

Micropalaeontology of the Chanali Limestone, Upper Cretaceous, of Hazara, West Pakistan

With 2 text figures and 8 plates

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Abstract

A sequence of limestones, considered as the basal beds of Eocene, have been identified as a mappable, lithostratigraphic unit and given a new formation name, the Chanali Limestone. The microfaunal studies of 5 samples, further reveal the presence of more than 30 species, 16 belonging to planktonic and 15 to benthonic foraminiferida and 3 to Ostracoda. An Upper Coniacian to Campanian age for the formation is established.

Introduction

The rocks under study are mainly spread over the district of Hazara and partly the Rawalpindi district of West Pakistan and Muzaffargarh district of Kashmir. The area lies between longitude 73.00 to 73.30 east and latitude 33.43 to 34.20 north, fully covering the Survey of Pakistan sheets, 43 F/4, 43 F/8, 43 G/1, and 43 G/5 and partly 43 F/7 and 43 G/2, an area of about 1000 square miles, see Fig. 1. For the purposes of mapping within the area and correlation outside, a detailed study of the Geology and Micropalaeontology of the rock sequence of doubtful age lying above the Giumal Sandstone and at the base of the Eocene rocks, was considered a necessity. While the geological investigations were carried out in the whole area, the Changla Gali section, 43 G/5, 442949, was selected for the micropalaeontological studies, because of the relatively soft nature of the limestones in its vicinity. The section is situated on the Murree-Abbottabad road, 10 miles north of Murree and five hundred feet south of the Changla Gali Police Station.

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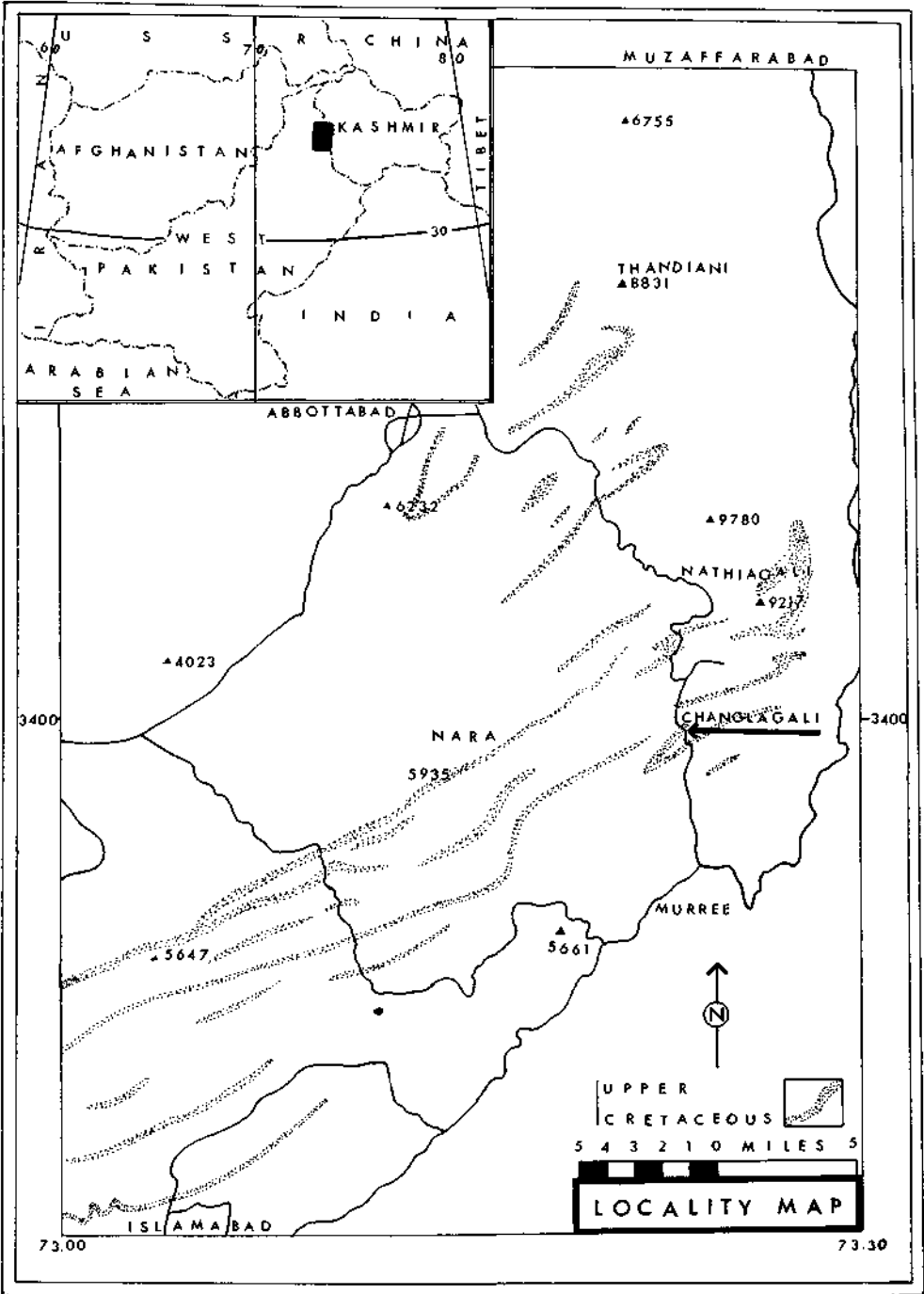


FIG. NO. 1

the stratigraphic part of the text and Dr. H. PLACHY for his helpful criticism.

Previous work

The first reference to the Geology of Hazara was made by Verchere 1866—67. In his paper, he gave a rough description of the north eastern end of Mount Sirban, rising east and south east of Abbottabad and identifying rocks from Carboniferous to Eocene. There was however no reference to the presence of the Upper Cretaceous rocks in the area.

WAAGEN and WYNNE, 1872, recognised the following succession:

6. Nummulitic
Thick limestone with some shales, fossils in places.
 5. Cretaceous
 - b) Thin bedded limestone without fossils, apparently.
 - a) Impure ferruginous, sandy, rusty weathering, with fossils.
 4. Jurassic
Black Spiti Shales
 3. Triassic
Thin bedded limestone and slaty shales, dolomite, limestone, fossiliferous beds.
 2. Below the Trias
Haematite, dolomite, quartzite, sandstone and breccia.
-
- unconformity
1. Semi-crystalline
Artock (?) Slate.

In the lower 10 to 20 feet part of the Cretaceous succession they described the rusty and orange coloured beds containing some Cretaceous fossils, followed by a group of thin bedded limestones, of grey colour with even bedding planes, but apparently without any organic remains, belonging either to the Cretaceous or the Nummulitic rocks. From their absence in other places at the base of the later formation, they considered it more likely to be a member of the former. Further on they found a probable correlation of these rocks together with the Giupal Sandstone and Chikkim Limestone and Shales together, of the Spiti area of Himalayas.

MIDDLEMISS, 1896, described the lower part as a slightly sandy limestone of bright orange colour, rarely grey, massive dotted all over with black cherty and ferruginous patches containing fossils, and considered them of Cenomanian age; followed by a series of well bedded limestones, 300 to 400 feet in thickness, of pale neutral grey colour weathering white. He described these limestones of very well and rather compact amorphous structure. There is a complete absence of fossils, except some extremely minute organisms, probably foraminifera. In the absence of proof, he preferred to place the grey limestones with the Tertiary, as the lowest bed of Nummulitic Series.

Recent Work

Between 1896 and 1959, there has been no work of any significance related to the above mentioned succession of rocks. During the recent remapping of Hazara, the author, 1962, recorded presence of limestones of Upper Cretaceous age, above the Giumal Sandstone of Lower Cretaceous age and below the Tertiary rocks. The following succession has been recognised in the Middle and Upper Mesozoic: —

Galis Group

	unconformity	
Chanali Limestone	Upper Cretaceous	
Giumal Sandstone	Lower Cretaceous	
Spiti Shale	Upper Jurassic	
	unconformity	
Sikhar Limestone (Triassic of Middlemiss)	Middle Jurassic	
Maira Formation	Lower Jurassic	
	unconformity	

Abbottabad Group

More detailed studies of the said limestones reveal the following facts:

a) The limestones are a distinct mappable lithostratigraphic unit, easily distinguished from the underlying Giumal Sandstone separated by an orange yellow arenaceous limestone marker bed and the overlying *Nummulite* bearing dark grey limestones and shales, separated by a break in deposition as marked by a laterite bed.

b) They are widely distributed in the area, with exposures, occasionally up to 38 miles apart e. g. Saidpur, 43 G/2, 130636, and Sangar Gali, 43 F/8, 222770.

c) They contain a definite Upper Cretaceous microfauna, as against the Lower Cretaceous and Paleocene of the underlying and overlying formations respectively.

d) They show a development of over 700 feet near Chanali, 43 G/5, 334870.

On the basis of the facts noted above a new formation, namely the Chanali limestone is established for the rocks henceforth known as grey limestones.

Lithology of the Chanali Limestone

With a rapid increase in the calcareous content, the underlying Giumal Sandstone passes upwards into an arenaceous limestone, 5 to 25 feet thick, of bright orange colour and rich in oysters which conspicuously stand above

their weathered surfaces. This bed serves as a marker between the Giumal Sandstone below and the limestones under study above.

There is a rapid increase in the argillaceous and calcareous content of the rocks which occasionally show pale and green dolomitic patches in a pale grey background with the occasional presence of oolites as seen near Bokan, 43 G/1, 105766. They are followed by thinly bedded fine grained limestone, with marly intercalations of few inches thickness. The limestones are light grey in colour, very fine grained and break with a conchoidal fracture. The weathered surfaces are conspicuously pale, cream grey and white. The platy habit of these limestones is well developed in the type area near Chanali and Danna Nuralan, 43 G/1, 243877. The south eastern exposures in the area are softer marly limestones followed towards the middle of the area by thinly bedded to thickly bedded and in the north west by thickly to thinly bedded. The thickness of the limestones varies from 150 feet in the south east to over 700 feet in the middle of the area. The weathered surfaces of the limestones sometimes show some echinoid remains.

Correlation of the Chanali Limestone

The pre-Chanali Limestone formations, the Spiti Shale and Giumal Sandstone of Hazara may be compared in Kohat, with the Chichali formation and Lumshiwai Sandstone, comprising respectively of 60 feet of rusty brown to dark green soft friable glauconitic and ferruginous sandstones and shales and 640 feet of hard quartzitic, glauconitic, ferruginous and calcareous sandstones. A similar sequence of rocks has been identified in Kala Chitta. In trans Indus parts of Salt range, a thick succession of brown, yellow, grey sandstones, gypseous clays and marls has been recognized as equivalent to the above sequence. The sequence of rocks in Spiti area seems to be quite identical to that of Hazara.

The overlying Chanali limestone of Hazara is represented by almost identical limestones in Kohat, Samana area and is of 370 feet thickness. A sequence of 150 to 230 feet thick, brownish, yellowish, light blue calcareous shale and sandstone ranging from Albian to Upper Cretaceous is represented in Kala Chitta. There is no record of the presence of such rocks in the Salt Range though it is interesting to note that according to KRISHNAN, 1960, "RAO has recorded the foraminifera *Globotruncana rosetta* of Maestrichtian age from limestone band of Nammal gorge". In Spiti, the Giumal series is followed by a sequence of 250 to 300 feet of grey or whitish limestones and calcareous, sandy, grey and green shales of Upper Cretaceous age, collectively known as Chikkim series.

Micropalaeontology and age of the Chanali Limestone

The microfaunal study of the above limestones is based on 5 rock samples, evenly distributed over a thickness of 150 feet and have been collected from Changla Gali, 43 G/5, 442949, area of Hazara. They reveal

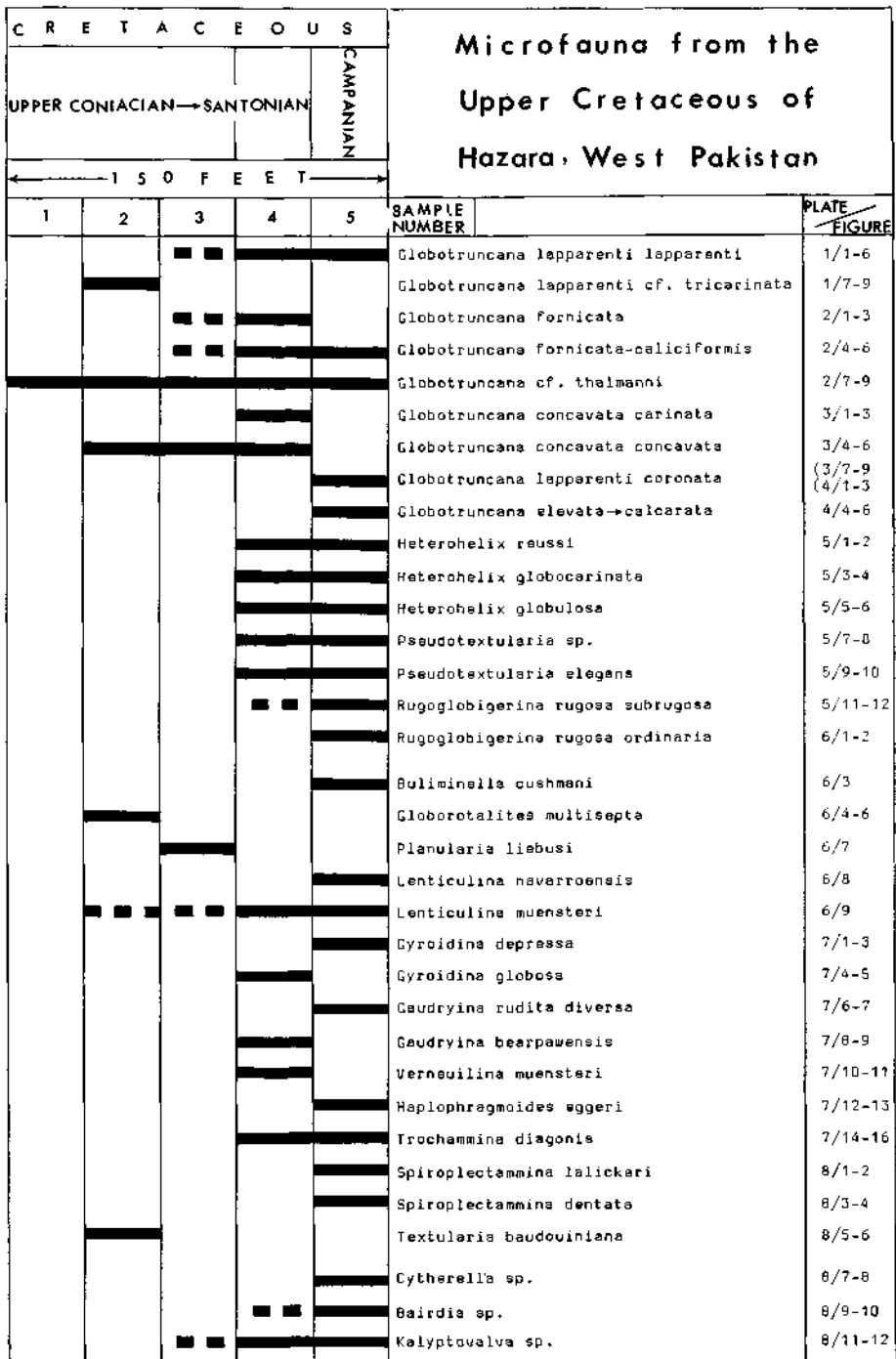


FIG. NO. 2

the presence of more than 30 species of microfauna recorded from this area for the first time. Though the preservation of the material was not good, it was found possible to compare them with the microfaunal assemblages from Europe and America, most particularly from Austria.

Globotruncana concavata is restricted from Upper Coniacian to Santonian in other areas. In the present study it ranges from sample No. 2 to 4. As such sample No. 2 is recognized as Upper Coniacian and No. 4 as Upper Santonian. The sample No. 1 is poorly represented in fauna and is arbitrarily placed at the base of Upper Coniacian till a definite evidence of its age is available, thereby settling the lower boundary for the time being. No species of *Globotruncana calcarata*, which in other areas is restricted to Upper Campanian, could be found in the section under study. Only intermediate forms between *Globotruncana elevata* and *Globotruncana calcarata*, showing spinal extension of one of the chambers has been recorded from sample No. 5 and is considered to be of Lower / Middle Campanian age, as the *Globotruncana elevata* is abundant in Lower Campanian, thereby settling the Upper boundary of the section under study. *Heterobelix reussi* and *Heterobelix globocarinata* range in other areas from Middle Coniacian to Middle Campanian and Upper Santonian to Lower Maestrichtian respectively. In this section they range from sample No. 4 to 5 and are considered to be from the overlap in their ranges in other areas, i. e. Santonian to Middle Campanian, confirming the above age derived with the help of the species of *Globotruncana*.

A further confirmation is provided by the species of *Rugoglobigerina subrugosa* and *Rugoglobigerina ordinaria* found from sample Nos. 4 to 5, and which in other areas range from Campanian to Lower and Middle Maestrichtian.

Though most of the benthonic Foraminiferida and Ostracoda have longer ranges, the recorded species have been found identical to those described from the Upper Cretaceous deposits of other European and American localities. The species of *Buliminella cushmani*, *Globorotalites multisepta*, *Planularia liebusi* and a few others have been found particularly useful.

The above discussion of the fauna from the Chanali Limestone of Hazara, shows a distinct Upper Coniacian to Lower Campanian age.

Systematic descriptions

Family *GLOBOTRUNCANIDAE* BROTZEN, 1942

Genus *Globotruncana* CUSHMAN, 1927

Globotruncana lapparenti lapparenti BROTZEN

(Plate 1, Figures 1—6)

1944 *Globotruncana lapparenti lapparenti* nom. nov. H. BOLLI, *Ecolog. Geol. Helv.* 37, p. 230, Fig. 1, Abb. 15, 16, pl. 9, Fig. 11.

1955 *Globotruncana mayaroensis* BOLLI, R. GANDOLFI, *Bull. Amer. Pal.* 36, p. 18, pl. 1, Fig. 2.

- 1957 *Globotruncana (Globotruncana) cf. lapparenti* BROTZEN, H. S. EDGELL, *Micropal.* 3, pl. 1, Fig. 2.
- 1962 *Globotruncana lapparenti* BROTZEN, D. HERM, Bayer. Akad. Wiss., mathem.-naturw. Kl., Abh., N. F. 104, p. 82—84, pl. 6, Fig. 2.
Globotruncana (Globotruncana) lapparenti linneiana D'ORBIGNY, E. A. PASSAGNO, *Micropal.* 8, p. 360, pl. 3, Fig. 7—9.
- 1963 *Globotruncana (Globotruncana) linneiana linneiana* (D'ORBIGNY), J. V. HINTE, *Jb. Geol. B.-A., Sonderb.* 8, p. 75, pl. 5, Fig. 1—2.
- 1966 *Globotruncana lapparenti lapparenti* BROTZEN, U. WILLE, *Jb. Geol. B.-A.* 106, p. 108—110, pl. 1, Fig. 1—13.

Periphery lobate, spiral side flat, umbilical side flat to slightly convex, bicarinate. Chambers rhomboid, 12—13, arranged in 2½ whorls, the 6 of the last whorl increase gradually in size. Suture curved to sinous, elevated. Umbilicus narrow.

Dimensions of the figured hypotype:

Larger diameter: 0.57 mm. and 0.66 mm.

Smaller diameter: 0.49 mm. and 0.56 mm.

Thickness: 0.16 mm. and 0.17 mm.

Sample No. of the figured hypotype: No. 5 and 4 respectively.

Stratigraphic range: Santonian to Campanian.

Globotruncana lapparenti cf. tricarinata (QUEREAU)

(Plate 1, Figures 7—9)

- 1936 *Globotruncana lapparenti* n. sp., F. BROTZEN, *Sverig. Geol. Unders. Ser. C.* 396, p. 175.
- 1944 *Globotruncana lapparenti tricarinata* (QUEREAU), H. BOLLI, *Ecolog. Geol. Helv.* 37, p. 232, Fig. 1, Abb. 19, 20, pl. 9, Fig. 13.
- 1957 *Globotruncana (Globotruncana) lapparenti* BROTZEN cf. *tricarinata* (QUEREAU), H. S. EDGELL, *Micropal.* 3, p. 113, pl. 3, Fig. 1—3.
- 1960 *Globotruncana lapparenti tricarinata* (QUEREAU), A. TOLLMANN, *Jb. Geol. B.-A.* 103, p. 193, pl. 21, Fig. 1.
- 1962 *Globotruncana tricarinata* (QUEREAU), D. HERM, Bayer. Akad. Wiss. mathem.-naturwiss. Kl., Abh., N. F. 104, p. 93, pl. 6, Fig. 4.
- 1963 *Globotruncana (Globotruncana) ventricosa* WHITE, J. V. HINTE, *Jb. Geol. B.-A., Sonderb.* 8, p. 86, pl. 7, Fig. 3.
- 1966 *Globotruncana lapparenti tricarinata* (QUEREAU), U. WILLE, *Jb. Geol. B.-A.* 106, p. 110, 111, pl. 2, Fig. 1—11.

Periphery lobate, spiral side flat to faintly convex, umbilical side convex, bicarinate with a third keel like edge on umbilical side. Chambers rhomboid, 10 to 11 arranged in 2 whorls, the 7 of the last whorl increase gradually in size. Sutures, curved elevated. Umbilicus wide, open.

Dimensions of the figured hypotype:

Larger diameter: 0.57 mm.

Smaller diameter: 0.44 mm.

Thickness: 0.16 mm.

Sample No. of the figured hypotype: No. 2.

Stratigraphic range: Upper Coniacian.

Globo truncana fornicata PLUMMER

(Plate 2, Figures 1—3)

- 1931 *Globo truncana fornicata* n. sp., H. PLUMMER, Univ. Texas Bull. 3101, p. 198, pl. 13, Fig. 4—6.
 1955 *Globo truncana fornicata fornicata* PLUMMER, R. GANDOLFI, Bull. Amer. Pal. 36, p. 40, pl. 2, Fig. 2.
 1957 *Globo truncana (Globo truncana) fornicata* PLUMMER, H. S. EDGELL, Micropal. 3, p. 112, pl. 3, Fig. 10—12.
 1962 *Globo truncana fornicata* PLUMMER, D. HERM, Bayer. Akad. Wiss. mathem.-naturwiss. Kl., Abh., N. F. 104, p. 78, pl. 7, Fig. 2.
 1966 U. WILLE, Jb. Geol. B.-A. 106, p. 105, 106, pl. 4, Fig. 1—9.

Periphery rounded, spiral side convex, umbilical side slightly convex, bicarinate, Chambers angular rhomboid, 12—13, arranged in 2½ whorls, the 5 of the last whorl increase gradually in size. Sutures elevated, curved on spiral side, curved to sinuous on the umbilical side. Umbilicus narrow.

Dimensions of the figured hypotype:

Larger diameter: 0.55 mm.

Smaller diameter: 0.50 mm.

Thickness: 0.25 mm.

Sample of the figured hypotype: No. 4.

Stratigraphic range: Sample No. 3—4, Upper Santonian.

Globo truncana fornicata PLUMMER — *caliciformis* (LAPPARENT)

(Plate 2, Figures 4—6)

Periphery rounded, spiral side convex, umbilical side slightly convex bicarinate. Chambers angular rhomboid, 13, arranged in 2½ whorls, the 5 of the last whorl increase gradually in size. Sutures curved elevated on spiral side, curved to sinuous on the umbilical side. Umbilicus, narrow, open.

Dimensions of the figured hypotype:

Larger diameter: 0.58 mm.

Smaller diameter: 0.54 mm.

Thickness: 0.27 mm.

Sample of the figured hypotype: No. 5.

Stratigraphic range: Sample No. 3, to 5, Santonian to Campanian.

Globo truncana cf. *thalmanni* GANDOLFI

(Plate 2, Figures 7—9)

- 1955 *Globo truncana thalmanni thalmanni* GANDOLFI, Bull. Amer. Pal. Vol. 36, No. 155, pp. 60—61, pl. 4, Figures 4 a—c.

Periphery rounded, spiral side convex, umbilical, slightly convex, unicarinate. Chambers crescentic, 10 to 11, arranged in about 2 whorls, the 4½ of the last whorl, increase rapidly in size. Sutures, elevated, curved on spiral side, curved to meandering on umbilical side. Umbilicus medium, open.

Dimensions of the figured hypotype:

Larger diameter: 0.69 mm.

Smaller diameter: 0.60 mm.

Thickness: 0.23 mm.

Sample of the figured hypotype: No. 5.

Stratigraphic range: Upper Coniacian to Lower Campanian.

Globotruncana cf. concavata carinata DALBIEZ

(Plate 3, Figures 1—3)

1955 *Globotruncana (Globotruncana) ventricosa carinata* DALBIEZ, p. 168, text fig. 8.

Periphery lobate, spiral side flat to slightly convex, umbilical side, convex, bicarinate (?). Chambers semicircular with a keeled edge on umbilical side, the last chamber being very large, and elliptical, 10, arranged in 2 whorls, the 6 of the last whorl increasing gradually in size, except the last very large chamber. Sutures depressed, keels elevated, radial. Umbilicus large, deep wide open.

Dimensions of the figured hypotype:

Larger diameter: 0.67 mm.

Smaller diameter: 0.53 mm.

Thickness: 0.37 mm.

Sample No. of figured hypotype: No. 4.

Stratigraphic range: Sample No. 4, Upper Santonian.

Globotruncana concavata concavata (BRÖTZEN)

(Plate 3, Figures 4—6)

1955 *Globotruncana (Globotruncana) ventricosa ventricosa* WHITE, DALBIEZ, p. 168, Figures 7 a—c.

1957 *Globotruncana concavata* (BRÖTZEN), BOLLI, p. 57, pl. 13, Figures 3 a—c.

1962 *Globotruncana concavata* (BRÖTZEN), D. HERM, p. 70, pl. 5, Fig. 4, Bayr. Paleont. Vol. 4, pt. 4, p. 569, pl. 71, Figures 4 a—c.

Periphery rounded to lobate, spiral side flat to convex, umbilical side convex, bicarinate. Chambers rhombic on spiral side, rounded on umbilical side, 13, arranged in 2 whorls, the 7 of the last, increase gradually in size. Sutures depressed, keels elevated, curved to radial. Umbilicus, deep, wide open.

Dimensions of the figured hypotype:

Larger diameter: 0.63 mm.

Smaller diameter: 0.57 mm.

Thickness: 0.33 mm.

Sample No. of figured hypotype: No. 4.

Stratigraphic range: Sample No. 2—4, Upper Coniacian to Santonian.

Globotruncana lapparenti coronata BOLLI

(Plate 4, Figures 1—3)

- 1944 *Globotruncana lapparenti coronata* nom. nov. H. BOLLI, *Ecolog. Geol. Helv.* 37, p. 233, Fig. Abb. 21, 22, pl. 9, Fig. 14—15.
 1960 A. TOLLMANN, *Jb. Geol. B.-A.* 103, p. 194, pl. 21, Fig. 2.
 1966 *Globotruncana lapparenti coronata* BOLLI, 1944, U. WILLE, *Jb. Geol. B.-A.* 106, p. 108, pl. 3, Fig. 1—10.

Periphery lobate, spiral side flat, umbilical side slightly convex bicarinate. Chambers, rhomboid, 11—13, arranged in $2\frac{1}{4}$ whorls, the 7 of the last whorl increase rapidly in size. Sutures curved, to sinuous, umbilicus, wide open.

Dimensions of the figured hypotype:

- Larger diameter: 0.75 mm.
 Smaller diameter: 0.67 mm.
 Thickness: 0.16 mm.

Sample of the figured hypotype: No. 5.
 Stratigraphic range: Lower Campanian.

Globotruncana elevata (BROTZEN) — *calcarata* CUSHMAN

(Plate 4, Figures 4—6)

Periphery lobate, spiral side flat, umbilical side convex, unicarinate. Chambers semicircular, except for the third but last chamber, which shows a spiral extension of the chamber. 11 chambers arranged in 2 whorls, the 6 of the last increase unevenly in size. Sutures depressed, curved to radial. Umbilicus narrow, open.

Dimensions of the figured hypotype:

- Larger diameter: 0.83 mm.
 Smaller diameter: 0.70 mm.
 Thickness: 0.35 mm.

Sample of the figured hypotype: No. 5.
 Stratigraphic range: Lower Campanian.

Genus *Rugoglobigerina* BRÖNNIMANN, 1952.*Rugoglobigerina rugosa subrugosa* (GANDOLFI 1955)

(Plate 5, Figures 11, 12)

- 1952 *Rugoglobigerina rugosa rugosa* (PLUMMER), BRÖNNIMANN, p. 28, Figs. 11, 12, 13.
 1955 *Globotruncana (Rugoglobigerina) rugosa rugosa* (PLUMMER), GANDOLFI, *Bull. Amer. Pal.* Vol. 36, p. 72, Fig. 6, a—c, text fig. 11 c.
 1967 *Rugoglobigerina rugosa subrugosa*, BANDY, *Micropal.* Vol. 13, No. 1, p. 21, text figs. 10/2.

Periphery lobate. Chambers hemispherical, inflated, 10, arranged in two whorls, $4\frac{1}{2}$ of last whorl, increase rapidly in size. Surface rugose.

Dimensions of the figured hypotype:

Larger diameter: 0.45 mm.

Smaller diameter: 0.36 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Upper Santonian to Lower Campanian.

Rugoglobigerina rugosa ordinaria (SUBBOTINA)

(Plate 6, Figures 1—2)

1953 *Globigerina rugosa ordinaria*, SUBBOTINA, Vses. Neft. Nauch. Isslad. Geol. Razved. Inst. Trudy., n. Ser., vypusk. 76.

1967 *Rugoglobigerina rugosa ordinaria* (SUBBOTINA), BANDY, Micropal. Vol. 13, No. 1, p. 21, text fig. 10/3.

Periphery lobate, Chambers hemispherical, 14, arranged in $2\frac{1}{2}$ whorls, the 6 of the last whorl increase unevenly in size. Sutures depressed, surface rugose.

Dimensions of the figured hypotype:

Larger diameter: 0.56 mm.

Smaller diameter: 0.52 mm.

Sample of the figured hypotype: No. 5.

Stratigraphic range: Sample 4—5, Upper Santonian to Lower Campanian.

Family *HETEROHELICIDAE* CUSHMAN, 1927

Genus *Heterohelix* EHRENBERG, 1841

Heterohelix reussi (CUSHMAN)

(Plate 5, Figures 1—2)

1938 *Gümbelina reussi* CUSHMAN, Cush. Lab. Foram. Res. Contr. Vol. 14, p. 11, pl. 12, Figs. 6—9.

1942 CUSHMAN & DEADERICK, Cush. Lab. Foram. Res. Contr. Vol. 18, p. 63, Pl. 15, Figs. 5—7.

1944 CUSHMAN, Cush. Lab. Foram. Res. Contr. Vol. 20, p. 90, pl. 14, Fig. 2.

1946 CUSHMAN, U. S. G. S. Prof. Pap. 206, p. 104, pl. 44, Fig. 18—19.

Test biserial, Chambers hemispherical, gradually increasing in size, Aperture a crescentic arch at the base of last formed chamber.

Dimensions of the figured hypotype:

Length: 0.31 mm.

Breadth: 0.17 mm.

Thickness: 0.10 mm.

Sample of the figured hypotype: No. 5.

Stratigraphic range: Upper Santonian to Lower Campanian.

Remarks: The recorded form carries some features of *Heterohelix moremani* and may have developed from the later. It can be differentiated from *Heterohelix globulosa* by the lesser inflation of the chambers and the flat test.

Heterohelix globocarinata (CUSHMAN)

(Plate 5, Figures 3—4)

1938 *Gümbelina globocarinata* CUSHMAN, Cush. Lab. Foram. Res. Contr. Vol. 14, p. 10, pl. 2, Figs. 4—5.

1942 CUSHMAN & DEADERICK, Cush. Lab. Foram. Res. Contr. Vol. 18, p. 63.

1946 CUSHMAN, U. S. G. S. Surv. Prof. Pap. 206, p. 107, pl. 46, Figs. 8 a—b.

Test biserial, early portion flat later inflated, rapidly increasing in width, Chambers, globular rapidly increasing in size, the last two covering most of the test, more than half. The last chamber has a tendency to extend laterally. Aperture a crescentic arch.

Dimensions of the figured hypotype:

Length: 0.38 mm.

Breadth: 0.35 mm.

Thickness: 0.26 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Upper Santonian to Lower Campanian.

Remarks: The last two chambers cover more than $\frac{1}{2}$ of the test and as such are easily distinguished from *Heterohelix reussi*. The lateral extension of the last chamber is not sufficient enough to place the form with *Pseudotextularia*.

Heterohelix globulosa (EHRENBERG)

(Plate 5, Figures 5—6)

1946 *Gümbelina globulosa* (EHRENBERG), CUSHMAN, U. S. G. S. Prof. pap. 206, p. 105, 106, pl. 45, Figs. 9—15.

1967 *Heterohelix globulosa* (EHRENBERG), BANDY, Micropal. Vol. 13, No. 1, p. 22—24, text fig. 10/3, 12/5.

Test biserial, Chambers globular, increasing rapidly in size. Aperture a low arch at the base of last chamber.

Dimensions of the figured hypotype:

Larger diameter: 0.35 mm.

Smaller diameter: 0.24 mm.

Thickness: 0.17 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Upper Santonian to Lower Campanian.

Genus *Pseudotextularia* RZEHAk, 1891*Pseudotextularia* sp.

(Plate 5, Figures 7—8)

Test biserial. Chambers rounded compressed laterally. Wall calcareous perforate, surface rough. A crescentic arch at the base of last chamber.

Dimensions of the figured specimen:

Length: 0.45 mm.

Breadth: 0.30 mm.

Thickness: 0.28 mm.

Sample of the figured specimen: No. 5.

Stratigraphic range: Upper Santonian to Lower Campanian.

Remarks: It differs from *P. elegans* in its much larger size, lesser lateral compression and absence of any surface ornamentation.

Pseudotextularia elegans (RZEHAk)

(Plate 5, Figures 9—10)

1936 *Pseudotextularia elegans* RZEHAk, M. F. GLAESSNER, Prob. of Palaeont. 1, p. 99, pl. 1, Figs. 1—2.

1966 *Pseudotextularia elegans* RZEHAk, U. WILÄE, Jb. Geol. B.-A. 106, p. 120—121, pl. 8, Fig. 10.

1967 *Pseudotextularia elegans elegans* RZEHAk, BANDY, Micropal. Vol. 13, No. 1, pp. 24—25, text fig. 12/12.

Test biserial. Chambers rounded in early stages, compressed laterally in later stages. Last two chambers show faint development of striations. Aperture a Crescentic arch.

Dimensions of the figured hypotype:

Length: 0.37 mm.

Breadth: 0.24 mm.

Thickness: 0.26 mm.

Sample No. of the figured hypotype: No. 4.

Stratigraphic range: Upper Santonian to Lower Campanian.

Family *TURRILINIDAE* CUSHMAN, 1927Genus *Buliminella* CUSHMAN 1911*Buliminella cushmani* SANDIDGE

(Plate 6, Figure 3)

1932 *Buliminella cushmani* Sandidge, Journ. Pal. Vol. 6, No. 3, p. 280, pl. 42, Figs. 18—19.

1946 CUSHMAN, U. S. G. S. Prof. Pap. 206, p. 119, pl. 50, Fig. 15.

1964 MARTIN, Jb. Geol. B.-A., Sonderb. 9, p. 89, pl. 11, Figs. 13 a—b.

The test sharply acute at the initial end, rounded at the apertural end. The maximum width is towards the middle of the test. Chambers 4—5 to a whorl, slightly inflated in the last whorl. Sutures distinct depressed. Aperture at the base of last chamber.

Dimensions of the figured hypotype:

Larger diameter: 0.33 mm.

Smaller diameter: 0.20 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Lower Campanian.

Family *OSANGULARIIDAE* LOEBLICH and TAPPAN, 1964

Genus *Globorotalites* BROTZEN 1942

Globorotalites multisepta (BROTZEN)

(Plate 6, Figures 4—6)

1936 *Globorotalia multisepta* BROTZEN, Sver. Geol. Under. Ser. C. No. 396, pp. 161—164, pl. 11, Figs. 7 a—c.

Test planoconvex, spiral side flat, umbilical side strongly convex, carinate. Chambers, 14—15, arranged in two whorls, the 7½ of the last whorl increase gradually in size. Last chamber partly enveloping the umbilicus. Suture depressed oblique on spiral side, radial to curved on the umbilical side. Aperture interiomarginal umbilical.

Dimensions of the figured hypotype:

Larger diameter: 0.26 mm.

Smaller diameter: 0.23 mm.

Thickness: 0.12 mm.

Sample of the figured hypotype: No. 2.

Stratigraphic range: Upper Coniacian.

Family *NODOSARIIDAE* EHRENBERG 1838

Genus *Planularia* DEFRANCE 1826

Planularia liebusi BROTZEN

(Plate 6, Figure 7)

1936 *Planularia liebusi* BROTZEN, Sver. Geol. Under. Ser. C. No. 396, p. 60, 61, pl. 4. Figs. 6 a—b.

Pyriiform with a distinct thick keel. Planispiral, much compressed, bilaterally symmetrical. Sutures elevated.

Dimensions of the figured hypotype:

Length: 0.58 mm.

Breadth: 0.35 mm.

Thickness: 0.14 mm.

Sample No. of the figured hypotype: No. 3.

Stratigraphic range: Sample 3, Lower Santonian.

Genus *Lenticulina* LAMARCK 1804

Lenticulina navarroensis extrauatus CUSHMAN

(Plate 6, Figure 8)

1946 *Robulus navarroensis* (PLUMMER), var. *extrauatus* CUSHMAN, U. S. G. S. Surv. Prof. Pap. 206, p. 52, pl. 17, Fig. 2.

Test planispiral, involute, periphery sharp, keeled. Chambers increase gradually in size. Sutures curved to radial fused into the test and visible only when wet. Surface not smooth. Aperture radial.

Dimensions of the figured hypotype:

Larger diameter: 0.87 mm.

Smaller diameter: 0.70 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Sample No. 5, Lower Campanian.

Lenticulina muensteri (RÖMER)

(Plate 6, Figure 9)

1932 *Robulus münsteri* RÖMER, CUSHMAN, Journ. Pal. Vol. 6, p. 334, pl. 50, Figs. 2 a—b.

1946 *Robulus münsteri*, RÖMER, CUSHMAN, U. S. G. S. Prof. Pap. 206, p. 53, pl. 17, Figs. 3 a—c.

Test planispiral, involute, periphery keeled. Chambers increase gradually in size. Sutures radial thick, ending in a central boss both fused with the test and visible only when wet. Surface not smooth. Aperture radial.

Dimensions of the figured hypotype:

Larger diameter: 0.60 mm.

Smaller diameter: 0.47 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Upper Coniacian to Lower Campanian.

Family ALABAMINIDAE HOFKER 1951

Genus *Gyroidina* D'ORBIGNY, 1826

Gyroidina depressa (ALTH)

(Plate 7, Figures 1—3)

1929 *Gyroidina depressa* (ALTH), CUSHMAN and CHURCH, Calif. Acad. Sci. Proc. 4th. Ser. Vol. 18, p. 515, pl. 41, Figs. 4—6.

Test compressed, spiral side nearly flat, umbilical side convex, periphery rounded. Chambers numerous, 10, in the last whorl. Sutures fused with the test to faintly depressed, radial to slightly curved. Wall smooth. Aperture interiomarginal umbilical.

Dimensions of the figured hypotype:

Larger diameter: 0.25 mm.

Smaller diameter: 0.23 mm.

Thickness: 0.11 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Sample No. 5, Lower Campanian.

Gyroidina globosa (HAGENOW)

(Plate 7, Figures 4, 5)

1931 *Gyroidina globosa* (HAGENOW), CUSHMAN, Journ. Pal. Vol. 5, p. 310, pl. 35, Figs. 19.

1946 CUSHMAN, U. S. G. S. Prof. Pap. 206, p. 140, pl. 58, Figs. 6—8.

Test trochoid, spiral side flat, umbilical side distinctly convex, periphery rounded. Chambers, 12—13 arranged in 2 whorls, the 6½ of the last increase gradually in size. Sutures fused with the test. Umbilicus very narrow. Aperture interiomarginal umbilical.

Dimensions of the figured hypotype:

Larger diameter: 0.28 mm.

Smaller diameter: 0.23 mm.

Thickness: 0.16 mm.

Sample No. of the figured hypotype: No. 4.

Stratigraphic range: Upper Santonian.

Family ATAXOPHRAGMIIDAE SCHWAGER, 1877

Genus *Gaudryina* D'ORBIGNY 1839

Gaudryina rudita diversa CUSHMAN and GOUDKOFF

(Pl. 7, Figures 6—7)

1944 *Gaudryina rudita* SANDIDGE var. *diversa* CUSHMAN and GOUDKOFF, Cush. Lab. Foram. Res. Contr. Vol. 20, pt. 3, p. 55, pl. 9, Fig. 6.

1964 MARTIN, Jb. Geol. B.-A., Sonderb. 9, p. 53, pl. 3, Figs. 5 a—b.

Test elongate, initial stage triserial, triangular in cross section, later biserial. Chambers gradually increasing in size, the last few slightly inflated. Sutures faintly depressed. Wall finely arenaceous. Aperture distinct at the base of last chamber.

Dimensions of the figured hypotype:

Length: 0.50 mm.

Breadth: 0.24 mm.

Thickness: 0.22 mm.

Sample No. of figured hypotype: No. 5.
Stratigraphic range: Lower Campanian.

Gaudryina bearpawensis WICKENDEN

(Plate 7, Figures 8—9)

1932 *Gaudryina bearpawensis* WICKENDEN, Roy. Soc. Canada, Trans. 3d Ser. Vol. 26, Sec. 4, p. 88, pl. 1, Fig. 7.

1937 CUSHMAN, Cush. Lab. Foram. Res. Spec. Pub. 7, p. 44, pl. 7, Figs. 5—7.

1946 CUSHMAN, U. S. G. S. Prof. Pap. 206, p. 34, pl. 7, Figs. 20—22.

Early portion triserial, later biserial. Chambers globular. Sutures distinct, depressed.

Dimensions of the figured hypotype:

Larger diameter: 0.33 mm.

Smaller diameter: 0.24 mm.

Thickness: 0.20 mm.

Sample No. of the figured hypotype: No. 4.

Stratigraphic range: Sample No. 4, Upper Santonian.

Genus *Verneuilina* D'ORBIGNY 1839

Verneuilina muensteri REUSS

(Plate 7, Figures 10—11)

1937 *Verneuilina münsteri* REUSS, CUSHMAN, Cush. Lab. Foram. Res. Spec. Publ. No. 7, p. 9, pl. 1, Figs. 9—13.

1964 MARTIN, Jb. Geol. B.-A., Sonderb. 9, p. 51, 52, pl. 3, Figs. 1 a—b.

Test pyramidal with sharp angles, sides flat to slightly concave, Chambers distinct. Sutures not very distinct particularly in early stages. Wall finely arenaceous. Aperture a slit at the base of the last chamber.

Dimensions of the figured hypotype:

Larger diameter: 0.30 mm.

Smaller diameter: 0.24 mm.

Thickness: 0.19 mm.

Stratigraphic range: Sample No. 4, Upper Santonian.

Family *LITUOLIDAE*, D'BLAINVILLE 1825

Genus *Haplophragmoides* CUSHMAN, 1910

Haplophragmoides eggeri CUSHMAN

(Plate 7, Figure 12—13)

1943 *Haplophragmoides eggeri* CUSHMAN, CUSHMAN & TODD, Cush. Lab. Foram. Res. Contr. Vol. 19, p. 51, pl. 9, Fig. 2.

1946 CUSHMAN, U. S. G. S. Prof. Pap. 206, p. 20, pl. 2, Fig. 9—10.

Test rounded, Chambers increase gradually in size, Sutures faintly depressed. Wall coarsely arenaceous. Aperture an arch at the base of the last chamber.

Dimensions of the figured hypotype:

Larger diameter: 0.36 mm.

Smaller diameter: 0.31 mm.

Thickness: 0.22 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Lower Campanian.

Family *TROCHAMMINIDAE* SCHWAGER, 1877

Genus *Trochammina* PARKER and JONES, 1859

Trochammina diagonis (CARSEY)

(Plate 7, Figures 14—16)

1927 *Trochammina diagonis* (CARSEY), CUSHMAN and WATERS, Cush. Lab. Foram. Res. Contr. Vol. 2, pt. 4, p. 84, pl. 10, Fig. 7 a—c.

1946 CUSHMAN, U. S. G. S. Prof. Pap. 206, p. 49—50, pl. 15, Figs. 1—3.

Test trochoid, somewhat compressed, spiral side almost flat, umbilical side convex. 7 chambers of the last whorl increase gradually in size. Sutures depressed. Wall distinctly arenaceous. Aperture a narrow slit at the base of the last chamber.

Dimensions of the figured hypotype:

Larger diameter: 0.37 mm.

Smaller diameter: 0.31 mm.

Thickness: 0.11 mm.

Sample No. of the figured hypotype: No. 4.

Stratigraphic range: Sample No. 4 to 5, Upper Santonian to Lower Campanian.

Family *TEXTULARIIDAE* EHRENBERG 1838

Genus *Spiroplectammina* CUSHMAN 1927

Spiroplectammina lalickeri ALBRITTON and PHLEGER

(Plate 8, Figures 1—2)

1937 *Spiroplectammina lalickeri* ALBRITTON and PHLEGER, Journ. Pal. Vol. 11, p. 353, Figs. 2—3.

1946 CUSHMAN, U. S. G. S. Prof. Pap. 206, p. 29, pl. 6, Figs. 28, 29.

Test elongate, flat, initial chambers planispiral, later biserial, Chambers gradually increasing in size. Sutures depressed. Wall arenaceous. Aperture at the base of the last formed chamber.

Dimensions of the figured hypotype:

Length: 0.80 mm.

Breadth: 0.29 mm.

Thickness: 0.16 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Sample No. 5, Lower Campanian.

Spiroplectammina dentata (ALTH)

(Plate 8, Figures 3—4)

1932 *Spiroplectammina dentata* (ALTH), CUSHMAN and JARVIS, U. S. Nat. Mus. Proc. Vo. 80, art. 14, p. 14, pl. 3, Figs. 7 a—b.

1946 CUSHMAN, U. S. G. S. Prof. Pap. 206, p. 27, pl. 5, Fig. 11.

Test much compressed, conical at the initial stages. Periphery sharp angular. Centre of the test raised into a ridge. Chambers many, increasing in width more than height. Sutures very faintly depressed to fused in the test to be noticed when wet. Wall finely arenaceous.

Dimensions of the figured hypotype:

Length: 0.60 mm.

Breadth: 0.37 mm.

Thickness: 0.18 mm.

Sample No. of the figured hypotype: No. 5.

Stratigraphic range: Lower Campanian.

Genus *Textularia* DEFRANCE, 1824

Textularia baudouiniana D'ORBIGNY

(Plate 8, Figures 5—6)

1839 *Textularia baudouiniana* D'ORBIGNY, Mem. Surles. foraminiferes.

1902 EGGER, Abh. d. 11/C. D. K. Akad. Wiss. XXI, Bd. 1, Alith. p. 24, pl. 2, Fig. 10—11.

Test conical, biserial, sutures indistinct apertural side flat. Aperture a slit at the base of the last chamber. Wall finely arenaceous.

Dimensions of the figured hypotype:

Length: 0.60 mm.

Breadth: 0.44 mm.

Thickness: 0.18 mm.

Sample No. of the figured hypotype: No. 2.

Stratigraphic range: Upper Coniacian.

OSTRACODA

Due to poor state of preservation of the Ostracods, occurring frequently in the above mentioned samples, it was not possible to find an exact deter-

mination. Any how the author thinks of the necessity to mention their presence. The following genera are suggested:

<i>Cytherella</i>	Plate 8, Figures 7—8
<i>Bairdia</i>	Plate 8, Figures 9—10
<i>Kalyptovalva</i>	Plate 8, Figures 11—12

It is for the first time that Ostracods are being reported from the section and it is hoped to specify them if a better preserved material is available.

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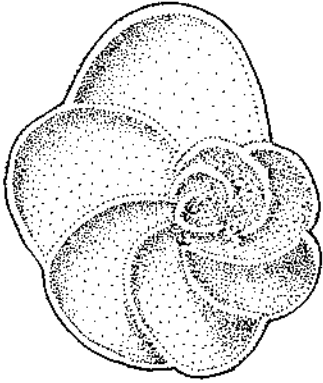
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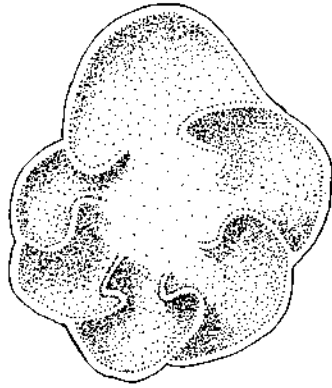
(Manuscript received and accepted for publication on April 30, 1968.)

PLATE 1

- | | |
|-----|--|
| 1—6 | <i>Globotruncana lapparenti lapparenti</i> |
| 7—9 | <i>Globotruncana lapparenti</i> cf. <i>tricarinata</i> |



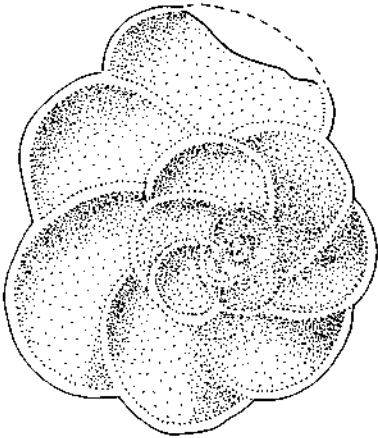
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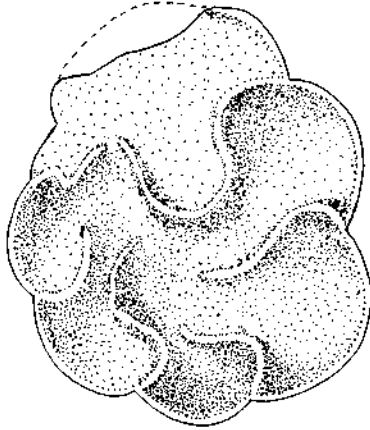
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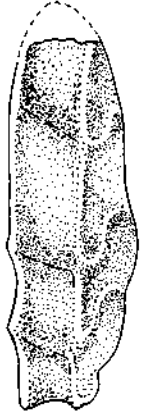
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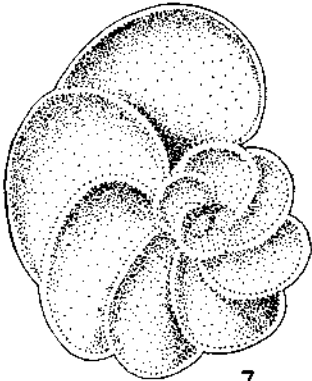
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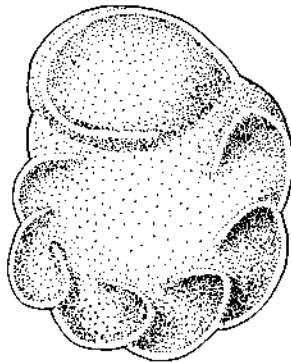
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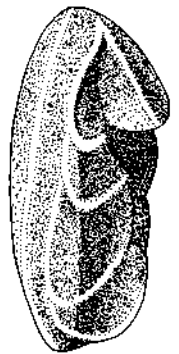
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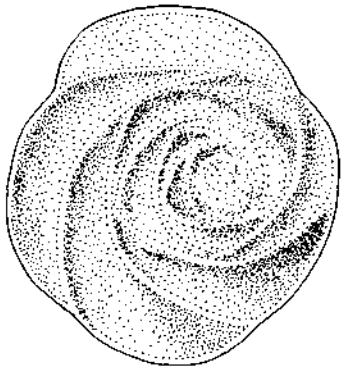
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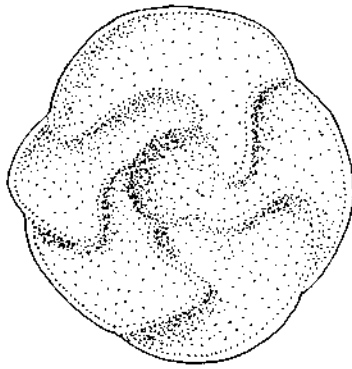
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PLATE 2

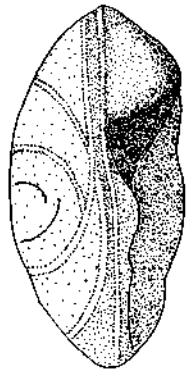
- | | |
|-----|---|
| 1—3 | <i>Globotruncana fornicata</i> |
| 4—6 | <i>Globotruncana fornicata-caliciformis</i> |
| 7—9 | <i>Globotruncana cf. thalmani</i> |



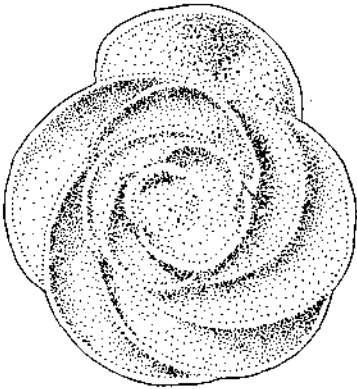
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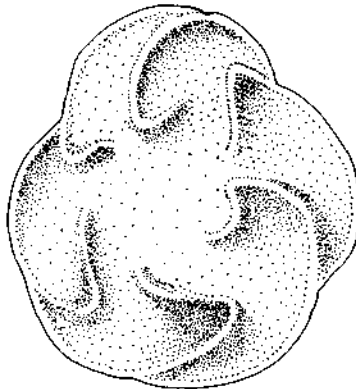
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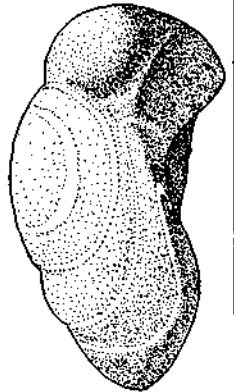
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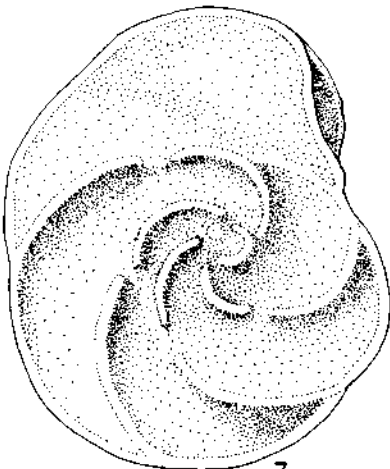
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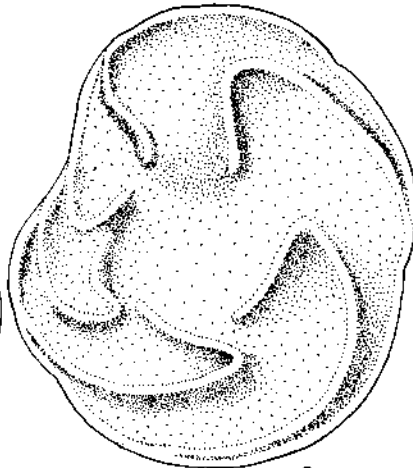
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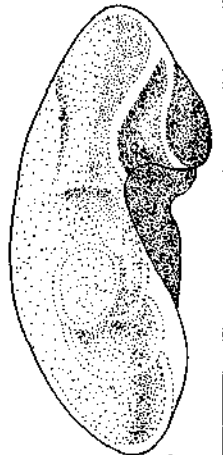
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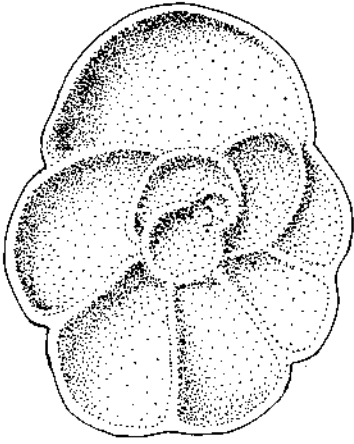
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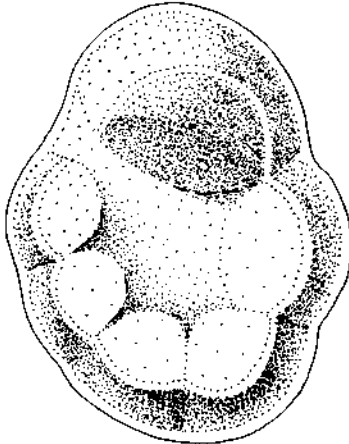
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PLATE 3

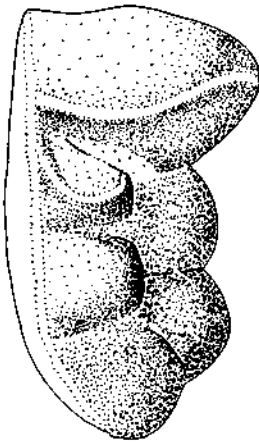
- | | |
|-----|--|
| 1—3 | <i>Globotruncana concavata carinata</i> |
| 4—6 | <i>Globotruncana concavata concavata</i> |
| 7—9 | <i>Globotruncana cf. lapparenti coronata</i> |



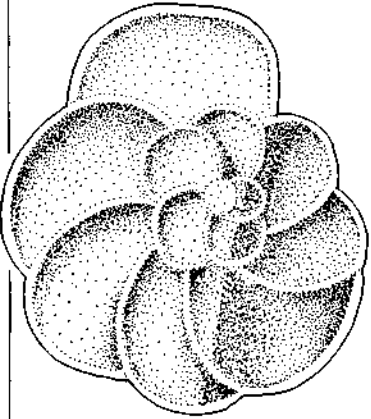
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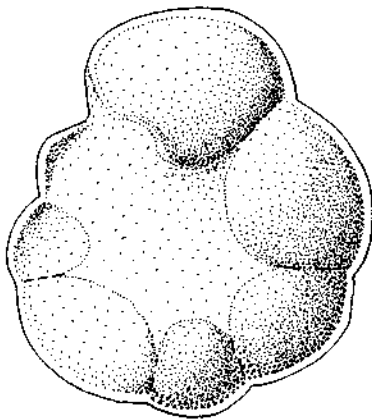
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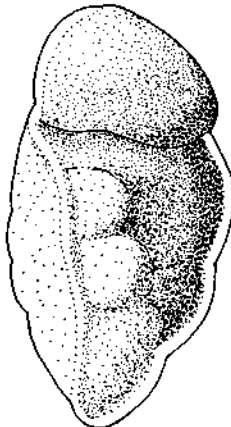
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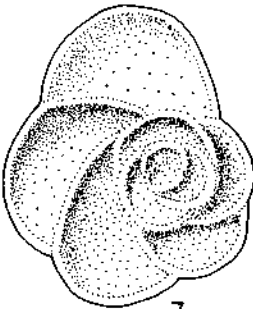
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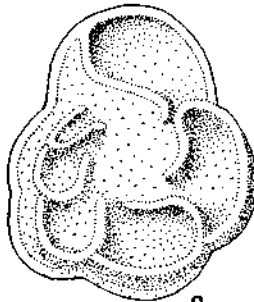
5



6



7



8



9

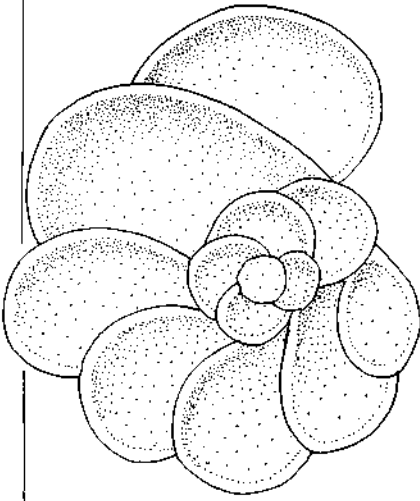
PLATE 4

1—3

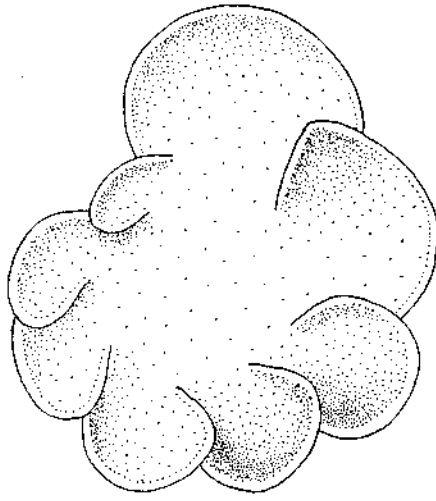
Globotruncana lapparenti coronata

4—6

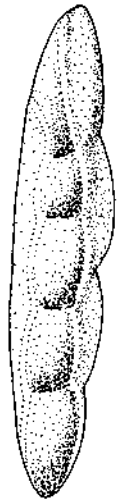
Globotruncana elevata-calcarata



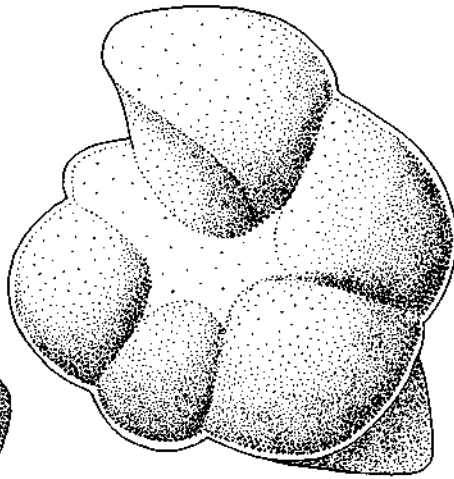
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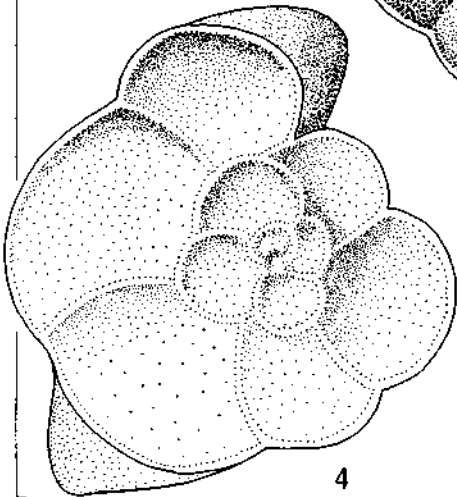
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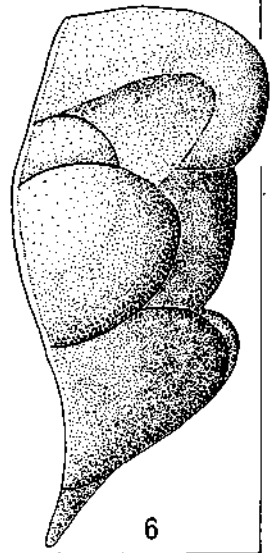
3



5



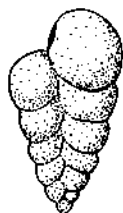
4



6

PLATE 5

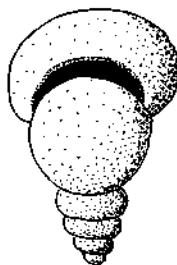
- | | |
|-------|---|
| 1—2 | <i>Heterohelix reussi</i> |
| 3—4 | <i>Heterohelix globocarinata</i> |
| 5—6 | <i>Heterohelix globulosa</i> |
| 7—8 | <i>Pseudotextularia</i> sp. |
| 9—10 | <i>Pseudotextularia elegans</i> |
| 11—12 | <i>Rugoglobigerina rugosa subrugosa</i> |



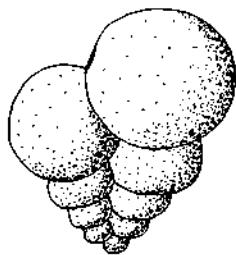
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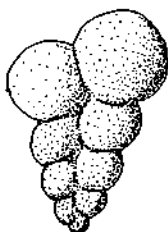
2



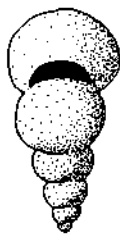
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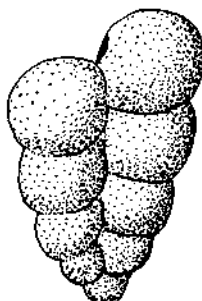
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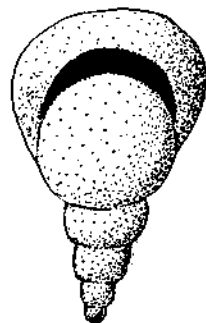
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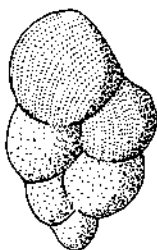
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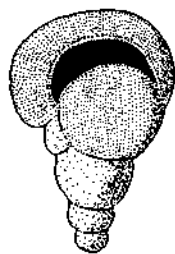
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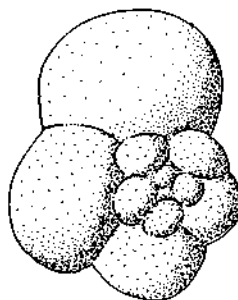
8



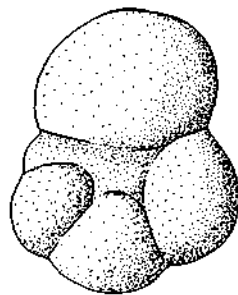
9



10



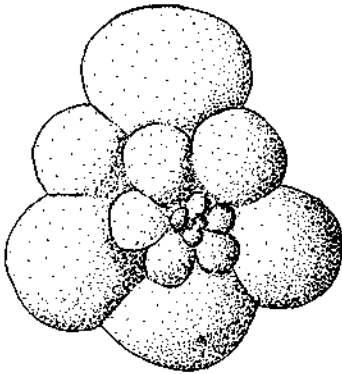
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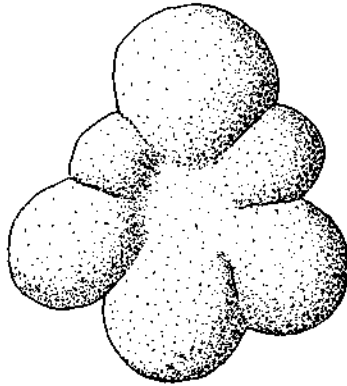
12

PLATE 6

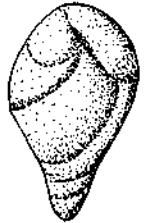
- | | |
|-----|--|
| 1—2 | <i>Rugoglobigerina rugosa ordinaria</i> |
| 3 | <i>Buliminella cushmani</i> |
| 4—6 | <i>Globorotalites multisepta</i> |
| 7 | <i>Planularia liebusi</i> |
| 8 | <i>Lenticulina navarroensis extravatus</i> |
| 9 | <i>Lenticulina muensteri</i> |



1



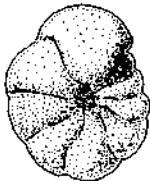
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3



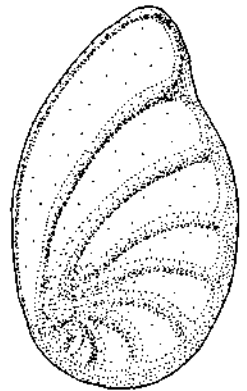
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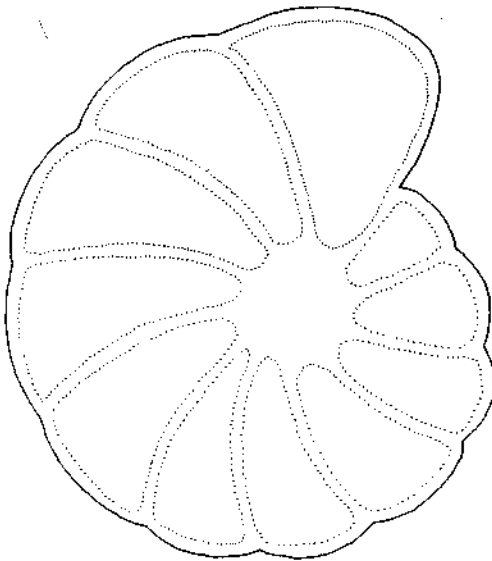
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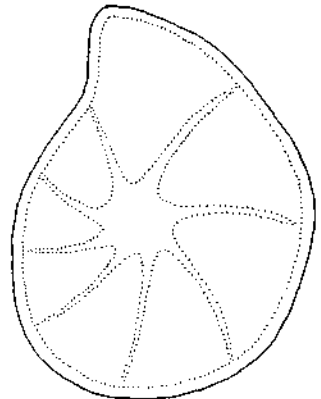
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7



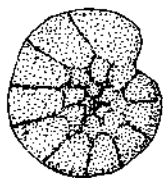
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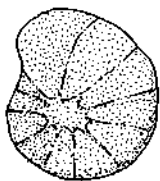
9

PLATE 7

- | | |
|-------|---------------------------------|
| 1—3 | <i>Gyroidina depressa</i> |
| 4—5 | <i>Gyroidina globosa</i> |
| 6—7 | <i>Gyroidina rudita diversa</i> |
| 8—9 | <i>Gyroidina bearpawensis</i> |
| 10—11 | <i>Verneuilina muensteri</i> |
| 12—13 | <i>Haplophragmoides eggeri</i> |
| 14—16 | <i>Trochammina diagonalis</i> |



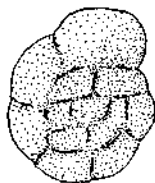
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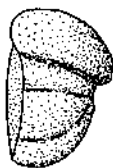
2



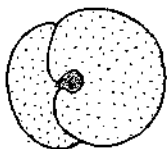
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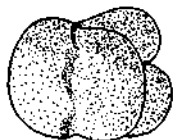
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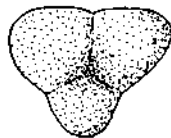
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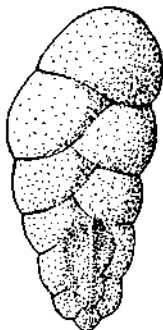
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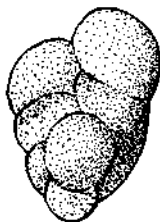
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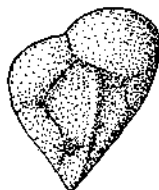
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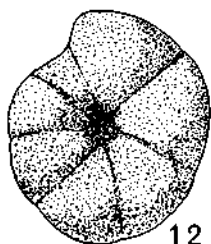
6



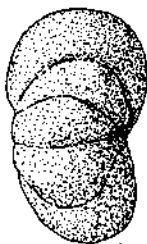
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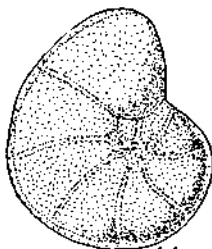
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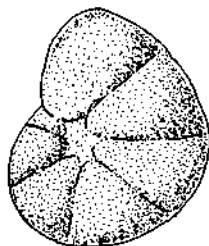
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13



14



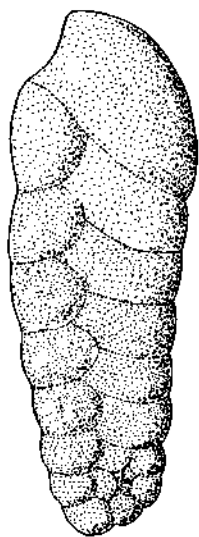
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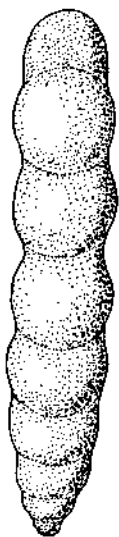
16

PLATE 8

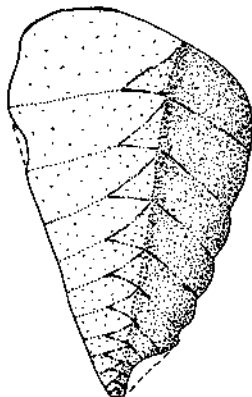
- | | |
|-------|-----------------------------------|
| 1—2 | <i>Spiroplectammina lalickeri</i> |
| 3—4 | <i>Spiroplectammina dentata</i> |
| 5—6 | <i>Textularia baudouiniana</i> |
| 7—8 | <i>Cytherella</i> sp. |
| 9—10 | <i>Bairdia</i> sp. |
| 11—12 | <i>Kalyptovalva</i> sp. |



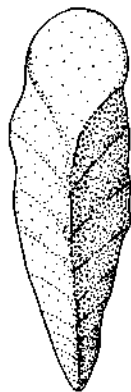
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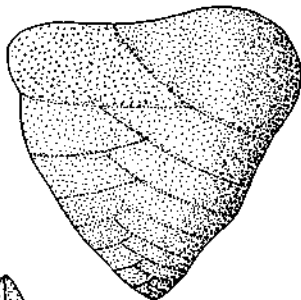
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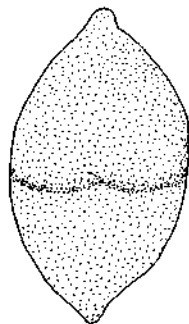
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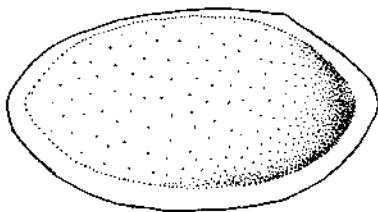
4



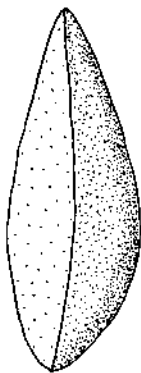
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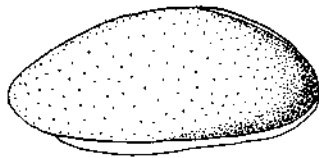
6



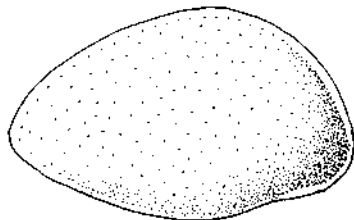
7



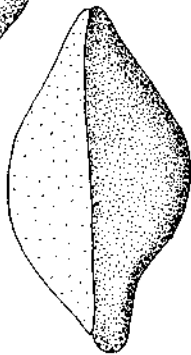
8



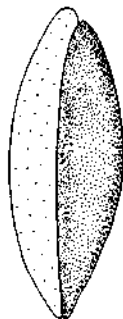
11



9



10



12