?1							14	2	3		7		2	2	1		1
P. praecursor														?3		?1			2	1				
P. obliquiloculata																								
P. okinawaensis															?1			1						?1
Clavatorella nicobarensis																								
Gen. et sp. indet.	1			1	2		1					2		1		2	1				3			
Total	216	228	244	229	242	265	275	246	259	232	261	242	255	240	164	264	280	265	232	272	235	259	254	223

Table 1b. (Continued)

	PL1								PL2				PL3			PL4								
	s-122	s-124	s-16	s-76	s-75	s-73	s-72	s-155	s-63	s-93	s-92	s-58	s-153	s-151	s-150	Yo-23	Yo-24	Th-1	Th-5	Th-9	60910	60911	60913	sp-22
Globigerina bulloides			1											4		3	5				2		1	
G. praebulloides	9		5	3	6	2	3			5			2	5	10	12		8	6	6	4	10	3	
G. foliata	20	15	22	16	19	15	18	19	18	14	9	2	14	20	51	15	7	14	29	33	26	26	22	26
G. foliata, var. A	1	2	2	1		1		4	?1	5		1	4	8	3	5	3			2	1			
G. falconensis	28	24	7	22	26	36	25	6	33	24	7	9	18	33	23	27	13	8	22	20	55	37	13	27
G. praecalida					?1	2	1	2		2					3	4	2	1	2	4	2	2	2	1
G. calida														2		2				1		1		
G. nepenthes	35	10	35	12	6	5	11				?1													
G. decoraperta	13	21	25	17	5	39	8	9	13	14	23	20	2	7	3	6	7	16	4	3	5	5	11	25
G. rubescens									1			?23			2		4	?22	3	3		6	4	4
G. cf. *apertura*																1	1	3					6	5
G. cf. *woodi*	1		3		1	4		4	8			1	1											
G. aff. *angustiumbilicata*																								
G. sp. A											1	2	1	8	1	5		5	3	7			1	3
G. sp. B																		1	1		2			
G. spp.	1	1																4						1
Globigerinoides bollii		1			5	1	3	1	2	2	2	5	1	2	1		2	2			2	1	2	1
G. cf. *kennetti*																						3		
G. canimarensis					1		1										1					1		
G. conglobatus	2		1	3	2	3		3		1	1	2	1				1					1		
G. bulloideus								2				2						3						
G. quadrilobatus	5	19	21	31	22	15	23	24	18	13	14	13	24	5	14	9	5	15	5	11	20	9	20	7
G. quadrilobatus sacculifer	1	9	4	8	5	1	4	9	17	4	8	3	9	3	4	5	6	8	21	6	10	4	10	3
G. fistulosus																								
G. obliquus	21	40	32	55	39	38	25	57	24	42	81	38	23	13	18	10	10	5	8	8	10	10	4	7
G. extremus	6	7	18	5	15	7	3	4	8	9	13	13	5		17	12	9	5	3	8	1	3	5	1
G. elongatus																1	8	3	8	3	3	3	1	6
G. pyramidalis															2	4	2	2	2	2	1	2	2	8
G. ruber	2			1	3	2	2	2	1	1	?1	1	6	6	25	38	27	15	16	17	24	20	19	29
G. aff. *tenellus*																1								1
G. spp.					2				1					2	2								1	
Globigerinita glutinata	30	15	21	4	15	27	7	26	10	14	25	16	25	12	16	10	31	20	16	9	6	9	8	29
G. uvula							1	2				1												
G. iota																								
G. parkerae										1							2							
Candeina nitida																		3	1					
Orbulina bilobata					1				1												1		1	
O. suturalis					1															1	1	1		
O. universa	5	2	2	3	2		4	5	10	3	4	5			1	4	1	3		1	1	1	2	1
Sphaeroidinellopsis kochi																								
S. seminulina seminulina	3	1	5		2		3		3					1										
S. seminulina subdehiscens	2	18	4	2	3	1			5		1	1	1	1										
S. paenedehiscens			1	1	3		2					1	1											
Sphaeroidinella dehiscens															1	8	2	1	3			1	6	
Prosphaeroidinella parkerae				3	1			2	2	1	17	1	4			4	2				3	4	2	1
Globoquadrina altispira	2	7	8	4	6	8	3	3	2	5	7	9	4	3	3	11	8	4	5	8	6	3	4	
G. altispira, var.										?1				1		3	1			1				
G. globosa	1		2	5	5	2	2	2	2					3	2	4	2	2	3	1		1	1	
G. venezuelana	3	4	7		5	2	2	8		4	7	6	3	7	1		2	5	7	2	5	7	6	
G. cf. *baroemoensis*												1		2		1		3	3	1			2	
G. sp. A																								
Globorotaloides variabilis var. A	?1			2	1	4				1	5	4	5	4					3	3		2	1	4
G. variabilis, var. B								2							1	?1		3	?2	2				10
Globorotalia (Turborotalia) anfracta								9	?2	4	3	6		3				4			3			
G. (T.) acostaensis	31	12	12	36	19	10	17	20	13	11	4	6	35	39	27	23	?2	1	2	6	2	2	?1	10
G. (T.) acostaensis, var. A	4	1	4	?2			8	16	1	1	3	1	9	14		8	1							
G. (T.) acostaensis, var. B		2			1						?1		4	1				1	1					2
G. (T.) acostaensis humerosa						1	2					1				6	2		1			1	2	
G. (T.) cf. *paralenguaensis*																								
G. (T.) scitula	2	2	10	1	2	1		?1	2	2	1	2	1		1	2		2	2	2		1	1	
G. (T.) cf. *subscitula*																								
G. (T.) crassaformis																		4	5	5	3	1	1	3
G. (T.) crassaformis, vars.																6	43	57	54	50	53	52	59	1
G. (T.) viola																								1
G. (T.) tosaensis																2	3	4	3	7	4	1	5	6
G. (T.) sp. A						1												3			1			
G. (T.) sp. B																								
G. (T.) spp.																								
Globorotalia (s.s.) truncatulinoides																								
G. (s.s.) aff. *pliozea*			1		2	1	6	2	7	1	2	5	4											
G. (Turborotalia) sp.	1						1		1					1										
G. (s.s.) margaritae			5	3		1	15	4	2	1	1	8												
G. (s.s.) ungulata				9			2	2		?2		2	?1	?1		1	1							2
G. (s.s.) cultrata		4		2	1	1	1		2	3	2		1	1	1	2			1	1	?2	?2		17
G. (s.s.) limbata				1	2	5			5	6	24	9	10	4	5	17	31	5	7	4	9	24	19	
G. (s.s.) merotumida			3																					
G. (s.s.) plesiotumida	2	13	3	3	10	5	1	2	4	?2					?2									
G. (s.s.) tumida		2	1	2	15	2	1		11			4		3	1	4	1	1	5	2		1		
G. (s.s.) tumida flexuosa											1	3												
G. (s.s.) sp. A				2	1					2	1													
G. (s.s.) spp.																								
Globigerinella obesa					1			?1		1	1		1							1				
G. pseudobesa													?1											
G. siphonifera		3			1			1		1		1		1		3	2							2
Hastigerina cf. *pelagica*																								
Pulleniatina primalis	1	2				2		2	2	3		1												
P. praecursor	1	8	2	6				5			4	7	7	5				1						
P. obliquiloculata					2						1	6				2								
P. okinawaensis								2	1		1	1	1											
Clavatorella nicobarensis																								
Gen. et sp. indet.	2				1		3			1			3	1		1								
Total	235	244	269	265	261	248	208	263	233	207	277	223	232	226	241	283	250	247	257	241	268	258	248	254

Table 1c. (Continued)

	PL5														N22									
	Sz-15	sp-24	Sz-11	Sz-9	Sz-1	sp-20	sp-19	sp-18	sp-17	sp-16	sp-15	sp-14	sp-13	sp-12	sp-11	sp-10	sp-9	sp-8	sp-7	sp-6	sp-5	sp-4	sp-3	sp-2
Globigerina bulloides	1	1	9	4	2				2		1				3	1		2	4	4	2	1	2	1
G. praebulloides				4	7	1	4	2	2	4	4	1	4	11	7		4	4	6	10	18	1		
G. foliata	16	4	24	21	33	30	32	23	25	47	18	11	11	9	7	7	12	21	7	6	18	10	21	18
G. foliata, var. A														?1										
G. falconensis	24	6	30	25	13	20	15	25	12	18	6	12	19	21	3	11	8	8	3	8	5	3	12	14
G. praecalida	2			6	3	12	2	2		2	1		4	3		2		3	6	9	4		2	3
G. calida			3	1	3	3		2		1	1			1	?1				1		1			
G. nepenthes																								
G. decoraperta	25	5	33	26	31	22	19	12	12	11	21	4	13	1	6	9	9	2		2	4		1	2
G. rubescens	3		8	3	3	6	3	4	6		5		3	5	2	6	?1	2				?1	2	
G. cf. *apertura*	4	2	4	9	3	8	2	6	1	6				1					2				2	
G. cf. *woodi*																								
G. aff. *angustiumbilicata*							2																	
G. sp. A	3		14	16		1									1	1		1						
G. sp. B																								
G. spp.													1			2	2							1
Globigerinoides bollii		1		4		2																		
G. cf. *kennetti*						2	4	4	5	5	2	4	1	4	1	3	3				7		5	1
G. canimarensis	1	1	1						1	2		2				1		2						
G. conglobatus	3	6	3	2	2	1	1			1	1				2	2	1	2		2	?2	5	2	1
G. bulloideus																								
G. quadrilobatus	10	35	13	19	10	19	7	12	20	20	13	21	20	17	16	14	24	27	10	27	26	22	18	33
G. quadrilobatus sacculifer	16	26	9	19	12	12	11	7	11	4	8	14	13	13	27	9	11	24	8	9	10		5	8
G. fistulosus	7			4	5																			
G. obliquus	6	6	3			8								1									?3	?2
G. extremus	1	3	3	4	3		1				3	1						6	1	3		1	10	1
G. elongatus	7	10	4	5	13	4	11	10	11	14	19	24	11	10	14	10	12	15	17	10	29	13	8	9
G. pyramidalis	7	8	4	10	3	8	3	1	7	8	4	14	12	25	20	14	7	13	8	7	8		2	6
G. ruber	29	36	36	29	29	58	51	45	63	70	90	48	68	40	56	41	56	45	111	60	63	58	37	51
G. aff. *tenellus*						1																		
G. spp.				1				1																
Globigerinita glutinata	22	1	17	11	16	25	40	69	36	46	35	18	25	19	15	32	8	14	32	19	15	45	21	7
G. uvula	1					1			?1	4			?2	2				4	5	2	1	11	1	8
G. iota																								
G. parkerae																								
Candeina nitida			1		1				1				1					1						
Orbulina bilobata				1		1																		
O. suturalis																								
O. universa	2	2	5	4	5	4	4		6	1	5	1	1			2	2	8	3	3		1	2	2
Sphaeroidinellopsis kochi																								
S. seminulina seminulina																								
S. seminulina subdehiscens																								
S. paenedehiscens																								
Sphaeroidinella dehiscens	3	14	2	2	3	7	3	2	4	6	9	1	1	1	1	4		2	1	2	2			1
Prosphaeroidinella parkerae	2					1	1	2	1	4	1	3	2		1	1	4							
Globoquadrina altispira	?1																							
G. altispira, var.																								
G. globosa		1											1										3	
G. venezuelana		2																						
G. cf. *baroemoensis*																								
G. sp. A	3							1					4	1	1	1	2		2	1		?1		
Globorotaloides variabilis var. A	?3	1	2	2	2	3	3			2	1	1	?2	4	2	5	2	2	2	2	2	4	8	3
G. variabilis, var. B	14	2	4		1	4	4	6	3	3	14	9	19	8	8	12	11	8	16	5	9	4	5	4
Globorotalia (*Turborotalia*) *anfracta*																1								
G. (*T.*) *acostaensis*	14	24	12	18	5	8	8	2	1	7	2	9	8	14	7	9	16	15	18	17		11	6	26
G. (*T.*) *acostaensis*, var. A																								
G. (*T.*) *acostaensis*, var. B		2		1									1								1	1		
G. (*T.*) *acostaensis humerosa*	4	4	10	6	6		3	1	3	1	2			1	2	1	1	5	2	5	15	8	10	11
G. (*T.*) cf. *paralenguaensis*																								
G. (*T.*) *scitula*	1		1			1	2		3		3			3		2	?2	1				?1		?1
G. (*T.*) cf. *subscitula*																								
G. (*T.*) *crassaformis*		5	6	6	12	2	9	2	2	4	5	4	8	12	7	28	17	6	16	10	2	8	16	15
G. (*T.*) *crassaformis*, vars.	3					3	20	2	7	2	2	3	1	8	3	8	13	8	5	2	2	2		7
G. (*T.*) *viola*	1	2	6		1			1				2		1	1	3	2		1		2			
G. (*T.*) *tosaensis*				2	1	1	2	3	3	1	1	3	4	1	2	1	2	1	2	6	4	2	2	3
G. (*T.*) sp. A																							?1	
G. (*T.*) sp. B						3						1	1											
G. (*T.*) spp.																								
Globorotalia (s.s.) *truncatulinoides*															2		1	3	3	3	2	3	6	6
G. (s.s.) aff. *pliozea*																								
G. (*Turborotalia*) sp.																								
G. (s.s.) *margaritae*																								
G. (s.s.) *ungulata*	?1					1				2	1		1	1	1	2	1	1	2		1		?2	
G. (s.s.) *cultrata*	5	32	4	2	4	1			1	2	8	2	2	1	2		4	8	5	4	2	4	11	6
G. (s.s.) *limbata*	14	2	13	13	22	?5	7	3	8	2	1													
G. (s.s.) *merotumida*																								
G. (s.s.) *plesiotumida*																								
G. (s.s.) *tumida*	5	28	3	3	8	7	?1	1	3	3	4	2		1	2	4	5	6	1	?1	2	1	3	1
G. (s.s.) *tumida flexuosa*																								
G. (s.s.) sp. A																								
G. (s.s.) spp.						1	1																	
Globigerinella obesa						?2	1		1	4	2	1	3	2			2		1			?3	?1	
G. pseudobesa																								
G. siphonifera	2		3	4	2	2	3		2							1		2		2			2	4
Hastigerina cf. *pelagica*			1																					
Pulleniatina primalis																								
P. praecursor	1				1																	?1	?1	?2
P. obliquiloculata				1		14	1	2	1	2	4		1	4	4	2	5	1	3	4	3			
P. okinawaensis	1		?1					1				1	1		1		2		1	1	2		1	4
Clavatorella nicobarensis	2																							
Gen. et sp. indet.		1							1	1	1	1				1		2	2			1		1
Total	270	273	292	288	265	315	281	254	266	310	298	218	269	247	228	253	252	275	307	246	264	227	234	263

Annotations on Taxonomy and/or on Stratigraphic Occurrence

For the sake of saving the pages, only brief notes on taxonomic problems and/or on stratigraphic occurrences of some taxa are given in the followings. By the same reason, it is avoided to list up "incomplete" taxonomic references for each a taxon and also to refer comprehensively all over numerous literatures concerning the Late Cenozoic planktonic foraminifera from the Pacific region. Main sources of references are three synthetic, well-described and -illustrated works by BLOW (1969), SAITO *et al.* (1981), and KENNETT and SRINIVASAN (1983). Instead, almost all taxa found from the Shimajiri Group are illustrated by scanning electron micrographs, nearly all of which are ×150 magnification for convenience to comparison. Some of them are accompanied with micrographs showing individual or ontogenetic variation. All specimens are deposited in the Department of Paleontology, National Science Museum, Tokyo.

Globigernina bulloides D'ORBIGNY, 1826 (Pl. 1, figs. 1, 2)

Sporadical occurrence of this essentially temperate to subpolar species is limited in the Pliocene and Pleistocene portions.

Globigerina praebulloides BLOW, 1959 (Pl. 1, figs. 3, 4)

Since this species is distinguishable from *G. bulloides* only by more constricted aperture, the latter species of authors, particularly young forms, might be included here. In the same sense, *Globigerina parabulloides* BLOW, 1959 is also included, although BLOW (1959) described that the species is to be separated from *G. praebulloides* in having an aperture "with a distinctive lip or thickened rim." Later he (1969) showed a different scanning electron micrograph without such a lip nor rim. Probably because of these combining procedures, *G. praebulloides* assigned here extends its uppermost occurrence, instead of the late Miocene, up to the Pleistocene, namely in the Chinen Formation.

Globigerina foliata BOLLI, 1957 (Pl. 1, figs. 5–8)

Compared with *G. praebulloides*, this species has still more constricted aperture and smaller test size in average; KENNETT and SRINIVASAN (1983) considered *G. foliata* as to be a variant of *G. praebulloides*. Some specimens show low-arched or even rather slit-shaped aperture as seen in Pl. 1, figs. 7, 8. A completely continuous occurrence was observed through the Shimajiri Group.

Globigerina foliata BOLLI, 1957, var. A (Pl. 1, figs. 9, 10)

Due to encrusting, this variety is provided with a wall surface similar to that of *Globorotalia* (*Turborotalia*) *incisa* BRÖNNIMANN and RESIG, 1971, at a glance, but an umbilical to extraumbilical aperture can be recognized by dissecting the later chambers.

Globigerina praecalida BLOW, 1959 (Pl. 1, fig. 13; pl. 2, fig. 1)

Although KENNETT and SRINIVASAN (1983) regarded this species as a variant of *Globigerinella calida* (PARKER), our specimens keep trochospiral coiling and umbilical-extraumbilical aperture till the adult stage, whose size is comparable with adult test of *G. calida*. The first appearance in the Shimajiri sequence seems to be located around the boundary between Zones PL1 and PL2; BLOW (1969) placed it in the Upper Miocene.

Globigerina calida PARKER, 1962 (Pl. 2, fig. 2)

This species was placed under the genus *Globigerinella* by SAITO *et al.* (1976, 1981) and also by KENNETT and SRINIVASAN (1983). In this paper, however, I retain its original generic position tentatively, since it has very close relationship with *G. praecalida* in morphology and stratigraphic occurrence. An evidence of the earlier (basal part of Zone PL4) yielding of this species is shown in Pl. 2, fig. 2. BLOW (1969) regarded its first appearance datum as a subordinate criterion for recognizing the base of Zone N23 and some authors (*e.g.*, BRÖNNIMANN and RESIQ, 1971; SAITO *et al.*, 1981) have

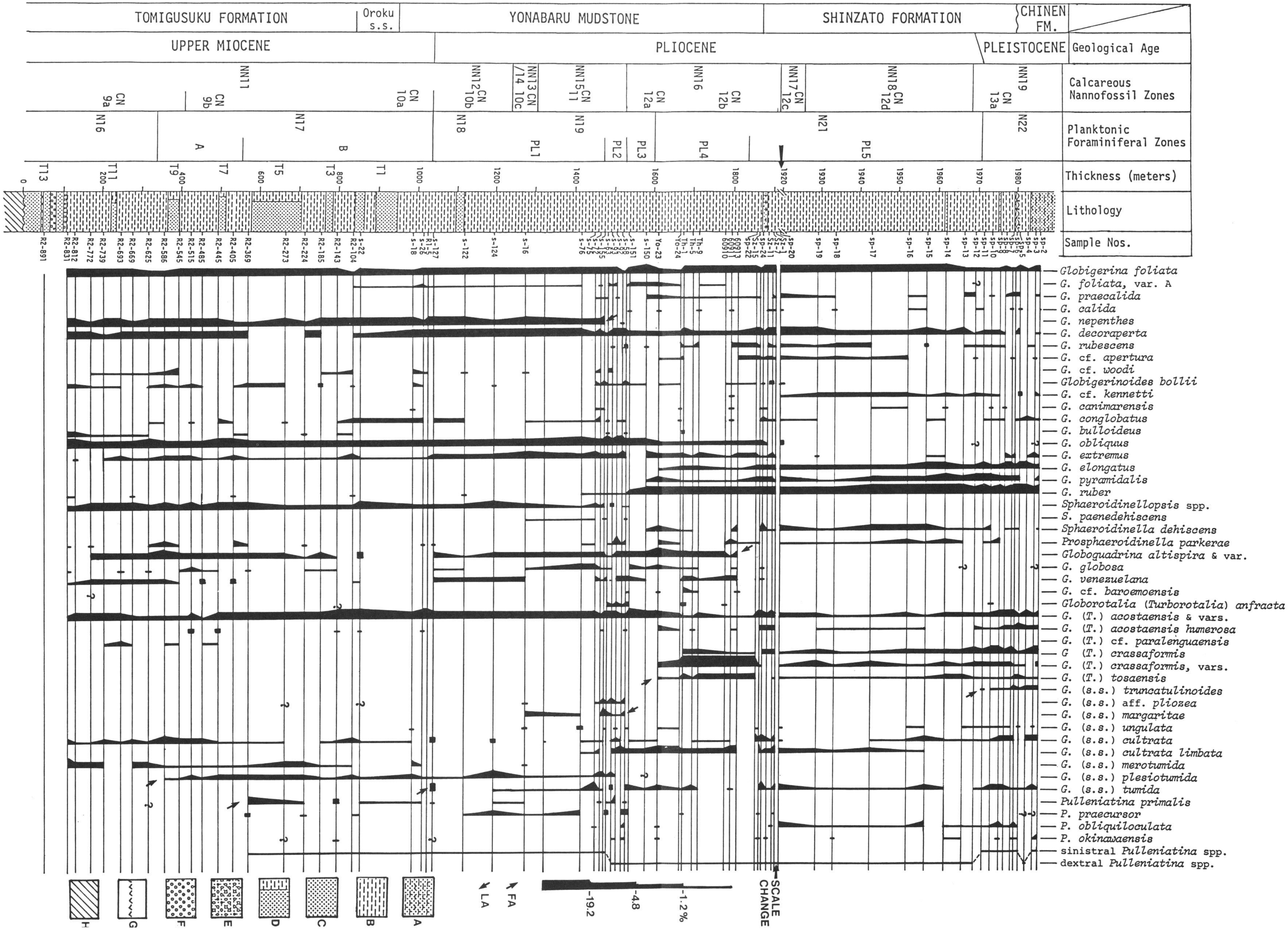

Fig. 1. Range chart of selected taxa of planktonic foraminifera, with logarithmic expression of their relative abundances.

FA: indicating the first appearance datum, LA: the last appearance datum, A: sandstone with limy nodules, B: massive siltstone, partly sandy, C: sandstone, D: sandstone rich alternation, E: conglomeratic sandstone, F: conglomerate, G: tuff, H: black phyllite of the Nago Formation. See Part 1 (Tanaka and Ujiié, 1984), for the further informations on geology and microbiostratigraphic zones.

accepted the datum.

Globigerina nepenthes TODD, 1957 (Pl. 2, figs. 3, 4)

Although this species was once subdivided into three subspecies by BRÖNNIMANN and RESIG (1971), any significant separation in their stratigraphic occurrences has not been recognized by themselves, UJIIÉ and SAMATA (1973) and this paper.

Globigerina decoraperta TAKAYANAGI and SAITO (Pl. 2, figs. 5, 6)

As noticed by SAITO *et al.* (1981), this species occurs up to Zone N22, despite of the previous opinions (*e.g.*, BLOW, 1969; NATORI, 1976; KENNETT and SRINIVASAN, 1983) which placed its last appearance datum in the Late Pliocene.

Globigerina rubescens HOFKER, 1956 (Pl. 2, fig. 7)

This species shows its first appearance in the Middle Pliocene, more precisely in Zone PL2 of the Shimajiri Group, as well as reported by BLOW (1969) and KENNETT and SRINIVASAN (1983).

Globigerina cf. ***woodi*** JENKINS, 1960 (Pl. 2, figs. 8, 9)

Excluding a few specimens, many found from the Upper Miocene to Lower Pliocene of the Shimajiri Group indicate not so highly arched aperture compared with typical form, which was described from New Zealand and has been reported from the lower Middle Miocene strata on the Sea of Japan coast of Honshu (UJIIÉ and HATSUKARI, 1973; SAITO and MAIYA, 1973).

Globigerina apertura CUSHMAN, 1918 (Pl. 2, fig. 10)

This species differs from *G.* cf. *woodi* in having more highly arched aperture and more lobulate chambers and in showing different stratigraphic occurrence, which ranges from Zone PL2 to N22 after the disappearance of the latter species in Zone PL1.

Globigerina aff. ***angustiumbilicata*** BOLLI, 1957 (Pl. 2, figs. 11, 12)

This minute species might be a juvenile form of some other species. However, I have frequently found the species from the Recent to Pleistocene sediments of Japan (*e.g.*, UJIIÉ, 1963; 1973).

Globigerina sp. A (Pl. 2, figs. 13, 14)

This small-sized species possesses a more lobulate and highly spired test in comparison with *Globigerinita glutinata* (EGGER), in which bullae is frequently developed (see also Pl. 7, figs. 1, 2). Both species have similar wall surface.

Globigerina sp. B (Pl. 2, fig. 15)

This is distinguished from *Globigerina praebulloides* in having more lobulate chambers, highly spired test, and thinner wall.

Globigerinoides bollii BLOW, 1959 (Pl. 3, fig. 1)

The last appearance is found in the lower part of Zone PL5, consistently with BLOW (1969) who designated it at the middle of Zone N21.

Globigerionides cf. ***kennetti*** KELLER and POORE, 1981 (Pl. 3, figs. 2–4)

While the range of typical species was designated as to be limited into an interval between Zones N16 and N18 by the original authors (KELLER and POORE, 1981), this related species ranges from the lower part of Zone PL5 to Zone N22, just replacing the range of *G. bollii*.

Globigerinoides canimarensis BERMÚDEZ, 1961 (Pl. 3, figs. 5, 6)

Although SAITO *et al.* (1981) regarded this as a junior synonym of *Globigerinoides conglobatus* (BRADY), the species is distinctive from the latter in possessing loosely attached chambers since the juvenile stage (compare Pl. 3, fig. 6 to Pl. 4, figs. 1 and 2 in particular). This much lobulate species has been reported even from Recent under the name of *G. conglobatus* as is the case of plankton-net tow samples from the southeastern Indian Ocean (UJIIÉ, 1968). BLOW (1969) placed the last appearance datum of *G. conglobatus carimarensis* within Zone N19.

Globigerinoides bulloideus CRESCENTI, 1966 (Pl. 4, fig. 3)

This may be the first report of the present Meditteranean to Atlantic species from the Pacific Ocean. The species seems to have much longer range than the designation by KENNETT and SRINIVASAN (1983).

Globigerinoides fistulosus (SCHUBERT, 1910) (Pl. 4, fig. 7; Pl. 5, fig. 1)

As far as the Shimajiri Group in Okinawa-jima is concerned, the occurrence is strictly limited around the boundary between the Shinzato and Yonabaru Formations so that it is locally useful for geographical tracing of the boundary.

Globigerinoides obliquus BOLLI, 1957 (Pl. 5, figs. 2–5)

Common and continuous yielding of the species almost terminates at the basal part of Zone PL5, even though sporadical occurrence can be seen till Zone N22 as well as shown by the previous workers.

Globigerinoides extremus BOLLI and BERMÚDEZ, 1965 (Pl. 5, figs. 6–8)

Rather common and continuous occurrence of this species terminates once near the base of Zone PL5 and reappears in Zone N22. The final appearance datum has been designated as to be in Zone 21 by authors (*e.g.*, BLOW, 1969; KENNETT and SRINIVASAN, 1983).

Globigerinoides elongatus (D'ORBIGNY, 1826) (Pl. 6, fig. 1)

This species occurs continuously and rather frequently after the initial appearance at the base of Zone PL4, *i.e.*, of Zone N21. The present appearance, which was observed in the upper N21 in Miyako-jima (UJIIÉ and OKI, 1973), might be a local phenomenon, because BLOW (1969), SAITO *et al.* (1981) and others recognized it in the middle part of Zone N16. Despite of KENNETT and SRINIVASAN'S (1983) opinion, this species can easily be discriminated from *Globigerinoides ruber* (D'ORBIGNY, 1839) by the highly and tightly coiled trochospire.

Globigerinoides pyramidalis (VAN DEN BROECK, 1976) (Pl. 6, figs. 2, 3)

The species is different from *G. ruber* in having a high trochospire since the juvenile stage and also from *G. elongatus* in showing a loosely coiled trochospire and more inflated chambers. The stratigraphic occurrence is quite similar to that of *G. elongatus*, although SAITO *et al.* (1981) thought that the species seems to be limited in the latest Pleistocene and Recent sediments.

Prosphaeroidinella parkerae UJIIÉ, 1976 (Pl. 7, figs. 7, 8)

Differing from *Sphaeroidinellopsis* and *Sphaeroidinella*, the genus *Prosphaeroidinella* lacks almost or completely a cortex layer. The type species, *Sphaeroidinella disjuncata* FINLAY, 1960, was thought as to represent merely an intermediate taxon between *Globigerinoides* and *Sphaeroidinellopsis* by KENNETT and SRINIVASAN (1983), who then placed the species under the genus *Sphaeroidinellopsis* and suppressed the genus *Prosphaeroidinella*, even though they newly proposed a number of "phylogenetically intermediate genera or subgenera" in the same book. At least, however, their criticism may be not valid for another species, *P. parkerae*, since the species shows the stratigraphic occurrence in parallel to those of *Sphaeroidinellopsis* and *Sphaeroidinella* species.

From another view-point, BOLLI and SAUNDERS (1981) doubted the validity of the genus *Prosphaeroidinella*. They noted that some intermediate forms can be observed between specimens similar to the holotype of *P. parkerae* and *Sphaeroidinellopsis hancocki* BANDY, 1975, and also between specimens similar to young *P. parkerae* and *Sphaeroidinellopsis seminulina* (SCHWAGER, 1866). Judging from the scanning electron micrographs illustrated in Plate 2 by them, however, there are not recognized truely intermediate types. Their figures 1 to 6, and 8 in Plate 2 indicate no trace of cortex layer development at all chambers consisting the last whorl so that these specimens must be belonged to *P. parkerae*. The remains of "intermediate specimens" have the "naked" wall surface without development of cortex layer only at the last chamber and, sometimes, at a part of the penultimate chamber so that these specimens can be classified as *S. seminulina* or *S. hancocki*. As far as my experience is concerned, the really intermediate form is quite seldom found implying that such a form represents merely an end member between two related but genetically distinguishable populations. Besides, the uppermost stratigraphic occurrence of *P. parkerae* seems to be located in Zone N22 far above those of *S. seminulina* and of *S. hancocki*; it means that there is not expected close associationship between *P. parkerae* and the latter two species.

Sphaeroidinellopsis seminulina (SCHWAGER, 1866), *s.l.* (Pl. 7, figs. 9–11)

In Table 1, I divided this species into *S. seminulina* and *Sphaeroidinellopsis subdehiscens* BLOW, 1959 but incline to agree with the opinion of SRINIVASAN and KENNETT (1981), who united together two species under *S. seminulina*. The stratigraphic range of the species, shown as *Sphaeroidinellopsis* spp. in Figure 1, seems to terminate near the top of Zone N19 for this case.

Sphaeroidinella dehiscens (PARKER and JONES, 1865) (Pl. 8, fig. 2)

Sphaeroidinella dehiscens immatura CUSHMAN is included here as a rare member. BLOW (1969) placed the base of Zone N19 near the first appearance datum of this species as well as recognized in Miyako-jima (UJIIÉ and OKI, 1974). In Okinawa-jima, however, the datum is located around the boundary between Zones N19 and N21 as stated already (p. 104).

Globoquadrina altispira (CUSHMAN and JARVIS, 1936), var. (Pl. 8, fig. 5)

This variant differs from the typical species by the lower trochospire; inbetween there is rare occurrence of intermediate forms.

Globoquadrina globosa BOLLI, 1957 (Pl. 9, figs. 1, 2)

This species disappears almost at the same time as *G. altispira*, though some reworked specimens are found from the upper horizon as exemplified by Pl. 9, Fig. 2.

Globoquadrina venezuelana (HEDBERG, 1937) (Pl. 9, figs. 3, 4)

A delayed occurrence of the species can be observed till the basal part of Zone PL5 (lower N21); BLOW (1969) noticed its last appearance datum in the middle part of Zone N19.

Globoquadrina* cf. *baroemoensis (LEROY, 1939) (Pl. 9, figs. 5–7)

While this form occurs in the portion between Zones PL2 and PL4, the typical species was regarded as to range from Zones N5 to N18 by KENNETT and SRINIVASAN (1983). A morphologically related species, *Globoquadrina pseudofoliata* PARKER, 1967 ranges from the basal part of Zone N19 to that of N22 or the higher horizon according to the original author.

Globorotaloides variabilis BOLLI, 1957, var. A (Pl. 9, figs. 9, 10)

This variety is considerably different from the typical species in having less flat spiral side of test, more inflated chambers, and four or four and a half chambers per whorl. Between this and next-cited varieties, there is rather gradual change in morphology. Both varieties occur throughout the Shimajiri sequence with a tendency increasing in number upwards, particularly in the case of variety B. The last appearance datum of *G. variabilis* has been considered as to be located around the end of Miocene (*e.g.*, BLOW, 1969; KENNETT and SRINIVASAN, 1983).

Globorotaloides variabilis BOLLI, 1957, var. B (Pl. 9, figs. 11–13)

Typical species differs from this variety in showing more rapidly increased whorl-height and in having more oblique sutures on the spiral side of the earlier stage. This variety somewhat resembles *Globorotaloides hexagona* (NATLAND), that has rapidly increased whorl-height, more lobulate equatorial outline of test, and more coarsely and regularly pitted wall (see such topotypic specimens from the San Pedro Basin, off California, as shown in Pl. 10, figs. 1, 2).

Globorotalia (Turborotalia) acostaensis BLOW, 1959, and vars. (Pl. 10, figs. 7–14; pl. 11, fig. 1)

This species occurs throughout the Shimajiri sequence in showing so variable morphology that any different name might be given individually. However, it is very difficult to subdivide these specimens into separate populations on the significant statistics. Only two varieties discriminated here. Differing from typical species, variety A has less number (four to three and a half) of chambers, which are inevitably more embraced, per a whorl. Variety B shows rapid growth of whorl-height in the later stage, resembling *Globorotalia (Turborotalia) acostaensis pseudopima* BLOW, 1969, whose initial appearance datum was regarded as to define the base of Zone N20 by BLOW (1969). As reported by many authors (*e.g.*, UJIIÉ and SAMATA, 1973), however, "*G.* (*T.*) *acostaensis pseudopima*" appeared in the earlier time.

Globorotalia (Turborotalia) acostaensis humerosa TAKAYANAGI and SAITO, 1962 (Pl. 11, figs. 2, 3)

This subspecies includes a type similar to *Globorotalia* (*Turborotalia*) *humerosa praehumerosa* NATORI, 1976 (see his Pl. 1, fig. 2). The stratigraphic range of this subspecies is rather identical to a combined range of *G.* (*T.*) *humerosa humerosa* (N20–N22) and *G.* (*T.*) *humerosa praehumerosa* (basal

N17–N21) of NATORI (1976). Whereas BLOW (1969) designated the initial appearance datum of this subspecies at the uppermost part of Zone N16 similarly to the case of the Shimajiri Group, KENNETT and SRINIVASAN (1983) assumed it in Zone N18.

Globorotalia* (*Turborotalia*)** cf. ***paralenguaensis BLOW, 1969 (Pl. 11, figs. 4, 5)

Few specimens are rather rarely found in Zones N16 and N17A. KENNETT and SRINIVASAN (1983) assigned the stratigraphic range of the typical species as to be from Zones 15 to N17A and regarded it as to represent a phylogenetic link between *Globorotalia* (*s.s*) *merotumida* BLOW and BANNER, 1965, and *Globorotalia lenguaensis* BOLLI, 1957, which was placed under the subgenus *Turborotalia* by BLOW (1969). When the scanning electron micrographs shown by KENNETT and SRINIVASAN (1983) as well as BLOW (1969) are compared from each other, nevertheless, *G. lenguaensis* is provided with more developed imperforate carina, which encircles the test periphery, than *G. paralenguaensis*. So it is hard to regard *G. paralenguaensis* as intermediate taxon connecting *G. lenguaensis* and *G. merotumida* which has typical marginal keel.

Globorotalia* (*Turborotalia*)** cf. ***subscitula CONATO, 1964 (Pl. 11, fig. 8; pl. 12, fig. 1)

In Zones N16 and N17 of the Shimajiri Group, there is rare but restricted occurrence of a turborotalid species that is similar to *Globorotalia* (*Turborotalia*) *scitula* (BRADY, 1882), s.l., but differs from this long-ranged species in having so fewer (four) and more embraced chambers, slightly less lobulate equatorial periphery, and somewhat thicker test throughout the ontogeny. These characters observed in the Shimajiri materials make us remember *G.* (*T.*) *subscitula* of BLOW (1969) rather than its original figures and description (CONATO, 1964; *fide* SAITO *et al.*, 1976).

Globorotalia* (*Turborotalia*) *crassaformis (GALLOWAY and WISSLER, 1927) (Pl. 12, figs. 2–4, 6)

Even though some varieties mentioned below are excluded, this species still shows broad variation in morphology, in particular, about periphery roundness in transverse section as exemplified in plate. Certain specimens have acute peripheral keel as seen in *Globorotalia* (*s.s*) *viola* BLOW, 1969 (see Pl. 12, figs. 5, 7). From *G. viola*, however, these specimens can be discriminated by more vaulted umbilical side. KENNETT and SRINIVASAN (1983) noted merely as "*Gr. viola* is probably no more than a tropical variant or subspecies of *Gr.* (*T.*) *crassaformis*". *G. viola* together with *G. crassaformis* and its varieties seem to appear almost simultaneously as *Globorotalia* (*Turborotalia*) *tosaensis*, limitedly for the instance of the Shimajiri sequence.

Globorotalia* (*Turborotalia*) *crassaformis (GALLOWAY and WISSLER, 1927), vars. (Pl. 12, figs. 8, 9; pl. 13, figs. 1, 3–6).

As previously experienced in the study of the Pleistocene faunas from the environs of Tokyo (UJIIÉ, 1963), I encountered a difficulty to subdivide *G.* (*T.*) *crassaformis* into different genetic populations with statistical significance. Unless much more specimens are treated, this problem will not be solved because there always are gradual changes in morphology and close associationship in stratigraphic occurrences.

It may be possible that a certain specific name is individually given for each a specimen. Among variants provided with almost three chamber per a whorl (vars. A and B), thick-walled one (var. B) resembles *Globorotalia inflata triangula* THEYER, 1973, and is relatively common in Zone PL5. While some specimens belonged to variety C is quite similar to topotypic specimens of *Globorotalai* (*Turborotalia*) *puncticulata* (DESHAYES, 1832), some others rather resemble *Globorotalia* (*Turbotoralia*) *inflata* (D'ORBIGNY, 1839). Variety C is relatively common in the earlier part of the range of *G.* (*T.*) *crassaformis* complex, whereas variety D, that is indentical to *Globorotalia* (*Turborotalia*) *crassaformis ronda* BLOW, 1969, occurs preferably in its later part.

Globorotalia (s.s.) ***truncatulinoides*** (D'ORBIGNY, 1839) (Pl. 14, figs. 1, 2)

Such a typical specimen as illustrated by NATORI (1976; pl. 6, fig. 6) from the Chinen Formation occurs seldom in the uppermost part of the Shimajiri Group, from which rather transitional forms are commonly found.

Globorotalia (s.s.) aff. ***pliozea*** HORNIBROOK, 1982 (Pl. 14, figs. 5–7)

The Shimajiri materials have the gross test morphology similar to those of the members belonged to the *Globorotalia* (*Globoconella*) *miozea* — *G.* (*G.*) *conoidea* — *G.* (*G.*) *conomiozea* lineage, which was proposed and well recognized in the Southwest Pacific region including New Zealand by authors (*e.g.*, MALMGREN and KENNETT, 1981; SRINIVASAN and KENNETT, 1981), but critically differ from them in possessing bilaterally compressed last and penultimate chambers at every ontogenetic stage. As far as this difference is concerned, the Shimajiri specimens are similar to *Globorotalia pliozea* HORNIBROOK that was described from the New Zealand Pliocene as a descendant of the above-mentioned lineage. This taxon, probably new species, shows a remarkable change from a globose test in the juvenile stage, which resembles the original figure of *Globorotalia miozea conoidea* WALTERS, 1965, to a bilaterally flattened test in the adult stage, in accompanying a rapid growth of whorl-height and then change of chamber-shape on spiral side.

This new taxon has been reported from many places of the North Pacific region under the different names such as *Globorotalia* (s.s.) *miozea miozea* and *G.* (s.s.) *miozea cibaoensis* from the Shimajiri Group in Okinawa-jima (NATORI, 1976), as *G.* (*s.s.*) aff. *cibaoensis* BERMÚDEZ from the same group in Miyako-jima (UJIIÉ and OKI, 1974), as *G.* (s.s.) *miozea cibaoensis* from a piston core in the northern Philippine Sea (UJIIÉ and MIURA, 1971), as *G.* (s.s.) aff. *cibaoensis* from the Sagara Group in western Shizuoka Prefecture, central Japan (UJIIÉ and HARIU, 1975), and probably as *G. miozea conoidea* from the Deep Sea Drilling Project Site 36, off northern California (OLSSON, 1971). Refering these reports, it can be said that the last appearance datum is located at the boundary between Zones PL2 and PL3 contemporarily with that of the boundary marker taxon, *Globorotalia* (s.s) *margaritae*, and that the first occurrence may be in Zone PL1 slightly earlier than *G.* (s.s.) *margaritae*. Such an associationship with *G.* (s.s.) *margaritae* in stratigraphic occurrence seems to be recognized for *G. pliozea* (HORNIBROOK, 1984).

***Globorotalia* (*Turborotalia*)** sp. (Pl. 15, fig. 1)

This species seems to be provided with some intermediate characters between *Globorotalia* (*Turborotalia*) *scitula* (BRADY, 1882) and the next-cited species. This is distinctive from three taxa which have been proposed as to represent such an intermediate form; *i.e.*, *Globorotalia juanai* BERMÚDEZ and BOLLI, 1969, *Globorotalia praemenardii* CATALANO and SPROVIERI, 1969, and *Globorotalia margaritae primitiva* CITA, 1973.

Globorotalia (s.s.) ***margaritae*** BOLLI and BERMÚDEZ, 1965 (Pl. 15, figs. 2, 3)

As mentioned already, the international datum plane of the last appearance of this species well defines the top of Zone PL2 and, at the same time, the local datum plane of its first appearance devides Zone PL2 into two subdivisions. Both planes are well traced over all the southern Okinawa-jima region.

Globorotalia (s.s.) ***ungulata*** BERMÚDEZ, 1960 (Pl. 15, figs. 4, 5)

NATORI (1976) proposed the initial appearance datum of the species within Zone N19 by his sequence of the Shimajiri Group. According to this study, however, his datum plane represents merely an initiation of its continuous occurrence, inasmuch as the sporadical yielding was found even in Zone N17B by this study. SAITO *et al.* (1981) and KENNETT and SRINIVASAN (1983) tentatively designated the range of this species as to be from Zone N21 to Recent.

Globorotalia (s.s.) sp. ex. interc. ***limbata*** (FORNASINI, 1902) and ***multicamerata*** CUSHMAN and JARVIS, 1930 (Pl. 15, fig. 7)

This intermediate form is united together as an end member of *G.* (s.s.) *limbata* population in occurrence chart (Table 1) and range chart (Fig. 1).

Globorotalia (s.s.) ***tumida flexuosa*** (KOCH, 1923) (Pl. 16, fig. 6)

Completely restricted occurrence of this subspecies is found in the upper part of Zone PL2, although NATORI (1976) recognized it all over the span of Zone 19 in the Shimajiri Group. SAITO *et al.* (1981) designated its last appearance datum in the Late Pleistocene.

Globorotalia (s.s.) sp. A (Pl. 17, fig. 1)

This unnamed species is identical to *Globorotalia* (s.s.) *crassula viola* BLOW reported from Miyako-jima by UJIIÉ and OKI (1974) and also probably to *Globorotalia* (s.s.) *crassula conomiozea* KENNETT from Okinawa-jima by NATORI (1976). These Shimajiri materials are more similar to *Globorotalia miozea conoidea* WALTERS than *G. conomiozea* KENNETT in having less vaulted umbilical side, but differ from the two taxa in showing rather sharply keeled periphery in the earlier part of the last whorl instead of bluntly angled periphsery.

Pulleniatina okinawaensis NATORI, 1976 (Pl. 18, figs. 3, 4)

The species is identical to *Pulleniatina*? sp. of UJIIÉ and OKI (1974) who recognized it in Zones 17 and 18 of the Shimajiri Group in Miyako-jima. In Okinawa-jima, this study designates the range as to be from Zones 17B to N22. *P. okinawaensis* is not typical *Pulleniatina* species because of less development of cortex layer, particularly at the juvenile stage, and because of indistinct streptospiral coiling.

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Explanation of Plates

(All figures ×150 otherwise noticed)

Plate 1

Figs. 1, 2. *Globigerina bulloides* D'ORBIGNY. Yo-24.
Figs. 3, 4. *Globigerina praebulloides* BLOW. s-75.
Figs. 5, 6. *Globigerina foliata* BOLLI. s-75.
Figs. 7, 8. *Globigerina foliata* BOLLI. With nearly slit-shaped aperture. Th-5.
Figs. 9, 10. *Globigerina foliata* BOLLI, var. A. With somewhat encrusted wall as is seen in *Globorotalia* (*Turborotalia*) *incisa* BRÖNNIMANN & RESIG at a glance. 9: 2-92; 10: s-155.
Figs. 11, 12. *Globigerina falconensis* BLOW. s-75.
Fig. 13. *Globigerina praecalida* BLOW. Young form, Yo-23.

Plate 2

Fig. 1. *Globigerina praecalida* BLOW. Yo-23.
Fig. 2. *Globigerina calida* PARKER. Yo-23.
Figs. 3, 4. *Globigerina nepenthes* TODD. s-75. 4: without bullae.

Figs. 5, 6. *Globigerina decoraperta* TAKAYANAGI & SAITO. 5: s-75; 6: Yo-24.
Fig. 7. *Globigerina rubescens* HOFKER. Yo-24.
Figs. 8, 9. *Globigerina* cf. *woodi* JENKINS. R2-545 m.
Fig. 10. *Globigerina apertura* CUSHMAN. Th-1.
Figs. 11, 12. *Globigerina* aff. *angustiumbilicata* BOLLI. sp.-19. 12: ×300.
Figs. 13, 14. *Globigerina* sp. A. Sz-9.
Fig. 15. *Globigerina* sp. B. Th-1.

Plate 3

Fig. 1. *Globigerinoides bollii* BLOW. s-75.
Figs. 2–4. *Globigerinoides* cf. *kennetti* KELLER & POORE. 2: s-75; 3, 4: s-16.
Figs. 5, 6. *Globigerinoides canimarensis* BERMÚDEZ. 5: Yo-24; 6: young form, sp-17.
Figs. 7, 8. *Globigerinoides conglobatus* (BRADY). 7: Sz-1; 8: gerontic form with abnormally compressed test-shape, Sz-15.

Plate 4

Figs. 1, 2. *Globigerinoides conglobatus* (BRADY). sp-22, 1: juvenile form; 2: young form.
Fig. 3. *Globigerinoides bulloideus* CRESCENTI. R2-831 m.
Fig. 4. *Globigerinoides quadrilobatus* (D'ORBIGNY). Th-9.
Figs. 5, 6. *Globigerinoides quadrilobatus sacculifer* (BRADY). Th-5.
Fig. 7. *Globigerinoides fistulosus* (SCHUBERT). Young form, Sz-9.

Plate 5

Fig. 1. *Globigerinoides fistulosus* (SCHUBERT). ×100, Sz-9.
Figs. 2–5. *Globigerinoides obliquus* BOLLI. 2, 3: R2-445 m, 4: showing delayed occurrence at sp-12; 5: abnormal gerontic form, 60910.
Figs. 6–8. *Globigerinoides extremus* BOLLI & BERMÚDEZ. 6: sp-8; 7, 8: Th-9.

Plate 6

Fig. 1. *Globigerinoides elongatus* (D'ORBIGNY). Th-9.
Figs. 2, 3. *Globigerinoides pyramidalis* (VAN DEN BROECK). Sz-9. 2: young form, 3: gerontic form.
Figs. 4, 5. *Globigerinoides ruber* (D'ORBIGNY). Th-9. 5: with less lobulated periphery and restricted aperture.
Fig. 6. *Globigerinoides* cf. *tenellus* PARKER. Yo-23.
Fig. 7. *Orbulina suturalis* BRÖNNIMANN. s-75.
Figs. 8, 9. *Orbulina bilobata* (D'ORBIGNY). 8: R2-625 m; 9: with an exposed antepenultimate chamber somewhat resembling *Praeorbulina transitoria* (BLOW), 60910.
Fig. 10. *Orbulina universa* D'ORBIGNY. s-75.

Plate 7

Figs. 1, 2. *Globigerinita glutinata* (EGGER). s-18. 1: without bullae.
Fig. 3. *Globigerinita uvula* (EHRENBERG). sp-7.
Fig. 4. *Globigerinita parkerae* (BERMÚDEZ). Yo-24.
Fig. 5. *Candeina nitida praenitida* BLOW. R2-104.5 m.
Fig. 6. *Candeina nitida nitida* D'ORBIGNY. Sz-11.

Figs. 7, 8. *Prosphaeroidinella parkerae* UJIIÉ. 7: somewhat similar to *Prosphaeroidinella disjuncta* (FINLAY), R2-545 m; 8: young form with bullae, s-76.
Figs. 9–11. *Sphaeroidinellopsis seminulina* (SCHWAGER), s.l. R2-545 m.

Plate 8

Fig. 1. *Sphaeroidinellopsis paenedehiscens* BLOW. s-72.
Fig. 2. *Sphaeroidinella dehiscens* (PARKER & JONES). Yo-23.
Fig. 3. *Sphaeroidinellopsis kochi* (CAUDRI). R2-695 m.
Fig. 4. *Globoquadrina altispira* (CUSHMAN & JARVIS). Yo-24.
Fig. 5. *Globoquadrina altispira* (CUSHMAN & JARVIS), var. Yo-23.

Plate 9

Figs. 1, 2. *Globoquadrina globosa* BOLLI. 1: Yo-23; 2: showing delayed occurrence at sp-3.
Figs. 3, 4. *Globoquadrina venezuelana* (HEDBERG). Th-5. 4: young form.
Figs. 5–7. *Globoquadrina* cf. *baroemoensis* (LEROY). 5, 7: Th-1; 6: s-75.
Fig. 8. *Globoquadrina* sp. A. sp-10.
Figs. 9, 10. *Globorotaloides variabilis* BOLLI, var. A. sp-10.
Figs. 11–13. *Globorotaloides variabilis* BOLLI, var. B. 11, 13: sp-10; 12: sp-11.

Plate 10

Figs. 1, 2. *Globorotaloides hexagona* (NATLAND). Topotypic specimens from the San Pedro Basin off California.
Figs. 3, 4. *Globorotalia* (*Turborotalia*) *anfracta* PARKER. Th-1.
Figs. 5, 6. *Globorotalia* (*Turborotalia*) sp. C. s-93.
Figs. 7–11. *Globorotalia* (*Turborotalia*) *acostaensis* BLOW. 7, 10: s-155; 8, 9: R2-143 m.
Figs. 12–14. *Globorotalia* (*Turborotalia*) *acostaensis* BLOW, var. A. With less number of chambers compared with typical form; 12: s-155; 13, 14: R2-831 m.

Plate 11

Fig. 1. *Globorotalia* (*Turborotalia*) *acostaensis* BLOW, var. B. Resembling *Globorotalia* (*Turborotalia*) *acostaensis pseudopima* BLOW. Sz-9.
Figs. 2, 3. *Globorotalia* (*Turborotalia*) *acostaensis humerosa* TAKAYANAGI & SAITO. 2: R2-515 m; 3: Sz-9.
Figs. 4, 5. *Globorotalia* (*Turborotalia*) cf. *paralenguaensis* BLOW. 4: R2-485 m; 5: R2-739 m.
Figs. 6, 7. *Globorotalia* (*Turborotalia*) *scitula* (BRADY). 6: gerontic form, s-124; 7: sp-17.
Fig. 8. *Globorotalia* (*Turborotalia*) aff. *subscitula* CONATO. Young form, R2-104.5 m.

Plate 12

Fig. 1. *Globorotalia* (*Turoborotalia*) aff. *subscitula* CONATO. R2-224 m.
Figs. 2–4, 6. *Globorotalia* (*Turborotalia*) *crassaformis* (GALLOWAY & WISSLER). 2: sp-15; 3: Sz-9; 4: remarkably keeled abnormal form, Sz-9; 6: keeled young form, sp-15.
Figs. 5, 7. *Globorotalia* (*Globorotalia*) *viola* BLOW. With less protruded umbilical side and slightly more embranced chambers compared with "keeled *G.* (*T.*) *crassaformis*". 5: sp-17; 7: Sz-11.
Figs. 8, 9. *Globorotalia* (*Turborotalia*) *crassaformis* (GALLOWAY & WISSLER), var. A. With almost three chambers per a whorl. 8: sp-10; 9: sp-12.

Plate 13

Fig. 1. *Globorotalia (Turborotalia) crassaformis* (GALLOWAY & WISSLER), var. B. sp-12.

Fig. 2. *Globorotalia (Turborotalia) puncticulata* (DESHAYES). Topotypic specimens from Rimini coast, Italy, through the courtesy of Francis L. PARKER.

Figs. 3–5. *Globorotaia (Turborotalia) crassaformis* (GALLOWAY & WISSLER), var. C. Yo-24.

Fig. 6. *Globorotalia (Turborotalia) crassaformis* (GALLOWAY & WISSLER), var. D. sp-12.

Plate 14

Figs. 1, 2. *Globorotalia (Turborotalia) tosaensis* TAKAYANAGI & SAITO. 1: sp-13; 2: Yo-24.

Figs. 3, 4. *Globorotalia (Globorotalia) truncatulinoides* (D'ORBIGNY). Rather transitional forms. 3: sp-11; 4: sp-3.

Figs. 5–7. *Globorotalia (Globorotalia)* aff. *pliozea* HORNIBROOK. 5: juvenile, 6: young, 7: adult stages, s-63.

Plate 15

Fig. 1. *Globorotalia (Globorotalia)* sp. s-63.

Figs. 2, 3. *Globorotalia (Globorotalia) margaritae* BOLLI & BERMÚDEZ. 2: s-58; 3: gerontic form, s-16.

Figs. 4, 5. *Globorotalia (Globorotalia) ungulata* BERMÚDEZ. 4: sp-11; 5: s-76.

Fig. 6. *Globorotalia (Globorotalia) cultrata* (D'ORBIGNY). ×100, s-151.

Fig. 7. *Globorotalia (Globorotalia) limbata* (FORNASINI)/*Globorotalia (Globorotalia) multicamerata* CUSHMAN & JARVIS intermediate form. sp-17.

Plate 16

Fig. 1. *Globorotalia (Globorotalia) limbata* (FORNASINI). Yo-24.

Fig. 2. *Globorotalia (Globorotalia) merotumida* BLOW & BANNER. R2-374 m.

Figs. 3, 4. *Globorotalia (Globorotalia) plesiotumia* BLOW & BANNER. 3: R2-515 m; 4: R2-369.1 m.

Fig. 5. *Globorotalia (Globorotalia) tumida* (BRADY). R2-5 m.

Fig. 6. *Globorotalia (Globorotalia) tumida flexuosa* (KOCH). ×100, s-58.

Plate 17

Fig. 1. *Globorotalia (Globorotalia)* sp. A. s-75.

Figs. 2–4. *Globigerinella obesa* (BOLLI). 2: jevenile form, R2-224 m; 3: young form, sp-19; 4: adult, sp-12.

Figs. 5, 6. *Globigerinella pseudobesa* (SALVATORINI). R2-545 m.

Figs. 7, 8. *Globigerinella aequilateralis* (BRADY). 7: involute type, s-151; 8: Yo-23. [=*G. siphonifer* in Table 1]

Plate 18

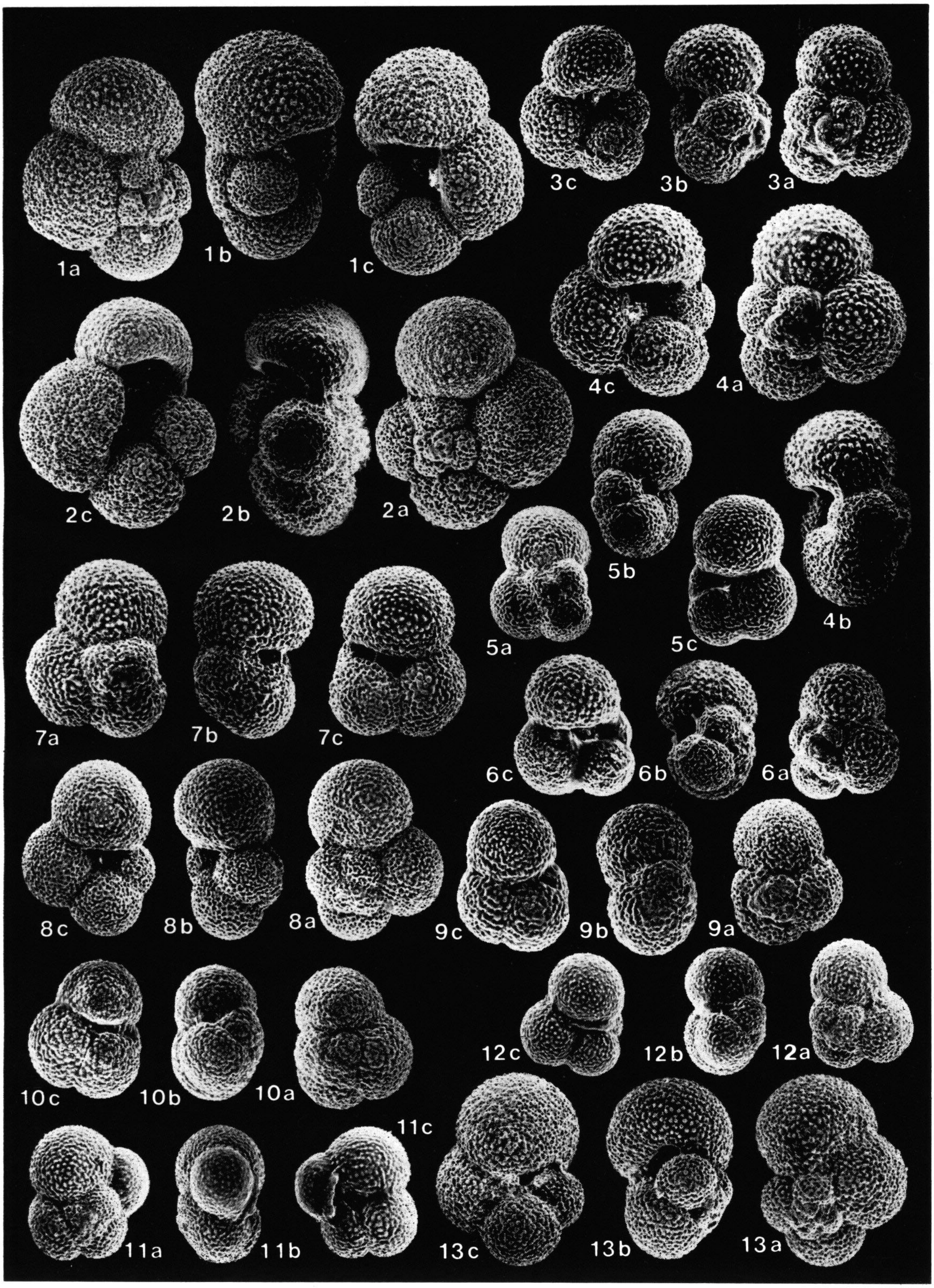
Figs. 1, 2. *Clavatorella nicobarensis* SRINIVASAN & KENNETT. Juvenile form, Sz-15; 2: ×300.

Figs. 3, 4. *Pulleniatina okinawaensis* NATORI. sp-9. 3: juvenile form.

Fig. 5. *Pulleniatina primalis* BANNER & BLOW. With somewhat re-crystalized wall surface and showing the lowermost occurrence in the studied sequence, *i.e.*, at R2-369.1 m.

Fig. 6. *Pulleniatina praecursor* BANNER & BLOW. s-58.

Fig. 7. *Pulleniatina obliquiloculata* PARKER & JONES. sp-12.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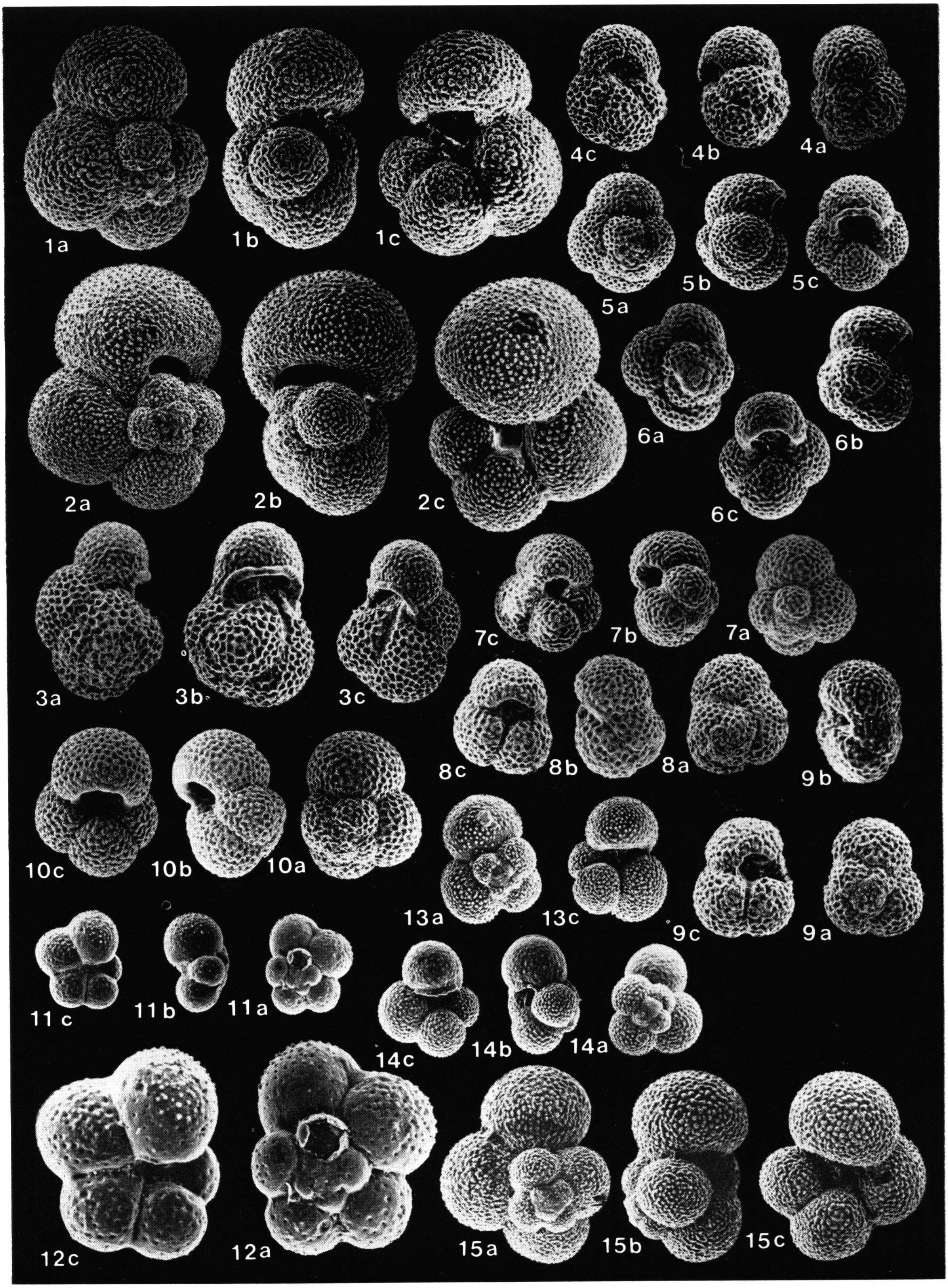
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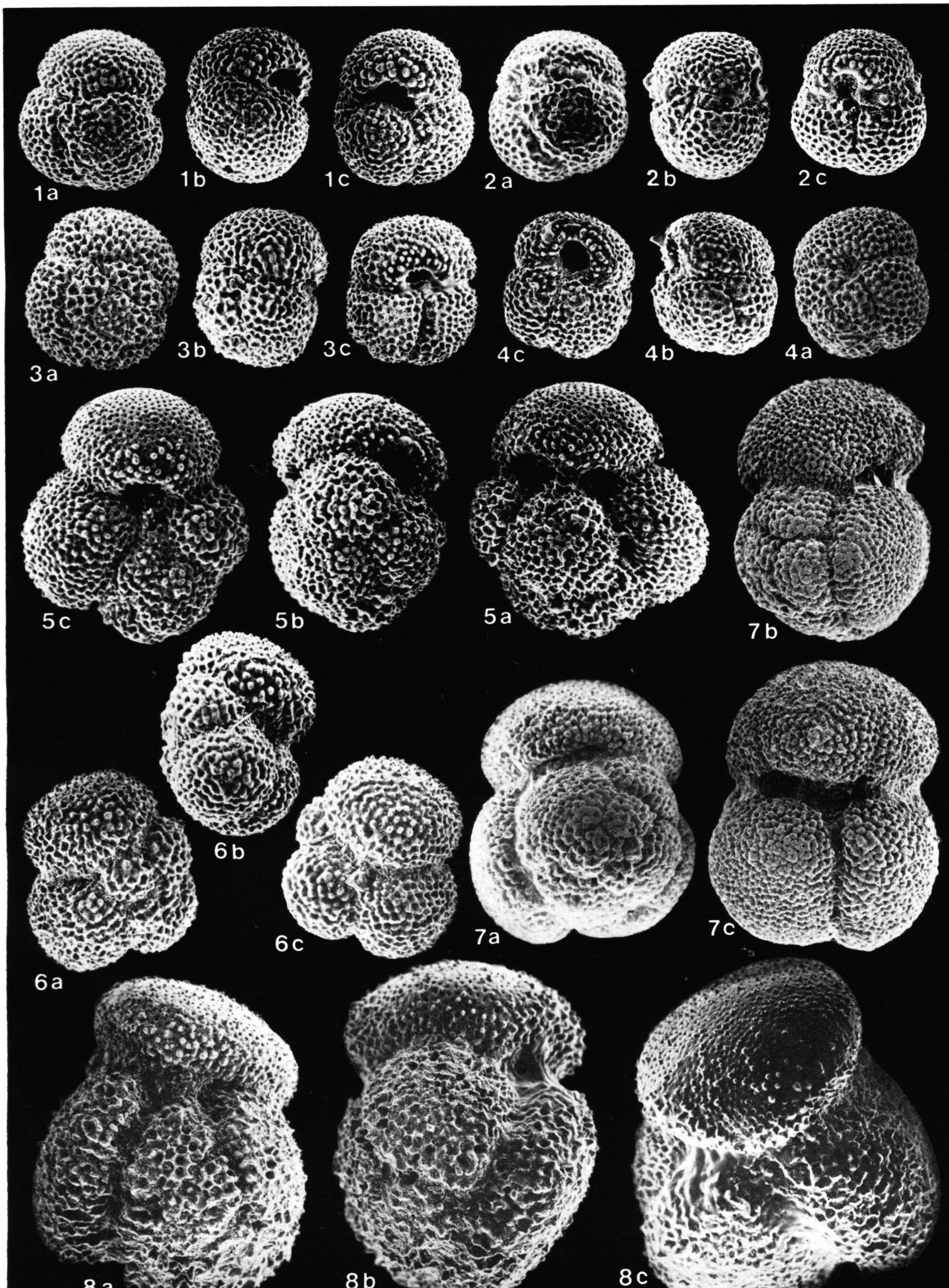
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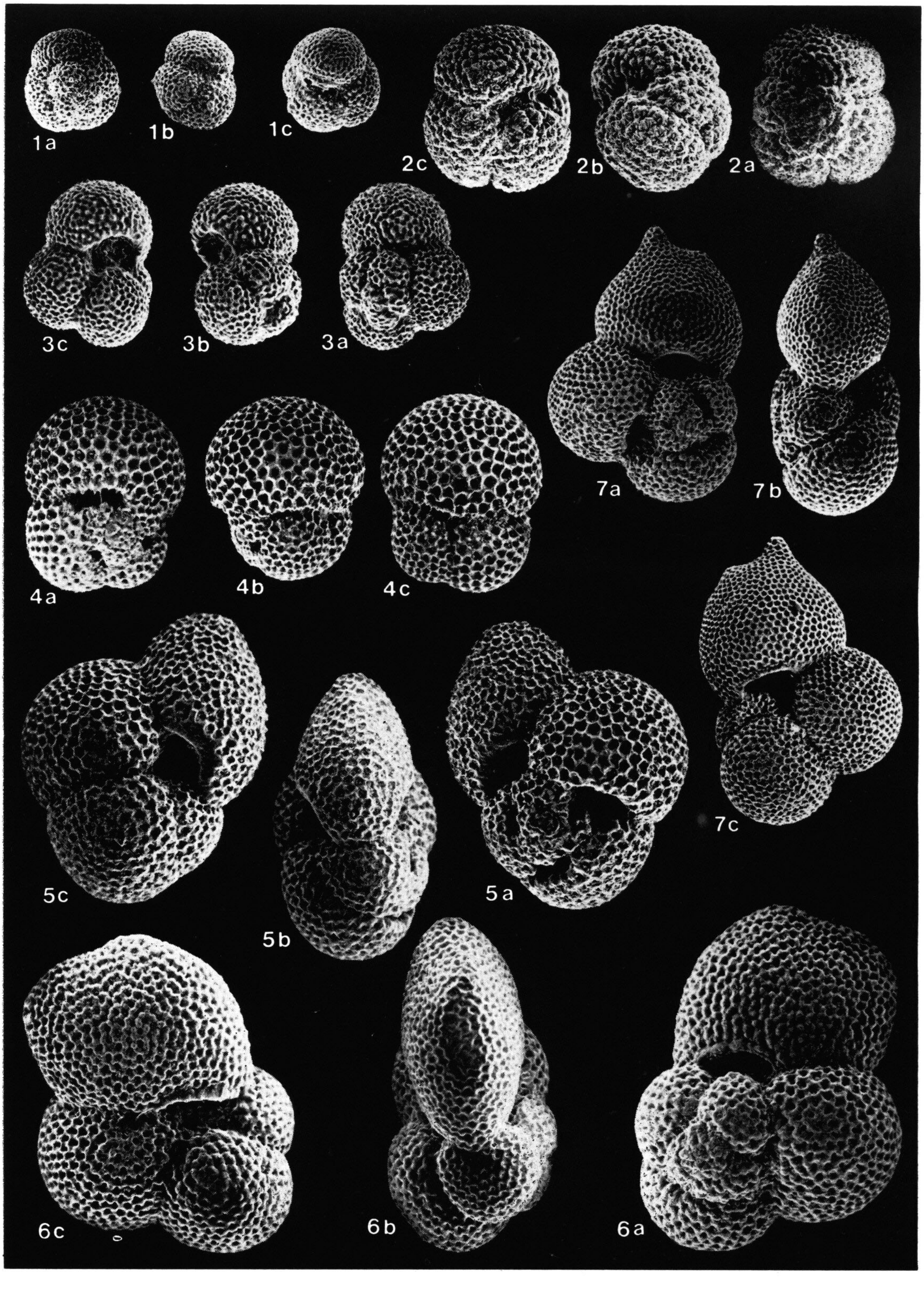
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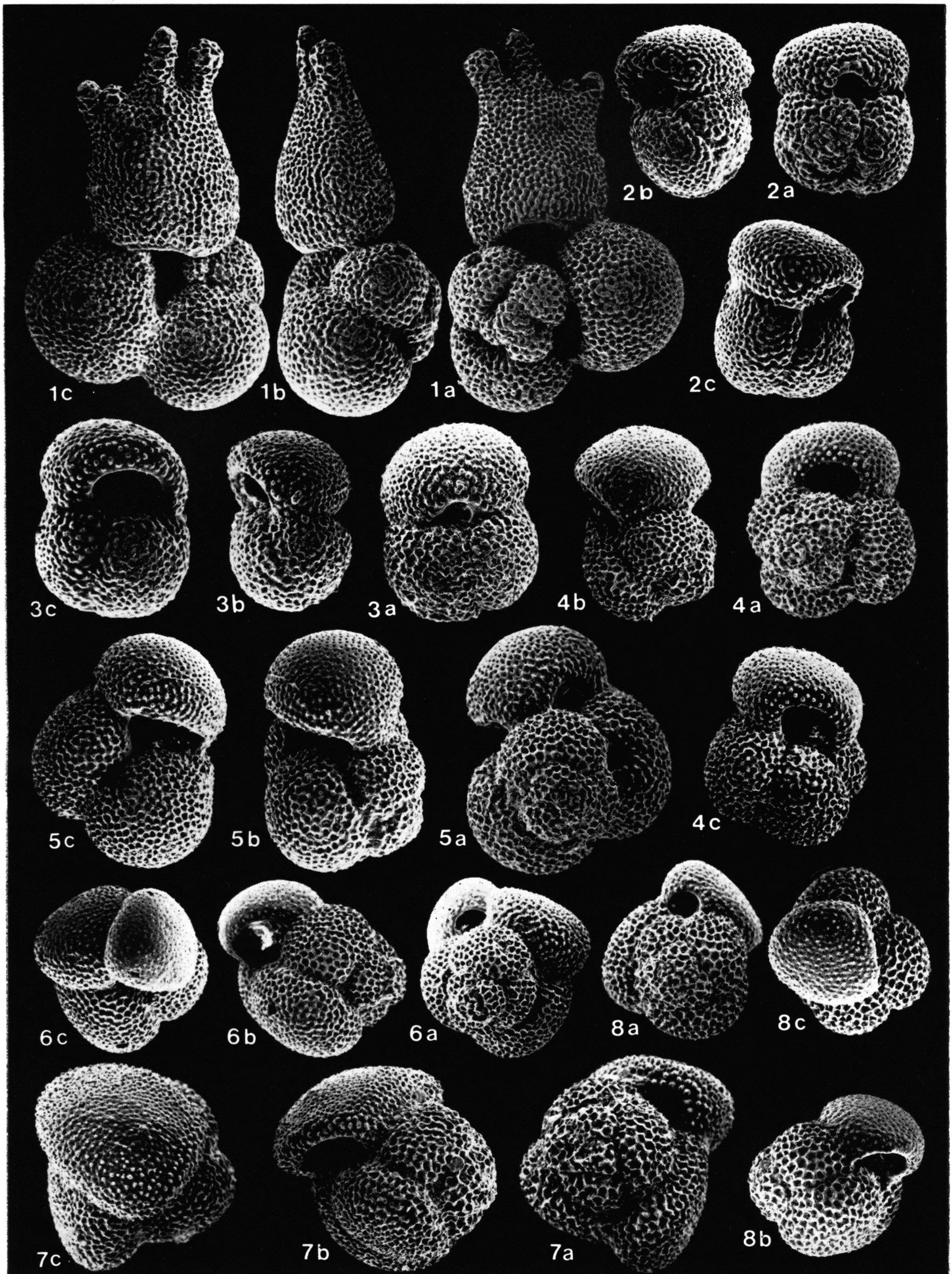
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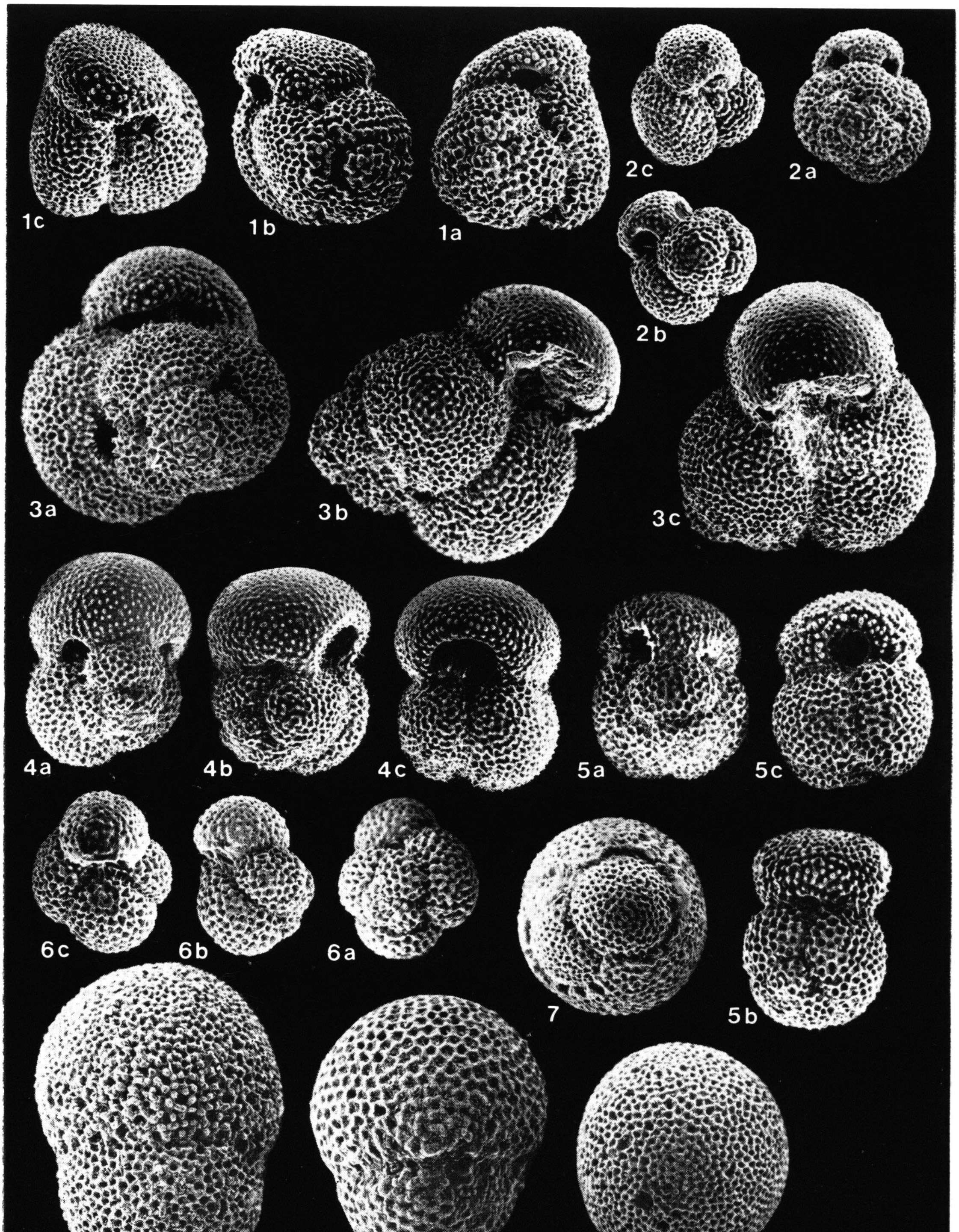
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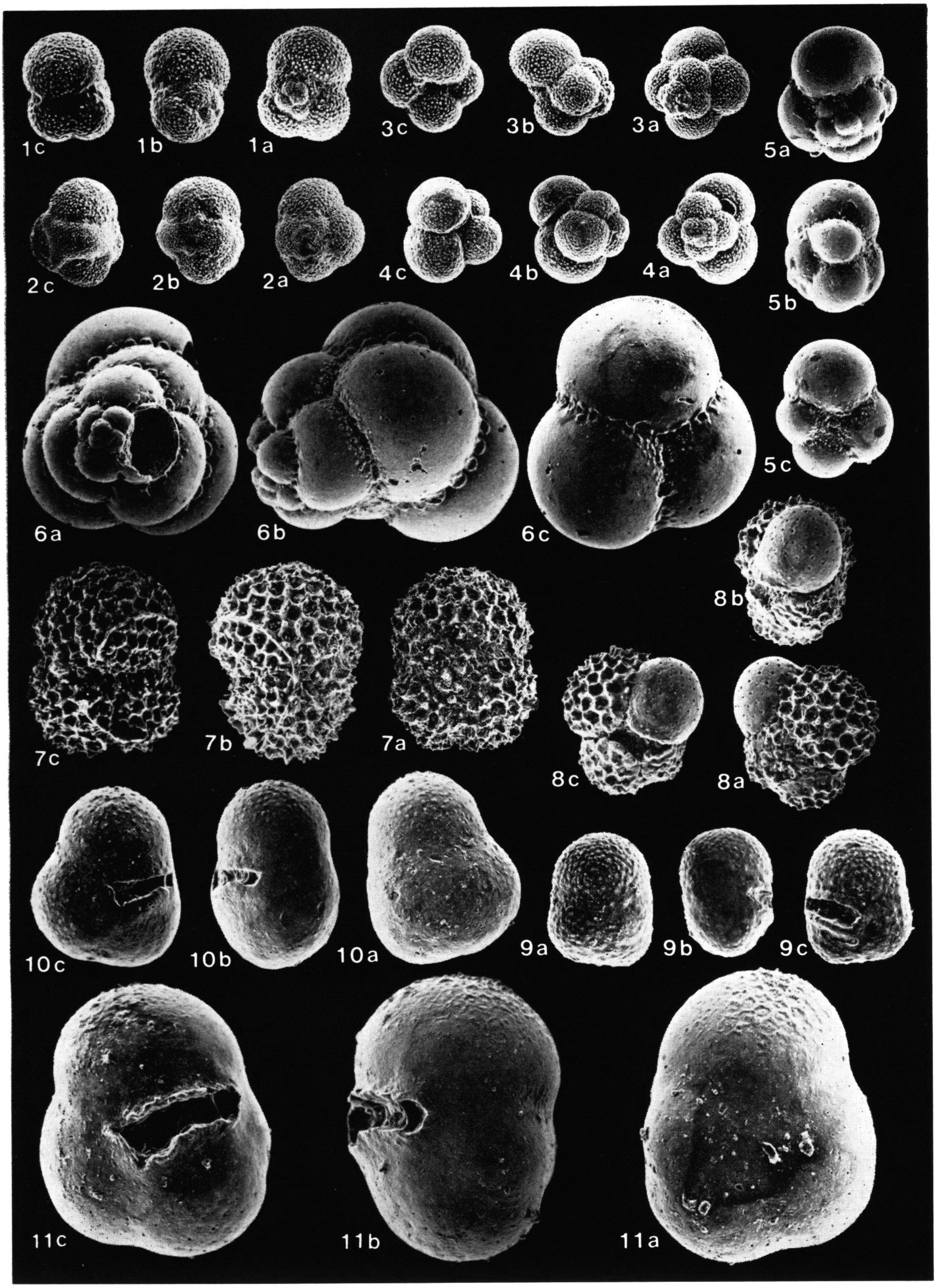
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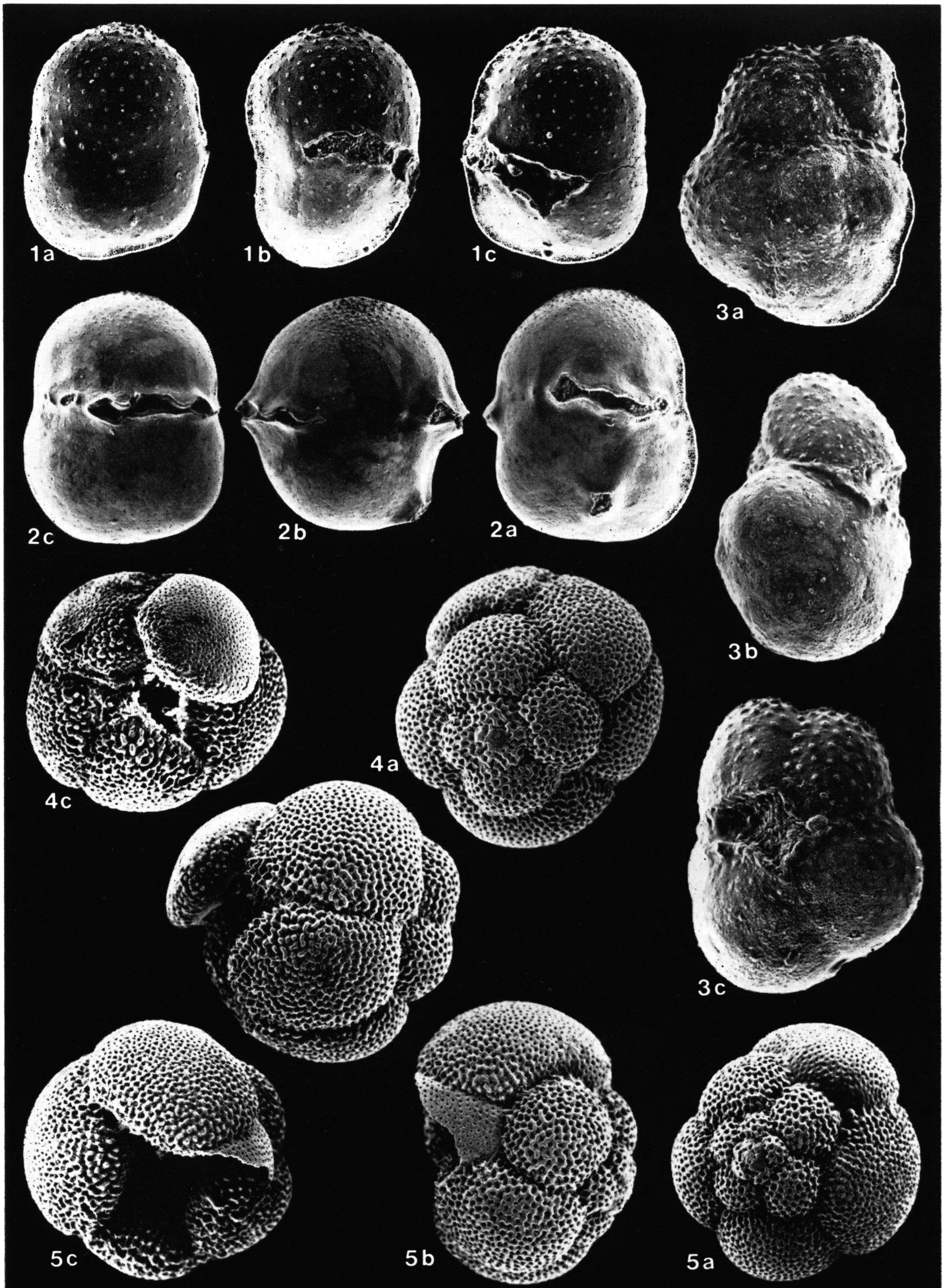
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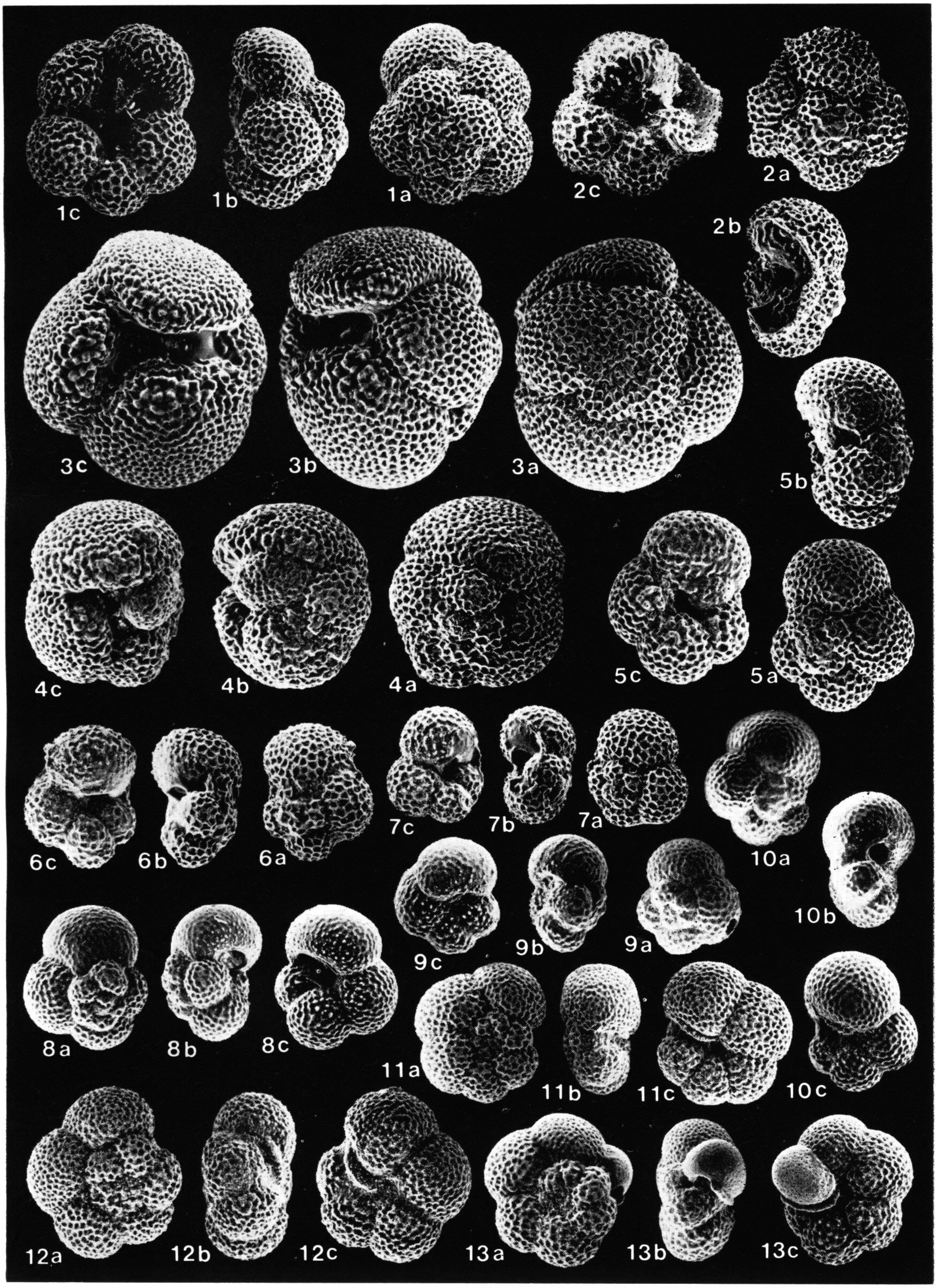
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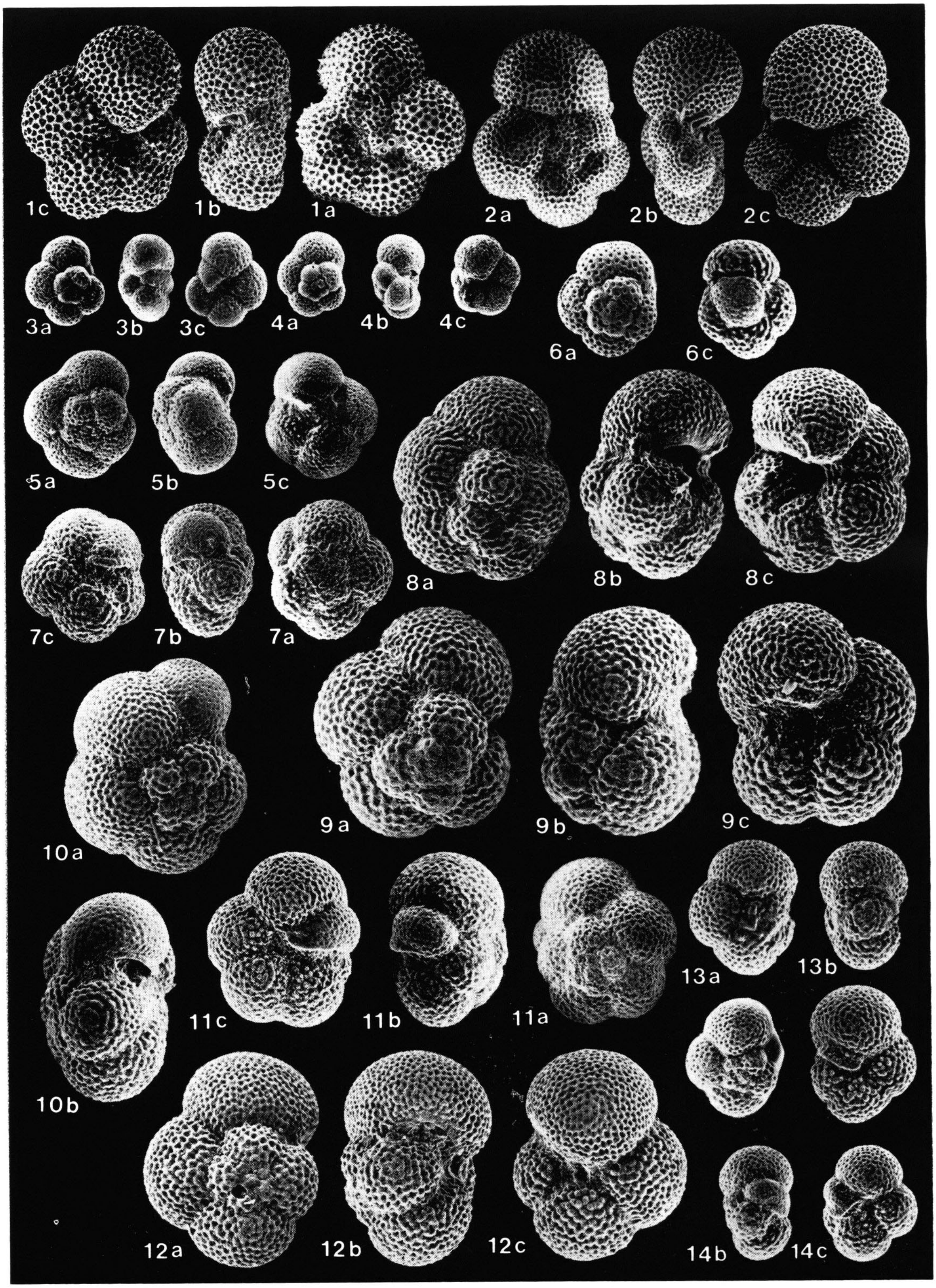
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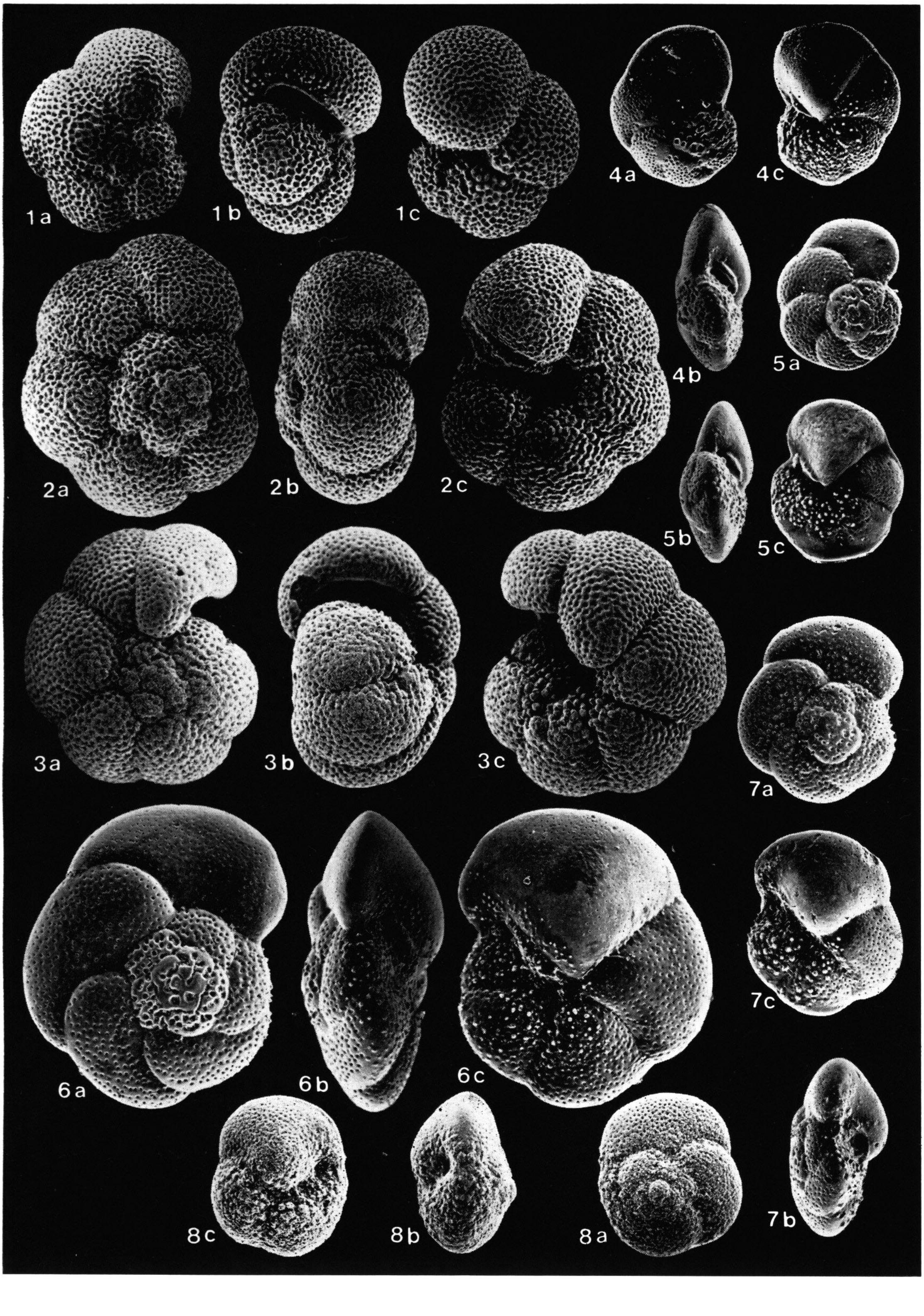
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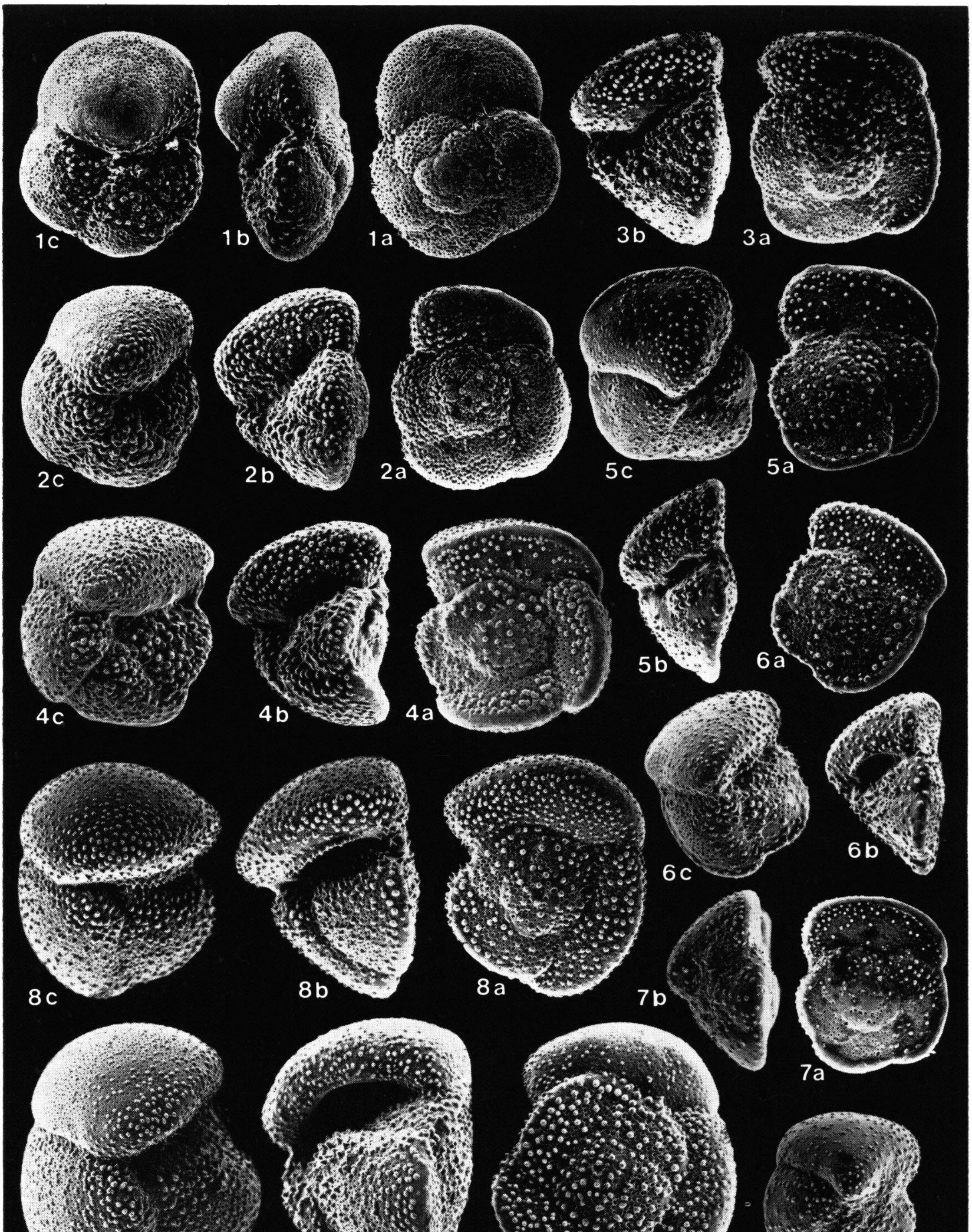
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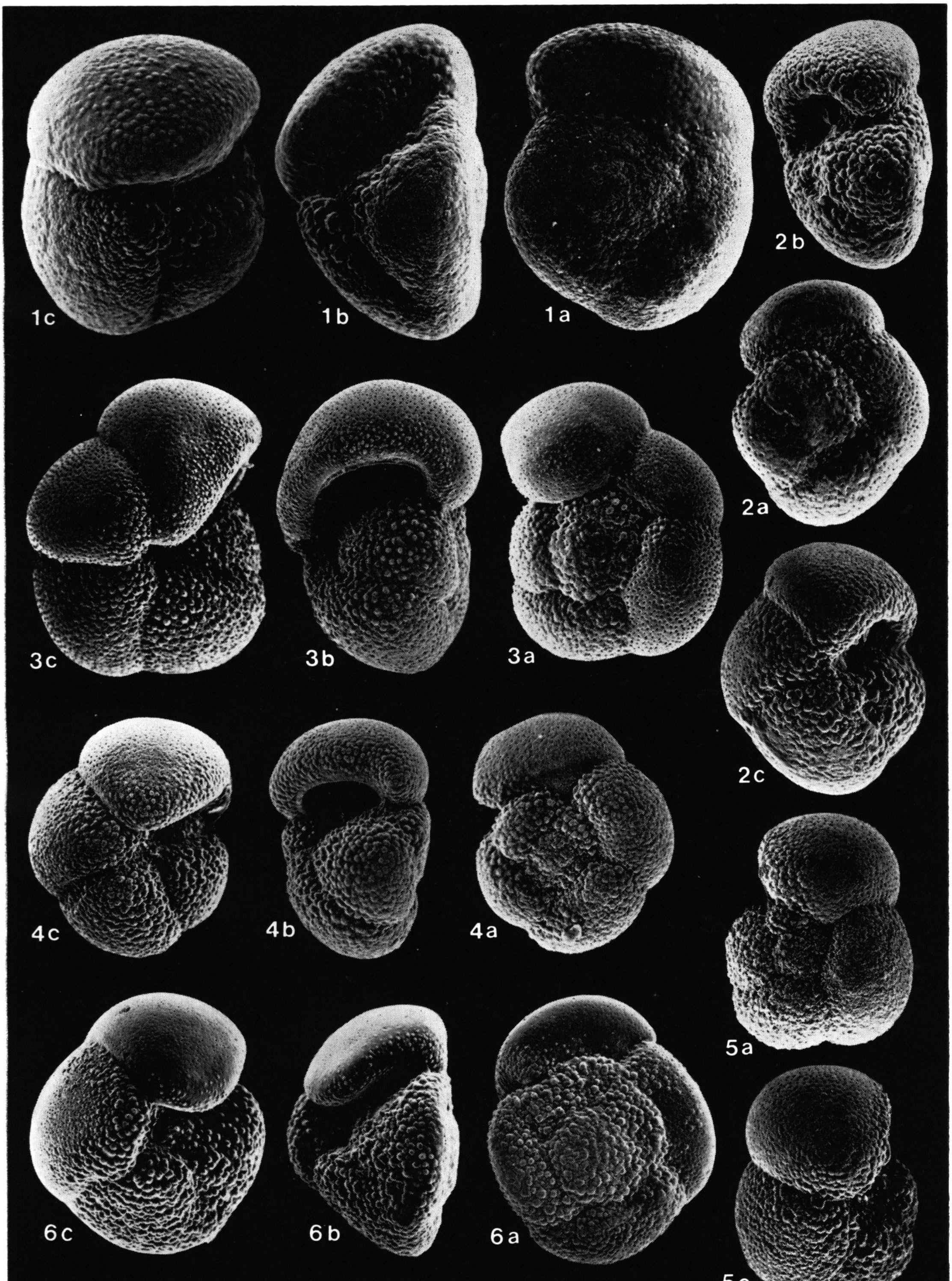
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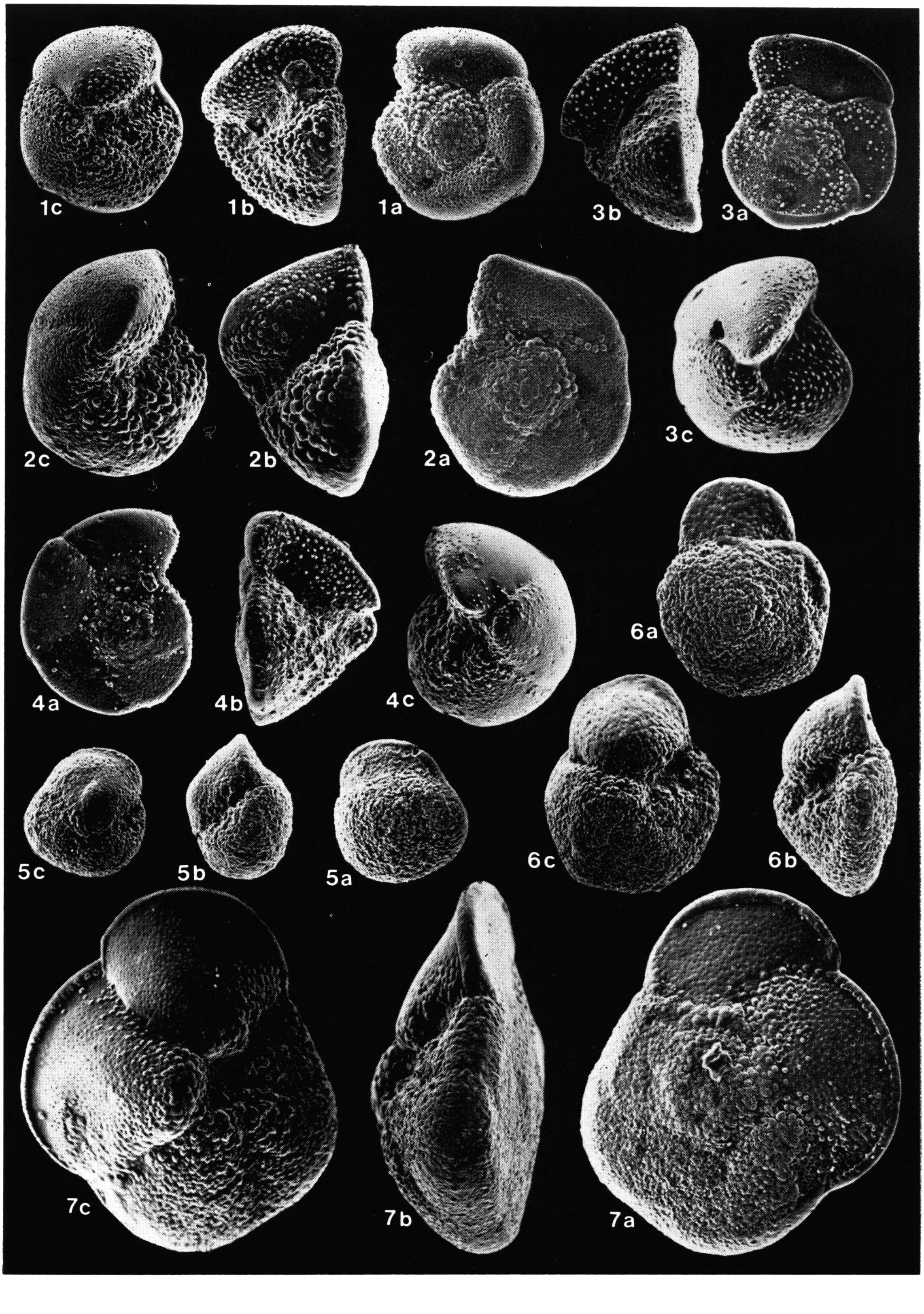
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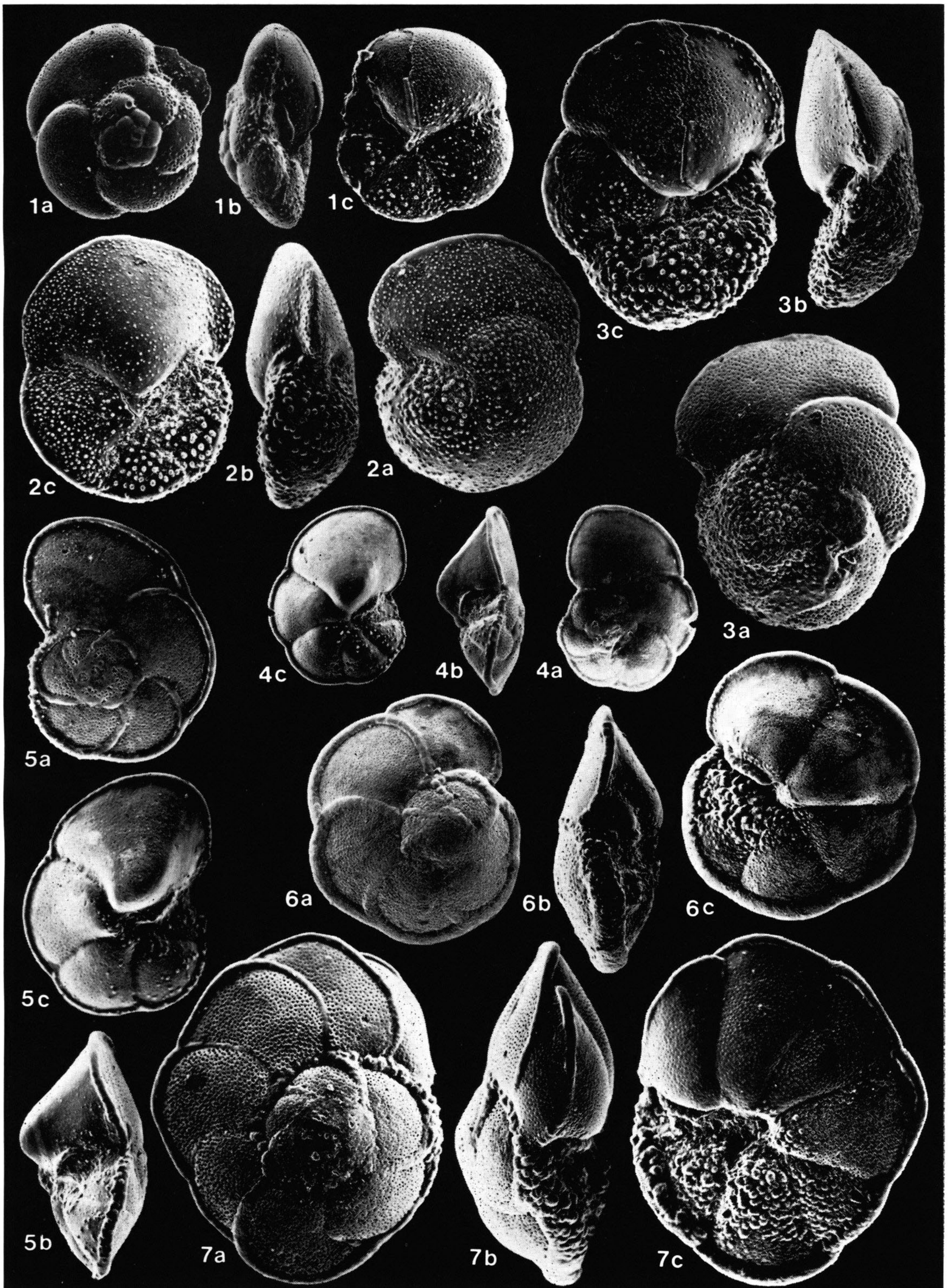
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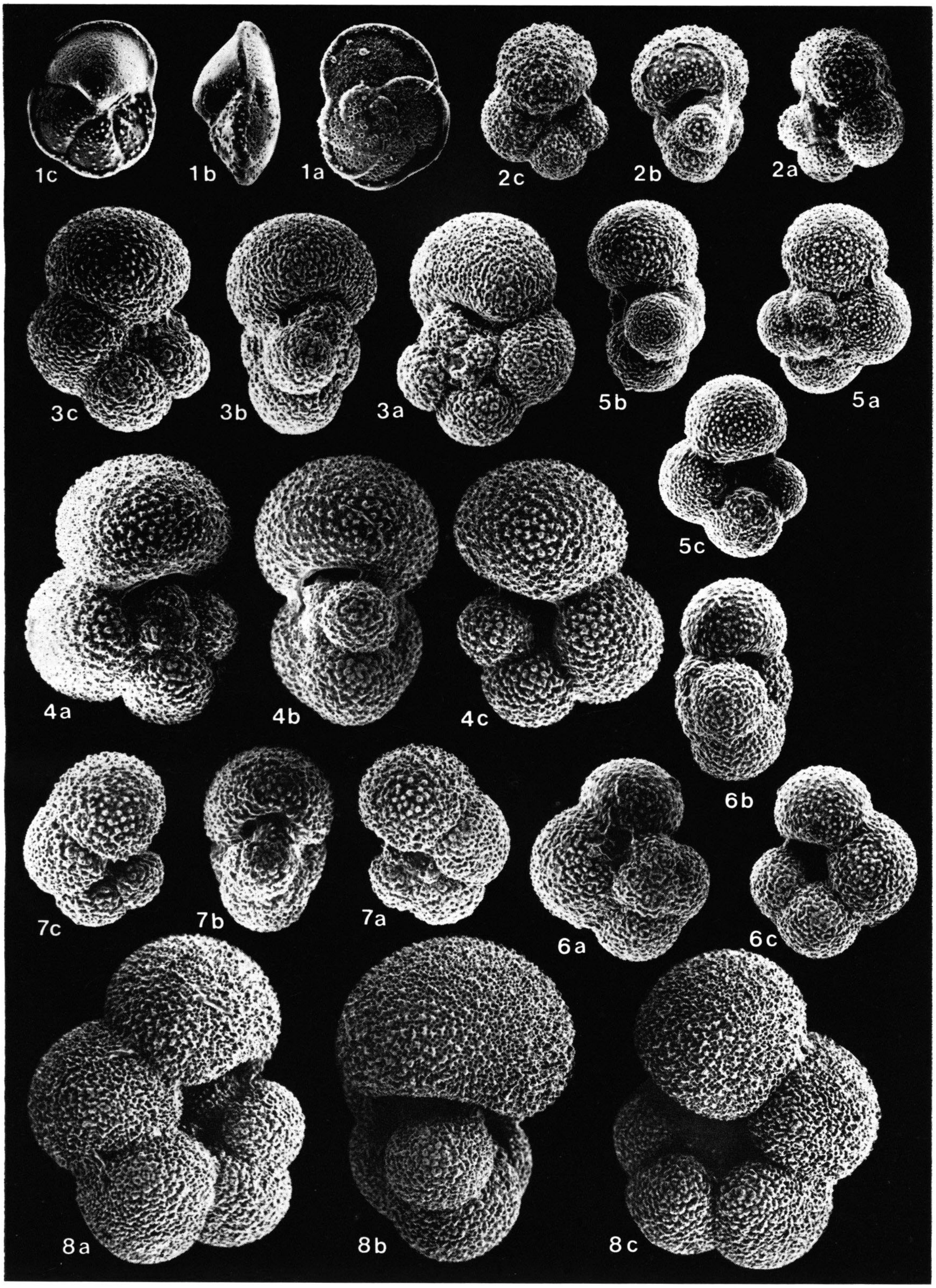
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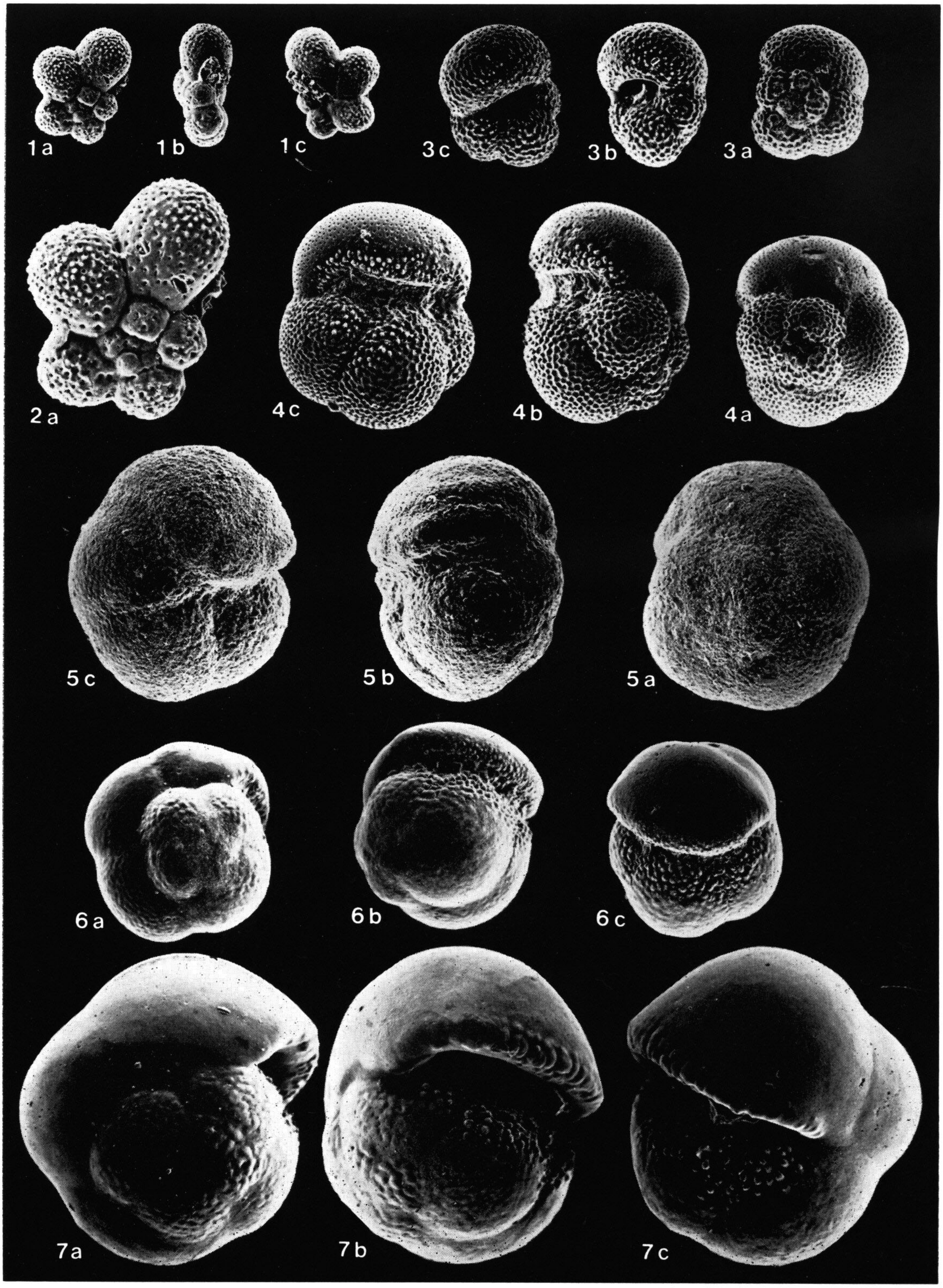
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