

Upper Miocene Planktonic Foraminifera From Bali

(with 7 plates and 3 figures)

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Abstract

Samples of Tertiary sediments discovered recently on the island of Bali by members of the Indonesian Geological Survey were studied. Among them three contain smaller foraminifera, which are particularly significant to the understanding of the geological setting of this island. Thirty three species and subspecies of planktonic foraminifera belonging to eight genera were identified. *Globigerina nepenthes*, *Globigerina rubescens*, *Sphaeroidinella seminulina*, *Sphaeroidinella dehiscens*, *Globigerinoides obliquus extremus*, *Globigerinoides ruber*, *Globorotalia cf acostaensis*, *Globorotalia margaritae*, *Globorotalia tumida*, *Globorotalia tumida flexuosa*, *Globorotalia crassaformis*, *Globorotalia cultrata*, *Pulleniatina primalis*, *Pulleniatina obliquiloculata obliquiloculata*, *Pulleniatina obliquiloculata praecursor*, and *Hastigerina aequilateralis* are the most important species among them. Assuming that the range of these species from Bali is similar to the range of the same species in the well known section at Bodjonegoro, East Java, the three Bali assemblages are assignable to the upper Miocene *Globigerinoides obliquus extremus*, *Globorotalia margaritae*, and *Globorotalia crassaformis* zones.

Introduction

Little is known about the paleontology of the island of Bali. The only article is by HARTONO (1964), which deals with the percentage of coiling direction of *Pulleniatina obliquiloculata* (PARKER & JONES) and *Globorotalia menardii* (D'ORBIGNY). Knowledge of the geology of this island is also very scanty. Except for the southern peninsula and Prapat Agung to the west, almost all tertiary sedimentary rocks are covered by volcanic products (SANDBERG, 1909, unpublished).

New exposures of Tertiary sediments were discovered by members of the Geological Survey of Indonesia during recent geological mapping and a number of samples were sent to the writer for age identification. Three of these contain smaller foraminifera of great importance for understanding of the geological setting of this island.

The purpose of this paper is to present the results of a study of the planktonic foraminifera of these three samples, in which thirty three species and subspecies belonging to eight genera were identified. All species are systematically described and illustrated. The planktonic foraminiferal assemblage is similar to that of well no. 1, Bodjonegoro, in the petroleum-bearing area of East Java (BOLLI, 1966), and thus a similar upper Miocene for the Bali rocks is indicated.

Sample localities

Two of the rock samples come from the banks of the rivers Taman and Mentjatu, near the villages of Padjahan and Galiukir, about 5 kilometers west of the main road between Tabanan and Singaradja (fig. 1; localities number LP 241 and LP 251). The sampled layers are tuffaceous marls, that dip south-eastward, respectively 16° and 20° . Sample number LP 251 contains a small amount of subangular quartz grains. The third sample, JDE III, is calcareous sandstone from the southern flank of Luwur hill near Padang Bay.

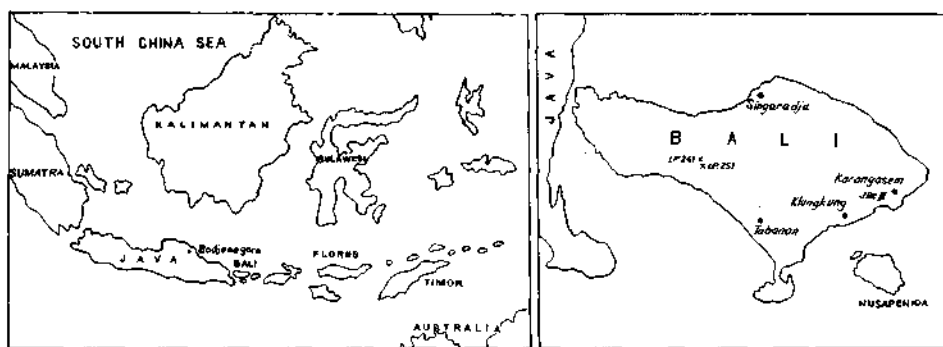


Fig 1 Map showing sample localities

Foraminifera assemblages

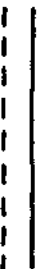
As far as the fossil content is concerned, the foraminifera specimens of sample LP 251 are best preserved. The fauna has been identified by comparison with descriptions of faunas of the Miocene Cipero and Lengua formations of Trinidad (BOLLI, 1957), Miocene and Pliocene beds from Papua and New Guinea (BELDFORD, 1962) and from localities in Java. Thirty-three species and subspecies of planktonic foraminifera belonging to eight genera have been identified. All of them are listed in the distribution chart in figure 2.

Sample LP 241 contains ten characteristic species: *Globigerina nepenthes*, *Globigerinoides obliquus extremus*, *Sphaeroidinella seminulina*, *Hastigerina aequilateralis*, *Pulleniatina primalis*, *Globigerina venezuelana*, *Globorotalia cultrata*, *Globorotalia menardii*, *Globorotalia tumida* and *Globorotalia cf acostaensis*. *Sphaeroidinella seminulina* is most abundant. Younger species such as *Globorotalia margaritae* and *Globorotalia crassaformis* are not represented. Except for *Globorotalia cf acostaensis*, *Globorotalia cultrata* and *Globigerina venezuelana*, all typical species of sample LP 241 are also found in sample LP 251 together with characteristic species such as *Globorotalia margaritae*, *Globorotalia tumida flexuosa*, *Sphaeroidinella debiscens*, *Globoquadrina altispira altispira*, *Globoquadrina altispira globosa* and *Globoquadrina dutertrei*. Sample JDE III contains important species such as *Pulleniatina obliquiloculata obliquiloculata*, *Pulleniatina*

ZONATION IN BOJONEGORO			SOME IMPORTANT SPECIES FOUND IN BALI ALSO IN BOJONEGORO ↓
LOWER MIOCENE	MIDDLE MIOCENE	UPPER MIOCENE	
EQUIVALENT OF GLOBOROTALIA TRUNCATILINDOIDES / GLOBOROTALIA RIMA INFLETA			<i>Globigerina nepenthes</i> <i>Hastigerina abquilateralis</i> <i>Sphaeroidinella seminulina</i> <i>Globorotalia acostaensis</i> <i>Globorotalia menardii</i> <i>Globorotalia margaritae</i> <i>Globorotalia tumida</i> <i>Globorotalia tumida flexuosa</i> <i>Globorotalia crassaformis</i> <i>Pulleniatina obliquiloculata</i> <i>Sphaeroidinella debiscens</i> <i>Globigerinoides obliquus extremus</i> <i>Globigerinoides obliquus obliquus</i> <i>Globigerina rubescens</i> <i>Globorotalia obesa</i> <i>Globigerinoides ruber</i> var. <i>Globorotalia scitula</i> <i>Globigerina venezuelana</i>
GLOBOROTALIA ALTISSIMA ALTISSIMA / GLOBOROTALIA CRASSIFORMIS			
GLOBOROTALIA MARGARITAE			
GLOBOROTALIA QUATRENI/ GLOBIGERINOIDES OBLIQUUS EXTREMUS			
GLOBOROTALIA ACOSTAENSIS			
GLOBOROTALIA MENARDII			
GLOBOROTALIA MAYERI			
GLOBIGERINOIDES RUBER			
GLOBOROTALIA FOHSI RO- BUSTA			
GLOBOROTALIA FOHSI LO- BATA			
GLOBOROTALIA FOHSI FOHSI			
GLOBOROTALIA FOHSI BA- BISANENSIS			
GLOBIGERINATELLA INSUETA			

Fig. 2

Range in Bojonegoro
Suggested extended range in Bali



obliquiloculata praecursor, *Sphaeroidinella debiscens*, *Hastigerina aequilateralis*, *Globigerinoides ruber* and *Globorotalia crassaformis*.

The most typical species of the above three samples occur also in the Miocene layers of well no. 1, Bodjonegoro (BOLLI, 1966). If the range of these species is comparable to the range of the similar assemblage at Bodjonegoro, the three localities on Bali are upper Miocene and correlatives of the *Globigerinoides obliquus extremus*, *Globorotalia margaritae* and *Globorotalia crassaformis* zones (figure 2).

At Bodjonegoro *Globigerina nepenthes* and *Sphaeroidinella seminulina* are restricted to the *Globorotalia acostaensis* zone, whereas in Bali they are found in *Globigerinoides obliquus extremus* and *Globorotalia margaritae* also, as represented by samples LP 241 and LP 251.

BANNER & BLOW (1967) consider that these two species range up to the *Sphaeroidinella debiscens* zone, which is correlated by BOLLI (1966) with the *Globorotalia margaritae* zone of well no. 1, Bodjonegoro. *Globorotalia tumida* which appears in Bodjonegoro near the top of the *Globorotalia margaritae* zone appears somewhat lower in Bali namely in the *Globigerinoides obliquus extremus* zone.

Description of species

The systematic arrangement of genera follows the classification of BOLLI, 1957.

Family *Orbulinidae* SCHULTZE, 1854

Genus *Globigerina* D'ORBIGNY, 1826

Globigerina rubescens HOFKER

(Pl. 2, Fig. 9)

1962 *Globigerina rubescens* HOFKER — PARKER, Micropaleontology vol. 8, no. 2, p. 226, figs. 17—18.

1964 *Globigerina rubescens* HOFKER — TODD, U. S. Geol. Surv. Prof. Paper, 260-CC, p. 1080, pl. 29, fig. 1.

Test small, high trochospiral; wall calcareous, perforate, strongly beaded; chambers about 12 to 13 arranged in 3 whorls; the four chambers of the last coil increase gradually in size. Sutures deeply depressed; aperture high arch in the umbilicus.

This species is frequently found in sample LP 251. Maximum diameter of figured species LP 251 = 0.28 mm., height of spiral coiling = 0.30 mm.

Globigerina glutinata (EGGER)

(Pl. 2, Fig. 12)

1962 *Globigerina glutinata* (EGGER) — PARKER, Micropaleontology, vol. 8, no. 2, p. 246, pl. 9, figs. 1—6.

Nr	S P E C I E S	LP.	LP.	JDE
		241	257	III
1	<i>Globigerinoides trilobus trilobus</i>	c	a	c
2	<i>Globigerinoides trilobus immaturus</i>	.	c	f
3	<i>Globigerinoides saeculiferus</i>	f	c	f
4	<i>Globigerinoides obliquus obliquus</i>	r	c	r
5	<i>Globigerinoides obliquus extremus</i>	f	c	.
6	<i>Globigerinoides conglobatus</i>	r	.	.
7	<i>Globigerinoides ruber</i>	.	.	f
8	<i>Globigerina venezuelana</i>	r	.	.
9	<i>Globigerina pachyderma</i>	.	f	.
10	<i>Globigerina sulcata</i>	.	r	.
11	<i>Globigerina nepenthes</i>	c	f	.
12	<i>Globigerina glutinata</i>	.	r	.
13	<i>Globigerina rubescens</i>	.	f	.
14	<i>Orbulina universa</i>	a	a	.
15	<i>Orbulina suturalis</i>	f	.	.
16	<i>Pulleniatina obliquiloculata obliquiloculata</i>	.	.	r
17	<i>Pulleniatina obliquiloculata praecursor</i>	.	.	f
18	<i>Pulleniatina primalis</i>	f	f	.
19	<i>Hastigerina aequilateralis</i>	r	.	r
20	<i>Globoquadrina altispira globosa</i>	.	r	.
21	<i>Globoquadrina altispira altispira</i>	.	c	.
22	<i>Globoquadrina dutertrei</i>	.	c	r
23	<i>Sphaeroidinella seminulina</i>	a	c	.
24	<i>Sphaeroidinella dehiscens</i>	.	r	f
25	<i>Globorotalia menardii</i>	a	a	a
26	<i>Globorotalia margaritae</i>	.	f	.
27	<i>Globorotalia scitula</i>	.	r	.
28	<i>Globorotalia tumida</i>	r	a	f
29	<i>Globorotalia tumida flexuosa</i>	.	r	.
30	<i>Globorotalia crassaformis</i>	.	.	f
31	<i>Globorotalia cf. acostaensis</i>	c	.	.
32	<i>Globorotalia cultrata</i>	f	.	.
33	<i>Globorotalia obesa</i>	r	c	.

Fig. 3. Distribution of planktonic foraminifera
a=abundant c=common f=frequent r=rare

1968 *Globigerina glutinata* (EGGER) — HERB, *Eclogae Geologicae Helvetiae*, vol. 61/2, p. 478, pl. 3, figs. 4—6.

Test small, trochospiral; wall calcareous, finely perforate, smooth; chambers about 12 to 13 arranged in 3 whorls; four in the last coil. Sutures deeply depressed; umbilicus covered by one bulla; small supplementary apertures are along the border line between bulla and chambers. Maximum diameter of figured species LP 251 = 0.22 mm.

Globigerina foliata BOLLI

(Pl. 2, Fig. 10)

1957 *Globigerina foliata* BOLLI — U. S. National Mus. Bull. 215, p. 111, pl. 24, fig. 1.

This species is rarely found in sample LP 251. Maximum diameter of figured species LP 251 = 0.28 mm.

Globigerina nepenthes TODD

(Pl. 2, Fig. 11)

1957 *Globigerina nepenthes* TODD — BOLLI, U. S. Nat. Mus. Bull. 215, p. 111, pl. 24, figs. 3—4.

Test small, trochospiral; wall calcareous, perforate; surface fairly smooth; chambers about 7 to 8 arranged in 2 whorls; the last one chamber sack-like in shape. Sutures depressed; aperture medium arch, bordered above by a thick lip. This species is commonly found in samples LP 241 and LP 251. Maximum diameter of figured species LP 241 = 0.30 mm.

Globigerina pachyderma (EHRENBERG)

(Pl. 2, Fig. 13)

1968 *Globigerina pachyderma* (EHRENBERG) — HERB, *Eclogae Geol. Helv.*, p. 473, pl. 3, figs. 1—2.

Shape of test trochospiral, periphery rounded; wall calcareous, surface smooth, small pores giving lattice-like appearance. Chambers about 13 arranged in 3 whorls, inflated, increase rapidly in size; sutures deeply depressed. Aperture medium arch, interiomarginal. This species is frequently found in sample LP 251. Maximum diameter of figured species LP = 0.35 mm.

Globigerina venezuelana HEDBERG

(Pl. 2, Fig. 14)

1957 *Globigerina venezuelana* HEDBERG — BOLLI, U. S. Nat. Mus. Bull. 215, p. 110, pl. 23, figs. 6—8.

This species is only found in sample LP 241. Maximum diameter of figured species LP 241 = 0.57 mm.

Genus *Pulleniatina* CUSHMAN, 1927
Pulleniatina primalis BANNER & BLOW

(Pl. 3 and 4, Figs. 20 and 21)

1967 *Pulleniatina primalis* BANNER & BLOW — *Micropal.*, vol. 13, no. 2, p. 142—143, pl. 1, fig. 2.

Shape of test trochospiral, axial periphery broadly rounded; wall calcareous, perforate; chambers about 12 to 13 arranged in about 3 whorls, the 5 chambers of the last coil increase rapidly in size. Sutures radial, slightly curved, deeply depressed. Aperture interiomarginal arch, extending ventrally along the base of apertural face, starting from umbilicus to the periphery; apertural face is thickened. This species is frequently found in sample LP 241. Two forms are figured. Twenty and five specimens have been picked up respectively from samples LP 241 and LP 251. All of them are sinistrally coiled. Maximum diameter of figured species LP 241 = 0.50 mm., LP 251 = 0.45 mm.

Pulleniatina obliquiloculata obliquiloculata (PARKER & JONES)

(Pl. 4, Fig. 23)

1967 *Pulleniatina obliquiloculata obliquiloculata* — BANNER & BLOW, *Micropaleontology*, vol. 13, no. 2, p. 137—139, pl. 3, fig. 4.

This species is found only in sample JDE III. Maximum diameter of figured species JDE III = 0.47 mm.

Pulleniatina obliquiloculata praecursor (BANNER & BLOW)

(Pl. 4, Fig. 22)

1967 *Pulleniatina obliquiloculata praecursor* — BANNER & BLOW, *Micropal.*, vol. 13, no. 2, p. 139—140, pl. 3, fig. 3.

Twenty specimens have been picked up from the sample JDE III, all of them are dextrally coiled. Maximum diameter of figured species JDE III = 0.62 mm.

Genus *Sphaeroidinella* CUSHMAN, 1927
Sphaeroidinella seminulina (SCHWAGER)

(Pl. 3, Figs. 17 and 18)

1957 *Sphaeroidinella rutschi* CUSHMAN & RENZ — BOLI, U. S. Nat. Mus. Bull. 215, p. 115, pl. 26, figs. 6—7.

1964 *Sphaeroidinella seminulina seminulina* (SCHWAGER) — BANDY, *Micropal.*, vol. 10, text-fig. no. 6, fig. 1.

Wall smooth, finely perforate, pores giving an almost lattice-like appearance; three to four chambers are in the last coil, the last one is sack-like in shape. Aperture interiomarginal. Two forms are figured, one without sack-like last chamber. Maximum diameter of figured species LP 251 = 0.60 mm., LP 251 = 0.52 mm.

Sphaeroidinella debiscens (PARKER & JONES)

(Pl. 3, Fig. 19)

- 1957 *Sphaeroidinella debiscens* (PARKER & JONES) — BOLLI, LOEBLICH & TAPPAN, U. S. Nat. Mus. Bull. 215, p. 32, pl. 6, figs. 1—5.
- 1962 *Sphaeroidinella debiscens* (PARKER & JONES) — PARKER, Micropal., vol. 8, no. 2, p. 234, pl. 5, figs. 1—2.

This species is frequently found in sample JDE III. Maximum diameter of figured species JDE III = 0.80 mm.

Genus *Globoquadrina* FINLAY, 1947*Globoquadrina altispira altispira* (CUSHMAN & JARVIS)

(Pl. 3, Fig. 16)

- 1957 *Globoquadrina altispira altispira* (CUSHMAN & JARVIS) — BOLLI, U. S. Nat. Mus. Bull. 215, p. 111, pl. 24, figs. 7—8.
- 1960 *Globoquadrina altispira* (CUSHMAN & JARVIS) — COLE, TODD & JOHNSON, Bull. American Pal., vol. 41, no. 186, p. 107, pl. 3, figs. 3—7.

Maximum diameter of figured species LP 251 = 0.50 mm., height of coiling = 0.45 mm.

Globoquadrina altispira globosa BOLLI

(Pl. 3, Fig. 15)

- 1957 *Globoquadrina altispira globosa* BOLLI — U. S. Nat. Mus. Bull. 215, p. 111, pl. 24, fig. 9.
- 1964 *Globoquadrina altispira* (CUSHMAN & JARVIS) — TODD, Geol. Surv. Prof. Paper, 260-CC, p. 1081, pl. 291, fig. 4.

Maximum diameter of figured species LP 251 = 0.57 mm., height of coiling = 0.40 mm.

Globoquadrina dutertrei (D'ORBIGNY)

(Pl. 5, Fig. 27)

- 1941 *Globigerina aff. cretacea* D'ORBIGNY — LEROY, Colorado School of Mines Quarterly, vol. 36, no. 1, pt. 1, p. 43, pl. 2, figs. 108—110.
- 1962 *Globoquadrina dutertrei* (D'ORBIGNY) — PARKER, Micropal., vol. 8, no. 2, p. 242 to 244, pl. 7, figs. 10—13.

Shape of test trochospiral, axial periphery broadly rounded; wall calcareous, perforate, surface coarsely pitted; chambers about 10 to 12 arranged in 2 to 3 whorls; the five chambers of the last coil increase fairly rapidly in size. Sutures radial, strongly depressed; aperture high arch, bordered above by thin lip. This species is rarely found in samples from Bali. Maximum diameter of figured species LP 241 = 0.42 mm.

Genus *Orbulina* D'ORBIGNY, 1839*Orbulina suturalis* BRÖNNIMANN

(Pl. 4, Fig. 25)

1957 *Orbulina universon* D'ORBIGNY — BOLLI, U. S. Nat. Mus. Bull. 215, p. 115, pl. 27, fig. 4.

This species is frequently found in sample LP 241. Maximum diameter of figured species LP 241 = 0.65 mm.

Orbulina universon D'ORBIGNY

(Pl. 4, Fig. 24)

1957 *Orbulina universon* D'ORBIGNY — BOLLI, U. S. Nat. Mus. Bull. 215, p. 115, pl. 27, fig. 5.

This species is found in samples LP 241 and LP 251. Maximum diameter of figured species LP 241 = 0.65 mm.

Genus *Globigerinoides* CUSHMAN, 1927*Globigerinoides trilobus trilobus* (REUSS)

(Pl. 1, Fig. 1)

1956 *Globigerinoides triloba* (REUSS) — BLOW, Micropal., vol. 2, no. 1, p. 62, fig. 1.

1960 *Globigerinoides triloba triloba* (REUSS) — JENKINS, Micropal., vol. 6, no. 4, p. 353, pl. 2, fig. 5.

This species is fairly abundant in samples LP 241 and LP 251. Maximum diameter of figured species LP 241 = 0.35 mm.

Globigerinoides trilobus immaturus LEROY

(Pl. 1, Fig. 2)

1957 *Globigerinoides triloba immatura* LEROY — U. S. Nat. Mus. Bull. 215, p. 113, pl. 25, figs. 5—6.

1962 *Globigerinoides quadrilobatus immatura* — BELDFORD, Bull. 62-1-N, Guinea Forum, p. 5, pl. 3, figs. 1—4.

This species is found commonly in sample LP 251. Maximum diameter of figured species LP 251 = 0.45 mm.

Globigerinoides sacculiferus (BRADY)

(Pl. 1, Fig. 3)

1957 *Globigerinoides triloba sacculifera* (BRADY) — BOLLI, U. S. Nat. Mus. Bull. 215, p. 113, pl. 25, figs. 5—6.

1962 *Globigerinoides quadrilobatus sacculifer* — BELDFORD, Bull. 62-1-N Guinea Forum, p. 5, pl. 4, figs. 1—6.

This species is fairly common in samples from Bali. Maximum diameter of figured species LP 251 = 0.50 mm.

Globigerinoides ruber D'ORBIGNY

(Pl. 2, Fig. 8)

1960 *Globigerinoides rubra* (D'ORBIGNY) — JENKINS, Micropal., vol. 6, no. 4, p. 354, pl. 2, figs. 8—9.

This species is frequently found in sample JDE III. Maximum diameter of figured species JDE III = 0.37 mm.

Globigerinoides obliquus obliquus BOLLI

(Pl. 1, Fig. 4)

1966 *Globigerinoides obliquus obliquus* BOLLI — Eclogae Geol. Helv., vol. 59, no. 1, pl. 1, figs. 18—19.

Maximum diameter of figured species LP 251 = 0.42 mm.

Globigerinoides obliquus extremus BOLLI & BERMUDEZ

(Pl. 1, Fig. 5)

1966 *Globigerinoides obliquus extremus* BOLLI & BERMUDEZ — Eclogae Geol. Helv. vol. 59, no. 1, pl. 1, figs. 17—21.

This subspecies is frequently found in samples LP 241 and LP 251. Maximum diameter of figured species LP 251 = 0.35 mm.

Globigerinoides conglobatus (BRADY)

(Pl. 1, Figs. 6 and 7)

1962 *Globigerinoides conglobatus* (BRADY) — BELDFORD, Bull. 62-1-N. Guinea Foram., p. 18, pl. 4, figs. 15—20.

Two different forms are illustrated. One with bulla covering the umbilicus. This species is found only in sample LP 241. Maximum diameter of figured species LP 241 = 0.55 mm and 0.55 mm.

Family *Hantkeninidae* CUSHMAN, 1927Genus *Hastigerina* THOMPSON, 1876*Hastigerina aequilateralis* (BRADY)

(Pl. 4, Figs. 26)

1957 *Hastigerina aequilateralis* (BRADY) — BOLLI, U. S. Nat. Mus. Bull. 215, p. 108, pl. 22, figs. 1—2.

1962 *Hastigerina aequilateralis* (BRADY) — BELDFORD, Bull. 62-1-N, Guinea Foram., p. 21, pl. 5, figs. 15—18.

This species is rarely found in samples of Bali. Maximum diameter of figured species LP 241 = 0.37 mm.

Family *Globorotaliidae* CUSHMAN, 1927Genus *Globorotalia* CUSHMAN, 1927*Globorotalia margaritae* BOLLI & BERMUDEZ

(Pl. 7, Fig. 39)

1965 *Globorotalia margaritae* BOLLI & BERMUDEZ — Boletín Informativo Asociación Venezolana De Geología Minería y petróleo, vol. 8, no. 5, p. 139, pl. 1, figs. 16—18.

Shape of test low trochospiral, spiral side very convex, umbilical side less convex; axial periphery acute with thin distinct keel. Wall calcareous, finely perforate, surface smooth finely pitted; chambers about 10 to 12 arranged in 2 to $2\frac{1}{2}$ whorls; the five chambers of the last coil increase fairly rapidly in size. Sutures on spiral side strongly curved, slightly depressed; on umbilical side radial and slightly curved. Aperture a slit bordered above by a small thin lip. In Bali this species is frequently found in sample LP 251. Eight specimens were selected, all of them are sinistrally coiled. Maximum diameter of figured species LP 251 = 0.35 mm.

Globorotalia crassaformis (GALLOWAY & WISSLER)

(Pl. 7, Fig. 38)

1949 *Globorotalia crassula* CUSHMAN & STEWART — BOOMGART, Doctoral thesis Univ. Utrecht Netherland, p. 143, pl. 13, fig. 16.

1962 *Globorotalia crassaformis* (GALLOWAY & WISSLER) — PARKER, *Micropal.*, vol. 8, no. 2, p. 253, figs. 17—18.

Shape of test trochospiral, umbilical side highly convex, spiral side nearly flat; axial periphery rounded. Wall calcareous, coarsely beaded; the four chambers of the last whorl increase gradually in size; sutures distinct, slightly curved on spiral side. Aperture a slit situated at the base of a flat apertural face.

This species is frequently found in sample JDE III. Five specimens were picked up, three of them are sinistrally coiled. Maximum diameter of figured species JDE III = 0.55 mm.

Globorotalia cultrata (D'ORBIGNY)

(Pl. 7, Fig. 40)

1962 *Globorotalia cultrata* (D'ORBIGNY) — PARKER, *Micropal.*, vol. 8, no. 2, p. 235, pl. 5, figs. 3—5.

Shape of test low trochospiral, spiral side slightly convex, umbilical side fairly concave; wall calcareous, surface smooth, beaded on thick keel; chambers about 12 arranged in $2\frac{1}{2}$ whorls, 6 in the last coil, inflated, the last two compressed. Sutures deeply incised, slightly curved on the umbilical side, strongly curved and limbate dorsally. Aperture is not clear. This species is found only in sample LP 241. Twenty specimens were picked up; all of them are dextrally coiled. Maximum diameter of figured species LP 241 = 0.67 mm.

Globorotalia tumida (BRADY)

(Pl. 7, fig. 37, Pl. 6, Figs. 34 and 35)

- 1957 *Globorotalia tumida* (BRADY) — BOLLI, LOEBLICH & TAPPAN, U. S. Nat. Mus. Bull. 215, p. 41, pl. 10, fig. 2.
 1964 *Globorotalia tumida* (BRADY) — TODD, U. S. Geol. Survey Prof. Paper, 260-CC, p. 1094, pl. 294, fig. 3.

Three forms of Bali species are illustrated one with slightly folded last chamber. This species is frequently found in samples LP 251 and JDE III, and rarely in sample LP 241. Fifteen specimens were picked up from each sample LP 251 and JDE III; all of them are sinistrally coiled. Maximum diameter of figured species LP 241 = 0.57 mm, LP 251 = 0.70 mm, and JDE III = 0.72 mm.

Globorotalia tumida flexuosa (KOCH)

(Pl. 6, Fig. 36)

- 1964 *Globorotalia tumida flexuosa* (KOCH) — TODD, U. S. Geol. Surv. Prof. Paper, 260-CC, p. 1094, pl. 294, fig. 4.

This subspecies is rarely found in sample LP 251. Maximum diameter of figured species LP 251 = 0.85 m.

Globorotalia menardii (D'ORBIGNY)

(Pl. 6, fig. 32, Pl. 5, Figs. 30 and 31)

- 1957 *Globorotalia menardii* (D'ORBIGNY) — BOLLI, U. S. Nat. Mus. Bull. 215, p. 120, pl. 29, figs. 6—10.
 1960 *Globorotalia menardii* (D'ORBIGNY) — JENKINS, Micropal., vol. 6, no. 4, p. 362, pl. 4, fig. 8.

This species is fairly abundant in all samples from Bali. Three forms are illustrated. Twenty-two specimens were picked up from sample LP 241 and thirty-one from sample JDE III; all of them are dextrally coiled. Of the 27 specimens picked up from sample LP 251, 24 are sinistrally coiled. Maximum diameter of figured species LP 241 = 0.85 mm., LP 251 = 0.70 mm., JDE III = 0.77 mm.

Globorotalia scitula (BRADY)

(Pl. 6, Fig. 33)

- 1945 *Globorotalia canariensis* (D'ORBIGNY) — CUSHMAN & STAINFORTH, Cush. Lab. Foram. Res., spec. publ., vol. 14, p. 70, pl. 3, fig. 12.
 1957 *Globorotalia scitula* (BRADY) — BOLLI, U. S. Nat. Mus. Bull. 215, p. 120, pl. 29, figs. 11—12.

Maximum diameter of figured species LP 251 = 0.40 mm.

Globorotalia obesa BOLLI

(Pl. 5, Fig. 29)

1957 *Globorotalia obesa* BOLLI, n. sp. — U. S. Nat. Mus. Bull. 215, pl. 19, pl. 29, fig. 2.

This species is common in sample LP 251. Maximum diameter of figured species LP 251 = 0.35 mm.

Globorotalia cf. *acostaensis* BLOW

(Pl. 5, Fig. 28)

1967 *Globorotalia* (*Turborotalia*) *acostaensis* BLOW — BANNER & BLOW, *Micropal.*, vol. 13, no. 2, pl. 1, fig. 1 and pl. 3, fig. 1.

Shape of test trochospiral, axial periphery broadly rounded; umbilicus slightly depressed; wall calcareous, surface beaded; chambers about 8 arranged in two whorls, 5 in the last coil. Sutures radial, slightly curved, deeply depressed; aperture a slit, opens from periphery to umbilicus, bordered above by a lip. This species is found only in sample LP 241. Maximum diameter of figured species LP 241 = 0.32 mm.

Acknowledgment

The writer wishes to express his thanks to Mr. M. M. PURBOHADIWIDJOJO of the Geological Survey of Indonesia and Dr. M. E. SCHMID of the Geological Survey of Austria for their invaluable suggestions and reading of the manuscript. Thanks are also extended to Messrs. Judo D. Elifas, L. Pardyanto and Muziel Alzwar for delivering the samples. The drawings in this report have been prepared by Mr. Tugiman, illustrator with the Paleontological Laboratory of the Geological Survey.

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DARWIN KADAR

plates 1 to 7

PLATE 1.

- Figs. 1 a—c. *Globigerinoides trilobus trilobus* (REUSS).
LP 241; 100 ×.
- Figs. 2 a—c. *Globigerinoides trilobus immaturus* LEROY.
LP 251; 64 ×.
- Figs. 3 a—c. *Globigerinoides sacculiferus* (BRADY).
LP 251; 64 ×.
- Figs. 4 a—c. *Globigerinoides obliquus obliquus* BOLLI.
LP 251; 64 ×.
- Figs. 5 a—c. *Globigerinoides obliquus extremus* BOLLI & BERMUDEZ.
LP 251; 64 ×.
- Figs. 6 a—c. *Globigerinoides conglobatus* (BRADY).
LP 241; 64 ×.
- Figs. 7 a—c. *Globigerinoides conglobatus* (BRADY).
LP 241; 64 ×.

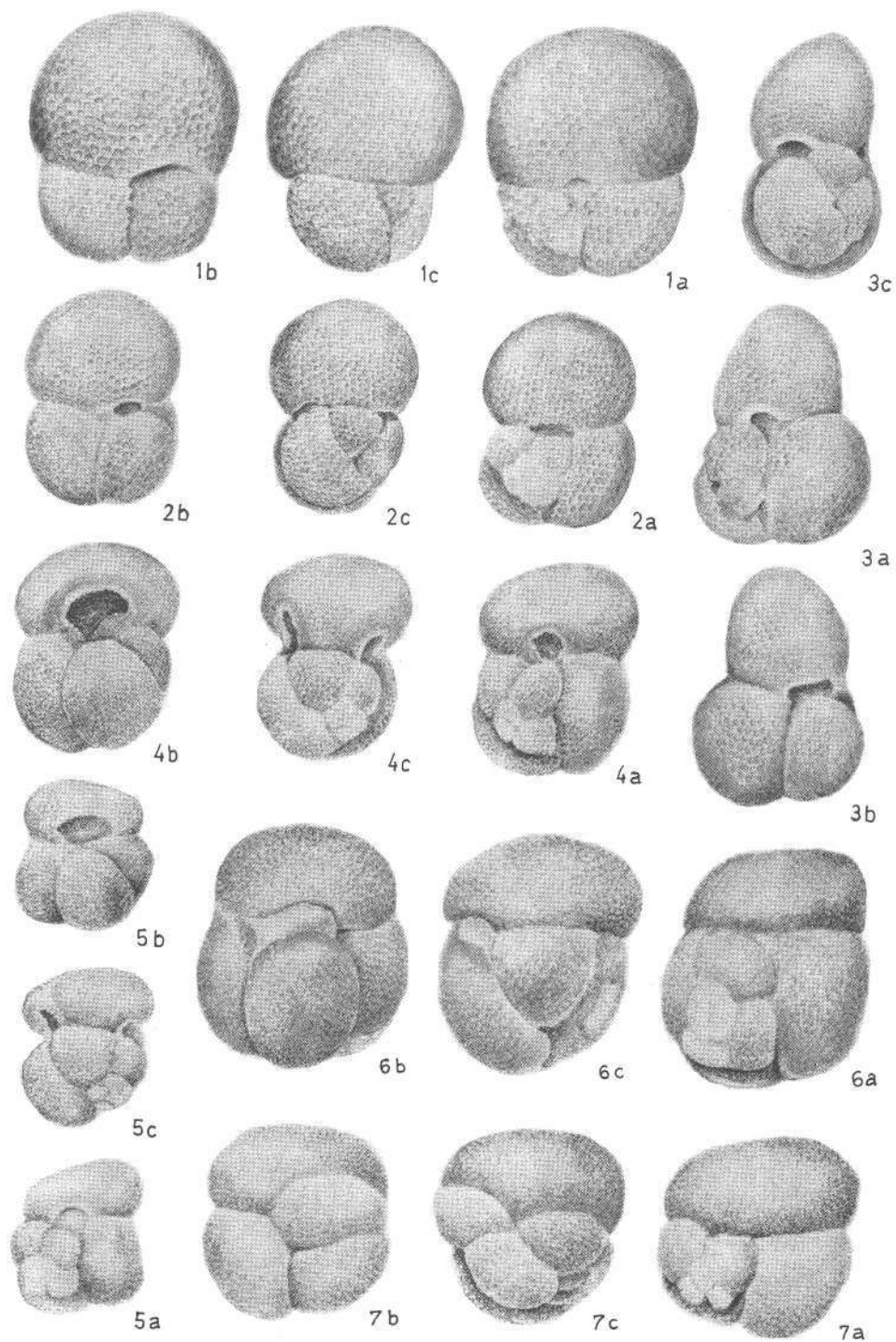


PLATE 2.

- Figs. 8 a—c. *Globigerinoides ruber* D'ORBIGNY.
JDE III; 100 ×.
- Figs. 9 a—c. *Globigerina rubescens* HOFKER.
LP 251; 100 ×.
- Figs. 10 a—c. *Globigerina foliata* BOLLI.
LP 241; 100 ×.
- Figs. 11 a—c. *Globigerina nepenthes* TODD.
LP 241; 100 ×.
- Figs. 12 a—c. *Globigerina glutinata* (EGGER).
LP 251; 100 ×.
- Figs. 13 a—c. *Globigerina pachyderma* (EHRENBERG).
LP 251; 64 ×.
- Figs. 14 a—c. *Globigerina venezuelana* HEDBERG.
LP 241; 64 ×.

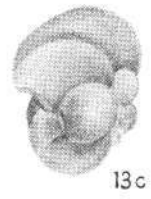
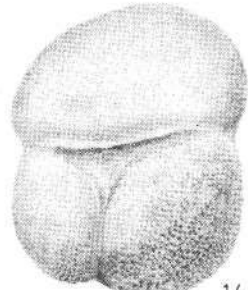
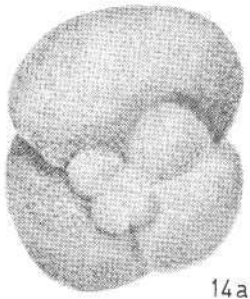
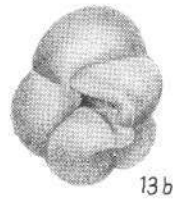
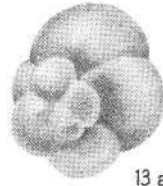
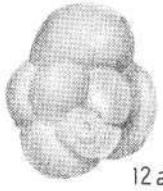
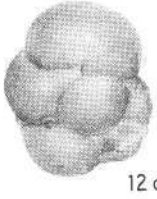
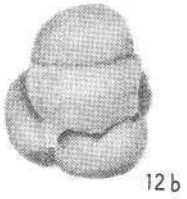
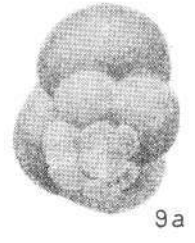
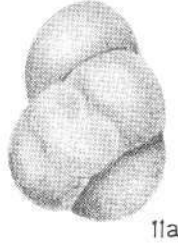
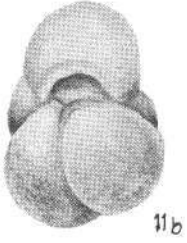
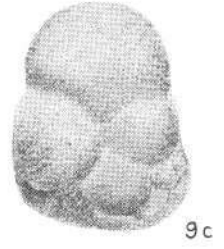
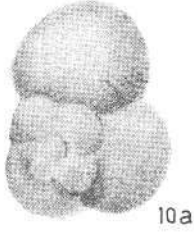
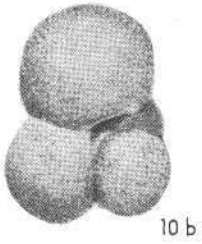
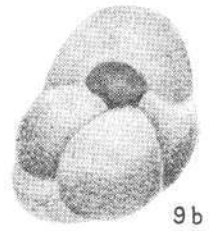
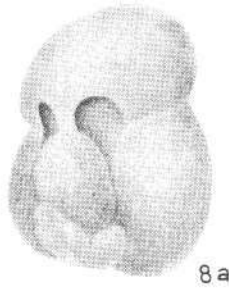
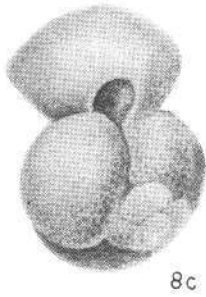
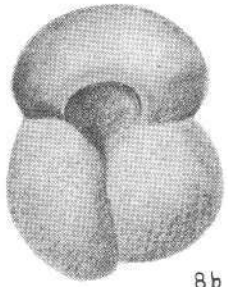
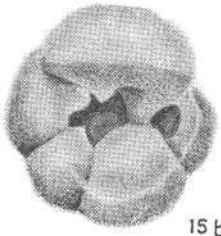
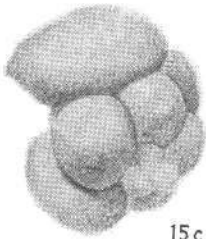


PLATE 3.

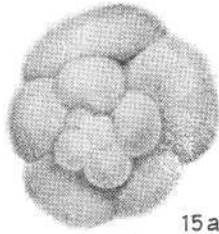
- Figs. 15 a—c. *Globoquadrina altispira globosa* BOLLI.
LP 251; 64 ×.
- Figs. 16 a—c. *Globoquadrina altispira altispira* (CUSHMAN & JARVIS).
LP 251; 64 ×.
- Figs. 17 a—c. *Sphaeroidinella seminulina* (SCHWAGER).
LP 251; 64 ×.
- Figs. 18 a—c. *Sphaeroidinella seminulina* (SCHWAGER).
LP 251; 64 ×.
- Figs. 19 a—c. *Sphaeroidinella debiscens* (PARKER & JONES).
JDE III; 50 ×.
- Figs. 20 a—c. *Pulleniatina primalis* BANNER & BLOW.
LP 241; 64 ×.



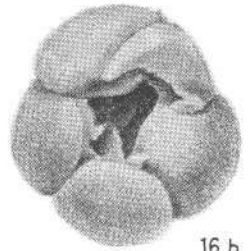
15 b



15 c



15 a



16 b



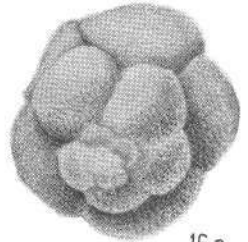
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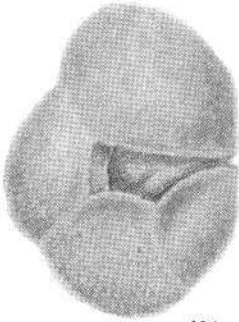
17 c



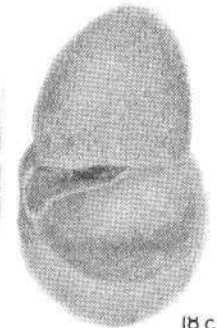
17 a



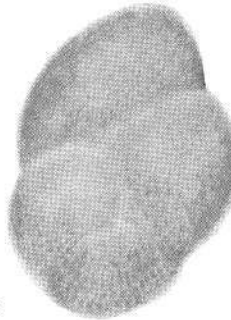
16 a



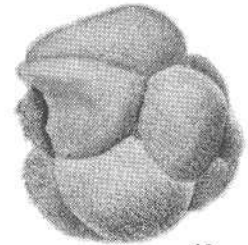
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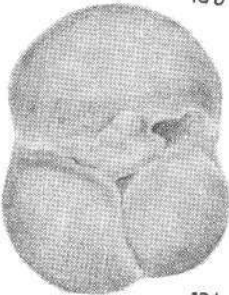
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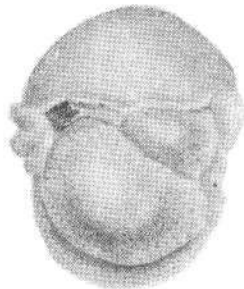
18 a



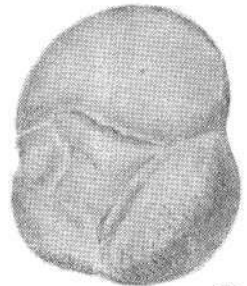
16 c



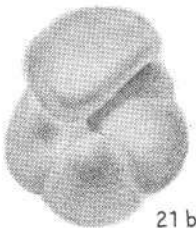
19 b



19 c



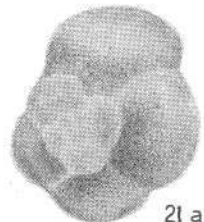
19 a



21 b



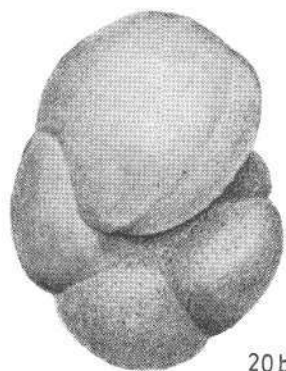
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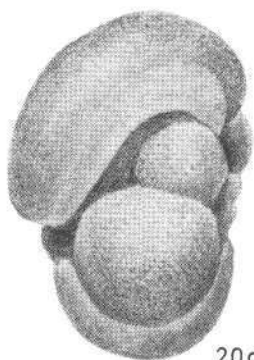
21 a

PLATE 4.

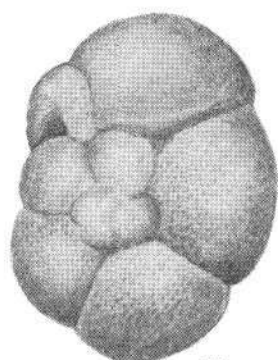
- Figs. 21 a—c. *Pulleniatina primalis* BANNER & BLOW.
LP 251; 64 ×.
- Figs. 22 a—c. *Pulleniatina obliquiloculata praecursor* (PARKER & JONES)
JDE III; 64 ×.
- Figs. 23 a—c. *Pulleniatina obliquiloculata obliquiloculata* (PARKER & JONES)
JDE III; 64 ×.
- Figs. 24. *Orbulina universa* D'ORBIGNY.
LP 241; 50 ×.
- Figs. 25 a—b. *Orbulina suturalis* BRÖNNIMANN.
LP 241; 50 ×.
- Figs. 26 a—c. *Hastigerina aequilateralis* (BRADY).
LP 241; 100 ×.



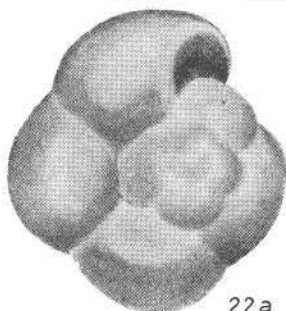
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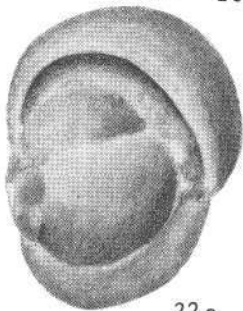
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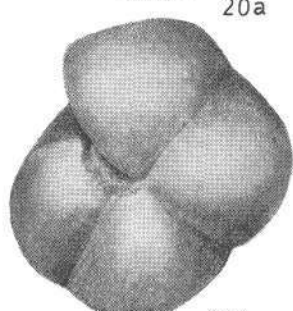
20a



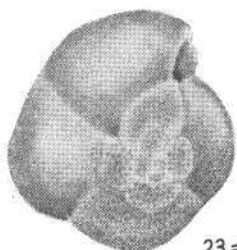
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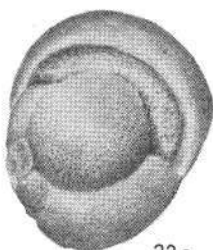
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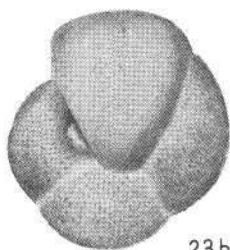
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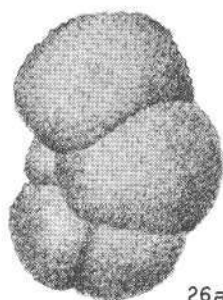
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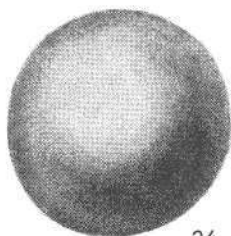
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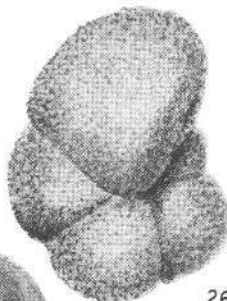
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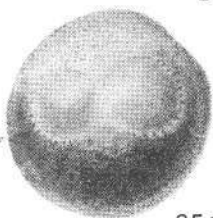
26a



24



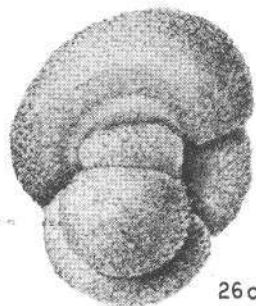
26b



25a



25b



26c

PLATE 5.

- Figs. 27 a—c. *Globoquadrina dutertrei* (D'ORBIGNY).
LP 241; 100 ×.
- Figs. 28 a—c. *Globorotalia* cf. *acostaensis* BLOW.
LP 241; 100 ×.
- Figs. 29 a—c. *Globorotalia obesa* BOLLI.
LP 251; 100 ×.
- Figs. 30 a—c. *Globorotalia menardii* (D'ORBIGNY).
LP 251; 64 ×.
- Figs. 31 a—c. *Globorotalia menardii* (D'ORBIGNY).
LP 241; 64 ×.

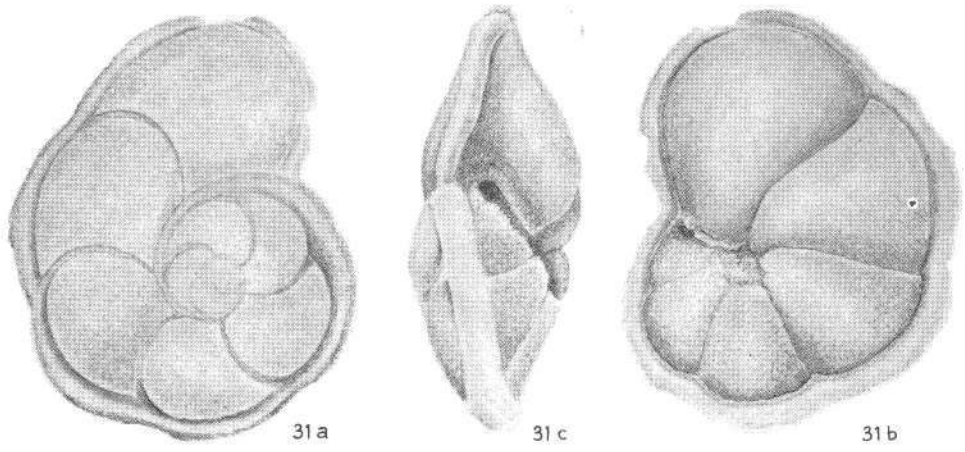
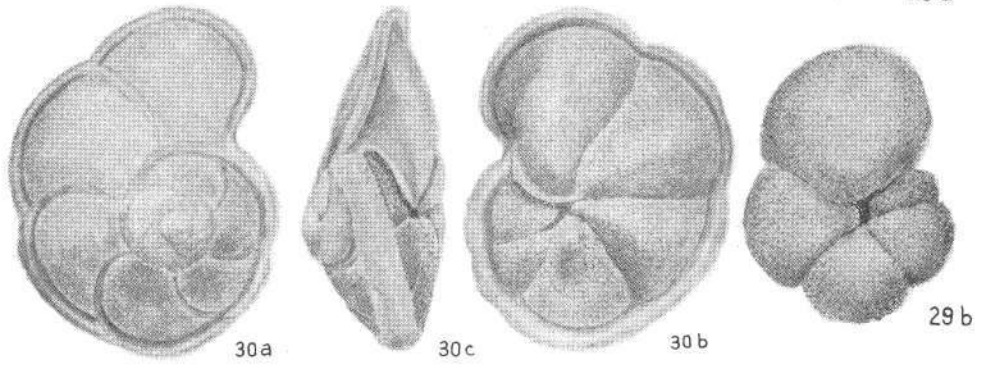
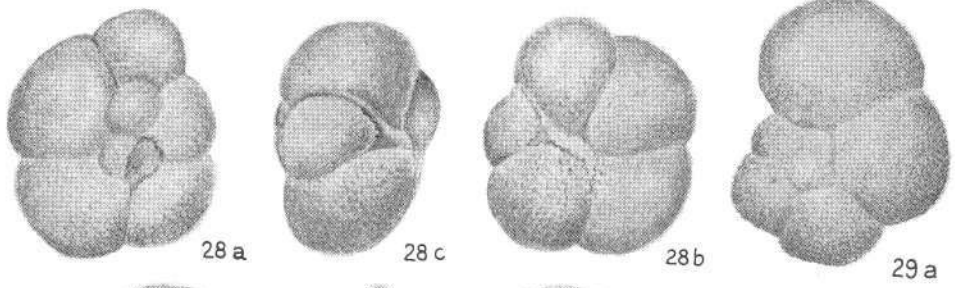
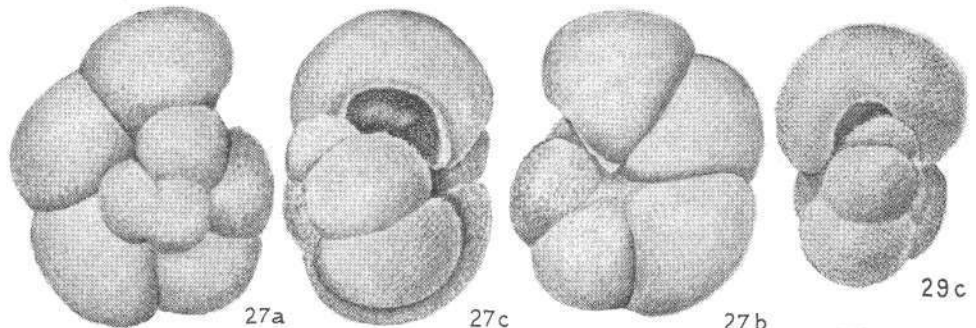
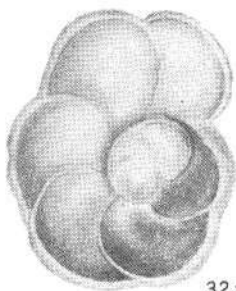


PLATE 6.

- Figs. 32 a—c. *Globorotalia menardii* (D'ORBIGNY).
JDE III; 50 ×.
- Figs. 33 a—c. *Globorotalia scitula* (BRADY).
LP 251; 64 ×.
- Figs. 34 a—c. *Globorotalia tumida* (BRADY).
LP 251; 64 ×.
- Figs. 35 a—c. *Globorotalia tumida* (BRADY).
LP 251; 64 ×.
- Figs. 36 a—c. *Globorotalia tumida flexuosa* (KOCH).
LP 251; 64 ×.



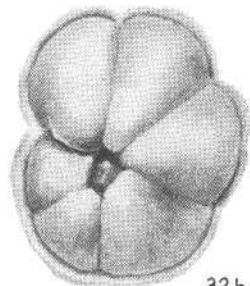
34c



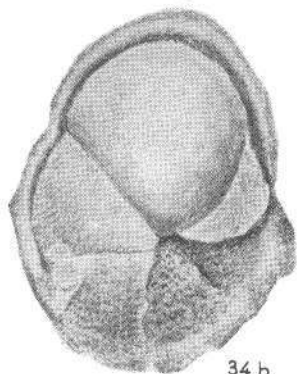
32a



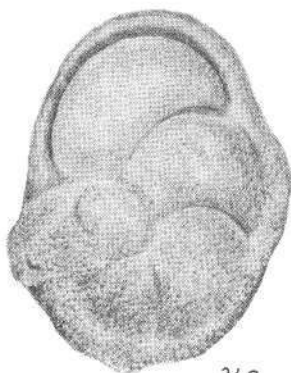
32c



32b



34b



34a



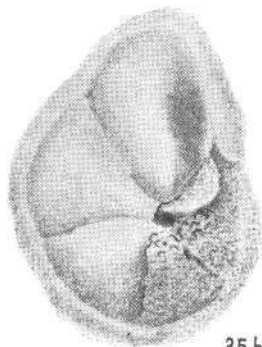
33a



33c



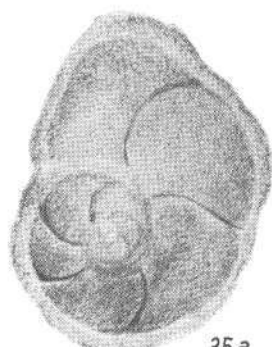
33b



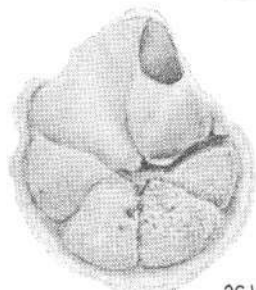
35b



35c



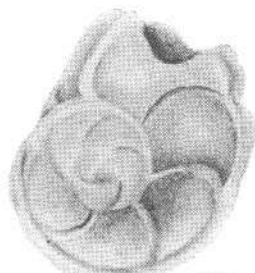
35a



36b



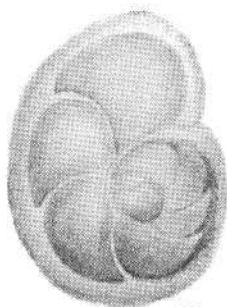
36c



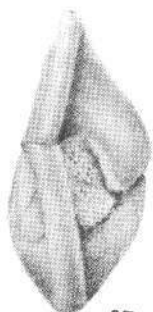
36a

PLATE 7.

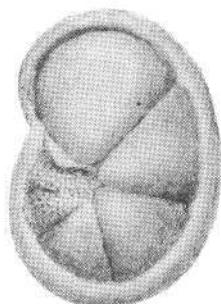
- Figs. 37 a—c. *Globorotalia tumida* (BRADY).
LP 241; 64 ×.
- Figs. 38 a—c. *Globorotalia crassaformis* (GALLOWAY & WISSLER).
JDE III; 64 ×.
- Figs. 39 a—c. *Globorotalia margaritae* BOLLI & BERMUDEZ.
LP 251; 100 ×.
- Figs. 40 a—c. *Globorotalia cultrata* (D'ORBIGNY).
LP 241; 64 ×.



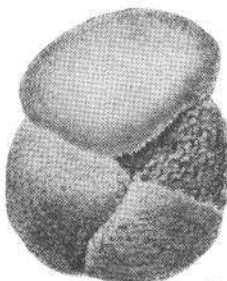
37a



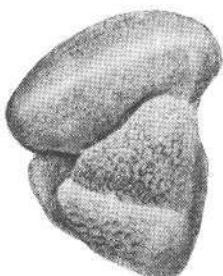
37c



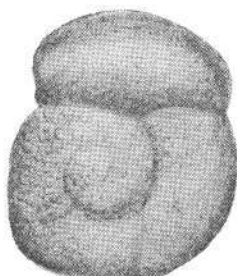
37b



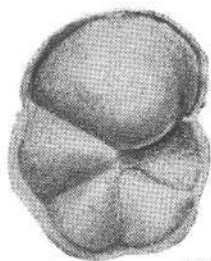
38 b



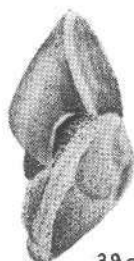
38 c



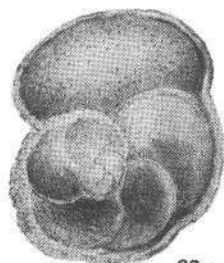
38 a



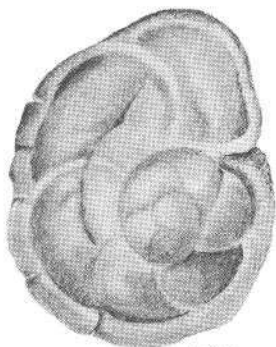
39 b



39c



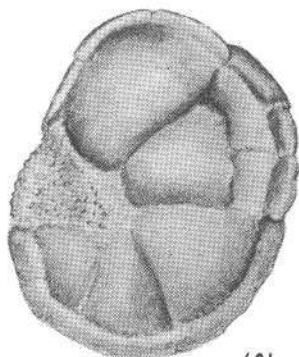
39 a



40a



40c



40b