CONTRIBUTIONS
FROM THE
CUSHMAN FOUNDATION
FOR
FORAMINIFERAL RESEARCH

VOLUME XIII, Part 3

July, 1962

Contents

1962

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XIII, PART 3, JULY, 1962

246. THE FORAMINIFERAL GENERA *CIBICIDES, HETEROLEPA, PLANULINA* AND *HOLMANELLA*, NEW GENUS

ALFRED R. LOEBLICH, JR., and HELEN TAPPAN
California Research Corporation, La Habra, California, and University of California, Los Angeles

ABSTRACT

The family Cibicididae is restricted to genera with radially fibrous wall microstructure and bilamellid septa. **Planulina** is bievolute with equatorial aperture, extending slightly onto the umbilical side. **Cibicides** is restricted to planoconvex forms, attached by the spiral side, with interiomarginal aperture extending along the spiral suture of the spiral side. The Anomalinidae include granular-walled bilamellid genera. **Heterolepa** Franzenau, 1884 is reinstated for free-living **Cibicides**-like forms with granular wall structure, and includes **Gemellides** Vasilenko, 1954, **Pninaella** Brotzen, 1948 and **Pseudotruncatulina** Andreae, 1884 as synonyms. **Holmanella**, n. gen. is erected for coarsely perforate **Planulina**-like forms with granular wall structure and vertical slit-like apertural extension.

In a recent publication, the writers (Loeblich and Tappan, 1961) proposed a suprageneric classification of the Rhizopodea in which the families of the Foraminiferida are based largely on wall composition, microstructure and lamellar character, as well as on life cycles and reproductive habits. When preparing this classification, the family Cibicididae was placed in the granular-walled superfamily Cassidulinacea, and the Anomalinidae (including the Planulininae) was placed in the radially built superfamily Orbitoidacea.

The type species of *Cibicides* had been stated by Wood (1949, p. 252) to be granular in structure and various other species of "*Cibicides*" were stated to be granular in microstructure by Wood and Haynes (1957, p. 46) and Reiss (1959), although Wood and Haynes then stated that *Cibicides refulgens* was radially built. The writers have also rechecked the wall of the type species of *Cibicides* and confirmed its radial structure. Wood and Haynes and Reiss have regarded the microstructure as not a valid basis even for generic separation, as both types were apparently present in this "genus." Nyholm (1961) has shown that *Cibicides* is a very specialized form with a distinctive life cycle. Vasilenko (1954, p. 186) had earlier proposed a revision of *Cibicides*, and erected the new subgenus *Gemellides*. The writers concur in the restriction of *Cibicides*, but regard *Gemellides* as a junior synonym of *Heterolepa* Franzenau, 1884, which is here reinstated. *Cibicides* is thus restricted to include the species attached by the spiral side, with radially built bilamellid walls, coarsely perforate spiral side and finely perforate umbilical side and non-porous apertural face, with interiomarginal aperture extending along the spiral suture on the spiral side.

Heterolepa includes granular-walled species previously placed in *Cibicides*, and its aperture extends both onto the umbilical side and along the spiral suture of the spiral side.

Planulina is similar to *Cibicides* in wall structure, but has an equatorial aperture extending slightly onto the less evolute umbilical side.

Anomalina and the Anomalinidae are granular walled and bilamellid. A new generic name is required for *Discorbinella valmonteensis* Kleinpell, as it has the wall structure of the Anomalinidae, rather than that of true *Discorbinella*, and the apertural characters are distinct from any described genus, although it resembles *Heterolepa* in the early ontogenetic stages. Brief descriptions and synonymies of the above mentioned genera follow.

Superfamily ORBITOIDACEA Schwager, 1876
Family CIBICIDIDAE Cushman, 1927

Test free or attached, trochospiral to nearly planispiral, or later spreading, irregular or cyclical; wall coarsely perforate, radial in structure, septa double (bilamellid); aperture interiomarginal, may extend onto spiral side and peripheral supplementary apertures may occur.

Subfamily PLANULININAE Bermúdez, 1952

Test free, trochospiral to nearly planispiral; aperture single.

Genus **Planulina** d'Orbigny, 1826

Planulina D'ORBIGNY, 1826, p. 280.

Type species: *Planulina ariminensis* d'Orbigny, 1826, fixed by subsequent designation by Galloway and Wissler, 1927, p. 66.

Test discoidal, compressed, low trochospiral, spiral side evolute, umbilical side partially evolute, periphery truncate, with thick imperforate keel; sutures strongly arched, thickened, non-perforate, septa double (bilamellid); wall calcareous, radial in structure, finely perforate, but with scattered large pores in addition, with secondarily added lamellae covering the umbilical region; aperture an equatorial, interiomarginal arch, with narrow bordering lip, extending somewhat onto the less evolute umbilical side beneath the flap-like chamber margin, both the apertural lip and the lip-like margin of the umbilical flaps imperforate.

Subfamily CIBICIDINAE Cushman, 1927

Test attached by the spiral side; primary aperture equatorial, may extend onto spiral side, and advanced forms may have multiple apertures.

Genus **Cibicides** Montfort, 1808

Cibicides MONTFORT, 1808, p. 122.

Storilus MONTFORT, 1808, p. 130, *type*: *S. radiatus* Montfort, 1808.

Polyxenes MONTFORT, 1808, p. 138, *type*: *P. cribratus* Montfort, 1808.

Cymbicides COSTA, 1839, p. 186 (*nom. null.?*).

Truncatulina D'ORBIGNY, 1826, p. 278, *type*: *Cibicides refulgens* Montfort, 1808.

Lobatula FLEMING, 1828, p. 232, *type*: *L. vulgaris* Fleming, 1828.

Soldanina COSTA, 1856, p. 246, *type*: *S. exagona* Costa, 1856.

Type species: *Cibicides refulgens* Montfort, 1808, fixed by original designation.

Test attached; planoconvex, trochospiral, spiral side flat to excavated, evolute, umbilical side strongly convex, involute, apertural face sharply angled and distinct from the umbilical side, periphery angular, with non-porous keel; wall calcareous, radial in microstructure, coarsely perforate on the spiral side, the large pores of the earlier chambers may be closed by lamellar thickening of the wall, finely perforate on the umbilical side, apertural face non-porous; aperture a low interiomarginal opening with narrow lip, and may extend along the spiral suture on the spiral side; during the life cycle the young involute schizont stage develops within a coniform agglutinated growth cyst, the 8-10 chambered schizont then breaking free.

Remarks: Wood (1949, p. 252) stated that *Cibicides refulgens* was granular in structure, but this was later corrected by Wood and Haynes (1957, p. 46). Some species previously referred to *Cibicides* have been noted by Wood and Haynes (1957) and Reiss (1959) to be granular, but these are referable to other genera. *Cibicides* is here restricted to those coarsely perforate, planoconvex forms with radial microstructure.

Superfamily CASSIDULINACEA d'Orbigny, 1839
Family ANOMALINIDAE Cushman, 1927

Test trochospiral to nearly planispiral, evolute on one or both sides; chambers simple; wall calcareous, coarsely perforate, granular in structure, bilamellid; primary aperture interiomarginal, equatorial or somewhat extending onto spiral or umbilical sides, and may also have additional peripheral apertures.

Subfamily ANOMALININAE Cushman, 1927

Single primary aperture, interiomarginal and equatorial or extending onto the spiral or umbilical sides, may have apertural flaps on the umbilical side beneath which the aperture opens into the chambers, and may also have secondary sutural openings on the periphery.

Genus **Heterolepa** Franzenau, 1884

Heterolepa FRANZENAU, 1884, p. 214.

Pseudotruncatulina ANDREAE, 1884, p. 122, *type*: *Rotalina dutemplei* d'Orbigny, 1846.

Pninaella BROTZEN, 1948, p. 119, *type*: *P. scanica* Brotzen, 1948.

Cibicides (Gemellides) VASILENKO, 1954, p. 186, *type*: *Cibicides (Gemellides) orcinus* Vasilenko, 1954.

Type species: *Heterolepa simplex* Franzenau, 1884 = *Rotalina dutemplei* d'Orbigny, 1846; fixed by subsequent designation, herein.

Test free, trochospiral, inequally biconvex or planoconvex, periphery bluntly angled, may have non-perforate keel, flat to slightly convex spiral side evolute, with relatively numerous chambers in slowly enlarging whorls, more convex umbilical side involute with radial sutures; wall calcareous, thick and lamellar, coarsely and regularly perforate, granular in structure, septa double (bilamellid); aperture slit-like, interiomarginal, extending about half the distance to the umbilicus on the umbilical side, and extending across the periphery on the spiral side and may also extend for some distance along the spiral suture.

Remarks: Franzenau originally included four species in *Heterolepa,* without designating a type species, *H. simplex* n. sp., *H. costata* n. sp., *H. praecincta* n. sp. and *H. bullata* n. sp. Ellis and Messina (1940) state that Franzenau designated *Rotalina dutemplei* as the type in 1885, but this was not in the original list of species, hence could not be selected as the type species. In 1885 (p. 152) Franzenau stated that *H. simplex* was a synonym of *Rotalina dutemplei* d'Orbigny. As the type must be one of the species originally included by Franzenau we hereby so designate *H. simplex.* During the same year, 1884, *Pseudotruncatulina* was described on the basis of the bilamellid walls and also had *Rotalina dutemplei* for type species. *Gemellides* (proposed as a subgenus of *Cibicides*) also originally included this species, but was separated on the basis of apertural characters. Regardless of the basis for separation, both *Pseudotruncatulina* and *Gemellides*, including the same species, are junior synonyms of *Heterolepa*. *Pninaella* was regarded as having secondarily much enlarged foramina, but the figured section shows well preserved septa in the early portion, hence it seems probable that the remaining septa were destroyed during preservation. *Pninaella scanica* seems otherwise much like *H. dutemplei* and certainly congeneric. The other species included by Brotzen (*Pulvinulina nitidula*) is probably not congeneric, as it is a very thin-walled form. Although previously regarded as closely related to *Cibicides,* and some species having been so referred erroneously, *Heterolepa* has a granular wall structure and is free rather than attached by the spiral side, and is thus related to the Anomalinidae, as here restricted, rather than to the Cibicidinae.

Genus **Holmanella** Loeblich and Tappan, n. gen.

Type species: *Discorbinella valmonteensis* Kleinpell, 1938.

Test free, large, compressed, enrolled, bievolute nearly planispiral but somewhat asymmetrical, with non-porous, broadly rounded peripheral margin; chambers gradually enlarging; sutures distinct, depressed, curved backwards at the periphery; wall calcareous, thin, very coarsely perforate, granular in microstructure, bilamellid; aperture in the young stage a low interiomarginal opening at one side of the periphery, in later stages with the low opening continuing along the spiral suture to connect with previous apertures, and with a perpendicular slit extending obliquely up the non-porous apertural face, all apertures bordered by a narrow lip.

Remarks: The type species has previously been regarded as belonging to *Cibicides* (Woodring, Bramlette and Kleinpell, 1936, p. 145), *Planulina* (Hoots, 1931, p. 113, 118) and *Discorbinella* (Kleinpell, 1938, p. 350). It differs from *Cibicides, Planulina* and *Discorbinella* in having a granular instead of a radially built wall, from *Discorbinella* in the coarsely perforate bilamellid wall, from *Discorbinella* and *Cibicides* in lacking a peripheral keel and from *Planulina* and *Cibicides* in being coarsely perforate on both sides of the test.

The generic name is in honor of William Holman, formerly with Standard Oil Company of California, Western Operations Incorporated, in recognition of his contributions to stratigraphic and paleontologic knowledge in California.

Types: Topotypes from the Miocene (Mohnian) Valmonte diatomite at Cabrillo Beach, 750 feet northwest of end of breakwater, San Pedro, California, are deposited in the Helen Tappan Loeblich Collection, University of California Los Angeles; University of California San Diego, Scripps Institution of Oceanography Marine Foraminifera Laboratory; Micropaleontological Laboratory, VNIGRI, Leningrad, U.S.S.R.; Micropaleontological Laboratory, Geological Institute, Academy of Science, Moscow, U.S.S.R.; New Zealand Geological Survey, Lower Hutt, New Zealand and the University of Adelaide, South Australia.

Geologic occurrence: Miocene (upper Mohnian Stage), California, U.S.A.

REFERENCES

ANDREAE, A., 1884, Beitrag zur Kenntniss des Elsässer Tertiars; Theil II - Die Oligocän-schichten: Geol. Spezialk. Elsass-Loth., Abh., Bd. 2, Heft 3, p. 1-239, pls. 1-12 (Strassburg).

BROTZEN, F., 1948, The Swedish Paleocene and its foraminiferal fauna: Sver. geol. Undersökning, Ser. C, no. 493, Årsbok 42, no. 2, p. 1-140, pls. 1-19.

COSTA, O. - G., 1839, Descrizione di alcune specie nuove di testacei freschi e fossili del Regno delle due Sicilie: R. Accad. Sci. Napoli, Cl. Fis. Storia Nat., Atti, v. 4, p. 175-192.

——, 1856, Paleontologia del Regno di Napoli, Parte II: Accad. Pontaniana Napoli, Atti, v. 7, fasc. 2, p. 113-378, pls. 9-27.

ELLIS, B. F. and MESSINA, A., 1940, Catalogue of Foraminifera: Amer. Mus. Nat. Hist.

FLEMING, J., 1828, A history of British animals, exhibiting the descriptive characters and systematic arrangement of the genera and species of quadrupeds, birds, fishes, mollusca and radiata of The United Kingdom. (Edinburgh).

FRANZENAU, A., 1884, *Heterolepa,* egy uj genus a Foraminiferák Rendjében: Természetrajzi Füzetek, v. 8, pt. 3, p. 181-184, 214-217, pl. 5.

———, 1885, Adalék nehány foraminifera héjszerkezetének ismeretéhez (Beitrag zur Kenntniss der Schalenstruktur einiger Foraminiferen): Magyar Nemz. Mús., Termész Füzetek, Köt. 9, no. 2, p. 92-94 (151-153), pl. 7.

GALLOWAY, J. J. and WISSLER, S. G., 1927, Pleistocene foraminifera from the Lomita Quarry, Palos Verdes Hills, California: Jour. Paleontology, v. 1, p. 35-87, pls. 7-12.

HOOTS, H. W., 1931, Geology of the eastern part of the Santa Monica Mountains, Los Angeles County, California: U. S. Geol. Survey Prof. Paper 165, p. 83-134, 2 figs., 19 pls.

KLEINPELL, R. M., 1938, Miocene stratigraphy of California: Amer. Assoc. Pet. Geologists, p. 1-450, pls. 1-22.

LOEBLICH, A. R., JR. and TAPPAN, H., 1961, Suprageneric classification of the Rhizopodea: Jour. Paleontology, v. 35, no. 2, p. 245-330.

MONTFORT, D. DE, 1808, Conchyliologie systématique et classification methodique des coquilles: v. 1, p. i-lxxxvii, 1-409.

NYHOLM, K. - G., 1961, Morphogenesis and biology of the foraminifer *Cibicides lobatulus*: Zoologiska Bidrag från Uppsala, Bd. 33, p. 157-196, pls. 1-5.

D'ORBIGNY, A., 1826, Tableau méthodique de la classe des Céphalopodes: Ann. Sci. Nat., v. 7, p. 245-314, pls. 10-17.

REISS, Z., 1959, The wall structure of *Cibicides, Planulina, Gyroidinoides,* and *Globorotalites*: Micropaleontology, v. 5, no. 3, p. 355-357, pl. 1.

VASILENKO, V. P., 1954, Anomalinidy. Iskopaemye Foraminifery SSSR: Trudy Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), n. ser., Vyp. 80, p. 1-282, pls. 1-36, textfigs. 1-42 (Leningrad).

WOOD, A. 1949, The structure of the wall of the test in the foraminifera; its value in classification: Geol. Soc. London, Quart. Jour., v. 104, p. 229-255, pls. 13-15.

——— and HAYNES, J., 1957, Certain smaller British Paleocene foraminifera. Part II - *Cibicides* and its allies: Cushman Found. Foram. Research, Contr., v. 8, pt. 2, p. 45-53, pls. 5, 6.

WOODRING, W. P., BRAMLETTE, M. N., and KLEINPELL, R. M., 1936, Miocene stratigraphy and paleontology of Palos Verdes Hills, Calif.: Am. Assoc. Pet. Geologists, Bull., v. 20, no. 2, p. 125-159, 1 pl.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XIII, PART 3, JULY, 1962

247. FAUNAL STUDIES OF RECENT FORAMINIFERA FROM THE SHORE SANDS OF THE STATE RIO GRANDE DO SUL IN SOUTHERN BRAZIL

DARCY CLOSS and MÁRIO C. BARBERENA
Department of Micropaleontology,[1] School of Geology,
University of Rio Grande do Sul, Pôrto Alegre, Brazil

ABSTRACT

Recent Foraminifera from shore sands off southern Brazil show in the southern part of the area a relationship with faunas off Argentina. Farther north a Brazilian fauna predominates with some admixture of the Argentinian. Forms typical of the Malvin Current do not occur. Between Atlântida and Rondinha, **Elphidium discoidale** is the most abundant species; **Nonionella atlantica** is second. The faunas near river mouths contain abnormal specimens. Samples from Tôrres (2 years) contain a meager fauna. The reason for this is not known.

INTRODUCTION

This paper gives the results of an investigation of shore samples taken along the coast of the State of Rio Grande do Sul and the southern part of the State of Santa Catarina (Lats. 34° S. - 29° S.). The stations were at the following localities: Barra do Chuí (boundary of Uruguay), Hermenegildo, Passo da Lagoa, Albardão, Cassino, São José do Norte, Mostardas, Solidão, Quintão, Cidreira, Tramandaí, Atlântida, Caramurú, Rondinha, Tôrres (boundary of the State of Santa Caterina) and Araranguá. Samples were taken every 10 km. The faunal differences between neighboring stations were few and, in the absence of place names along large portions of the coast, we prefer to mention only stations with known place names (*see* text fig. 1). The length of the studied area is 700 km., of which 620 are in Rio Grande do Sul and the northern 80 km. in Santa Caterina. Most of the area is composed of flat, sand beaches; only in the extreme northern part (Tôrres) are there basaltic and arenaceous cliffs and hills.

Most of the samples were collected during the summer. Numerous samples from the stations at Barra do Chuí, Cassino, Tramandaí and Tôrres were collected at various seasons, and fundamental differences were not observed between those collected in the summer and at other seasons. The samples were floated with carbon tetrachloride. An examination of the residues was not necessary since tests with heavy walls, such as *Textularia,* floated.

The hydrological characteristics of the area have been studied very little. Emilsson (1956, pp. 64-67) and the results of oceanographic cruises by ships of the "Diretoria de Hidrografia" during the International Geophysical Year furnish the most modern data. According to these, the surface water has a minimum temperature of about 18° C. and a maximum between 23° C. and 27° C. The salinity of the surface water does not show very great changes during the year: between 32 o/oo and 36 o/oo. All these data are for offshore areas. At such nearshore localities as Cassino, Tramandaí and Tôrres, the variations are greater because fresh water from the rivers decreases the salinity.

Cordial thanks are given to Prof. Irajá Damiani Pinto (Pôrto Alegre) and Mr. Emídio P. Martino (Santa Vitória) for their helpful aid in the collection of samples. The writers wish to express their gratitude to Dr. E. Boltovskoy (Buenos Aires) for generously supplying material for comparison and for stimulating faunistical discussions, either personally or by correspondence.

DISCUSSION

The coast of Rio Grande do Sul has been but little studied in the past. A recent study by Narchi (1956) includes one sample (Lat. 30° 22′ S.) and the important work by Boltovskoy (1959a) describes 260 Brazilian species. Both of these studies were of offshore areas.

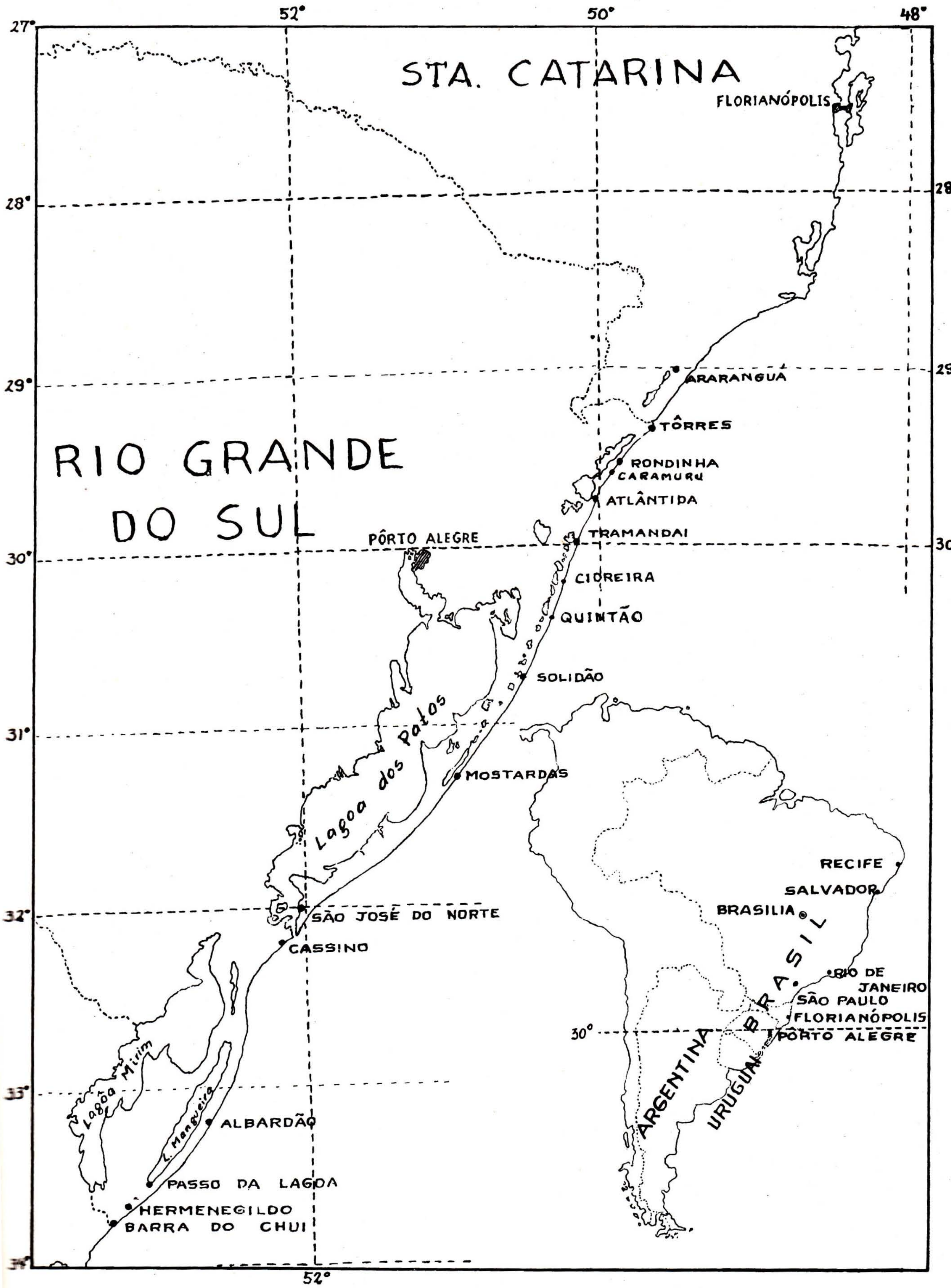
The most common forms off our coast are: *Elphidium discoidale* (d'Orbigny), *Buccella frigida* (Cushman), *B. peruviana campsi* (Boltovskoy) small specimens, *Quinqueloculina seminulum* (Linné) and *Rotalia beccarii* ex gr. *parkinsoniana* (d'Orbigny). The dominant form is *Elphidium discoidale* which is very abundant in all the samples and can be considered as the most typical form of our shores. The occurrence and frequencies of the species encountered are given in Table 1.

Elphidium discoidale specimens show great variation. The most variable character is the umbilical area which may or may not have a plug, or different forms of granulations. The periphery is generally rounded. A few specimens are opaque.

Rotalia beccarii ex gr. *parkinsoniana* is also an extremely variable form especially in the convexity, transparency, plug, number of chambers, and sutures. These variations are greater in samples where the river fresh water decreased the salinity.

The following forms are less frequent but are regularly present: *Pyrgo nasuta* Cushman, *Massilina secans* (d'Orbigny), *Nonionella atlantica* Cushman, *Bulimina marginata* d'Orbigny, *B. patagonica* d'Orbigny,

1 Research in our department is partly supported by grants from the Rockefeller Foundation and the "Conselho Nacional de Pesquisas."



TEXT FIGURE 1

Map showing the area studied, with the localities mentioned in the text.

	BARRA DO CHUI	HERMENEGILDO	PASSO DA LAGOA	ALBARDÃO	CASSINO	SÃO JOSÉ DO NORTE	MOSTARDAS	SOLIDÃO	TRAMANDAI	ATLÂNTIDA	CARAMURU	RONDINHA	TÔRRES	ARARANGUÁ
TEXTULARIA GRAMEN									MR		MR	MR		F
TEXTULARIA CANDEIANA										MR				
QUINQUELOCULINA SEMINULUM	R	R	R	R	F	F	F	F	F	F	E	R	E	E
QUINQUELOCULINA ISABELLEI	MR				MR		MR		MR					
QUINQUELOCULINA ATLANTICA														MR
QUINQUELOCULINA AFF. FRIGIDA	MR				R			MR	MR					F
QUINQUELOCULINA POLYGONA									MR					
QUINQUELOCULINA LAMARCKIANA									E					
MASSILINA SECANS					E		E	E	F	E	E	E	R	F
TRILOCULINA TRIGONULA									MR					R
PYRGO NASUTA			MR		MR		R	E	A	R				R
NODOSARIA CATESBYI						MR		MR						MR
LAGENA SULCATA ELYELLII														MR
LAGENA LAEVIS F. TYPICA						MR								
LAGENA LAEVIS F. PERLUCIDA						E			MR					MR
OOLINA COSTATA						R								
GLOBULINA CARIBAEA						MR		MR						MR
GUTTULINA PROBLEMA									MR					
NONIONELLA ATLANTICA	MR		MR		E	E	E	F	F	A	A	A	F	F
BULIMINA MARGINATA F. TYPICA	MR			MR	R	R	E	E	E	E	E		R	F
BULIMINA MARGINATA F. SUBALATA						MR		R	E					E
BULIMINA MARGINATA F. ECHINATA						MR	MR		MR					
BULIMINA MARGINATA F. ACULEATA									E	MR	MR		MR	R
BULIMINA PATAGONICA F. TYPICA	MR		E	E	E	MR	R	R	E	E			R	F
BULIMINA PATAGONICA F. GLABRA				MR	MR					R			R	E
BULIMINA PSEUDO-AFFINIS					MR	MR		MR	MR	MR			R	E
VIRGULINA PAUCILOCULATA									MR					MR
BOLIVINA STRIATULA F. TYPICA	MR		MR	MR		MR	MR		MR	MR				R
BOLIVINA PUSILLA														MR
UVIGERINA PEREGRINA F. PARVULA						R	MR	MR	MR	E	R	E		F
DISCORBIS WILLIANSONI	MR			MR	MR									
POROEPONIDES LATERALIS	R	MR	F	R	R	R	R	E	E	R			R	R
BUCCELLA FRIGIDA	F	A	A	A	F	A	E	E	E	R	F	E	R	R
BUCCELLA PERUVIANA CAMPSI	E	E	E	E	E	F	E	E	E	R	F	E	MR	E
ROTALIA BECCARII EX-GR PARKINSONIANA	MR	MR	R	R	F	F	F	F	F	E	E	E	R	E
ROLSHAUSENIA ROLSHAUSENI			MR		R		R	E	E	F	R		MR	F
ELPHIDIUM DISCOIDALE (D)	F	F	F	A	A	A	A	A	A	F	A	A	F	A
CANCRIS SAGRA									MR					
CIBICIDES BERTHELOTI F. TYPICA						R	R		F	R	MR	E		MR
CIBICIDES BERTHELOTI F. BOUEANA					E		E	E	F	E		R	MR	F
ORBULINA UNIVERSA									E					
GLOBIGERINOIDES RUBRA F. TYPICA					MR	MR	R	E	F	E	R	MR	MR	E
GLOBIGERINOIDES RUBRA E. TRILOBA						MR		R	F					E
GLOBIGERINOIDES RUBRA F. PYRAMIDALIS									MR	MR				
GLOBOROTALIA MENARDII									MR					

TABLE 1

Distribution of species. MR, very rare (1 specimen); R, rare (2-4 specimens); E, scarce (5-10 specimens); F, frequent (11-25 specimens); A, abundant (more than 25 specimens).

Bolivina striatula Cushman, *Poroeponides lateralis* (Terquem), *Rolshausenia rolshauseni* (Cushman and Bermúdez), *Cibicides bertheloti* (d'Orbigny) and *Globigerinoides ruber* (d'Orbigny).

Massilina secans is represented by forms that are quite different from those from the Argentinian shelf. This is especially true of the smallest specimens. The compression, the arrangement of the chambers which sometimes are quinqueloculine, the ornamentation by slight striae which are rarely present, and the rounded or keeled periphery are all variable characters. A comparison with the meridional material shows that our specimens have the same range of variability except that along our coast the specimens are smaller and the chambers are more inflated.

Bulimina marginata is an infrequent but constant form and shows the same great variability mentioned by previous authors. The shape of the chambers and especially the ornamentation of the undercut margins are features that vary greatly.

Poroeponides lateralis shows great variability of the last-formed chamber and many authors differentiate *E. repandus* from this species because one has an open and the other a closed umbilicus. This character, as observed by Tinoco (1955, p. 38), is not clear, and we found specimens that show a transition between an open and closed umbilicus so that we prefer to consider the two forms as *P. lateralis* until further study clarifies this problem.

The following species occur in still smaller numbers: *Textularia gramen* d'Orbigny, *Quinqueloculina labellei* d'Orbigny, *Q.* aff. *Q. frigida* Parker, *Lagena laevis* (Montagu), *Bulimina pseudoaffinis* Kleinpell, and *Uvigerina peregrina,* forma *parvula* Cushman.

Textularia gramen and *T. agglutinata* can be easily distinguished in the northeastern regions (Bahia) (Closs and Barberena, 1960b, p. 21) since the former shows small forms with a characteristically greater width, less inflated chambers and indistinct sutures while the latter shows specimens with a greater length than width, well inflated chambers and well defined but depressed sutures. The peripheral margins are variable in character. In our southern samples, the specimens show a great similarity to *T. gramen* but may be larger and more inflated. Comparison with topotypes of d'Orbigny (Cuba and Vienna Basin) and hypotypes of Madeiros Tinoco (Cabo Frio) and Boltovskoy (meridional material) lead us to consider our specimens as *T. gramen.*

The specimens of *Quinqueloculina* aff. *Q. frigida* are small and characteristically composed of aggregates of yellowish-white sand grains which include poorly distributed but visible mica grains.

The following species are represented by rare or single specimens: *Textularia candeiana* d'Orbigny, *Quinqueloculina atlantica* Boltovskoy, *Q. polygona* d'Orbigny, *Q. lamarckiana* d'Orbigny, *Triloculina trigonula* (Lamarck), *Nodosaria catesbyi* d'Orbigny, *Lagena sulcata* (Walker and Jacob), *Oolina costata* Williamson, *Globulina caribaea* d'Orbigny, *Guttulina problema* d'Orbigny, *Bolivina pusilla* Schwager, *Discorbis williamsoni* (Chapman and Parr), *Orbulina universa* d'Orbigny, *Cancris sagra* (d'Orbigny), and *Globorotalia menardii* (d'Orbigny).

The examination of the foraminiferal fauna of the shores of Rio Grande do Sul shows that:

a) the foraminiferal association of the southern part of the region studied (from Barra do Chuí to Albardão) shows a close relationship to that of the coastal zone of the continental shelf of Argentina. The greater part of the predominant species are the same in both areas (compare Boltovskoy, 1959b, p. 33). *Buccella frigida* can be considered the dominant form although *Elphidium discoidale* is also abundant. *Quinqueloculina seminulum, Buccella peruviana campsi, Rotalia beccarii* ex gr. *parkinsoniana* and *Bulimina patagonica* are well distributed species. Furthermore, it is interesting to note that not a single planktonic specimen was found in this region. *Bulimina marginata, Uvigerina peregrina* forma *parvula* and *Cibicides bertheloti,* typical forms of the Brazilian shelf (Boltovskoy, 1959a, p. 27), are also absent here.

b) From Cassino to Araranguá a change in the fauna is noted. The dominant species now is *Elphidium discoidale,* and *Buccella frigida* is less common. The great abundance of *Elphidium* was also noted by Boltovskoy (1959a, p. 27) in his samples from our continental shelf. *Bulimina marginata* and *Cibicides bertheloti* become frequent. In addition, *Globigerinoides ruber,* a typical planktonic form of the Brazilian shelf, is constantly present and becomes increasingly common in samples from Tramandaí. In this northern region of our coast, the Brazilian type of Foraminifera predominate, although they are mixed with Argentinian type Foraminifera.

c) Typical Malvin (Falkland) Current specimens (Boltovskoy, 1959b, p. 37) are absent; this indicates that the current probably passes near our coast but does not touch it.

d) It is interesting to note that a great number of species that were described by Boltovskoy from central Argentine (San Blas and San Jorge) are present in smaller numbers off our coast.

e) *Nonionella atlantica* is an abundant form in the area between Atlântida and Rondhina and can be considered, after *Elphidium discoidale,* the most common form and also typical of our northern shore samples.

f) Samples collected near river mouths such as those at Cassino, Tramandaí, and Tôrres show a greater tendency to vary from the normal characters. In addition, abnormal forms of such species as *Elphidium discoidale, Nonionella atlantica* and *Rotalia beccarii* were observed.

g) Samples from Tôrres, collected at various points and seasons during the last two years, always contain a very poor fauna; the reason for this is not readily apparent.

SELECTED BIBLIOGRAPHY

BOLTOVSKOY, E., 1954a, Foraminíferos del Golfo San Jorge: Rev. Inst. Nac. Invest. Cienc. Nat. y Mus. Bernardino Rivadavia, vol. 3, no. 3, pp. 79-246, 19 pls.

———, 1954b, Foraminíferos de la Bahía San Blas: Rev. Inst. Nac. Invest. Cienc. Nat. y Mus. Bernardino Rivadavia, vol. 3, no. 4, pp. 247-300, pls. 20-29.

———, 1957, Los Foraminíferos del estuario del Rio de la Plata y su zona de influencia: Rev. Inst. Nat. Invest. Cienc. Nat. y Mus. Bernardino Rivadavia, vol. 6, no. 1, pp. 1-77, 11 pls.

———, 1959a, Foraminíferos Recientes del Sur de Brasil y sus relaciones con los de Argentina e India del Oeste: Serv. Hidrogr. Naval, H.1005, 120 pp., 20 pls.

———, 1959b, La Corriente de Malvinas (un estudio en base a la investigación de Foraminíferos): Serv. Hidrogr. Naval, H.1015, 96 pp., 3 pls.

CARVALHO, J. P., and CHARMONT, E. M. L., 1952, Sôbre alguns Foraminifera da costa do Estado de São Paulo: Bol. Inst. Oceanogr., vol. 3, fasc. 1-2, pp. 77-97, 1 pl.

CLOSS, D., and BARBERENA, M. C., 1960a, Foraminíferos Recentes de Praia do Cassino (Rio Grande, R. G. S.): Escol. Geol. P. Alegre, Bol. 5, pp. 1-29, 3 pls.

———, and ———, 1960b, Foraminíferos Recentes de Praia da Barra (Salvador, Bahia): Escol. Geol. P. Alegre, Bol. 6, pp. 7-50, 7 pls.

CUSHMAN, J. A., and PARKER, F. L., 1931, Recent Foraminifera from the Atlantic coast of South America: Proc. U. S. Natl. Mus., vol. 80, art. 3, pp. 1-24, 4 pls.

EMILSSON, I., 1956, Relatório e resultados físico-químicos de três cruzeiros oceanográficos em 1956: Contr. Avulsas Inst. Oceanogr., Física, no. 1, 70 pp.

NARCHI, W., 1956, Foraminíferos Recentes do Brasil. Famílias Miliolidae, Peneroplidae e Alveolinellidae: Bol. Inst. Oceanogr., vol. 7, fasc. 1-2, pp. 161-192, 4 pls.

ORBIGNY, A. D', 1839, Foraminíferas: *in* Historia física, política y natural de la Isla de Cuba: vol. 6, pp. 1-180, 12 pls.

———, 1846, Foraminifères fossiles du Bassin Tertiaire de Vienne: 312 pp., 12 pls.

TINOCO, I. M., DE, 1955, Foraminíferos Recentes de Cabo Frio, Estado do Rio de Janeiro: D.N.P.M., D.G.M., 42 pp., 4 pls.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XIII, PART 3, JULY, 1962

248. HANTKENININAE IN THE TERTIARY ROCKS OF TANGANYIKA

W. M. RAMSAY
The University, Glasgow

ABSTRACT

The development of the systematic classification within the Hantkenininae is discussed and a summary of the criteria for the identification of certain genera and subgenera presented. Species of Hantkenininae are described for the first time from the coastal Tertiary rocks of Tanganyika. A new type of spine ending is noted, found particularly in **Hantkenina lehneri.** A new technique of measurement seems to be of value in the assessment of subgenera.

INTRODUCTION

In recent years pelagic foraminifera of the Globigerinacea have been proved to be of stratigraphical value, occurring in a wide variety of sediments and having an intercontinental contemporaneity. Of these, various species of the Hantkenininae are particularly important in stratigraphical zonation of the Eocene which seems to be of world-wide application. They have been recorded by Cushman, Nuttall, Rey, Thalmann, Bronnimann, Bolli, Shokhina, Subbotina, Loeblich and others, in South America, Trinidad, Barbados, The United States, Europe, Africa, Asia and Australasia. This study is the first record of them in Tanganyika and represents an initial stage in the application of pelagic foraminifera to stratigraphical problems in East Africa.

LOCALITIES AND DEPOSITORY

The specimens of Hantkenininae studied in this paper occur in three samples collected by Dr. W. G. Aitken from the Tertiary sediments of the Tanganyika coastal area. Of these samples two yielded an abundant and fairly well preserved fauna and the third a few diagnostic specimens. The sample numbers prefixed WA are collection numbers of the Tanganyika Geological Survey.

No. WA 1960 is from a point 425 yards west by south of the Prison, Kilwa Masoko.

No. WA 1963 is from a point 510 yards south-west of the Prison, Kilwa Masoko.

No. WA 1981 is from Lindi Creek, below Kitunda Bluffs on the shore near the oil jetty.

The figured specimens from these localities are now deposited in the Microfossil Collection, Department of Geology, the University of Glasgow, Scotland.

Nos. FO/10/1 to FO/10/8 are from locality WA 1963 and are figured specimens Plate 16, figs. 1, 2, 15, 3, 4, 5, 6 and 7 respectively.

Nos. FO/10/9 to FO/10/18 are from locality WA 1981 and are figured specimens Plate 16, figs. 10, 8, 9, 17, 16, 13, 14, 18, 12 and 11 respectively.

LITHOLOGY AND ASSOCIATED FAUNA

All the host sediments are light grey calcareous clays, weathering brownish, containing appreciable amounts of detrital quartz grains. The greater part of these are rounded to sub-rounded, occasionally pitted, and range in size from 0.1 mm. to 1.0 mm. There are also a few larger quartz fragments up to 2.0 mm. in WA 1981 and WA 1960 and nests of small angular quartz grains often occur in the interior of ostracod valves. Abundant bioclastic fragments of lamellibranchs, echinoids, gastropods and bryozoans are present and alveolinids, assilinids and other larger foraminifera are found along with globigerinids and lagenids. Ostracoda are numerous in WA 1963 and WA 1981 but few in WA 1960. The occurrence of plant organic fragments suggests that the samples have lain partly within the zone of weathering. The indications are that the sediments were deposited as littoral calcareous muds in shelf environments.

Many specimens in WA 1963 and WA 1981 have unbroken tests except for the spines, and uncrushed apertures, while the specimens in WA 1960 are slightly broken or crushed.

SYSTEMATIC CLASSIFICATION WITHIN THE HANTKENININAE

History

At present, various authors subscribe to differing views on the classification within the Hantkenininae and it is proposed, therefore, to give a résumé of the genus *Hantkenina* since its inception. Cushman (1925) erected the genus *Hantkenina* with *H. alabamensis* as the type-species, and since that date at least sixteen species have been described, though some of these are now placed in synonymy. In 1937, Bermudez erected the subgenus *Sporohantkenina,* type-species *H. brevispina* Cushman, 1925. Thalmann, however, in 1942, showed that *H. brevispina* Cushman, 1925, was correctly placed in *Hantkenina s. s.* and, therefore, erected a new subgenus *Cribrohantkenina* with the type-species *H. bermudezi* nom. nov. for *H. brevispina* Bermudez, 1937 (non *H. brevispina* Cushman, 1925). At the same time, he erected three other new subgenera: *Aragonella,* type-species *H. aragonensis* Nuttall, 1930, from *H. mexicana* Cushman, 1925, var. *aragonensis* Nuttall, 1930; *Applinella,* type-species *H. dumblei* Weinzierl and Applin, 1929; and *Hantkenina s. s.* Thalmann subgen. nov., type-species *H. alabamensis* Cushman, 1925, including *Sporohantkenina* Bermudez, 1937, as a synonym. The subgenus *Cribrohantkenina* was elevated later to generic rank by Cushman (1948) apparently on the basis of its possessing a cribrate aperture. In 1950 Bronnimann published a reappraisal of the morphological criteria for subdivision, and erected another new subgenus *Hantkeninella*, type-species *H. primitiva* Cushman and Jarvis, 1929, the type-species having been elevated to specific rank by Thalmann, 1942, from *H. alabamensis* var. *primitiva* Cushman and Jarvis, 1929. Bolli *et al.* (1957) and Banner and Blow (1959) published critical classifications dealing, in particular, with synonymy which is discussed belowed.

Taxonomy of subgenera present in East Africa

Aragonella Thalmann, 1942, type-species: *H. aragonensis* Nuttall, 1930.

Thalmann's original differentiation of *Applinella* from *Aragonella* was on the basis of the chambers in *Applinella* being less distinctly separated at the periphery and the spines being situated at the anterior angle of the chambers. The aperture was unknown. Bolli *et al.* (1957) placed *Applinella* in subjective synonymy with *Hantkenina s. s.* They apparently did this on the basis that they believed the lectotype of *Hantkenina dumblei* to possess the same form and position of spines as do the later chambers of a topotype of *H. alabamensis* and the holotype of *H. alabamensis primitiva.* Bolli *et al.* stated, however, that variation of spine location within a species, or even on a single specimen, is considerable. The lectotype of *H. dumblei* has a broken last chamber and does not properly show an adult aperture. It should be noted that Thalmann's figures and later specific descriptions of *H. dumblei* show that the basal lobes of the aperture are very weakly developed, unlike those of *H. alabamensis,* and the spines do not appear to be sutural. This would tell against the grouping of *Applinella* in synonymy with *Hantkenina s. s.* as suggested by Bolli *et al.* Banner and Blow (1959) placed *Applinella* in synonymy with *Aragonella* apparently on the basis that both subgenera have a primary aperture in the form of a simple arched opening with insignificant basal lobes. There is, in fact, little or no difference in apertural form between *H. dumblei,* the type of *Applinella,* and species of *Aragonella.* Similarity, moreover, occurs in that the spines are never truly sutural in *H. dumblei* and separation of the chambers at the periphery occurs in the adult stages of both *H. dumblei* and species of *Aragonella.* Thalmann's criteria for the separation of *Applinella* from *Aragonella* are therefore considered inadequate and *Applinella* is accordingly placed in synonymy with *Aragonella.*

Hantkenina s.s. Thalmann, 1942, type-species: *H. alabamensis* Cushman, 1925.

H. primitiva, the type-species of *Hantkeninella,* is distinguished from species of *Hantkenina s.s.* only by the possession of an early spineless stage visible in the last whorl. This is the criterion put forward by Bronnimann for the distinction of *Hantkeninella* as a separate subgenus. As Bronnimann showed, later in 1950, *H. alabamensis* also has an early spineless stage hidden, however, by later whorls. The criterion for the distinction of *Hantkeninella* is here considered inadequate and *Hantkeninella* is accordingly placed in synonymy with *Hantkenina s.s.*

Cribrohantkenina Thalmann, 1942, type-species: *Cribrohantkenina bermudezi* Thalmann, 1942.

Specimens of *Hantkenina,* from Alabama, were described by Barnard (1954) as showing a trend towards the development of the cribrate apertural condition from the typical triradiate aperture. He suggested that this showed a phyletic link between *Hantkenina* and *Cribrohantkenina* and went on to question the validity of the latter even as a subgenus. Similar intermediate conditions have been noted in some Tanganyika specimens. Since the apertural pattern of the test is a direct reflection of metabolism and cytoplasmic activity, the change from a triradiate to a cribrate condition must be considered of fundamental genetic importance. Hence *Cribrohantkenina* is regarded in this work as a valid genus.

Morphological Criteria for Generic and Subgeneric Determination

Despite the views of Bolli and others, the main morphological criterion for subdivision within the Hantkenininae must be the condition of apertural development. The positioning of spines and chamberal separation are factors of lesser importance in that they do not reflect in so direct a manner the possible cytoplasmic activity of the animal as do the apertures. Spines are late-stage structural elaborations serving as stabilisers in flotation, as protective processes, and possibly as conductors for secondary cytoplasmic streaming. Chamberal separation is in turn a feature of inflation, volumetric increase and manner of growth and not a fundamental biocharacter. Hence the main morphological criteria may be arranged in order of importance:— aperture development, spine positioning and chamber separation.

1. Single aperture, not cribrate.
   Genus *Hantkenina* Cushman, 1925, type-species *H. alabamensis* Cushman, 1925.

(a) Primary aperture tripartite with well developed basal lobes. Spines on anterior sutures in later chambers. Adult chambers not separated from each other at periphery.
   Subgenus *Hantkenina* Thalmann, 1942, type-species *H. alabamensis* Cushman, 1925. (Synonyms *Sporohantkenina* Bermudez, 1937; *Hantkeninella* Bronnimann, 1950).

(b) Primary aperture a simple arch lacking or with weakly developed basal lobes. Spines in adult chambers situated posterior to anterior suture. Chambers showing separation at periphery (lobulate appearance in side view).
   Subgenus *Aragonella* Thalmann, 1942, type-species *H. mexicana* Cushman var. *aragonensis*

Nuttall, 1930. (Synonym *Applinella* Thalmann, 1942).

2. Cribrate aperture.
Genus *Cribrohantkenina* Thalmann, 1942, type-species *Cribrohantkenina bermudezi* Thalmann, 1942.

SYSTEMATIC DESCRIPTIONS

Family HANTKENINIDAE Cushman, 1927
Subfamily HANTKENININAE Cushman, 1927
Genus **Hantkenina** Cushman, 1925
Subgenus **Aragonella** Thalmann, 1942
(Synonym: *Applinella* Thalmann, 1942, type-species *Hantkenina dumblei* Weinzierl and Applin, 1929)

Hantkenina (Aragonella) mexicana Cushman

Plate 16, figure 1

Hantkenina mexicana CUSHMAN, 1925, Proc. U. S. Natl. Mus., vol. 66, no. 2567, p. 3, vol. 1, p. 160, pl. 25, fig. 18; NUTTALL, 1930, Jour. Paleontology, vol. 4, p. 284, pl. 23, figs. 13, 17; SHOKHINA, 1937, Moscow Univ. Lab. Pal., Prob. Pal., vols. 2-3, pp. 432-433, 439, pl. 2, figs. 5-8, p. 433, text fig. 55; REY, 1938, Soc. géol. France. Bull., sér. 5, vol. 8, fasc. 5-6, pp. 322, 328, 331, pl. 22, figs. 4, 5, p. 328, text fig. c; SUBBOTINA, 1953, Trudy Vses. Neft. Nauch - issled. Geologo-Razved. Inst. (V.N.I.G.R.I.), n. s. 76, pp. 131, 132, p. 131, text fig. 6.

Hantkenina (Aragonella) mexicana THALMANN, 1942, Am. Jour. Sci., vol. 240, p. 812 (listed only); BRONNIMANN, 1950, Jour. Paleontology, vol. 24, p. 405, 407, pl. 55, figs. 1-6.

Description.—The test is planispirally coiled and slightly evolute. The last whorl is composed of 5-6 chambers. The chambers are well separated peripherally, the test having a lobulate appearance in side view even in the adult. The sutures are distinct and straight in the earlier stages but the last three in the ultimate whorl are straight in their upper part but convex towards the anterior in the lower umbilical area, thus giving a sickle-shaped appearance. The chambers tend to be inflated peripherally but slightly compressed laterally in the umbilical region. In side view the chambers sometimes taper gradually into hollow spines and sometimes show a sloping 'shoulder' (or 'shoulders') before tapering more quickly into spines. The spines often arise from the middle of the chamber periphery when seen in side view but may lie to the anterior of this. The walls are perforate and hyaline. The surface is smooth.

The aperture is very clearly seen in a good percentage of the available material. It is an arched opening extending up the apertural face to slightly less than one-half of the height of the chamber. The aperture widens slightly towards the base of the chamber with a tendency to develop small basal lobes. Thin imperforate lateral lips are present, continuing distinctly round the top of the aperture where the apertural face is slightly indented.

Dimensions.—Figured specimen Pl. 16, fig. 1. Diameter (as specified in table 1) 0.5 mm. Length of vertical ray of aperture 0.25 mm. Length of apertural face 0.5 mm. Spine lengths 0.25 mm. - 0.3 mm.

Remarks.—Nuttall's original description of *H. mexicana* var. *aragonensis*, 1930, (later raised to specific rank by Thalmann, 1942), stated that the chambers are generally larger and more inflated than in *H. mexicana* and always taper more gradually into the terminal spines.

Nuttall's figure 17, pl. 23, shows the last unbroken chamber tapering gradually into the spine, and figure 16, pl. 23, shows the last chamber just as inflated and tapering into the terminal spine in the same fashion as the last chamber in the specimen in figure 2, pl. 24. Yet the specimens figs. 16, 17, pl. 23, are placed by Nuttall in *H. mexicana* and the further specimen fig. 2, pl. 24, is placed in *H. mexicana* var. *aragonensis*. In side view each specimen figured shows a variation in its chambers in tapering into spines. Sometimes one chamber tapers into its spine abruptly on one side and much less abruptly on the other. One chamber may show an abrupt taper while another on the same specimen shows a less abrupt taper. Figure 3, pl. 24, does not show great variation in this character. A photograph of the lectotype of *H. mexicana* var. *aragonensis*, kindly sent by Dr. R. Cifelli of the United States National Museum (personal communication), does not show the chambers to be more inflated than those of *H. mexicana* when in edge (apertural) view. The lectotype corresponds to fig. 1, pl. 24, in Nuttall's paper. There would seem to be some confusion regarding the lectotype, since Bolli *et al.* (1957) state their figured specimen, figs. 3a, b, pl. 2, to be the lectotype and this apparently corresponds to fig. 3, pl. 24, in Nuttall's paper. Bolli *et al.* show the first two chambers of the last whorl not tapering gradually into the spines and their figure differs slightly from Nuttall's. The differences are mainly in the outline of each chamber figured and in the main characteristic stated by Nuttall, namely, that of the chamber tapering into the spine.

If the variety is valid then Nuttall's description requires amplification. Indeed, Rey (1938) mistakenly stated that *H. mexicana* var. *aragonensis* is distinguished by its more elongate chambers, possibly being influenced by Nuttall's fig. 3, pl. 24. This latter figure shows chambers very like the middle chambers of the last whorl of specimens of *H. lehneri*. Rey's (1938) fig. 3, pl. XXII, appears to be that of a laterally compressed *H. lehneri*.

Because of the morphological variation now known in *H. mexicana* it is probable that *H. mexicana* var. *aragonensis* should be placed in synonymy with *H. mexicana*. Bronnimann (1950a) considered that the two forms are "the extreme variants of a single species." If the two are in fact synonymous, changes in nomenclature will be necessary since *H. mexicana* var. *aragonensis* is the subgenotype of *Aragonella*. Examination and comparison of type material seems to be imperative.

Occurrence.—Tanganyika: sample nos. WA 1960 and WA 1963, Kilwa Masoko area.

(Range reported outside Tanganyika: Lower and Middle Eocene.)

Hantkenina (Aragonella) lehneri Cushman and Jarvis

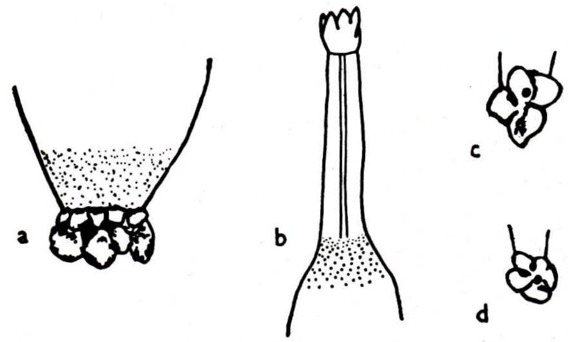
Plate 16, figures 2, 3, 4, 5, 15

Hantkenina lehneri CUSHMAN and JARVIS, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 16, pl. 3, fig. 8; SHOKHINA, 1937, Moscow Univ. Lab. Pal., Prob. Pal., vols. 2-3, pp. 435, 439, pl. 2, fig. 1, (after Cushman and Jarvis); REY, 1938, Soc. géol. France. Bull. sér. 5, vol. 8, fasc. 5-6, ?fig. 3, pl. XXII; SUBBOTINA, 1953, Trudy Vses. Neft. Nauch.-issled. Geologo-Razved. Inst. (V.N.I.G.R.I.), n.s. 76, p. 130, pl. 37, fig. 12, ?figs. 9a, b.

Hantkenina (Aragonella) lehneri THALMANN, 1942, Am. Jour. Sci., vol. 240, p. 812 (listed only); BRONNIMANN, 1950, Jour. Paleontology, vol. 24, p. 408, pl. 55, figs. 7, 8.

Description.—The test is composed of planispirally arranged chambers, at least in the last whorl which has 5-6 chambers. The coiling is slightly evolute. The chambers are generally cylindrical in shape and the test shows very conspicuous lobulation. The sutures are distinct and generally straight although the last suture in the adult may show a slight curvature in the umbilical area, being convex forwards. The chambers increase fairly rapidly in length, the last chamber being nearly twice as long as the penultimate one. Hollow spines are developed peripherally on the chambers, generally by prolongation along the chamber axis and are formed by a gradual tapering from the chambers which they equal in length.

The spines may show a thickening at their ends instead of the normal tapering to a point. A direct end view often shows the spine to have developed four or five thick glassy petaloid protuberances (text fig. 1c, d). Again in side view the thickened end may give the appearance of a crown or coronet (Pl. 16, figs. 3, 4, 5). In two instances such a coronet is seen at the end of a chamber in place of the normal spine (Pl. 16, fig. 15). No apertures can be seen at the ends of the spines but one or two show what appear to be pores between the petaloid protuberances. The surface is coarse on the earliest chambers of the last whorl and



TEXT FIGURE 1

Camera lucida drawings of the 'coronct' feature in *H. (A.) lehneri*. Fig. a - 'coronet' in place of spine (specimen pl. 16, fig. 15); fig. b - tubulospine showing 'coronet' (specimen pl. 16, fig. 4); figs. c, d - end view of spines showing petaloid effect with ?pores (specimens pl. 16, figs. 3 and 5 respectively). Figs. a, c, d, × 80 approx.; fig. b, × 60 approx.

thereafter appears to be smooth. Walls perforate, hyaline.

The aperture is an arch, sometimes very narrow, extending about one-third to two-fifths of the way up the apertural face. Towards the bottom of the face, the aperture shows a tendency to widen into slight lateral lobes. Thin, sometimes wide, lateral lips are present, continuing distinctly round the top of the aperture where the apertural face is slightly indented. The lips are imperforate.

Dimensions.—Figured specimen Pl. 16, fig. 2. Diameter (as specified on table 1) almost 0.7 mm. Length of vertical ray of aperture 0.3 mm. Length of apertural face 0.7 mm. Spine lengths 0.4 mm. - 0.7 mm.

Remarks.—*H. lehneri* is distinguished from *H. mexicana* by the greater peripheral separation and the long cylindrical chambers seen even in young specimens.

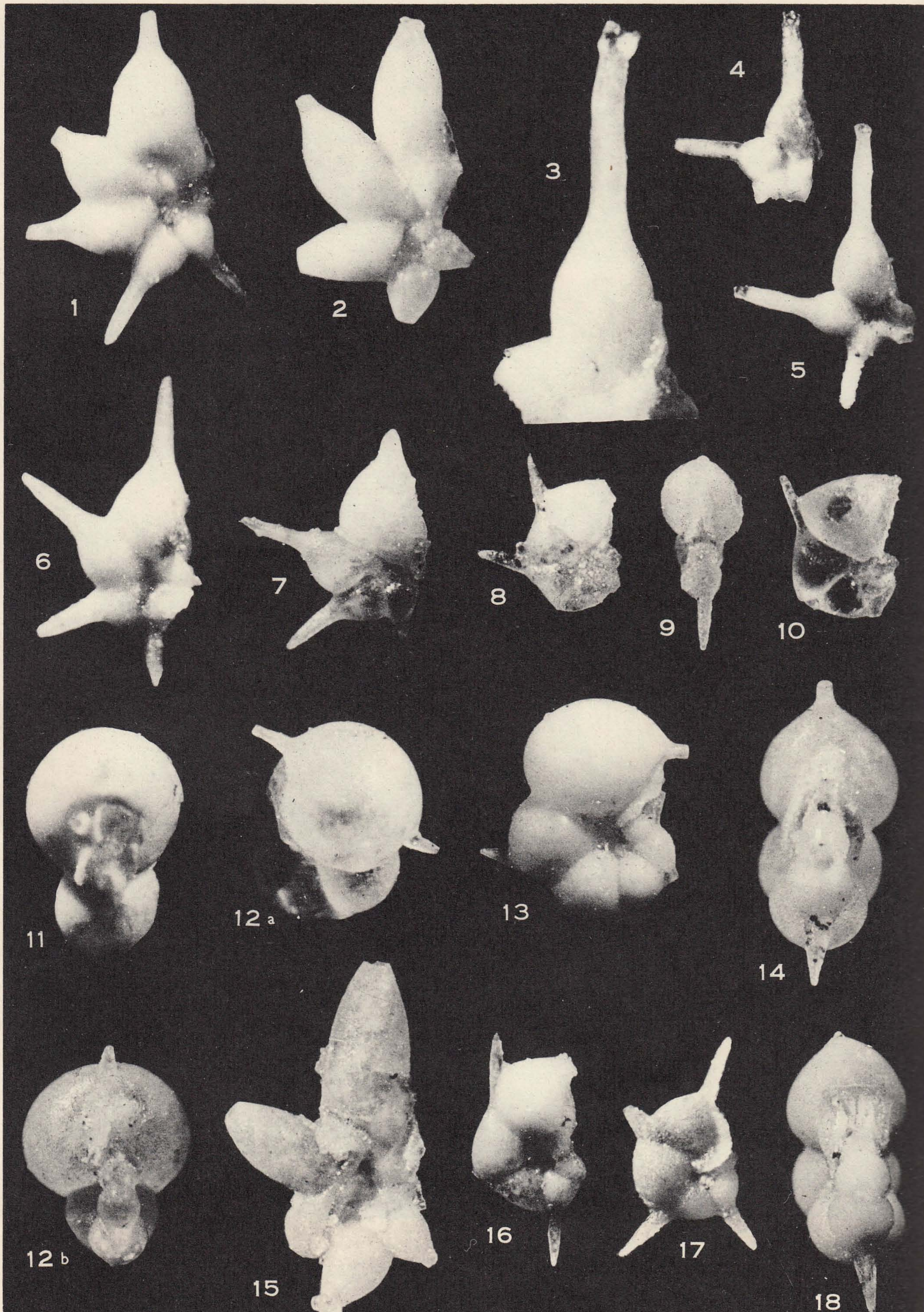
The petaloid appearance of the spines occurs in a very slight degree on one spine of a specimen of *H. liebusi* so it is not suggested that this spinal feature is of specific value but it may have an environmental significance. One specimen of *H. lehneri* shows an abnormality in having a chamber doubled over on itself so that its spine lies across the umbilicus and is terminally reverted. This chamber lies immediately after a chamber with the 'crown' thickening in place of the spine (Page 82). This suggests that the test of the animal was damaged during life causing the breaking cff of the spine and its replacement by a coronet in one chamber and the abnormal growth of the next. The thickened spine endings may result from resurgence of test growth following injury. Despite extensive work on *Hantkenina* from Trinidad, Barbados, South

EXPLANATION OF PLATE 15

Foraminiferal assemblage, Tramandaí Beach

The following species can be seen: *Elphidium discoidale, Nonionella atlantica, Quinqueloculina seminulum, Pyrgo nasuta, Rotalia beccarii* ex gr. *parkinsoniana, Bulimina marginata, Buccella frigida, Buccella peruviana campsi, Poroeponides lateralis, Cibicides bertheloti* and *Globigerinoides ruber.* × 35.

Closs and Barberena: Recent Foraminifera, southern Brazil



Ramsay: Hantkenininae in the Tertiary of Tanganyika

America and the United States this feature has not been recorded before and may prove to be found only on specimens from the Tanganyika area.

Subbotina's (1953) figures 9a, b, page 137, are similar to many young tests of *H. lehneri* from Tanganyika. The young specimens are easily distinguished by the cylindrical form and the greater peripheral separation of the chambers from the young of *H. liebusi* as shown by Bronnimann (1950a). Subbotina's fig. 9a, p. 137, shows the suggestion of a thickened spine ending as seen in so many tests of *H. lehneri* from Tanganyika.

Occurrence.—Tanganyika: sample no. WA 1963, Kilwa Masoko area.

(Range reported outside Tanganyika: Lower and Middle Eocene).

Hantkenina (Aragonella) liebusi Shokhina

Plate 16, figures 6, 7

Hantkenina liebusi SHOKHINA (part), 1937, Moscow Univ. Lab. Pal., Prob. Pal. vols. 2-3, pp. 426, 427-432, 439, pl. 2, figs. 2a, b, 3, pp. 428-432, text figs. 1-8, 11-13, 16-22, 24-29, 31-49; REY (part), 1938, Soc. géol. France Bull., sér. 5, vol. 8, fasc. 5-6, pp. 326, 327, 328, 329, pl. XXII, figs. ?8, 9, p. 329, text figs. a, b; SUBBOTINA, 1953, Trudy Vses. Neft. Nauch.-issled. Geologo-Razved. Inst. (V.N.I.G.R.I.) n.s. 76, pp. 132, 133, p. 137, figs. 11a, b, ?8.

Hantkenina cf. *liebusi* SHOKHINA, 1937, Moscow Univ. Lab. Pal., Prob. Pal., vols. 2-3, p. 433, text figs. 56, 57.

Hantkenina (Applinella) liebusi THALMANN, 1942, Am. Jour. Sci., vol. 240, p. 812 (listed only); BRONNIMANN, 1950, Jour. Paleontology, vol. 24, pp. 410, 411, pl. 56, figs. 1, 2, 18, 19, 23, p. 406, text fig. 2.

Description.—The test is planispiral, laterally compressed and almost completely involute. The last whorl shows 4-6 chambers which are slightly separated peripherally, the sutures being distinct and straight or very slightly convex anteriorly in the umbilical area. The chambers are slightly inflated. The spines arise from the chambers well anterior to the middle of each chamber and almost touch the anterior suture in some cases, so that peripherally each chamber has a long posterior 'shoulder' from the posterior suture to the spine and a very much shorter 'shoulder' from the spine to the anterior suture. The walls are perforate and hyaline. The surface is granular in the earlier chambers but smooth in the last one or two chambers.

The aperture is not very clearly seen but seems to be an arched opening extending about halfway up the apertural face and widening slightly at the base showing a tendency to develop weak basal lobes. Imperforate lateral lips are present, continuing distinctly round the top of the aperture.

Dimensions.—Figured specimen Pl. 16, fig. 7. Diameter (as specified in table 1) 0.4 mm. Length of vertical ray of aperture 0.2 mm. Length of apertural face 0.4 mm. Spine lengths 0.25 mm.

Remarks.—Relative to the chamberal axis the spines of *H. liebusi* are more anterior in position than those of *H. mexicana* and the chambers exhibit less peripheral separation and lobulation. It is similar to *H. mexicana* in its aperture.

Occurrence.—Tanganyika: sample nos. WA 1960 and WA 1963, Kilwa Masoko area.

(Range reported outside Tanganyika: Lower ?, Middle and Upper Eocene.)

Subgenus **Hantkenina** Cushman, s. s.

(Synonyms: *Sporohantkenina* Bermudez, 1937, type-species *Hantkenina brevispina* Cushman, 1925; *Hantkeninella* Bronnimann, 1950, type-species *Hantkenina primitiva* Cushman and Jarvis, 1929)

Hantkenina (Hantkenina) australis Finlay

Plate 16, figure 10

Hantkenina australis FINLAY, 1939, Roy. Soc. New Zealand Trans., vol. 68, pp. 538-539, pl. 69, fig. 5.

Hantkenina (Hantkenina) australis THALMANN, 1942, Am. Jour. Sci., vol. 240, pp. 811, 818 (listed only); BRONNIMANN, 1950, Jour. Paleontology, vol. 24, pp. 413-414, pl. 56, figs. 20, 21.

EXPLANATION OF PLATE 16

Figure 3, × 80 approx.; all other figures, × 40. Locations and depository numbers page 79.

FIGS.		PAGE
1.	*Hantkenina (Aragonella) mexicana* Cushman. Lateral view.	81
2-5, 15.	*Hantkenina (Aragonella) lehneri* Cushman and Jarvis. 2. Lateral view. 3-5. Lateral views of immature specimens showing spines with 'coronet' ends. 15. Lateral view, showing 'crown' in place of spine and terminally reverted spine.	82
6, 7.	*Hantkenina (Aragonella) liebusi* Shokhina. Lateral views.	83
8, 9.	*Hantkenina (Hantkenina) primitiva* Cushman and Jarvis. 8. Lateral view. 9. Apertural view.	84
10.	*Hantkenina (Hantkenina) australis* Finlay. Lateral view	83
11.	*Cribrohantkenina bermudezi* Thalmann. Apertural view.	86
12a, b, 13, 14, 18.	*Hantkenina (Hantkenina) suprasuturalis* Bronnimann. 12a. Postero-lateral view showing backwardly pointing spine. 12b. Apertural view showing subdivided aperture. 13. Lateral view, penultimate spine end just showing. 14. Apertural view of subdivided aperture just approaching that shown by fig. 18. 18. Apertural view, showing subdivided aperture. Apertural face cracked.	85
16, 17.	*Hantkenina (Hantkenina) alabamensis* Cushman. Lateral views.	84

Description.—The test is partly evolute with a small umbilicus and shows an angular outline, the peripheral edges of the chambers being only very slightly curved. The last whorl is composed of 5 chambers. The chambers are triangular in side view and slightly inflated. The last two chambers at their posterior sutures touch the preceding spines progressively farther up the spines (as in *H. suprasuturalis* and some specimens of *H. alabamensis*) but the chambers do not envelop the spines. The last chamber is almost twice the size of the penultimate one. The sutures are distinct and slightly sigmoidal. The spines are sutural on all chambers except in the case of the earliest spine of the last whorl where it is situated just behind the anterior suture. The only unbroken spine is slim and about as long as the chamber from which it arises.

The surface is granular in the earlier whorls and the first chamber of the last whorl. The remaining chambers are smooth. The walls are perforate and hyaline. The test has a glassy appearance.

The aperture is an arched slit extending slightly more than three-quarters up the apertural face, widening slightly near the base of the face and giving rise to two basal lobes which are very narrow slits extending, one on each side of the last chamber, to the umbilicus. Thin imperforate lateral lips are present, continuing distinctly round the top of the aperture.

Dimensions.—Figured specimen Pl. 16, fig. 10. Diameter (as specified in table 1) almost 0.3 mm. Length of vertical ray of aperture 0.2 mm. Length of apertural face almost 0.3 mm. Spine lengths 0.2 mm.

Remarks.—*H. australis* is distinguished from *H. alabamensis* mainly by its angular outline. Finlay's (1939) figure shows the encroachment of a posterior suture up the preceding spine, a condition which he stated did not occur.

Occurrence.—Tanganyika: sample no. WA 1981, Kitunda Bluffs, Lindi area. Rare.

(Range reported outside Tanganyika: Middle and Upper Eocene.)

Hantkenina (Hantkenina) primitiva
Cushman and Jarvis
Plate 16, figures 8, 9

Hantkenina alabamensis var. *primitiva* CUSHMAN and JARVIS, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 16, pl. 3, figs. 2, 3; SHOKHINA, 1937, Moscow Univ. Lab. Pal., Prob. Pal., vols. 2-3, pp. 435, 439, 448-449, 452, pl. 1, figs. 8-9, (after Cushman and Jarvis); BOLLI *et al.*, 1957, U. S. Natl. Mus. Bull. 215, p. 27, pl. 2, figs. 7a, b.

Hantkenina (*Hantkenina*) *primitiva* THALMANN, 1942, Am. Jour. Sci., vol. 240, p. 811 (listed only).

Hantkenina (*Hantkeninella*) *primitiva* BRONNIMANN, 1950, Jour. Paleontology, vol. 24, p. 416-417, pl. 56, figs. 4, 26, 27; BRONNIMANN, 1950, Eclog. Geol. Helvet., vol. 43, p. 246-248, 250, fig. A and fig. C 1, 2.

Description.—The test is elliptical in side view and involute, or very slightly evolute, with 5-6 chambers in the whorl. The chambers show some inflation, the last one being distinctly bulbous (as in some specimens of *H. alabamensis*) and sometimes covering part of the penultimate spine.

Lobulation of the earlier part of the last whorl is distinct. The sutures are distinct and straight. The first chamber, or first two chambers of the last whorl bear no spines. The first spines arise from the chambers slightly behind the anterior sutures or just touching them and the later spines arise on the anterior sutures and sometimes have the same appearance as those of *H. suprasuturalis*. The earlier spines are axial, the later tend to point forwards. The earlier chambers have a granular surface, the later are smooth. The walls are finely perforate, hyaline.

The aperture is a tripartite slit, fairly narrow, the vertical arch extending at least three-quarters of the way up the apertural face and the basal lobes extending to the umbilicus. Thin imperforate lateral lips are present which are continuous, but greatly suppressed, round the top of the aperture. The lips may be wide and may cover a small part of the umbilicus.

Dimensions.—Figured specimen Pl. 16, fig. 9. Diameter (as specified in table 1) 0.3 mm. Length of vertical ray of aperture 0.2 mm. Length of apertural face 0.3 mm. Spine lengths 0.2 mm.

Remarks.—The only difference between *H. primitiva* and *H. alabamensis* is the former's lack of spines in the early part of the last whorl. It is known that *H. alabamensis* lacks spines in an earlier whorl, and Bolli *et al.* (1957) retain *H. primitiva* as a variety of *H. alabamensis*. It is here retained as a full species after Thalmann, 1942, and Bronnimann, 1950, on the grounds of the differing conditions of spinosity in the adult forms of the two species.

Occurrence.—Tanganyika: sample no. WA 1981, Kitunda Bluffs, Lindi area.

(Range reported outside Tanganyika: Upper Eocene.)

Hantkenina (Hantkenina) alabamensis Cushman
Plate 16, figures 16, 17

Hantkenina alabamensis CUSHMAN, 1925, U. S. Natl. Museum Proc., vol. 66, pp. 3-4, pl. 1, figs. 1-6, pl. 2, fig. 5, p. 3, text fig. 1; CUSHMAN, 1927, Jour. Paleontology, vol. 1, p. 160, pl. 25, fig. 17; HOWE, 1928, Jour. Paleontology, vol. 2, p. 14, fig. 1; CUSHMAN, 1935, U. S. Geol. Survey Prof. Paper 181, pp. 49, 50, pl. 13, figs. 1-5; CORYELL and EMBICH, 1937, Jour. Paleontology, vol. 11, pp. 299, 300, pl. 43, fig. 10; SHOKHINA, 1937, Moscow Univ. Lab. Pal., Prob. Pal., vols. 2-3, pp. 434-435, 439, p. 434, text figs. 61, 62, 63, pl. 1, figs. 3-7; REY, 1938, Soc. géol. France Bull., sér. 5, vol. 8, fasc. 5-6, pp. 325, 329, 331, pl. XXII, figs. 13, 15, 17, p. 330, text figs. d, e; SUBBOTINA, 1953, Trud

Vses. Neft. Nauch.-issled. Geologo-Razved. Inst. (V.N.I.G.R.I.), n. s. 76, pp. 129, 130, 133, 134, p. 137, figs. 6, 7; LOEBLICH *et al.*, 1957, U. S. Natl. Mus. Bull. 215, pp. 26, 27, pl. 2, figs. 8a, b.

Hantkenina brevispina CUSHMAN, 1925, U. S. Natl. Mus. Proc., vol. 66, p. 2, pl. 2, fig. 3; CUSHMAN, 1927, Jour. Paleontology, vol. 1, p. 160, pl. 26, fig. 1; SHOKHINA, 1937, Moscow Univ. Lab. Pal., Prob. Pal., vols. 2-3, pp. 435-436, 439, pl. 1, fig. 1; REY, 1938, Soc. géol. France Bull., sér. 5, vol. 8, fasc. 5-6, pp. 326, 329, 331, pl. XXII, fig. 14, p. 330, text fig. a.

Hantkenina (Hantkenina) alabamensis THALMANN, 1942, Am. Jour. Sci., vol. 240, p. 811, pl. 1, figs. 3a-f; STAINFORTH, 1948, Jour. Paleontology, vol. 22, p. 127, pl. 25, fig. 3; BRONNIMANN, 1950, Jour. Paleontology, vol. 24, pp. 414-415, pl. 56, figs. 10, 14-16; BRONNIMANN, 1950, Eclog. Geol. Helvet., vol. 43, p. 250, fig. C, 3, 4.

Hantkenina (Hantkenina) brevispina THALMANN, 1942, Am. Jour. Sci., vol. 240, p. 811, pl. 1, fig. 4.

Description.—The test is planispiral, involute, the last whorl composed of 5 chambers. The outline of the test is subcircular. The last whorl shows a gradual increase in the size and a slight inflation of the chambers. The sutures are distinct, depressed and straight. The spines of the last whorl appear to arise on the sutures and point slightly forwards in the direction of coiling. The only exception is the spine of the earliest chamber seen in the last whorl. This spine is subsutural, arising from the chamber just behind the anterior suture. The surface is generally smoother in the last two chambers and granular in the earlier ones. The walls are perforate, hyaline.

The aperture in most specimens is crushed. Where still recognisable it is seen to be tripartite. The vertical slit extends almost to the top of the apertural face. The lateral lobes extend to the umbilicus. Imperforate lateral lips are present, being well developed along the sides of the aperture and although continuous around the aperture they are almost completely suppressed at the top of the aperture.

Dimensions:

Figured specimens Pl. 16,	fig. 17.	fig. 16.
Diameter (as specified in table 1)	0.3 mm.	0.3 mm.
Length of vertical ray of aperture	0.18 mm.	0.17 mm.
Length of apertural face	0.2 mm.	0.2 mm.
Spine lengths	0.25 mm.	0.25 mm.

Remarks.—Wide variation occurs in this species. An occasional specimen tends to be slightly evolute. The outline of the test varies from subcircular to subelliptical. The chambers show a wide diversity in the rate of growth increment and the amount of inflation, with the last chamber sometimes showing a marked increase in size and strong inflation. Such final chambers often show a tendency to grow backwards round the spine of the penultimate chamber as in *Hantkenina suprasuturalis*. One or two tests have the last two chambers with an almost straight peripheral margin as in *H. australis*. The aperture varies, in different specimens, from very narrow to slightly broader and shows this variation no matter how inflated may be the chamber.

One specimen shows slight abnormality in having a spine doubled back at the end, probably an environmental feature.

Occurrence.—Tanganyika: sample no. WA 1981, Kitunda Bluffs, Lindi area.

(Range reported outside Tanganyika: Upper Eocene).

Hantkenina (Hantkenina) suprasuturalis Bronnimann

Plate 16, figures 12a, b, 13, 14, 18

? *Hantkenina inflata* REY (*non* Howe), 1938, Soc. géol. France Bull., sér. 5, vol. 8, fasc. 5-6, p. 327, pl. XXII, fig. 18, p. 330, text fig. f.

Hantkenina (Hantkenina) suprasuturalis BRONNIMANN, 1950, Jour. Paleontology, vol. 24, p. 416, pl. 56, figs. 12, 13.

Description.—The test is planispiral, involute with a deep umbilicus, and subelliptical in side view with 5-6 chambers in the last whorl. The earlier chambers are moderately inflated but the last two or three chambers are so inflated as to be bulbous or globular and show a great increase in size, swelling backwards and partially or completely enveloping the base of the preceding spines. In the earlier part of the last whorl the spines are sutural or occasionally subsutural; later they appear anterior to the sutures because of the following chamber's development. The last chamber appears to show two spines, the posterior one being in fact the spine of the penultimate chamber piercing the roof of the last chamber. The sutures are distinct, incised and straight. The earlier chambers have a granular surface, the later ones are smooth. The wall is finely perforate, hyaline.

The aperture is a tripartite slit. The arch in the apertural face extends almost to the base of the spine and may have a triangular appearance in the apertural face. The two basal lobes of the aperture extend to the umbilicus. Wide lateral lips are present which slightly or almost wholly cover the umbilicus. Relicts of earlier lateral lips may also be seen in the umbilical area. As in *H. (H.) alabamensis,* the lips are greatly suppressed around the top of the aperture. The lips are imperforate.

Dimensions.—Figured specimen Pl. 16, fig. 13. Diameter (as specified in table 1) 0.36 mm. Length of vertical ray of aperture 0.17 mm. Length of apertural face 0.2 mm. Spine lengths 0.2 mm.

Remarks.—The last chamber may not completely envelop the antecedent spine base and the aperture shows variation in width from specimen to specimen. One specimen, almost transparent, shows a very narrow imperforate zone round the base of the lateral lips which are themselves imperforate. In this specimen the apertural face appears to be more indented than usual around the aperture.

Four adult specimens, which by all other characters would be placed in *H. suprasuturalis,* show apertures which are abnormal. (Pl. 16, figs. 12b, 14, 18). In these the arch is subdivided in the apertural face, producing apertural conditions in the adult which are similar to some recorded in young stages of *Cribrohantkenina.* Similar apertures have been reported by Barnard (1954, pp. 385-387) in *Hantkenina* from Alabama (*vide supra* p. 80). The lateral lips of these subdivided apertures are quite distinct all round the apertures. The lips are imperforate.*

Three East African specimens of *H. suprasuturalis* show a slight abnormality in that the penultimate spine points backward.

Occurrence.—Tanganyika: sample no. WA 1981, Kitunda Bluffs, Lindi area.

(Range reported outside Tanganyika: Upper Eocene).

Genus **Cribrohantkenina** Thalmann, 1942
Cribrohantkenina bermudezi Thalmann
Plate 16, figure 11

Hantkenina inflata HOWE, 1928, Jour. Paleontology, vol. 2, p. 14, text fig. 2.

Hantkenina danvillensis HOWE and WALLACE, 1934, Jour. Paleontology, vol. 8, pp. 35-37, pl. 5, figs. 14, 17.

Hantkenina (Sporohantkenina) brevispina BERMUDEZ, 1937, Soc. Cubana Hist. Nat. Mem., vol. 11, pp. 151, 152, pl. 19, figs. 7-10.

Hantkenina (Cribrohantkenina) bermudezi THALMANN, 1942, Am. Jour. Sci., vol. 240, p. 812, pl. 1, fig. 5, 6a-c; BRONNIMANN, 1950, Jour. Paleontology, vol. 24, pp. 417-419, pl. 56, figs. 6-9, 24, 25.

Cribrohantkenina brevispina CUSHMAN, 1948, The Foraminifera, their classification and economic use, 4th ed., key pl. 54, figs. 1, 2.

Cribrohantkenina bermudezi BOLLI, *et al.,* 1957, U. S. Natl. Mus. Bull. 215, pp. 28-29, pl. 2, figs. ?9a, ?9b, 10a, 11a, b.

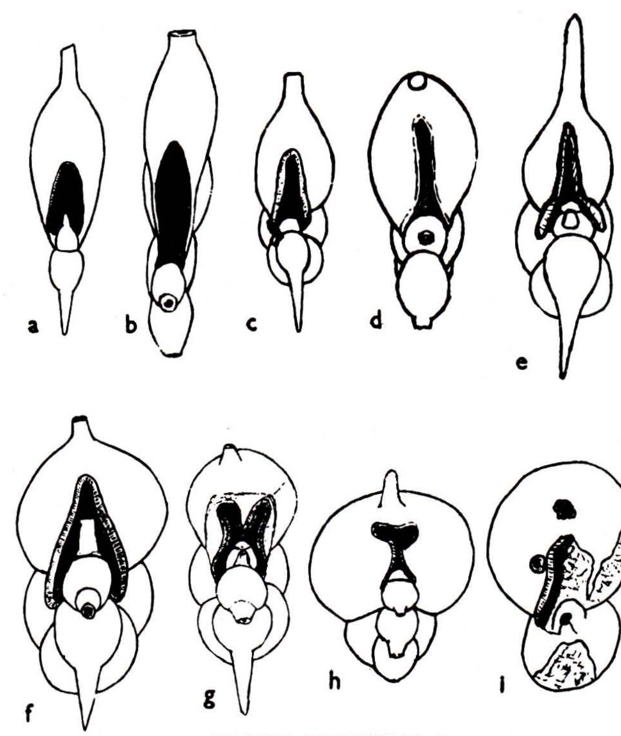
Description.—Only the worn remains of almost globular chambers of one specimen were found. It is distinctive in showing the main vertical ray of a triradiate aperture with one small, round, areal aperture to one side. Presumably a corresponding small areal aperture existed on the other side but the test is broken and does not show it. The existence of a multiple aperture places this specimen in the genus *Cribrohantkenina.*

Remarks.—The presence of the main vertical apertural ray and the very low number of small round apertures (one each side) indicates that the specimen belongs to an early part of the morphogenetic series leading to the fully cribrate condition. It would appear to be a development from such stages as those seen in specimens of *Hantkenina (Hantkenina) suprasuturalis* which show a subdivided vertical apertural ray.

Occurrence.—Tanganyika: sample no. WA 1981, Kitunda Bluffs, Lindi area. Rare.

(Range reported outside Tanganyika: Upper Eocene).

* For fuller discussion of these subdivided apertures, see 'Fundamentals of Mid-Tertiary Stratigraphical Correlation' by Eames, F. E., Banner, F. T., Blow, W. H., and Clarke, W. J., Cambridge Univ. Press, 1962, published since submission of this manuscript.



TEXT FIGURE 2

Camera lucida drawings of apertural views. Fig. a - *H. (A.) mexicana;* fig. b - *H. (A.) lehneri;* fig. c. - *H. (A.) liebusi;* fig. d - *H. (H.) australis;* fig. e - *H. (H.) alabamensis;* figs. f, g, h - *H. (H.) suprasuturalis;* fig. i - *Cribrohantkenina bermudezi.* Figs, a, b, c, f, g, h, i, × 30 approx.; figs. d, e, × 40 approx.

MORPHOLOGY AND MORPHOGENY

In this work certain aspects of the morphology and its sequential pattern have been noted which may be developed with further study.

Size

No statistical variation studies of species have been carried out as yet and unfortunately most measurements found in systematic descriptions are only of spine lengths and diameters. The latter are usually of little value since in no instance is an indication given of the exact position. In practice, the positions of measurements vary with each author. In this study, a particular pattern of measurements has been made on a few specimens.

This pattern seems to indicate the relationship of the species within each subgenus in a fashion other than that of apertural lobation. Thus, those in the subgenus *Aragonella* show the ratio of length of aperture to length of apertural face to be 1:2 and those in the subgenus *Hantkenina s. s.* show this ratio to be greater than 2:3. That these ratios do not depend on the degree of inflation of the chambers can be seen from the fact that there is a noticeable difference in the inflation of the chambers of *H. alabamensis* and *H. suprasuturalis* yet the ratio for each is the same. It may be noted that the figures of *H. dumblei* from Weinzierl and Applin (1929) appear to give a ratio which confirm it as being in the subgenus *Aragonella.*

The difference in the ratios is an indication of the more tangential attitude of the later chambers to the direction of coiling in the members of the subgenus *Hantkenina s.s.* compared with the axial attitude of the chambers in those of the subgenus *Aragonella.*

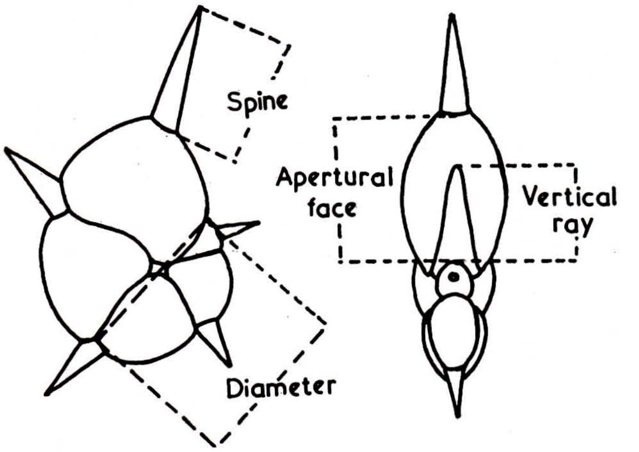
TABLE I

	Diametrical distance from point where apertural face meets previous whorl to spine base of opposite chamber, measured through umbilicus.	Length of vertical ray of aperture/length of apertural face (measured from previous whorl).	Spine lengths.	
H. mexicana	0.5 mm.	0.25 mm./0.5 mm.	Greatest unbroken Probable greatest	0.25 mm. 0.3 mm.
H. lehneri	almost 0.7 mm.	0.3 mm./0.7 mm.	Greatest unbroken (young spec.) Possible in adult	0.4 mm. 0.7 mm.
H. liebusi	0.4 mm.	0.2 mm./0.4 mm.		0.25 mm.
H. australis	almost 0.3 mm.	0.2 mm./almost 0.3 mm.		0.2 mm. +
H. primitiva	0.3 mm.	0.2 mm./0.3 mm.	Unbroken (fourth last chamber)	0.2 mm. +
H. alabamensis	0.3 mm. 0.3 mm.	0.18 mm./0.2 mm. 0.17 mm./0.2 mm.		0.25 mm.
H. suprasuturalis	0.36 mm. 0.35 mm.	0.17 mm./0.2 mm. 0.16 mm./0.2 mm.		0.2 mm. 0.2 mm.

Under the first two headings, all specimens measured, except the second of *H. suprasuturalis,* are figured. Spine measurements, throughout the paper, are not always from figured specimens.

Granularity

The granularity of the earlier chambers and the smoothness of the later larger chambers, found in all species, indicate a relative thinning of the wall in the later chambers. This may arise as a result of the increase of chamberal size accelerating at a greater rate than the increase in supply of calcium carbonate during the addition of the final chambers.



TEXT FIGURE 3
Positions of measurements in Table 1.

Spinose Condition

The spine lengths are found to be greatest in the species of *Aragonella* but there is probably wide enough variation in all species for this feature to have no intrinsic value.

The East African specimens show the previously cited morphogenetic shift in spine position from being truly subsutural and pointing radially in *H. mexicana* and *H. lehneri* to being sutural and pointing anteriorly in *H. alabamensis* and *H. suprasuturalis* (cf. Rey 1938).

The aberrant spine growth, particularly noted in *H. lehneri* in Tanganyika, is a feature hitherto not recorded. As yet, there is no evidence pointing to a specific or varietal significance and it may well result from local conditions.

STRATIGRAPHY AND CORRELATION

Kilwa Masoko

The samples WA 1960 and WA 1963 contain only *Hantkenina (Aragonella) mexicana, Hantkenina (Aragonella) lehneri* and *Hantkenina (Aragonella) liebusi.* It is stated in the Tanganyika Geological Survey Memoir 1956 No. 1 Part 1. "recent information suggests that Lower Eocene is not, in fact, present . . . . . anywhere in the Tanganyika coastal area."

The range of *Hantkenina s.s.* is stated by Thalmann (1942) and Banner and Blow (1959) to be Middle and Upper Eocene but the complete absence of *Hantkenina s. s.* in the samples need not necessarily mean that they are Early Eocene in age. *Hantkenina (Aragonella) liebusi* is noted by Shokhina (1937) to be confined to the Middle Eocene in the North Caucasus and by Rey (1938) to be absent from the Lower Eocene in the Rharb of Morocco. *Hantkenina (Aragonella) lehneri* is stated to be confined to the Lower Eocene in the Rharb of Morocco by Rey (1938), absent in the North Caucasus by Shokhina (1937) and Lower and Middle Eocene by Thalmann (1942). In sample WA 1963 *Hantkenina (Aragonella) liebusi* and *Hantkenina (Aragonella) lehneri* occur together and on the evidence this sample can only be said to be Early to Middle Eocene in age. Sample WA 1960 contains a few specimens of *Hantkenina (Aragonella) mexicana* and one specimen of *Hantkenina (Aragonella) liebusi* and this may be either Early or Middle Eocene in age.

The only conclusion which can be reached from the material is that Lower and/or Middle Eocene is present in the Kilwa Masoko area.

Lindi

Sample WA 1981 appears to have been collected from near the base of the Kitunda Beds (Type locality Kitunda Bluffs, eastern side of the Lindi Creek).

The presence of *Hantkenina (Hantkenina) primitiva* and *Hantkenina (Hantkenina) alabamensis* shows a Late Eocene age. *Cribrohantkenina* is known elsewhere only from the Upper Eocene and is represented here by only one broken adult specimen showing an early stage in the cribrate aperture. This, coupled with the evidence of adult specimens of *Hantkenina (Hantkenina) suprasuturalis* showing an apertural condition approaching that of *Cribrohantkenina,* points to an early but not basal Late Eocene age (cf. Henning 1937, p. 127). The worn specimen of *Cribrohantkenina bermudezi* indicates some reworking within the Upper Eocene and the finding in sample No. WA 1981 of a worn chamber, of *Hantkenina (Hantkenina) lehneri,* similar to the fourth last chamber of the specimen shown on Pl. 16, figure 15, indicates reworking of Middle Eocene rocks into Upper Eocene strata.

Acknowledgments.—The author would like to acknowledge Professor T. N. George's criticism of the manuscript and the advice and encouragement of Dr. R. H. Cummings in the study and preparation.

BIBLIOGRAPHY

BANNER, F. T. and BLOW, W. H., 1959, The classification and stratigraphical distribution of the Globigerinaceae, Part 1: Palaeontology, vol. 2, part 1, p. 1-27.

BARNARD, T., 1954, *Hantkenina alabamensis* Cushman and some related forms: Geological Magazine, vol. XCI, no. 5, pp. 384-390.

BERMÚDEZ, P. J., 1937, Notas sobre *Hantkenina brevispina* Cushman: Soc. Cubana Hist. Nat. Memoirs, vol. 11, pp. 151-152.

BOLLI, H., LOEBLICH, A. R., JR., and TAPPAN, H., 1957, Planktonic foraminiferal families Hantkeninidae, Orbulinidae, Globorotaliidae, and Globotruncanidae: U. S. Natl. Mus. Bull. 215, pp. 1-51, pls. 1-11.

BRONNIMANN, P., 1950a, The genus *Hantkenina* Cushman in Trinidad and Barbados, B. W. I.: Jour. Paleontology, vol. 24, pp. 397-420.

———, 1950b, Weitere Beobachtungen an *Hantkeninen*: Eclog. Geol. Helvet., vol. 43, pp. 245-251.

CORYELL, H. N., and EMBICH, J. R., 1937, The Tranquilla Shale (Upper Eocene) of Panama and its foraminiferal fauna: Jour. Paleontology, vol. 11, pp. 289-305.

CUSHMAN, J. A., 1925, A new genus of Eocene Foraminifera: U. S. Natl. Museum Proc., vol. 66, no. 2567, pp. 1-4.

———, 1927, Some characteristic Mexican fossil Foraminifera: Jour. Paleontology, vol. 1, pp. 147-172.

———, 1935, Upper Eocene Foraminifera of the Southeastern United States: U. S. Geol. Surv. Prof. Paper 181.

———, 1948, The Foraminifera, their classification and economic use. 4th ed., Harvard Univ. Press.

———, and JARVIS, P. W., 1929, New Foraminifera from Trinidad: Cushman Lab. Foram. Research Contr., vol. 5, pp. 6-17.

FINLAY, H. J., 1939, New Zealand Foraminifera: the occurrence of *Rzehakina, Hantkenina, Rotaliatina,* and *Zeauvigerina*: Roy. Soc. New Zealand Trans., vol. 68, pt. 4, pp. 534-543.

HENNIG, E., 1937, Der Sedimentstreifen des Lindi-Kilwa-Hinterlandes (Deutsch-Ostafrika): Palaeontographica, suppl. VII, II reihe, teil II, lief. 2.

HOWE, H. V., 1928, An observation on the range of the genus *Hantkenina*: Jour. Paleontology, vol. 2, pp. 13-14.

———, and WALLACE, W. E., 1934, Apertural characteristics of the genus *Hantkenina* with description of a new species: Jour. Paleontology, vol. 8, pp. 35-37.

NUTTALL, W. L. F., 1930, Eocene Foraminifera from Mexico: Jour. Paleontology, vol. 4, pp. 271-293.

REY, M., 1938, Distribution stratigraphique des *Hantkenina* dans le Nummulitique du Rharb (Maroc): Soc. géol. France Bull., sér. 5, vol. 8, pp. 321-340.

SHOKHINA, V. A., 1937, The genus *Hantkenina* and its stratigraphical distribution in the North Caucasus: Moscow Univ. Lab. Pal., Prob. Pal., vols. 2-3, pp. 425-441.

STAINFORTH, R. M., 1948, Applied micropaleontology in Central Ecuador: Jour. Paleontology, vol. 22, pp. 113-151.

SUBBOTINA, N. N., 1953, Fossil foraminifera of the U. S. S. R., *Globigerinidae, Hantkeninidae* and *Globorotaliidae*: Trudy Vses. Neft. Nauch.-issled. Geologo-Razved. Inst. (V.N.I.G.R.I.), n. s. 76, pp. 1-239. Leningrad.

THALMANN, H. E., 1942, Foraminiferal genus *Hantkenina* and its subgenera: Am. Jour. Sci., vol. 240, pp. 809-820.

WEINZIERL, L. L., and APPLIN, E. R., 1929, The Claiborne Formation on the Coastal Domes: Jour. Paleontology, vol. 3, pp. 384-410.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XIII, PART 3, JULY, 1962

249. *OPERCULINA* AND ASSOCIATED FORAMINIFERA FROM THE PALEOCENE OF THE N.E. FEZZAN, LIBYA

JOHN HAYNES
University College of Wales, Aberystwyth

ABSTRACT

Operculina alpina multiseptata Silvestri and **Operculina thouini** in Silvestri's sense are considered synonymous. **O. alpina multiseptata** occurs as internal casts and appears to be a dolomitized form of **O. thouini.** This population of operculines is identical with **O. sindensis** Davies and is here regarded as a subspecies of **O. canalifera** d'Archiac. Hitherto, the earliest Tertiary transgressions in this part of the Fezzan were thought to be Lutetian. As can now be shown, the foraminifera recovered from the base of the section confirm the Paleocene age suggested by the occurrence of operculines of **"Ranikothalia"** type.

INTRODUCTION

The Lower Tertiary deposits in the Hon area of the N.E. Fezzan are chiefly limestones and marls with a marked absence of quartzitic detritus. The lowest beds outcrop in an escarpment marking the western edge (and old shore line) of the Sirte basin. This runs north from Dor el Gani in the far south to the sombre uplands of the Gebel Soda and continues along the Gebel Uaddan, overlooking the Giofra Oasis, as far as Bu Ngem. These deposits are also well exposed in the depressions of El Fogaha and El Heira.

This area is well known from the descriptions of Desio (1935), Alberici (1939), Chiesa (1940) and Lelubre (1949). It has also been the scene of considerable exploration by Esso Standard (Libya) Inc. since 1956, (R. Brown 1958, Esso Report 32). According to the work published prior to Esso investigations, the Tertiary transgressions did not reach this part of the Fezzan until the Middle Eocene and the oldest deposits were considered to be early Lutetian. This conclusion was based upon the ranges of the macrofauna, chiefly long-ranging molluscan species including many known from the Lower Eocene elsewhere. The only foraminifera discovered in the lower part of the section at that time (apart from indeterminate alveolines at the top of the Gebel Uaddan escarpment) were *Operculina alpina* var. *multiseptata* Silvestri discovered by Chiesa (1936) at Dor Bescescim, south-east of Bir el Fatima near Bu Ngem, and *Operculina thouini* d'Orbigny discovered by Desio in El Fogaha depression. It is interesting that Silvestri (1934, 1937), when describing these suites of specimens, suggested that they both indicated the Lower Eocene. Chiesa, however, when describing the zone with *O. multiseptata* along the western scarp front of the Gebel lladdan at Wadi Amur and Wadi Ruega states, (free translation) "The Wadi Amur Series is the most complete and comprises the lowest levels of the Middle Eocene; the presence of *Operculina alpina* var. *multiseptata* Silvestri in the series more or less confirms this conclusion. *Operculina alpina* is a Priabonian species but is widespread in the Middle and Upper Eocene; this Libyan variety, attributed by Prof. Silvestri to Lower Eocene probably represents the lowest level of M. Eocene." This view of the age of the deposits is followed by Desio (1951) and Lelubre (1949).

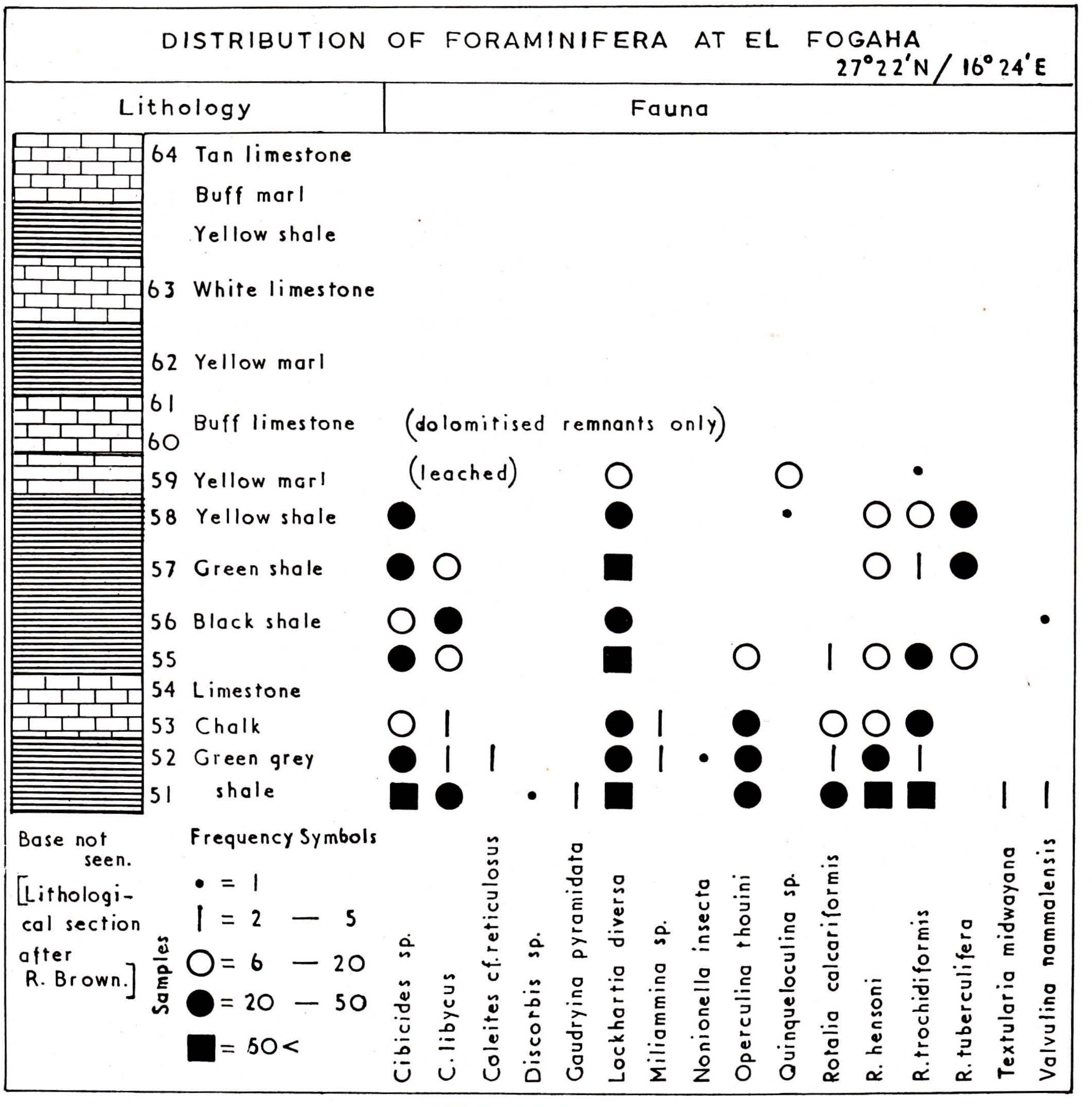
Collecting by Esso Field Party IV in the Fogaha depression in early 1958 established that *Operculina thouini* in Silvestri's sense occurred in abundance in the lower part of the section together with *Lockhartia diversa* Smout and other species which indicated a Paleocene age. This immediately raised the question of the age and relationships of the beds with *O. alpina multiseptata.* It thus became necessary to sample what appeared to be equivalent strata further north and in particular to collect at Dor Bescescim. In May 1958, I was given the opportunity to do this and visited various localities in the Hon area and the Giofra.

SOME DETAILS OF THE SECTIONS

As the detailed description of the Hon area by R. Brown will doubtless eventually be made public it is sufficient here to give enough details of the sections to show the similarity of the strata exposed at Dor Bescescim and El Fogaha and the virtual identity of the faunas apart from preservation. Lithological details of these sections are given in text figs. 1 and 2 together with distribution charts of the species recovered. Faunal counts were made on picked material from samples of 100 grams original weight. Due to variable breakdown and preservation these are, of course, very approximate.

Both sections consist of approximately 60 metres of dark shales (weathering buff) marls and limestones. The limestones include chalks and tend to become progressively more dolomitic up the section. Thus, at El Fogaha while the lower part of the section is unaltered the "Buff limestone" shows a leached fauna at the base in sample 59 and dolomited remnants only in samples 60 and 61. Above this horizon no recognisable fauna was recovered. At Dor Bescescim alteration and dolomitization is much more extensive. Samples 13 and 16 show partial alteration but the fauna is still recognisable. At all the other horizons sampled the fauna is reduced to dolomite casts.

The full list of foraminifera species recovered from the lower 37 metres of El Fogaha section is as follows:

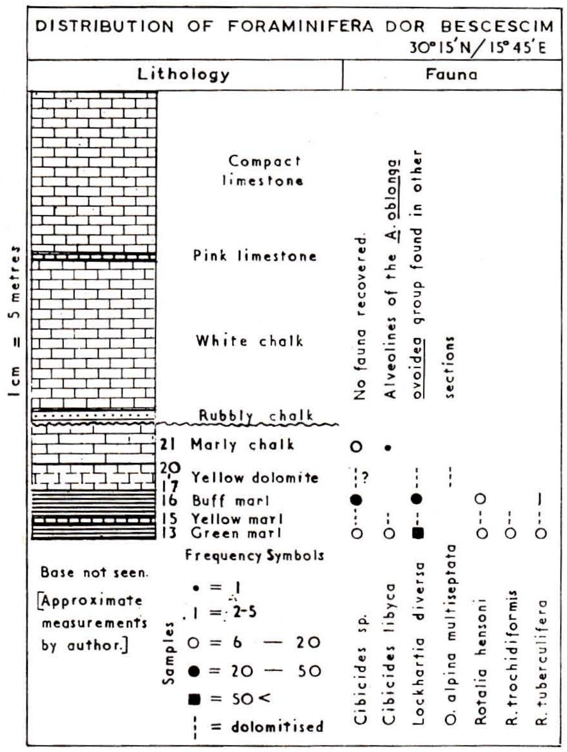


TEXT FIGURE 1

Cibicides sp.
Cibicides libyca Leroy Paleocene, Egypt.
Coleites cf. *C. reticulosus* (Plummer) Paleocene, Texas.
Discorbis sp.
Gaudryina pyramidata (Cushman) U. Cretaceous, Trinidad.
Lockhartia diversa Smout Paleocene, Qatar.
Miliammina sp.
Nonionella insecta (Schwager) Paleocene, Egypt.
Operculina thouini d'Orb. in Silvestri's sense.
Quinqueloculina sp.
Rotalia calcariformis (Schwager) Paleocene, Egypt.
Rotalia hensoni Smout Paleocene, Qatar.
Rotalia trochidiformis Lamarck Paleocene to Lutetian.
Rotalia tuberculifera Reuss Maestrichtian, Netherlands.
Textularia midwayana Lalicker Paleocene, Texas.
Valvulina nammalensis Haque Paleocene, Pakistan.

There is little doubt concerning the Paleocene age of this fauna especially when the presence of operculines of *"Ranikothalia"* type is considered also. The limited number of species present is also noticeable as well as the marked dominance of *Rotalia* and *Lockhartia* with *Cibicides* and *Operculina*. This suggests shallow, warm-water conditions, possibly of open lagoonal type. The lower part of El Fogaha section is then of Paleocene age (at least to the top of the "Buff limestone") and of shallow-water facies.

The fauna recovered at Dor Bescescim, approxi-



TEXT FIGURE 2

mately 150 miles north, is essentially the same as that recovered from El Fogaha.

Cibicides sp.
Cibicides libyca
Lockhartia diversa
Operculina alpina multiseptata Silvestri
Rotalia hensoni
Rotalia trochidiformis
Rotalia tuberculifera

The small total number is certainly a direct result of the conditions of preservation. In the 'Yellow dolomite,' for instance, specimens of *Lockhartia,* reduced to balls of dolomite crystals, can be recognised but other species, apart from the operculines, cannot.

The fauna is restricted to the lower part of the section below the 'Rubbly' or 'Nodular chalk' which rests on an erosion surface in the Marly chalk. Alveolines of the *Alveolina ovoidea - oblonga* d'Orbigny plexus were discovered along the escarpment in limestones equivalent to the 'Compact Limestones' at the top of this section. An early Eocene (Ypresian) age for these upper beds is therefore indicated. The erosion surface below the Nodular chalk may thus represent the Paleocene - L. Eocene boundary.

THE OPERCULINES

Specimens of *Operculina alpina multiseptata* Silvestri were found at Dor Bescescim only, in the Yellow dolomite, samples 18, 19 and 20, (Specimens from sample 20 are described below) and occur either as internal casts or impressions. On visiting the section some time elapsed before the species was discovered, not on the bedding planes as was expected but on vertical joint planes in the dolomite. The tendency for large numbers of specimens to occur more or less in the vertical plane suggests that the operculines lived upright on the sea bed or attached to algae and were very gradually entombed by lime mud. This again may be an indication of quiet lagoonal conditions. Another explanation could be that the shells were turned up by the churning action of worms though there is no other evidence of this.

Operculina thouini in Silvestri's sense was found in the lower part of the section at El Fogaha ranging up to the Black shale above the White limestone. The specimens are relatively unaltered although recrystallised to some extent.

As might be expected from their occurrence and the similarity of the associated faunas, close comparison and measurement (description below) leads to the conclusion that these species are merely differently preserved members of one population. This population is almost identical with *O. sidensis* Davies of the Ranikot here considered a subspecies of *O. canalifera* d'Archiac.

SYSTEMATIC PART

Genus **Operculina** d'Orbigny, 1826
Operculina canalifera sindensis (Davies)
Plates 17, 18

1853, *Operculina canalifera* D'ARCHIAC (pars) *In* d'Archiac and Haime. Description des Animaux Fossiles du Groupe Nummulitique de l'Inde, pp. 182, 346, pl. 12; figs. 1 a-c; pl. 35, fig. 5, 5a, pl. 36, figs. 15, 15a, 16, 16a.

1926, *Operculina canalifera* d'Archiac, NUTTALL, Geol. Mag. vol. LXIII, pp. 117-118, pl. XI, figs. 1, 2.

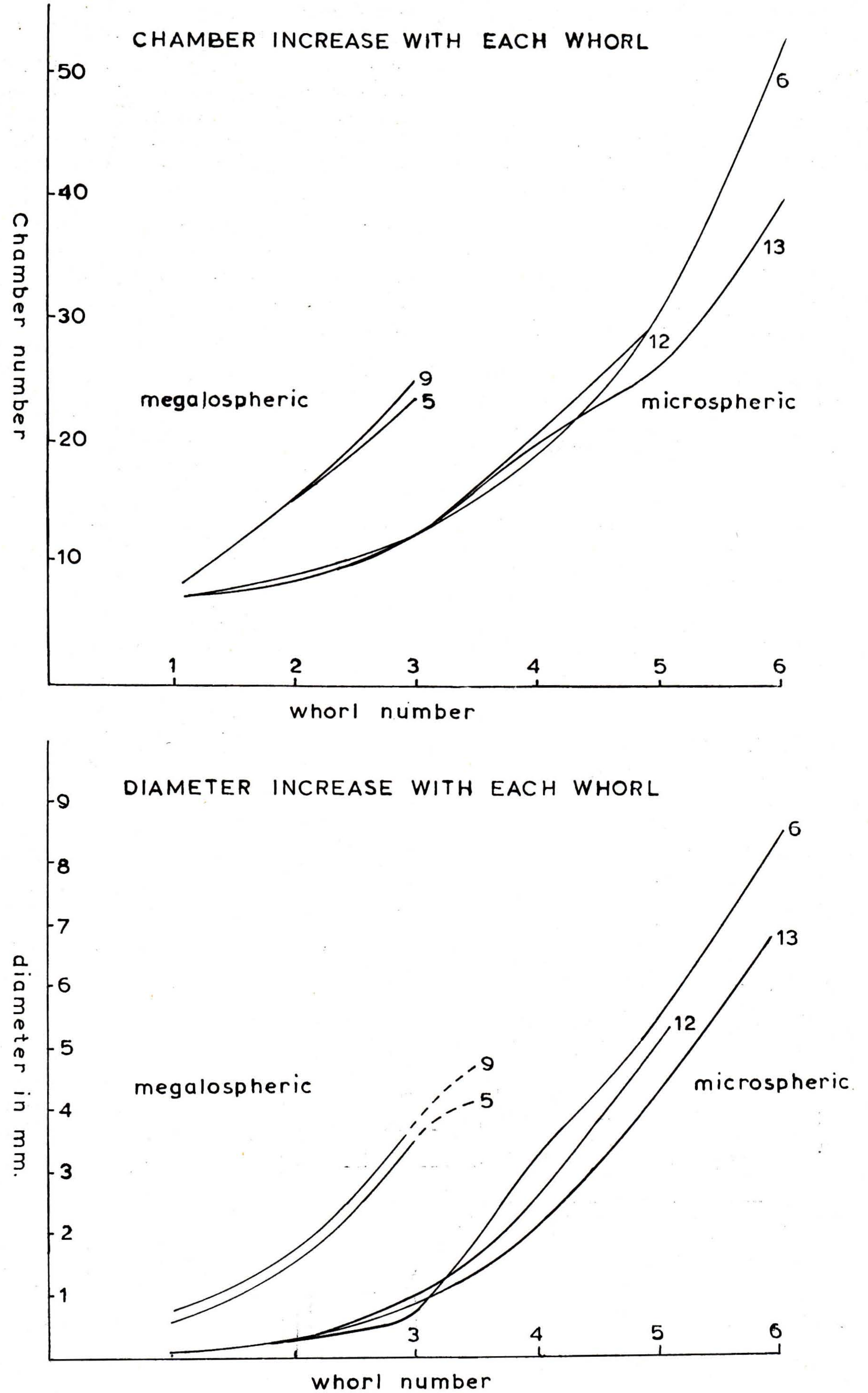
1927, *Operculina sindensis* DAVIES, Geol. Soc. London, Quart. Jour., vol. 83, p. 274, pl. 19, figs. 10-13.

1935, *Operculina thouini* d'Orbigny, SILVESTRI, Missione Scientifica della Reale Accademia d'Italia a Cufra. (1931-IX), vol. III, p. 11, pl. 2, fig. 16.

1937, *Operculina alpina* var. *multiseptata* SILVESTRI, Soc. Geol. Ital., Boll., vol. 56, p. 204, pl. 9, figs. 1-4.

Distinguishing features.—A subspecies of *O. canalifera* distinguished by its smooth surface and by the occasional development only of granules along the septa.

Description.—Test evolute, except in the initial part of the microspheric generation; compressed, with a pinched gutter on either side of the whorl below the massive marginal cord; whorls few, up to 6 in the microspheric generation, up to 3½ in the megalospheric generation; chambers high with almost straight septa curving back towards the margin, numbers increasing from 8 in the first whorl to 25 in the third whorl of megalospheric specimens and from 7 in the first whorl to approximately 50 in the sixth whorl of microspheric specimens; wall lamellar and radial, dividing in the roof of each chamber to cover the preceding septum; chamber wall minutely porous; marginal cord massive, prismatic and coarsely canaliculate; ornament includes um-



TEXT FIGURE 3

Graphs showing relation between chamber number, whorl number and diameter in selected specimens of *O. canalifera sindensis*.

bilical pustules and occasional granules developed along the septa, especially well seen in weathered specimens.

Dimensions.—Diameter more than doubles with each whorl, and is therefore more than 2d, (Davies, 1945) dropping to below this value in the sixth whorl of microspheric specimens. Total diameter is up to 9 mm. in the microspheric generation and up to 5 mm. in the megalospheric generation.

Proloculus diameter: megalosphere = .20 mm., followed by a round second chamber; microsphere = .025 mm. approx.

Thickness: .5 mm. between cords; 1.0 mm. at embossed centre.

Chamber height: About 1.5 mm. in the last whorl of microspheric specimens.

Variation.—Nearly all specimens show a certain amount of axial rotation as well as actual variation in chamber height. This makes preparation of thin sections difficult. From over a score of specimens sectioned and measured a selected five with complete measurements available are graphed in fig. 3. The table of measurements is given below:

TABLE OF MEASUREMENTS

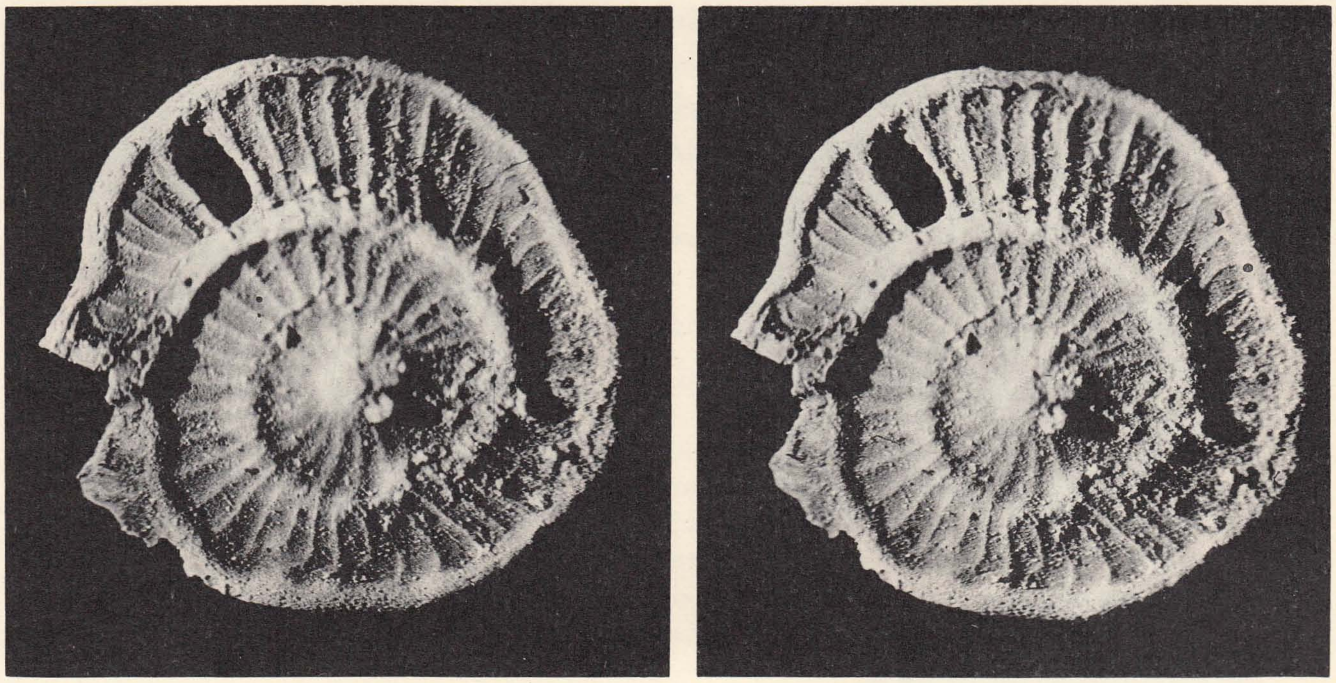
Specimen		6	12	13	5	9
Generation		Microspheric			Megalospheric	
Total whorl number		6⅓	5	6	3½	3½
Chambers visible on exterior		56	30	40	30	30
Chamber number.	whorl 1	7	7	7	8	8
	2	9	8	8	15	15
	3	12	12	12	24	25
	4	21	19	20	15½	10½
	5	30	30	26	-	-
	6	54	+3	40	-	-
	7	+8	-	-	-	-
Diameter (mm.).	whorl 1	.1	.1	.1	.6	.8
	2	.3	.31	.3	1.5	1.7
	3	.7	1.0	.9	3.5	3.8
	4	3.3	2.6	2.1	-	-
	5	5.5	5.1	4.3	-	-
	6	8.5	-	7	-	-
	Total	8.5	5.1	7	4.2	4.8
Opening Rate.	whorl 1	-	-	-	-	-
	2	3d	3d	3d	2.6d	2.1d
	3	2.3d	3.3d	3d	2.3d	2.2d
	4	4.7d	2.6d	2.2d	-	-
	5	1.6d	1.9d	2d	-	-
	6	1.6d	-	1.6d	-	-

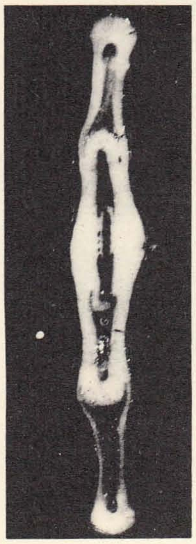
EXPLANATION OF PLATE 17

FIGS. PAGE

1-5. *Operculina canalifera sindensis* (Davies) 92

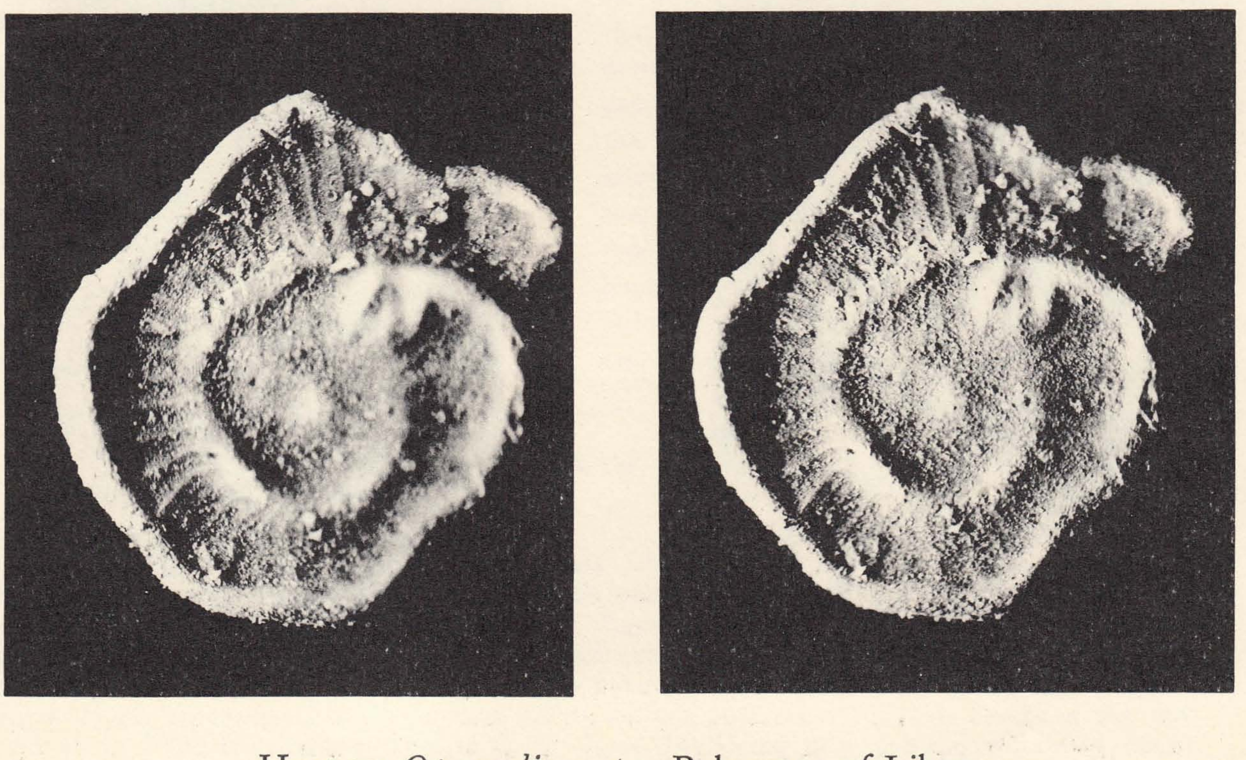
These figures represent *Operculina thouini* in Silvestri's sense, from El Fogaha. 1. × 8. Stereo-pair of microspheric specimen with prominent, raised sutures (emphasized with ammonium chloride). N. B. If a stereoscope is not available hold the plate about a foot away and look between the photos with eyes unfocused until a row of three images can be seen. Concentrate on the middle one and moving the plate either backwards or forwards bring it into focus and full relief. 2. × 8. Axial section of microspheric specimen. The initial part is involute whereas in the later whorls the alar prolongations are pinched off below the marginal cord. 3. × 24. Detail of axial section showing the radiate structure of the massive, canaliculate marginal cord. 4. × 110. Detail of equatorial section showing the 'double septum' and pores in the chamber wall (lower left) picked out with pyrite. The chamber is filled with calcite. 5. × 8. Stereo-pair showing irregular specimen.


1

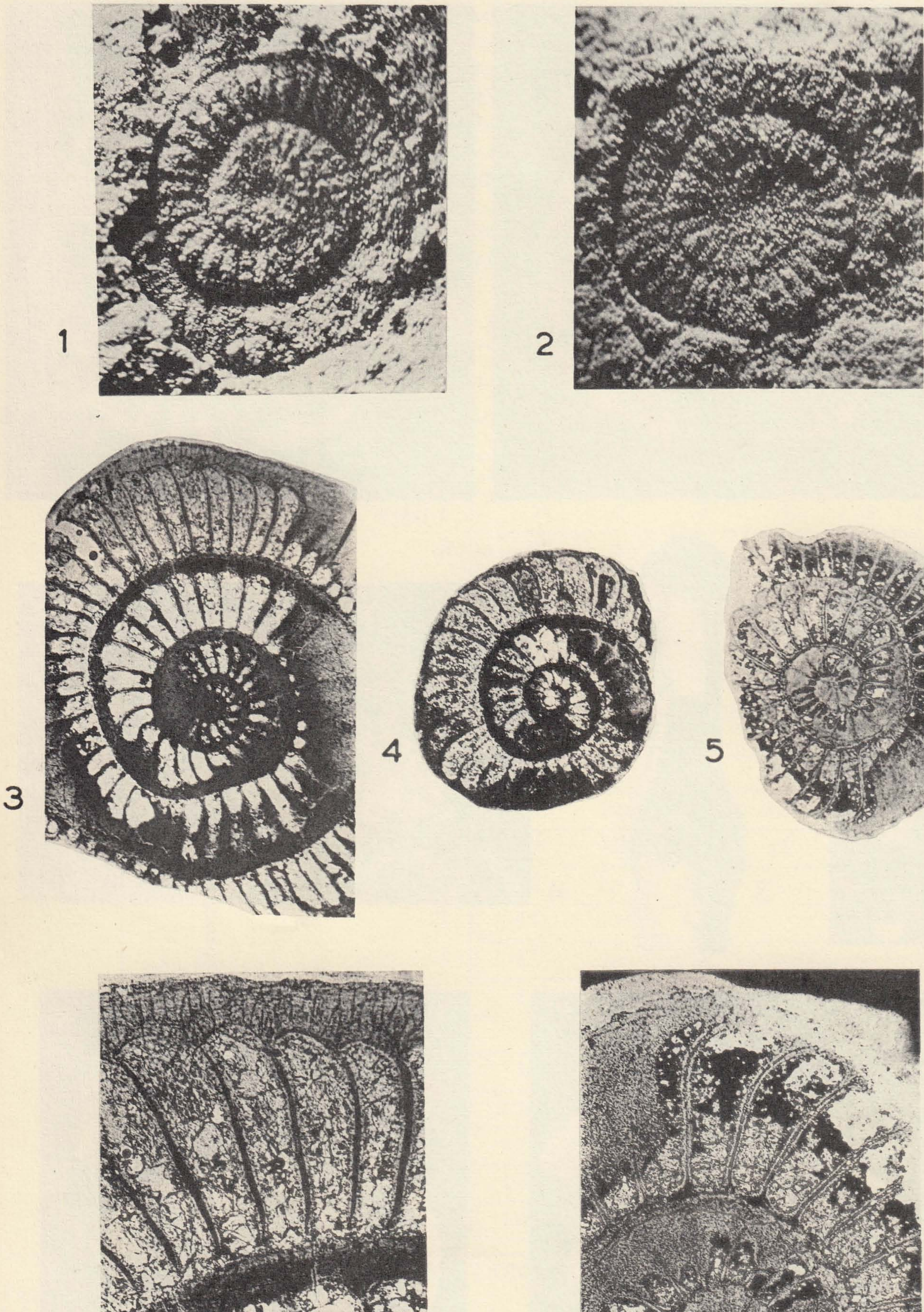

2


3


4


5

Haynes: *Operculina*, etc., Paleocene of Libya



Haynes: *Operculina*, etc., Paleocene of Libya

As is well shown by the table and graphs, increase in chamber number and diameter with each whorl is logarithmic. There is distinct dimorphism, the megalospheric generation showing an acceleration equal to 1½ whorls growth of the microspheric generation (without development of the final whorl). Cumulative increase of chambers is fairly constant with increase in diameter but the increase of chamber number is faster in the early involute portion of the microspheric generation.

Discussion.—Specimens of *Operculina alpina* var. *multiseptata* fall well within the size range of specimens of *O. thouini* from El Fogaha. For instance the two specimens illustrated, Pl. 18, figs. 1 and 2, are approximately 5.5 mm. in diameter and specimens up to 9 mm. were also collected. The approximate number of chambers visible on the periphery of the specimens illustrated is 40. As shown by the graphs for *O. thouini*, microspheric specimens tend to reach 5 mm. in diameter by the 5th whorl and to show between 30 and 40 chambers at the periphery.

As can be seen from the photographs, Pl. 18, figs. 3, 4, 5, the dolomite casts closely resemble the equatorial sections of *O. thouini*. The shape of the chambers is the same and the marginal cord is represented in the casts by a pronounced groove. This leads inevitably to the conclusion that the two species are members of the same interbreeding population.

The question now arises of the relation of this form to the well-known *Operculina sindensis* Davies. Examination of topotypes of this species and the related *O. canalifera* d'Archiac in the Davies collection at the British Museum of Natural History leads to the following conclusions: *O. sindensis* can be considered a smooth variety of *O. canalifera* and *O. thouini* in Silvestri's sense although smaller is otherwise identical with *O. sindensis*.

O. thouini d'Orbigny was described from the Suessonian supérieur (L. Eocene) of Couiza and Mortolieu (Aude) France and may represent a L. Eocene end member of the *canalifera - sindensis* plexus. However, as no type figure was published until 1904 (by Fornasini) and whereas *O. canalifera* was well established in 1853 it is thought correct and less confusing to refer the Libyan population (considered as a subspecies) to *O. canalifera sindensis*.

Generic status.—Present opinion on the classification of the Nummulitidae is divided (Caudri 1944, Cizancourt 1948, Cole 1953, 1958a, b, 1959, 1960, 1961, Nagappa 1959, Smout and Eames 1960). In particular the status of *Operculinella, Operculinoides* and *Ranikothalia* are in dispute. Cole, for instance, would place all these in synonymy with *Nummulites* (as *Camerina*) together with *Operculina.*

In *O. canalifera sindensis* the test is evolute, except for the initial whorls in the microspheric generation, with a few whorls rapidly expanding in height. The diameter is more than doubled with each additional whorl. These characters, together with the very large, coarsely reticulate marginal cord led Caudri to include this species in her genus, *Ranikothalia*. However, the species chosen as type for this genus, *N. nuttalli* Davies, has numerous involute whorls and apart from its enlarged marginal cord appears to be a typical nummulite. In this connection, it is interesting that Cole 1960, supposes both *N. nuttalli* and *O. sindensis* to be synonymous with *N. planulutus* Lamarck. Although this view is not followed here, it is probable that *O. canalifera* was derived from a nummulite of this group by mutations that led to pinching off of the alar prolongations of the chambers as they increased in height. *O. canalifera sindensis* appears to be the most advanced member of a plexus that also includes *R. sahnii* Davies, 1952, and *Operculinoides bermudezi* Palmer, Sachs 1957. Certainly it appears to represent a Paleocene operculine stock distinct from that represented by the later American and Caribbean species generally referred to *Operculinoides* Hanzawa (Vaughan and Cole 1936) and *Operculinella* Yabe (Smout and Eames 1960). The wall structure in *O. canalifera sindensis* is not demonstrably different from that of the simple, radiate *Nummulites* from which it derives, thus no support is found for the views of Nagappa (1959). What we see in this plexus is merely the appearance of an operculine trend in a stock possessing enlarged marginal cords. If subgeneric distinction is introduced it would presumably have to be extended to *Nummulites* with reticulate septa and perhaps also to species where the alar prolongations are reduced by thickening of the chamber wall and development of polar plugs, as in *N. globosa* Leymerie.

EXPLANATION OF PLATE 18

FIGS. PAGE

1-7. *Operculina canalifera sindensis* (Davies) 92

1, 2. × 8. *Operculina alpina* var. *multiseptata* Silvestri from the 'Yellow dolomite' at Dor Bescescim. 3-7. *Operculina thouini* in Silvestri's sense, from El Fogaha. 3. × 8. Equatorial section of large microspheric specimen. 4. × 8. Equatorial section of megalospheric specimen. Note the round chamber which follows the proloculus. 5. × 8. Equatorial section of microspheric specimen, "double septa" picked out by pyrite. 6. × 24. Detail of equatorial section of megalospheric specimen (Fig. 3) showing calcite infilling and recrystallisation cracks in the marginal cord. Note lamellar structure of cord. 7. × 24. Detail of equatorial section of microspheric specimen (Fig. 5) showing calcite and pyrite infilling.

ASSOCIATED FAUNA

Genus **Cibicides** Montfort, 1808
Cibicides libyca LeRoy

1953, *Cibicides libycus* LeRoy, Mem. 54. Geol. Soc. America, p. 24, pl. 5, figs. 1-3.

Genus **Coleites** Plummer, 1934
Coleites cf. **C. reticulosus** (Plummer)

See 1926, *Pulvinulina reticulosus* Plummer, Texas Univ. Bull. 2644, p. 152, pl. 12, fig. 5.

The Libyan specimens lack the ragged flange of the types from the Midway.

Genus **Gaudryina** d'Orbigny, 1839
Gaudryina pyramidata Cushman

1930, *Gaudryina (Pseudogaudryina) pyramidata* Cushman, Cushman Lab. Foram. Research, Spec. Pub. 7, pl. 12, fig. 13.

Genus **Lockhartia** Davies, 1932
Lockhartia diversa Smout

1954, *Lockhartia diversa* Smout, Lower Tert. Foram. Qatar, p. 52, pl. 111, figs. 1-20.

Libyan specimens show the same size range, up to 3 mm. diameter, and the same ornament as the types.

Genus **Nonionella** Cushman, 1926
Nonionella insecta (Schwager)

1883, *Anomalina insecta* Schwager, Palaeontogr. Beitr. Naturg. Vorzeit, Cassel, Deutschland, Bd. 30 (Folge 3, Bd. 6) Pal. Theil, Abth. 1, p. 128, pl. 28 (5), fig. 2.

1953, *Nonionella insecta* LeRoy, Mem. 54, Geol. Soc. America, p. 42, pl. 10, figs. 15-17.

Genus **Rotalia** Lamarck, 1804
Rotalia calcariformis (Schwager)

1883, *Discorbina calcariformis* Schwager, Palaeontogr. Beitr. Naturg. Vorzeit, Cassel, Deutschland, Bd. 30 (Folge 3, Bd. 6), Pal. Theil, Abth. 1, p. 120, pl. 27, fig. 9.

1953, *Rotalia calcariformis* LeRoy, Mem. 54, Geol. Soc. America, p. 48, pl. 10, figs. 18-20.

Rotalia hensoni Smout

1954, *Rotalia hensoni* Smout, Lower Tert. Foram. Qatar, p. 45, pl. XV, fig. 8.

Rotalia trochidiformis Lamarck

1804, *Rotalia trochidiformis* Lamarck, Ann. Mus. Hist. nat. Paris, vol. 5, pp. 183-185.

1954, *Rotalia trochidiformis* Smout, Lower Tert. Foram. Qatar, p. 43, pl. 1, figs. 1-6.

Rotalia tuberculifera Reuss

1862, *Rotalia tuberculifera* Reuss, Palaeont. Beitr. K. Akad. Wiss. Wien, Math.-Naturw. Cl., Sitzber., Bol. 44 (Jahrg. 1861), Abth. 1, p. 313, pl. 2, fig. 2.

Genus **Textularia** Defrance, 1824
Textularia midwayana Lalicker

1935, *Textularia midwayana* Lalicker, Cushman Lab. Foram. Research, Contr., vol. 11, p. 49, pl. 6, figs. 7-9.

Genus **Valvulina** d'Orbigny, 1826
Valvulina nammalensis Haque

1956, *Valvulina nammalensis* Haque, Mem. Geol. Surv. Pakistan, vol. 1, p. 47, pl. 21, figs. 10-11.

ACKNOWLEDGEMENTS

I should like to thank Esso Standard (Libya) for permission to publish this paper based on material collected while in their employ; also R. Brown, Esso Field Party Chief, for guidance and stimulating discussion in the field; also Dr. David Hughes, Esso Palaeontologist, for drawing my attention to the problem.

REFERENCES

Alberici, E., 1939, Osservazioni sui giacimenti fossiliferi eocenici dei dintorni di El-Fugha (Sahara Libico): Soc. Ital. Sci. Nat. Milano, Attiv. vol. 78, pp. 357-384, figs. 3, pls. 1.

Caudri, C. M. B., 1944, The larger Foraminifera from San Juan de los Morros, State of Guarico, Venezuela: Bull. Am. Paleontology, vol. 28, no. 114, pp. 356-404, pls. 30-34.

Chiesa, C., 1940, La Serie Eocenica del Gebel Uaddan nella Giofra (Libya): Mus. Libico Storia Nat., Ann., vol. 2, pp. 189-202, 4 figs.

Cizancourt, M. de, 1948, Nummulites de l'île de la Barbade: Géol. Soc. France, Mém. no. 57, vol. 27, pp. 1-36, 2 pls.

Cole, W. S., 1953, Criteria for the recognition of certain assumed camerinid genera: Bull. Am. Paleontology, vol. 35, no. 147, pp. 29-46, pls. 1-3.

———, 1958a, Names and variation in certain American larger Foraminifera - No. 1: Bull. Am. Paleontology, vol. 38, no. 170, pp. 179-213, pls. 18-25.

———, 1958b, Names and variation in certain American larger Foraminifera, particularly the camerinids - No. 2: Bull. Am. Paleontology, vol. 38, no. 173, pp. 261-284, pls. 32-34.

———, 1959, Names and variation in certain Indo-Pacific camerinids: Bull. Am. Paleontology, vol. 39, no. 181, pp. 349-371, pls. 28-31.

———, 1960, The Genus Camerina: Bull. Am. Paleontology, vol. 41, no. 190, pp. 189-205, pls. 23-26.

———, 1961, Names and variation in certain Indo-Pacific camerinids - No. 2 a reply: Bull. Am. Paleontology, vol. 43, no. 195, pp. 111-128, pls. 14-16.

Davies, L. M., 1945, Classification of spiral foraminifera: Nature, vol. 155, p. 81.

———, 1952, *Ranikothalia sahnii* n. sp. and *R. savitrae* n. sp.: A possible link between the Paleocene faunas of the East and West Indies: The Palaeobotanist, vol. 1, pp. 155-158, pls. 1.

DESIO, A., 1935, Misione Scientifica della Reale Academia d'Italia a Cufra (1931-IX); vol. 1. Studi Geologici sulla Cirinaica, sul Deserto Libico, sulla Tripolitania e sul Fezzan Orientali: R. Accad. d'Italia, Viaggo di Studio ed Esplorazioni, 3, Rome, pp. 465, figs. 60, pls. 7.

———, 1951, Cenno Reassuntivo sulla Costituzione Geologica della Libia: 18th International Geological Congress, 1948, Rept. pt. 14, pp. 47-53.

FORNASINI, C., 1904, Illustrazione di Specie Orbignyane di 'Nummulitidae' institute nel 1826: Boll. Soc. Geol. Ital., vol. 22, pp. 395-398, pl. 14.

LELUBRE, M., 1949, Géologie du Fezzan Oriental: Bull. Soc. Géol. France, Paris (5), vol. 19, pp. 251-261, pls. 1.

NAGAPPA, Y., 1959, Notes on *Operculinoides* Hanzawa, 1935: Palaeontology, vol. 2, pt. 1, p. 156-160, pls. 21-23.

SACHS, K. N., 1957, Restudy of some Cuban larger Foraminifera: Contr. Cushman Found. Foram. Research, vol. VIII, pt. 3, p. 106-120, pls. 14-17.

SILVESTRI, A., 1934, Su di alcuni Foraminiferi Terziari della Sirtica: R. Accad. Italia, Misione Sci. Cufra, vol. 3, pp. 5-30, pls. 3.

———, 1937, Fossile Eocenico Singolare della Tripolitania: Soc. Geol. Italiana, vol. 56, f. 2, pp. 203-208, pls. 1.

SMOUT, A. H., 1954, Lower Tertiary Foraminifera of the Qatar Peninsular: Brit. Mus. (Nat. Hist.), p. 1-96, pts. 15.

SMOUT, A. H. and EAMES, F. E., 1960, The distinction between *Operculina* and *Operculinella*: Contr. Cushman Found. Foram. Research, vol. 11, pt. 4, no. 213, pp. 109-114.

VAUGHAN, T. W. and COLE, W. S., 1936, New Tertiary Foraminifera of the Genera Operculina and Operculinoides from N. America and the West Indies: Proc. U. S. Natl. Mus., vol. 83, no. 2996, pp. 487-496, pls. 35-38.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XIII, PART 3, JULY, 1962

250. THE TYPE SPECIMENS OF *GLOBIGERINA QUADRILOBATA* D'ORBIGNY, *GLOBIGERINA SACCULIFERA* BRADY, *ROTALINA CULTRATA* D'ORBIGNY AND *ROTALIA MENARDII* PARKER, JONES AND BRADY

F. T. BANNER and W. H. BLOW
BP Exploration Co. Ltd., Sunbury-on-Thames, Middlesex, England

In 1960 we published descriptions of lectotypic, syntypic and neotypic specimens of many species which are deposited in the collections of the Muséum Nationale de l'Histoire Naturelle, Paris, and the British Museum (Natural History), London. Prior to this study no adequate authoritative descriptions of the type specimens had been published and tradition, often confused and contradictory in its beliefs, was the principal basis upon which currently published determinations were being made. The descriptions of the carefully selected types (*op. cit.*) were as objective as we could make them, and we kept our more subjective remarks separate, in the hope of initiating discussion amongst specialists as to the biological affinities and stratigraphical values of the species represented.

Ruth Todd (1961) has raised certain objections to the acceptance of the lectotype of *Globigerina quadrilobata* d'Orbigny, 1846, and the neotype of *Rotalina cultrata* d'Orbigny, 1839. These objections fall into two categories: first, the objective validity of the type, and, second, the subjective utility of the taxon so typified. We will briefly discuss these for each taxon in turn.

1. *Globigerina quadrilobata* d'Orbigny, 1846.

It is a matter of opinion as to whether or not the syntypes of *G. quadrilobata* conform either to the concept of the species which has grown amongst palaeontologists over the last century or to d'Orbigny's original description. It seems to us that d'Orbigny's original diagnosis (1846, p. 164: "G. testa ovata-convexa, gibbosa, punctata, subtus umbilicata, loculis quatuor sphaericis, subaequalibus, ultimo sphaerico") is satisfied by the lectotype. This lectotype was of the same morphology as the majority of the syntypes, and we have been able to find no other species with a punctate wall (at least, in the sense of having the perforations emphasized by superficial pits), and with four subequal spherical chambers (at least, in the last whorl) in an ovate-convex, gibbous test, in any sample available to us from the Vindobonian of Nussdorf. Todd (1961, p. 121) points out that d'Orbigny did not mention the presence of supplementary dorsal apertures, however; we must also point out that these dorsal sutural apertures are often small and difficult to see, especially in fossil material which is infilled, and if the specimen d'Orbigny drew (1846, pl. 9, fig. 7-10) was really of only 0.25 mm. diameter it must have been a small specimen, probably a juvenile comparable in ontogenetic development to the first whorl only of the lectotype, where the sutural supplementary apertures would be very small — indeed, such small specimens often lack sutural dorsal apertures altogether. We have no reason to doubt that the specimens labelled *"Globigerina quadrilobata* d'Orb., Tortonien, Nussdorf, Autriche" in the A. d'Orbigny collection in Paris, are authentic syntypes, and it appears to us untrue to say that they "do not fulfill even the minimum qualifications of what it was obviously the author's intention to describe."

Todd (*loc. cit.*) believes that *G. quadrilobata* should be suppressed as a synonym of the more frequently used name *Globigerina sacculifera* Brady, 1877. We had hoped that the differences between these forms had been made clear (Banner and Blow, 1960, pp. 17-19, 21-24), especially since Brady's form is now represented by a lectotype. We believe that *Globigerinoides quadrilobatus* (d'Orbigny) is morphologically distinct from both *Globigerinoides quadrilobatus sacculifer* (Brady) and *G. quadrilobatus trilobus* (Reuss) and that its recognition is important in the understanding of the phylogeny of these forms. The phylogeny of this group has already been covered in part by us (*loc. cit.*), is dealt with in further detail in another work (Eames, *et al.*, 1962), and *G. quadrilobatus* (*s. s.*) is shown to be the progenitor of the two other forms mentioned above.

2. *Rotalina cultrata* d'Orbigny, 1839.

We do see why the neotype of *R. cultrata* d'Orbigny cannot reasonably be said to conform with either d'Orbigny's description or his intentions. Todd (*op. cit.*, p. 122) quotes d'Orbigny (1839, p. 76) in the belief that his vernacular "légèrement pointillée" means either "a punctate or hispid wall surface." As d'Orbigny (*loc. cit.*) had already given the formal diagnosis "Testa ovali, depressissima, punctata . . . . " with no mention of hispidity or surface rugosity, the fact that the test of *R. cultrata* was believed by d'Orbigny to be perforate (probably weakly so) but not markedly hispid seems very likely. This agrees with the neotype (Banner and Blow, 1960, pp. 34-5). When d'Orbigny believed that a test was rugose he said so (d'Orbigny, 1839, p. 97, for *Rosalina candeina*: "rugosa"; "rugueuse," "tuberculées") and when he described *Truncatulina advena* (which, as Todd says, is illustrated in a manner which suggests it has a wall similar to that of *Rotalina cultrata*) he stated (p. 87) that the test was marked by "très petits points" — which, to us, means "very finely perforate." It is clear, however, from the examples quoted by Todd, that d'Orbigny's illustrations are not always wholly reliable, for his figures of *Rotalina sagra* (1839, pl. 5, figs. 13-15) show no perforations at all, even though authors have assigned this species to the perforate genus *Cancris* (see Barker, 1960, p. 218).

The neotype is bigger than the specimen measured by d'Orbigny as Todd points out (*op. cit., loc. cit*). The samples from the Recent sands off Cuba, from amongst which the neotype was selected, show, as do many other Recent samples, that specimens identical in their structure and proportions range in size from 0.3 mm. or less to 1.0 mm. or more in diameter. From study of both fossil and Recent assemblages, we concluded that a relatively large test, probably representing a fully-grown individual, would more fully and clearly represent the characteristic morphology of the species for which the neotype was intended — for which, we believe, a name was intended by d'Orbigny. The neotype conforms fully with d'Orbigny's formal diagnosis, which continues: "carinata, cultrata, supra subcomplanata, subtus convexiuscula; spira subplana, anfractibus duobus limbatis; loculis sex ovatis, contectis, supra limbatis" (d'Orbigny, 1839, p. 76); it also, we believe, agrees well with the original illustrations (*op. cit.*, pl. 5, figs. 7-9), and we know of no other Recent species which does so.

"Rotalia (Rotalie) menardii" was *nomen nudum* in d'Orbigny, 1826 (p. 273, list No. 26); as we have already pointed out (1960, pp. 31-3), the name never possessed taxonomic availability, or, for that matter, biological meaning. D''Orbigny's 1826 publication was, most clearly, an attempt to classify the foraminifera, merely giving lists of examples for his families, in the same way as his later "Prodrome" (1852) was a synthesis for stratigraphers. Many of the 1826 names, including *"Rotalia (Rotalie) menardii,"* were never validly published, or described, or even used again by d'Orbigny. It is clear that, if *"Rotalia menardii* d'Orbigny, 1826" were valid, it would not be necessary to seek plenary powers to suppress the junior name *Rotalina cultrata* d'Orbigny, 1839, in its favour.

The taxon which must be considered is *Rotalia menardii* Parker, Jones and Brady, 1865, which is now described on the basis of a selected lectotype (Banner and Blow, 1960, p. 31, pl. 6). Both Todd and ourselves consider that *Globorotalia menardii* (Parker, Jones and Brady) and *G. cultrata* (d'Orbigny) are conspecific, but we do not believe them to be fully synonymous, for two reasons. First, *G. cultrata* (*s. s.*) is not known to occur beneath the Upper Miocene (Sarmatian), and studies of large collections of rich samples from Papua, Venezuela, Sicily, Trinidad, etc., confirm this. *G. cultrata menardii* is known to evolve and become distinct in the uppermost Burdigalian (Lower Miocene) (Bolli, 1957, pp. 99, 102, 120; Blow, 1959, pp. 98, 215; Banner and Blow, 1960, p. 28). If the two forms are merely variants, then there is no reason why they should not always have been contemporaries. Second, Waller and Polski (1959) have stated that the two forms have different ecological restriction in Recent seas. Consequently, we have good reason to believe that *G. cultrata cultrata* (d'Orbigny) is a distinguishable genetic entity, of stratigraphical and ecological significance, and should be taxonomically distinguished from its ancestor, *G. cultrata menardii* (Parker, Jones and Brady).

REFERENCES

(Additional to those given in Banner and Blow 1960, *q. v.*)

BANNER, F. T., and BLOW, W. H., 1960, Some primary types of species belonging to the superfamily Globigerinaceae: Cushman Found. Foram. Research, Contr., v. 11, pt. 1, pp. 1-41, pls. 1-8, figs. 1, 2. (*cum. bibl.*).

BARKER, R. W., 1960, Taxonomic notes on the species figured by H. B. Brady in his report on the foraminifera dredged by H. M. S. *Challenger* during the years 1873-1876. Soc. Econ. Paleontologists and Mineralogists, Spec. Pub. No. 9, 238 pp., 115 pls.

EAMES, F. E., BANNER, F. T., BLOW, W. H., and CLARKE, W. J., 1962, Fundamentals of mid-Tertiary stratigraphical correlation. Cambridge Univ. Press, 160 pp., 17 pls., 23 figs.

D'ORBIGNY, A., 1852, Prodrome de palaéontologie stratigraphique universelle des animaux mollusques et rayonnés. V. Masson, Paris. Vol. 3, 196 pp.

TODD, R., 1961, On selection of lectotypes and neotypes: Cushman Found. Foram. Research, Contr., v. 12, pt. 4, pp. 121-2.

WALLER, H. O., and POLSKI, W., 1959, Planktonic foraminifera of the Asiatic shelf: Cushman Found. Foram. Research, Contr., v. 10, pp. 123-6, pl. 10, figs. 1, 2.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XIII, PART 3, JULY, 1962

251. A REVIEW OF THE PLANKTONIC FORAMINIFERA FROM THE UPPER CRETACEOUS OF CALIFORNIA

JOSEPH J. GRAHAM
School of Mineral Sciences, Stanford University

ABSTRACT

A summary report is given of the pertinent data thus far published on California Late Cretaceous planktonic Foraminifera. This includes a sequential recording of these open-sea floating forms from both surface and subsurface strata, reproductions of the original illustrations of the fossils as well as a tabulation of their areal distribution and chronological position within this division of geologic time, a compilation of the synonymies of various species, and a list of bibliographic references.

The earliest report on planktonic Foraminifera from what are now considered to be Upper Cretaceous [Cenomanian] strata in California is that by A. C. Lawson in 1895.[1] Sometime before, Lawson had prepared a number of sections from the limestone in the Franciscan rocks and submitted them to Charles Schuchert of the United States National Museum for examination. Schuchert reported that on the basis of undeformed tests of the genera *Globigerina* and *Orbulina,* as well as two benthonic forms, *Rotalia* and *Textularia,* "it seems to be more reasonable to suppose the age of the limestone to be Mesozoic or Cenozoic rather than Paleozoic." However, Charles D. Walcott of the United States Geological Survey after studying the same sections was a little more specific in his time designation, stating that he thought the association of these fossils indicated an age not earlier (older) than Cretaceous. Lawson himself was of the opinion that the Franciscan rocks, of which the foraminiferal limestones were an integral part, "belonged with great probability to either the Cretaceous or Jurassic." He also mentioned that at an earlier date and on the basis of rather questionable evidence J. D. Whitney and G. F. Becker had concluded the series was of Cretaceous age.

In the years that followed most stratigraphers working in the Coast Ranges assigned the Franciscan rocks for one reason or another to the Upper Jurassic, and it was not until 1942 — on the occasion of the more detailed foraminiferal studies of Hans E. Thalmann (1942) — that the Cretaceous age of the limestone portion of the series was finally confirmed. (It should be pointed out here that there is some question as to the identification of the forms referred by Schuchert to *Orbulina;* most authorities on planktonic Foraminifera believe that the genus does not occur in pre-Miocene strata anywhere in the world.)

Not until 1929, however, were planktonic Foraminifera first specifically identified from deposits of Cretaceous age in California (J. A. Cushman and C. C. Church—Some Upper Cretaceous Foraminifera from near Coalinga, California: Proc. Calif. Acad. Sci., 4th ser., vol. 18, no. 16, pp. 497-530). These fossils—*Globotruncana arca* (Cushman) and *Ventilabrella ornatissima* Cushman and Church n. sp. from Fresno County —were among the 43 species obtained from the "Chico shale" at the 1135-foot level of the California Northern Petroleum Company well #19 in the Alcalde Hills, west of Coalinga. Thirteen years later, 1942, Thalmann (*Globotruncana* in the Franciscan limestone, Santa Clara County, California: Geol. Soc. America, Bull., vol. 53, no. 12, pt. 2, p. 1838) recognized single- and double-keeled foraminifers — *Globotruncana* sp. aff. *G. appenninica* Renz and *G. linneiana* (d'Orbigny) respectively — in the Permanente Quarry [Cupertino quadrangle] about five miles south of Los Altos. As previously stated, the presence of these latter species in the aforementioned Franciscan unit definitely placed it in the Upper Cretaceous (not older than Turonian and not younger than Santonian according to Thalmann). Thalmann was also of the opinion that the Permanente limestone "probably represents the correlative of the Calera limestone member of the Franciscan as mapped in the San Francisco folio." A year later (1943) the same author (Upper Cretaceous age of the "Franciscan" limestone near Laytonville, Mendocino County, California: Geol. Soc. America, Bull., vol. 54, no. 12, p. 1827) disclosed the presence of *Globotruncana renzi* Gandolfi, *Globigerina cretacea* d'Orbigny, and a small *Gümbelina* sp. in a slightly siliceous "Franciscan" limestone cropping out east of the Redwood Highway in the northern part of the state. He regarded the Laytonville outcrop as a synchronous [Turonian Stage] deposit of the Calera limestones of the Permanente Cement Company, Santa Clara County, and of the Calera Limestone at its type locality in Calera Valley, San Mateo County. (Later Thalmann, *in* Irwin 1957 —Franciscan Group in Coast Ranges and its equivalents in Sacramento Valley, California: Am. Assoc. Petroleum Geologists, vol. 41, no. 10, pp. 2284-2297— stated that the Calera is Cenomanian rather than Turonian in age, the Permanente Calera Limestone with its planktonic foraminiferal assemblage *Rotalipora-Schackoina-Globigerina-Praeglobotruncana* of the *delrioensis* type is "clearly and undoubtedly Cenomanian in age . . . [and] Other bodies of limestone nearby, as well as the limestone near Laytonville, con-

1 Lawson, A. C., Sketch of the geology of the San Franciscan Peninsula: Fifteenth Ann. Rept., 1893-94, U. S. Geol. Surv., pp. 399-476, pls. 5-12. **Also see:** A contribution to the Geology of the Coast Ranges, by this same author, **in** American Geologist, vol. 15, pp. 342-356, 1895.

tain tests of the genera *Ticinella* sp., *Thalmanninella* sp., and *Globigerina* sp., of the *washitensis* group, and [that] this small assemblage is typical for Upper Albian to basal Cenomanian."

Then in chronological order are the following additional publications on California Cretaceous planktonic Foraminifera:

1943. I. F. WILSON — Geology of the San Benito Quadrangle, California: Geol. Soc. America, Bull., vol. 52, no. 12, pt. 2, p. 1960.

Globotruncana arca (Cushman) and *Ventilabrella ornatissima* Cushman and Church, together with numerous calcareous benthonic species, are recorded from the Butts Ranch Shale (Panoche Group) in San Benito County.

1944. L. G. HERTLEIN and U. S. GRANT IV — The geology and paleontology of the marine Pliocene of San Diego, California: Mem. San Diego Soc. Nat. Hist., vol. 2, pt. 1, Geol., 72 p.

Globotruncana arca (Cushman) was identified in an assemblage of ten species from near the middle of an Upper Cretaceous outcrop at the south end of Point Loma, San Diego County.

1944. J. A. CUSHMAN and P. P. GOUDKOFF — Some Foraminifera from the Upper Cretaceous of California: Contr. Cushman Lab. Foram. Research, vol. 20, pt. 3, pp. 53-64, pls. 9-10.

Globotruncana canaliculata (Reuss) is noted and illustrated from Moreno Gulch, Fresno County.

1944. A. S. CAMPBELL and B. L. CLARK — Radiolaria from the Upper Cretaceous of middle California: Geol. Soc. America, Spec. Papers 57, viii + 61 p.

Globigerina cf. *G. triloba* Reuss and *Globotruncana arca* (Cushman) are listed from the upper portion of the "Coral Hollow" shales [now termed Moreno Grande] of the Tesla area, Alameda County.

1945. P. P. GOUDKOFF — Stratigraphic relations of Upper Cretaceous in Great Valley, California: Am. Assoc. Petroleum Geologists, Bull., vol. 29, no. 7, pp. 956-1007.

Four planktonic species are mentioned among the 67 Foraminifera recorded from various zones: *Globotruncana arca* (Cushman), ranging from the D-1 zone to G-1 and with "characteristic occurrence" in zones D-2 and E; *Globotruncana canaliculata* (Reuss), with an F-1 to G-2 zonal range and a "characteristic occurrence" in F-1, F′-1 and F-2; *Guembelina globulosa* (Ehrenberg), with a D-2 to G-1 range and a "characteristic occurrence" in the F′-1 zone; and *Ventilabrella ornatissima* Cushman and Church with a D-2 to G-1 range and a "characteristic occurrence" in D-2 only.

1948. A. S. HUEY — Geology of the Tesla Quadrangle, California: State of California, Div. Mines Bull. 140, 75 p.

Globotruncana arca (Cushman) is recorded from the Upper Cretaceous Moreno Grande Formation near Tesla in Alameda County. (This species was previously registered (1944) by Campbell and Clark.)

1948. J. A. CUSHMAN and RUTH TODD — A foraminiferal fauna from the New Almaden district, California: Contr. Cushman Lab. Foram. Research, vol. 24, pt. 4, pp. 90-98, pl. 16.

Globigerina almadenensis, Globorotalia california, G. decorata, G. almadenensis, and *Planomalina ? almadenensis* — all new species — and two other floating forms as well, *Globigerina* sp. and *Hastigerinella* sp., were found in limestones or within the crumbly material near the contact of the Calera Limestone and the greenstone tuffs of the Franciscan Group in Santa Clara County. (See Synonymic List in the present paper for taxonomic changes.)

1949. M. F. GLAESSNER — Foraminifera of Franciscan (California): Am. Assoc. Petroleum Geologists, Bull., vol. 33, no. 9, pp. 1615-1617.

The resemblance of the following planktonic species from the New Almaden district, California (see Cushman and Todd, 1948) to forms from the Albian and Cenomanian of the Alps is recognized: *Hastigerinella* sp. to *Schackoina pentagonalis* Reichel, *Globigerina almadenensis* Cushman and Todd and *"Anomalina" roberti* Gandolfi, *"Globorotalia" californica* Cushman and Todd to the group of *Globotruncana ticinensis* Gandolfi, *Globotruncana decorata* Cushman and Todd to another type of the group of *G. ticinensis* Gandolfi and close to *G. delrioensis* (Plummer) and *G. ticinensis* var. Gandolfi, *G. almadenensis* Cushman and Todd to *Rotalipora cushmani* (Morrow) var. *evoluta* Sigal, and *Planomalina ? almadenensis* Cushman and Todd to *"Planulina" buxtorfi* of Gandolfi.

1951. O. L. BANDY — Upper Cretaceous Foraminifera from the Carlsbad area, San Diego County, California: Jour. Paleontology, vol. 25, no. 4, pp. 488-513, pls. 72-75.

Globigerinella aspera (Ehrenberg), *Globotruncana arca* (Cushman), *G. canaliculata* (Reuss), *G. rosetta* (Carsey), and *Gümbelina striata* (Ehrenberg) are described and figured from among 56 Campanian species and varieties.

1951. B. M. PAGE, J. G. MARKS, and G. W. WALKER — Stratigraphy and structure of mountains northeast of Santa Barbara, California: Am. Assoc. Petroleum Geol. Bull., vol. 35, no. 8, pp. 1727-1780.

Globotruncana arca (Cushman) is listed in an assemblage of eleven species from the Upper Cretaceous Debris Dam Sandstone and among the thirteen species of the Upper Cretaceous (approximately upper Senonian or Maastrichtian) Pendola Formation.

1951. M. B. PAYNE — Type Moreno Formation and overlying Eocene strata on the west side of the San Joaquin Valley, Fresno and Merced counties, California: State of California, Dept. Nat. Res., Special Rept. 9, 29 p.

Globotruncana arca (Cushman) is present in the middle and the upper 5,000 feet of the Panoche Group and *G. conica* White in the Dosados Shale, Tierra Loma Shale, and the Marca Shale of the Moreno Formation.

1952. C. C. Church — Cretaceous Foraminifera from the Franciscan Calera Limestone of California: Contr. Cushman Found. Foram. Research, vol. 3, pt. 2, pp. 68-70, text-figs. 1-2.

Globotruncana (Rotalipora) appenninica Renz var. *typica* Gandolfi, *Globotruncana (G.) stephani* Gandolfi var. *turbinata* Reichel, and *Schackoina cenomana* (Schacko) are figured or mentioned from the type Calera Limestone at Rockaway Beach, San Mateo County.

1953. C. F. Green in L. I. Briggs — Geology of the Ortigalita Peak Quadrangle, California: State of California, Div. Mines, Bull. 167, 61 p.

Globotruncana arca (Cushman), *Globigerina cretacea* d'Orbigny, and *Guembelina globulosa* (Ehrenberg) occur among the sixteen species from the Moreno Shale of the Dog Leg Creek area, Merced County.

1954. M. L. Natland and W. T. Rothwell, Jr. — Fossil Foraminifera of the Los Angeles and Ventura regions, California: State of California, Dept. Nat. Res., Bull. 170, Chapter 3, pp. 33-42.

Globotruncana arca (Cushman) is designated as one of the characteristic Cretaceous species of the Ventura Basin, the Santa Ana Mountains, and San Diego County.

1955. Klaus Küpper — Upper Cretaceous Foraminifera from the "Franciscan Series" New Almaden district, California: Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, pp. 112-118, 123, pl. 18.

Globotruncana (Rotalipora) globotruncanoides Sigal, *G. (Rotalipora) appenninica appenninica* (Renz), *G. (Rotalipora) evoluta* Sigal, *G. (Thalmanninella)* sp., *G. (Rotundina) aumalensis* (Sigal), *G. (Rotundina) stephani stephani* (Gandolfi), *G. (Rotundina) california* (Cushman and Todd), *Planomalina buxtorfi* (Gandolfi), and *Globigerina* sp. are figured and described from early or medial Cenomanian strata in Santa Clara County. (See this paper for nomenclatural changes of several of the pelagic species recorded by Cushman and Todd (1948) and by Church (1952) from the Cretaceous of the New Almaden district and the type area of the Franciscan Calera Limestone respectively.)

1956. Klaus Küpper — Upper Cretaceous pelagic Foraminifera from the "Antelope shale," Glenn and Colusa counties, California: Contr. Cushman Found. Foram. Research, vol. 7, pt. 2, pp. 40-47, pl. 8, 1 text-fig.

Globotruncana (Praeglobotruncana) stephani (Gandolfi) *turbinata* (Reichel), *G. (Praeglobotruncana) renzi primitiva* n. subsp., *Globotruncana* n. sp. indet., *Schackoina* sp. cf. *S. gandolfi* Reichel, and *S. cenomana* (Schacko) *bicornis* Reichel are recorded and illustrated from Upper Cenomanian rocks from northern California strata. (Also see this paper for nomenclatural changes of several of the species listed by Church (1952) from the type locality of the Calera Limestone.

1956. Paul Brönnimann and N. K. Brown, Jr. — Taxonomy of the Globotruncanidae: Eclogae geol. Helv., vol. 48, no. 2, pp. 503-561.

Globotruncana (Rotundina) aumalensis (Sigal) and *G. (Rotundina) stephani stephani* (Gandolfi) of Küpper (1955) are placed in the synonymy of *Praeglobotruncana delrioensis* (Plummer).

1959. H. E. Thalmann — New names for foraminiferal homonyms — IV: Contr. Cushman Found. Foram. Research, vol. 10, pt. 4, pp. 130-31.

Globotruncana küpperi, new name, is proposed for *Globotruncana (Praeglobotruncana) renzi* Gandolfi and Thalmann subsp. *primitiva* Küpper, 1956, from the Upper Cenomanian "Antelope shale."

1959. J. J. Graham and C. C. Church — Upper Cretaceous Foraminifera from Stanford University Campus, California: Geol. Soc. America, Bull., vol. 70, no. 12, pt. 2, pp. 1610-11.

Globotruncana arca (Cushman), *G. elevata stuartiformis* Dalbiez, and *G. fornicata* Plummer are among the important stratigraphic markers of the Campanian siltstone cropping out beneath the Willow Road bridge over San Francisquito Creek in Santa Clara County.

1960. E. F. Trujillo — Upper Cretaceous Foraminifera from near Redding, Shasta County, California: Jour. Paleontology, vol. 34, no. 2, pp. 290-346, pls. 43-50, 3 text-figs.

Praeglobotruncana hansbolli, Rugoglobigerina kingi, and *R. praehelvetica* — new species — are described and illustrated, and *Globotruncana canaliculata* (Reuss), *G. helvetica* Bolli, *G. linneiana* (d'Orbigny), *G. renzi* Gandolfi, *G. schneegansi* Sigal, and *Heterohelix globulosa* (Ehrenberg) are recorded from middle Turonian, Coniacian, and Santonian outcrops in northern California.

1960. O. T. Marsh — Geology of the Orchard Peak area, California: California Div. Mines, Special Rept. 62, 42 p.

Globorotalia [= *Globorotalites*] cf. *G. micheliniana* (d'Orbigny) is noted from the Upper Jurassic [? Late Cretaceous] Hex Formation of Kern County.

1960. J. J. Graham and D. K. Clark — *Lacosteina paynei,* a new species from the Upper Cretaceous of California: Contr. Cushman Found. Foram. Research, vol. 11, pt. 4, pp. 115-116, 1 fig., 1 pl.

"Globigerinella" aspera (Ehrenberg), *Globotruncana arca* (Cushman), *Heterohelix globulosa* (Ehrenberg), *Pseudoguembelina excolata* (Cushman) and *Rugoglobigerina rugosa* (Plummer) are reported from

the Maastrichtian Uhalde and Moreno formations of Fresno County.

1961. A. R. LOEBLICH, JR., and HELEN TAPPAN — Cretaceous planktonic Foraminifera: Part I - Cenomanian: Micropaleontologist, vol. 7, no. 3, pp. 257-304, pls. 1-8.

Praeglobotruncana stephani (Gandolfi), *Rotalipora cushmani* (Morrow), *R. greenhornensis* (Morrow), and *Schackoina cenomana* (Schacko) are recorded and except for *Schackoina cenomana* are figured from the middle to upper Cenomanian of the Fruto Quadrangle, Glenn County, and *Hedbergella trocoidea* (Gandolfi), *Planomalina buxtorfi* (Gandolfi), *Praeglobotruncana stephani* (Gandolfi), and *Rotalipora greenhornensis* (Morrow) are mentioned as occurring in the middle to late Cenomanian strata of the New Almaden district. (Also see this paper for nomenclatural changes of some of the planktonic species recorded by Cushman and Todd (1948), Church (1952), Küpper (1955; 1956), and Brönnimann and Brown (1956).

1961. J. J. GRAHAM and D. K. CLARK — New evidence for the age of the G-1 zone in the Upper Cretaceous of California: Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, pp. 107-114, 2 text-figs., 1 pl.

"Globigerinella" aspera (Ehrenberg), *Globotruncana fornicata* Plummer, *G. linneiana* (d'Orbigny), *G. linneiana tricarinata* (Quereau), *G.* aff. *G. paraventricosa* Hofker, *G. ventricosa* White, *Heterohelix striata* (Ehrenberg), *Heterohelix* sp., *Pseudotextularia elegans* (Rzehak), *Rugoglobigerina* aff. *R. ordinaria* Subbotina, and *R. rugosa* (Plummer) are illustrated from the Campanian portion of the Panoche Formation, San Luis Creek Quadrangle, Merced County.

It is interesting to note that several planktonic foraminiferal species have been observed in strata of Maastrichtian age in California but no formal descriptions and illustrations of these fossils have been published to date.

Acknowledgments.—The writer wishes to thank the Shell Companies Foundation for a grant-in-aid toward publication of this review and Alfred R. Loeblich, Jr., California Research Corporation, La Habra, Helen Tappan Loeblich, University of California at Los Angeles, and Agustín Ayala Castañares of Mexico City for data on the taxonomy of several species.

CALIFORNIA UPPER CRETACEOUS PLANKTONIC FORAMINIFERA — their bibliographic references, age designations, and synonyms.

1. *Clavihedbergella simplex* (Morrow). LOEBLICH and TAPPAN, 1961, Micropaleontologist, vol. 7, no. 3, p. 279 (middle to late Cenomanian).
   ?*Hastigerinella* sp. CUSHMAN and TODD, 1948, Contr. Cushman Lab. Foram. Research, vol. 24, pt. 4, p. 98, pl. 16, fig. 20 (Early Cretaceous).
   Schackoina sp. cf. *S. gandolfi* Reichel. Küpper, 1956, Contr. Cushman Found. Foram. Research, vol. 7, pt. 2, p. 44, pl. 8, figs. 4a-c (late Cenomanian).
2. [?] *Globigerina* sp. CUSHMAN and TODD, 1948, Contr. Cushman Lab. Foram. Research, vol. 24, pt. 4, p. 96, pl. 16, fig. 17 (Early Cretaceous).
3. *"Globigerinella" aspera* (Ehrenberg). BANDY, 1951, Jour. Paleontology, vol. 25, no. 4, p. 508, pl. 75, figs. 3a-c (Campanian); GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 113, pl. 5, figs. 6a-c (Campanian). Some micropaleontologists place this species in the genus *Planomalina* Loeblich and Tappan, 1946.
4. *"Globotruncana arca* (Cushman)." CUSHMAN and CHURCH, 1929, Proc. Calif. Acad. Sci., Fourth ser., vol. 18, no. 16, p. 518, pl. 41, figs. 1-3 (Late Cretaceous).
5. *Globotruncana arca* (Cushman). BANDY, 1951, Jour. Paleontology, vol. 25, no. 4, p. 509, pl. 75, figs. 1a-c (Campanian).
6. *Globotruncana canaliculata* (Reuss). TRUJILLO, 1960, Jour. Paleontology, vol. 34, no. 2, p. 341, pl. 50, figs. 2a-c (Coniacian).
   [*Non*] *Globotruncana canaliculata* Reuss *in* BANDY, 1951, Jour. Paleontology, vol. 25, no. 4, p. 509, pl. 75, figs. 2a-c (Campanian).
   [*Non*] *Globotruncana canaliculata* (Reuss) *in* CUSHMAN and GOUDKOFF, 1944, Contr. Cushman Lab. Foram. Research, vol. 20, pt. 3, p. 62, pl. 10, figs. 10a-b (Late Cretaceous).
7. *Globotruncana fornicata* Plummer. GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 112, pl. 5, figs. 10a-c (Campanian).
8. *Globotruncana helvetica* Bolli. TRUJILLO, 1960, Jour. Paleontology, vol. 34, no. 2, pp. 341-342, pl. 50, figs. 2a-c (middle Turonian).
9. *Globotruncana linneiana* (d'Orbigny). TRUJILLO, 1960, Jour. Paleontology, vol. 34, no. 2, pp. 342-343, pl. 49, figs. 8a-c (middle Turonian - Coniacian - Santonian); GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 111, pl. 5, figs. 11a-c (Campanian).
   ?*Globotruncana canaliculata* (Reuss). CUSHMAN and GOUDKOFF, 1944, Contr. Cushman Lab. Foram. Research, vol. 20, pt. 3, p. 62, pl. 10, figs. 10a-b (Late Cretaceous).
   ?*Globotruncana canaliculata* (Reuss). BANDY, 1951, Jour. Paleontology, vol. 25, no. 4, p. 509, pl. 75, figs. 2a-c (Campanian).
10. *Globotruncana linneiana tricarinata* (Quereau). GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 112, pl. 5, figs. 8a-c (Campanian).

TABLE 1

Distribution of Planktonic Foraminifera in the Upper Cretaceous of California (only illustrated and described species are listed)	Middle to Late Cenomanian				Middle Turonian	Coniacian	Santonian	Campanian			
	I	II	III	IV	V			VI	VII	VIII	IX
	New Almaden district, Santa Clara County	Clark Valley, Glenn County	San Mateo County	Glenn and Colusa Counties	Near Redding, Shasta County. Numbers correspond to those in species list			Merced County	Carlsbad Area, San Diego County	Moreno Gulch, Fresno County	Coalinga Area, Fresno County
1. *Clavihedbergella simplex* (Morrow) — 5, 10*	1			1							
2. [?]*Globigerina* sp. Cushman and Todd — 5	2										
3. "*Globigerinella*" *aspera* (Cushman) — 1, 7								3	3		
4. "*Globotruncana arca* (Cushman)" — 3											4
5. *Globotruncana arca* (Cushman) — 1									5		
6. *Globotruncana canaliculata* (Reuss) — 18						6					
7. *Globotruncana fornicata* Plummer — 7								7			
8. *Globotruncana helvetica* Bolli — 17					8						
9. *Globotruncana linneiana* (d'Orbigny) — 7, 17					9	9	9	9	?9	?9	
10. *Globotruncana linneiana tricarinata* (Quereau) — 7								10			
11. *Globotruncana* aff. *G. paraventricosa* Hofker — 7								11			
12. *Globotruncana renzi* Gandolfi — 17					12						
13. *Globotruncana rosetta* (Carsey) — 1									13		
14. *Globotruncana schneegansi* Sigal — 17					14						
15. *Globotruncana ventricosa* White — 7								15			15
16. *Gublerina ornatissima* (Cushman and Church) — 3, 13											
17. *Hedbergella brittonensis* Loeblich and Tappan — 9, 11	17										
18. *Hedbergella trocoidea* (Gandolfi) — 5, 11	18					18					
19. *Heterohelix globulosa* (Ehrenberg) — 17											
20. *Heterohelix striata* (Ehrenberg) — 1, 7								20	20		
21. *Heterohelix* sp. — 6								21			
22. *Planomalina buxtorfi* (Gandolfi) — 5, 9, 11	22										
23. *Praeglobotruncana hansbolli* Trujillo — 17						23					
24. *Praeglobotruncana stephani* (Gandolfi) — 2, 9, 10, 11	24	24	24	24							
25. *Pseudotextularia elegans* (Rzehak) — 7								25			
26. *Rotalipora cushmani* (Morrow) — 12		26									
27. *Rotalipora evoluta* Sigal — 2, 5, 9, 11	27		27								
28. *Rotalipora greenhornensis* (Morrow) — 5, 9, 10, 11	28	28		28							
29. *Rugoglobigerina kingi* Trujillo — 17						29					
30. *Rugoglobigerina* aff. *R. ordinaria* Subbotina — 7								30			
31. *Rugoglobigerina praehelvetica* Trujillo — 17					31						
32. *Rugoglobigerina rugosa* (Plummer) — 7								32			
33. *Schackoina multispinata* (Cushman and Wickenden) — 10, 11				33							
34. *Ticinella aprica* Loeblich and Tappan — 11	34										

* Numbers following species names refer to publications in Bibliography.

11. *Globotruncana* aff. *G. paraventricosa* Hofker. GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 112, pl. 5, figs. 7a-c (Campanian).

12. *Globotruncana renzi* Gandolfi. TRUJILLO, 1960, Jour. Paleontology, vol. 34, no. 2, p. 343, pl. 50, figs. 3-4a-c (middle Turonian).

13. *Globotruncana rosetta* (Carsey). BANDY, 1951, Jour. Paleontology, vol. 25, no. 4, pp. 509-510, pl. 75, figs. 4a-c (Campanian).

14. *Globotruncana schneegansi* Sigal. TRUJILLO, 1960, Jour. Paleontology, vol. 34, no. 2, p. 343-344, pl. 49, figs. 9a-c (middle Turonian).

15. *Globotruncana ventricosa* White. GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 112, pl. 5, figs. 9a-c (Campanian).

16. *Gublerina ornatissima* (Cushman and Church). MONTANARO GALLITELLI, 1957, U. S. Nat. Mus. Bull. 215, pp. 140-141, pl. 32, figs. 6a-b only (Late Cretaceous).

    Ventilabrella ornatissima CUSHMAN and CHURCH, 1929, Proc. Calif. Acad. Sci., Fourth ser., vol. 18, no. 16, p. 512, pl. 39, figs. 12-15 (Late Cretaceous).

17. *Hedbergella brittonensis* LOEBLICH and TAPPAN, 1961, The Micropaleontologist, vol. 7, no. 3, p. 274 (middle to late Cenomanian).

    Globigerina sp. Küpper, 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, p. 117, pl. 18, figs. 9a-c (early or middle Cenomanian).

18. *Hedbergella trocoidea* (Gandolfi). LOEBLICH and TAPPAN, 1961, The Micropaleontologist, vol. 7, no. 3, p. 277 (middle to late Cenomanian).

    Globigerina almadenensis CUSHMAN and TODD, 1948, Contr. Cushman Lab. Foram. Research, vol. 24, pt. 4, pp. 95-96, pl. 16, figs. 18-19 (Early Cretaceous).

19. *Heterohelix globulosa* (Ehrenberg). TRUJILLO, 1960, Jour. Paleontology, vol. 34, no. 2, p. 344, pl. 50, figs. 10a-b (Coniacian).

20. *Heterohelix striata* (Ehrenberg). GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 109, pl. 5, figs. 4a-b (Campanian).

    Gümbelina striata (Ehrenberg). BANDY, 1951, Jour. Paleontology, vol. 25, no. 4, p. 510, pl. 75, figs. 8-9a-b (Campanian).

21. *Heterohelix* sp. GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 109, pl. 5, figs. 3a-b (Campanian).

22. *Planomalina buxtorfi* (Gandolfi). KÜPPER, 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, p. 117, pl. 18, figs. 8a-b (early or middle Cenomanian); LOEBLICH and TAPPAN, 1961, The Micropaleontologist, vol. 7, no. 3, p. 269 (middle to late Cenomanian).

    Planomalina ? almadenensis CUSHMAN and TODD, 1948, Contr. Cushman Found. Foram. Research, vol. 24, pt. 4, p. 98, pl. 16, figs. 25a-b (Early Cretaceous).

23. *Praeglobotruncana hansbolli* TRUJILLO, 1960, Jour. Paleontology, vol. 34, no. 2, p. 339, pl. 49, figs. 7a-c (middle to late Cenomanian).

24. *Praeglobotruncana stephani* (Gandolfi). LOEBLICH and TAPPAN, 1961, The Micropaleontologist, vol. 7, no. 3, p. 284, pl. 6, figs. 3a-c (middle to late Cenomanian).

    Globorotalia californica CUSHMAN and TODD, 1948, Contr. Cushman Lab. Foram. Research, vol. 24, pt. 4, p. 96, pl. 16, fig. 22-23 (Early Cretaceous).

    Globotruncana (Globotruncana) stephani Gandolfi var. *turbinata* Reichel, BOLLI *in* CHURCH, 1952, Contr. Cushman Found. Foram. Research, vol. 3, pt. 2, p. 69, text-fig. 1, bottom (early or middle Late Cretaceous).

    Globotruncana (Rotundina) aumalensis (Sigal). KÜPPER, 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, p. 116, pl. 18, figs. 5a-c (early or middle Cenomanian).

    Globotruncana (Rotundina) stephani stephani (Gandolfi). KÜPPER, 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, p. 116, pl. 18, figs. 6a-c (early or middle Cenomanian).

    Globotruncana (Praeglobotruncana) stephani (Gandolfi) *turbinata* (Reichel). KÜPPER, 1956, Contr. Cushman Found. Foram. Research, vol. 7, pt. 2, p. 43, pl. 8, figs. 1a-c (late Cenomanian).

    Globotruncana (Praeglobotruncana) renzi (Thalmann and Gandolfi) subsp. *primitiva* KÜPPER, 1956, Cushman Found. Foram. Research, vol. 7, pt. 2, p. 43, pl. 8, figs. 2a-c (late Cenomanian).

    Globotruncana küpperi Thalmann, new name for *Globotruncana (Praeglobotruncana) renzi* (Thalmann and Gandolfi) subsp. *primitiva* Küpper, 1956. THALMANN, 1959, Contr. Cushman Found. Foram. Research, vol. 10, pt. 4, p. 130.

25. *Pseudotextularia elegans* (Rzehak). GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 111, pl. 5, figs. 5a-b (Campanian).

26. *Rotalipora cushmani* (Morrow). LOEBLICH and TAPPAN, 1961, Micropaleontologist, vol. 7, no. 3, p. 297, pl. 8, figs. 5a-c (middle to late Cenomanian).

27. *Rotalipora evoluta* Sigal. LOEBLICH and TAPPAN, 1961, Micropaleontologist, vol. 7, no. 3, p. 298 (middle to late Cenomanian).

    Globorotalia almadenensis CUSHMAN and TODD,

EXPLANATION OF PLATE 19

(figures reproduced from the original sources)

FIGS. PAGE

1A-1B. *Clavihedbergella simplex* (Morrow) of LOEBLICH and TAPPAN, 1961 ... 103
1Aa-c. "*Schackoina* sp. cf. *S. gandolfi* Reichel" of KÜPPER, 1956. × 52.5. 1Aa, umbilical view; 1Ab, edge view; 1Ac, spiral view. Late Cenomanian, Glenn County.
1B. [?]*Hastigerinella* sp. of CUSHMAN and TODD, 1948. × 19. Side view. Middle to late Cenomanian, New Almaden district.

2. [?]*Globigerina* sp. CUSHMAN and TODD, 1948. × 19. Spiral view. Middle to late Cenomanian, New Almaden district ... 103

3A-3B. "*Globigerinella*" *aspera* (Ehrenberg). ... 103
3Aa-c. *Globigerinella aspera* (Ehrenberg) of BANDY, 1951. × 60. 3Aa, dorsal view; 3Ab, edge view; 3Ac, ventral view. Campanian, Carlsbad area.
3Ba-c. "*Globigerinella*" *aspera* (Ehrenberg) of GRAHAM and CLARK, 1961. × 60. 3Ba, spiral view; 3Bb, edge view; 3Bc, umbilical view. Campanian, Merced County.

4. "*Globotruncana arca* (Cushman)" of CUSHMAN and CHURCH, 1929. × 30. 4a, umbilical view; 4b, edge view; 4c, spiral view. Campanian, near Coalinga. ... 103

5. *Globotruncana arca* (Cushman) of BANDY, 1951. × 25. 5a, spiral view; 5b, edge view; 5c, umbilical view. Campanian, Carlsbad area. ... 103

6. *Globotruncana canaliculata* (Reuss) of TRUJILLO, 1960. × 29. 6a, umbilical view; 6b, edge view; 6c, spiral view. Coniacian, Redding area. ... 103

7. *Globotruncana fornicata* Plummer of GRAHAM and CLARK, 1961. × 38. 7a, spiral view; 7b, edge view; 7c, umbilical view. Campanian, Merced County. ... 103

8. *Globotruncana helvetica* Bolli of TRUJILLO, 1960. × 29. 8a, umbilical view; 8b, edge view; 8c, spiral view. Middle Turonian, Redding area. ... 103

9A-9D. *Globotruncana linneiana* (d'Orbigny). ... 103
9Aa-c. *Globotruncana linneiana* (d'Orbigny) of TRUJILLO, 1960. × 31. 9Aa, umbilical view; 9Ab, edge view; 9Ac, spiral view. Coniacian, Redding area.
9Ba-b. [?]*Globotruncana canaliculata* (Reuss) of CUSHMAN and GOUDKOFF, 1944. × 25. 9Ba, spiral view; 9Bb, umbilical view; ?Campanian, Moreno Gulch.
9Ca-c. [?]*Globotruncana canaliculata* (Reuss) of BANDY, 1951. × 25. 9Ca, spiral view; 9Cb, edge view; 9Cc, umbilical view. Campanian, Carlsbad area.
9Da-c. *Globotruncana linneiana* (d'Orbigny) of GRAHAM and CLARK, 1961. × 37. 9Da, spiral view; 9Db, edge view; 9Dc, umbilical view. Campanian, Merced County.

10. *Globotruncana linneiana tricarinata* (Quereau) of GRAHAM and CLARK, 1961. × 40. 10a, spiral view; 10b, edge view; 10c, umbilical view. Campanian, Merced County ... 103

11. *Globotruncana* aff. *G. paraventricosa* Hofker of GRAHAM and CLARK, 1961. × 40. 11a, spiral view; 11b, edge view; 11c, umbilical view. Campanian, Merced County. ... 105

12A-12B. *Globotruncana renzi* Gandolfi of TRUJILLO, 1960. × 29. 12Aa-12Ba, umbilical views; 12Ab-12Bb, edge views; 12Ac-12Bc, spiral views. Middle Turonian, Redding area. ... 105

13. *Globotruncana rosetta* (Carsey) of BANDY, 1951. × 25. 13a, spiral view; 13b, edge view; 13c, umbilical view. Campanian, Carlsbad area. ... 105

14. *Globotruncana schneegansi* Sigal of TRUJILLO, 1960. × 31. 14a, umbilical view; 14b, edge view; 14c, spiral view. Middle Turonian, Redding area. ... 105

15. *Globotruncana ventricosa* White of GRAHAM and CLARK, 1961. × 40. 15a, spiral view; 15b, edge view; 15c, umbilical view. Campanian, Merced County. ... 105

16A-16C. *Gublerina ornatissima* (Cushman and Church). ... 105
16A-16Ba-b. [*Ventilabrella ornatissima* CUSHMAN and CHURCH, 1929] × 30. 16A and 16Ba, side views; 16Bb, end view; 16Bc, edge view.
16Ca-b. *Gublerina ornatissima* (Cushman and Church) of MONTANARO GALLITELLI, 1957. × 50. 16Ca, side view; 16Cb, (opposite side of 16Ca, etched), Campanian, near Coalinga.

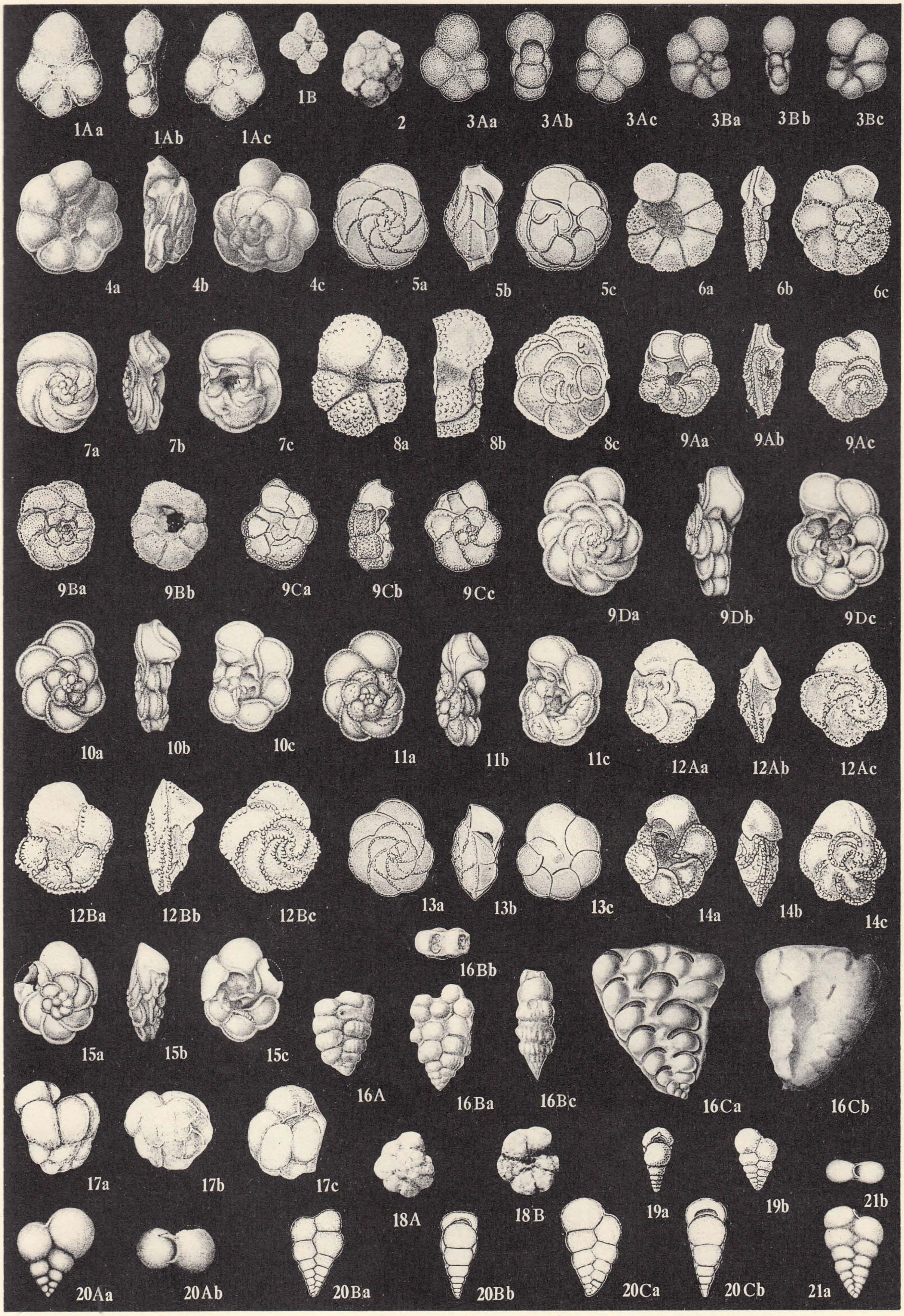
17. *Hedbergella brittonensis* LOEBLICH and TAPPAN, 1961. ... 105
17a-c. "*Globigerina* sp." of KÜPPER, 1955. × 22.5. 17a, edge view; 17b, spiral view; 17c, umbilical view. Middle to late Cenomanian, New Almaden district.

18A-18B. *Hedbergella trocoidea* (Gandolfi) of LOEBLICH and TAPPAN, 1961 ... 105
18A-18B. [*Globigerina almadenensis* CUSHMAN and TODD, 1948] × 19. 18A, spiral view; 18B, umbilical view. Middle Cenomanian, New Almaden district.

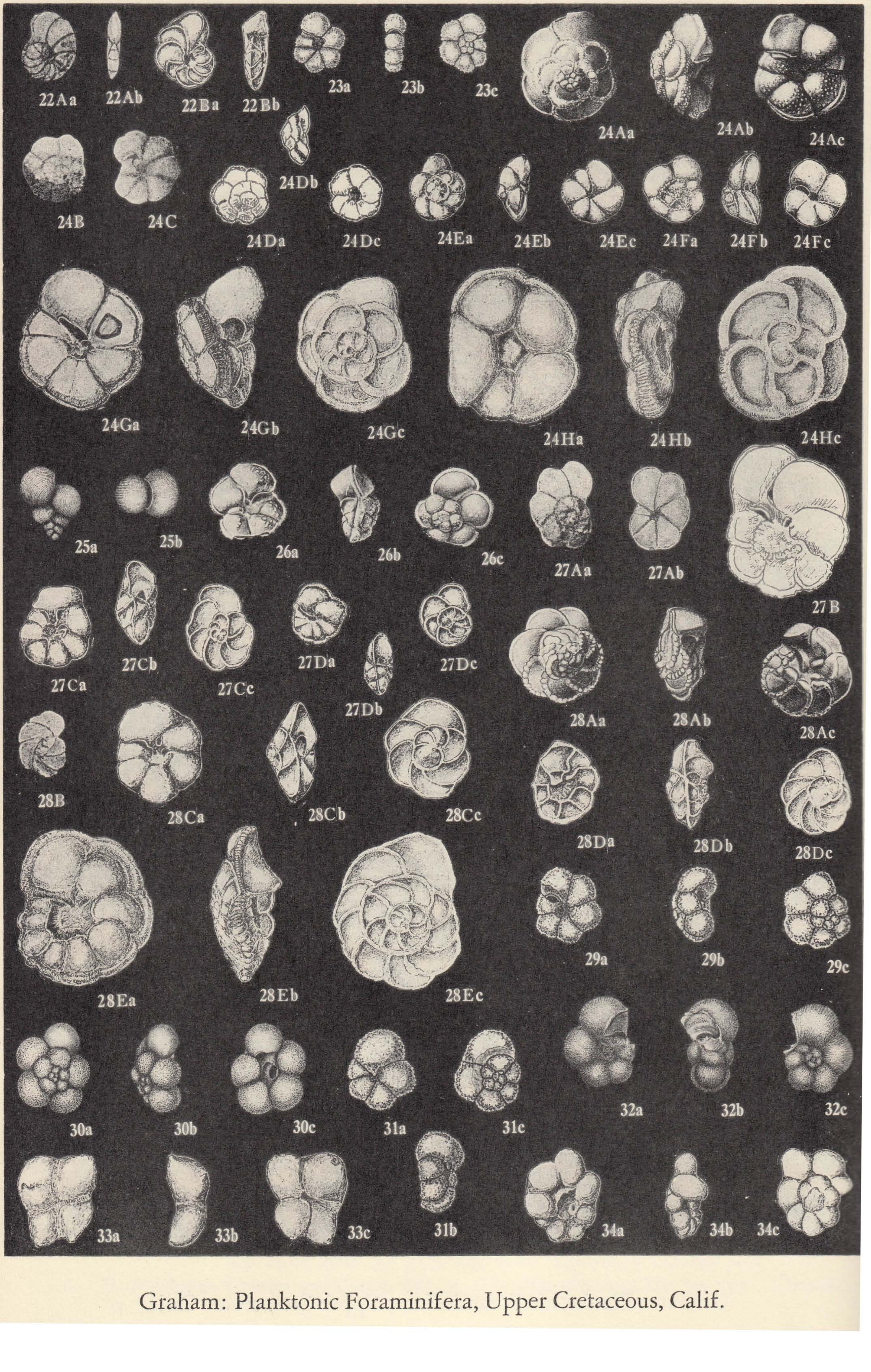
19. *Heterohelix globulosa* (Ehrenberg) of TRUJILLO, 1960. × 36. 19a, edge view; 19b, side view. Coniacian, Redding area. ... 105

20A-20C. *Heterohelix striata* (Ehrenberg). ... 105
20Aa-b. *Heterohelix striata* (Ehrenberg) of GRAHAM and CLARK, 1961. × 56.5. 20Aa, side view; 20Ab, top view. Campanian, Merced County.
20B and 20C. *Guembelina striata* (Ehrenberg) of BANDY, 1951. × 40. 20Ba and 20Ca, side views; 20Bb and 20Cb, edge views. Campanian, Carlsbad area.

21. *Heterohelix* sp. GRAHAM and CLARK, 1961. × 37.5. 21a, side view; 21b, top view. Campanian, Merced County. ... 105



Graham: Planktonic Foraminifera, Upper Cretaceous, Calif.



Graham: Planktonic Foraminifera, Upper Cretaceous, Calif.

EXPLANATION OF PLATE 20

(figures reproduced from the original sources)

FIGS. PAGE

22A-22B. *Planomalina buxtorfi* (Gandolfi). 105

22Aa-b. [*Planomalina ? almadenensis* CUSHMAN and TODD, 1948.] × 19. 22Aa, side view; 22Ab, edge view. Middle to late Cenomanian, New Almaden district.

22Ba-b. *Planomalina buxtorfi* (Gandolfi) of KÜPPER, 1955. × 22.5. 22Ba, side view; 22Bb, edge view. Middle to late Cenomanian, New Almaden district.

23. *Praeglobotruncana hansbolli* TRUJILLO, 1960. × 31. 23a, umbilical view; 23b, edge view; 23c, spiral view. Coniacian, Redding area. 105

24A-24H. *Praeglobotruncana stephani* (Gandolfi). 105

24Aa-c. *Praeglobotruncana stephani* (Gandolfi) of LOEBLICH and TAPPAN, 1961. × 37.5. 24Aa, spiral view; 24Ab, edge view; 24Ac, umbilical view. Middle to late Cenomanian, Glenn County.

24B-C. [*Globorotalia californica* CUSHMAN and TODD, 1948.] × 19. 24B, spiral view; 24C, umbilical view. Middle to late Cenomanian, New Almaden district.

24Da-c. "*Globotruncana* (*Globotruncana*) *stephani* Gandolfi var. *turbinata* Reichel" BOLLI *in* CHURCH, 1952. × ?. 24Da, spiral view; 24Db, edge view; 24Dc, umbilical view. Early Cenomanian, San Mateo County.

24Ea-c. "*Globotruncana* (*Rotundina*) *aumalensis* (Sigal)" of KÜPPER, 1955. × 22.5. 24Ea, spiral view; 24Eb, edge view; 24Ec, umbilical view. Middle to late Cenomanian, New Almaden district.

24Fa-c. "*Globotruncana* (*Rotundina*) *stephani stephani* (Gandolfi)" of KÜPPER, 1955. × 22.5. 24Fa, spiral view; 24Fb, edge view; 24Fc, umbilical view. Middle to late Cenomanian, New Almaden district.

24Ga-c. "*Globotruncana* (*Praeglobotruncana*) *stephani* (Gandolfi) *turbinata* (Reichel)" of KÜPPER, 1956. × 52.5. 24Ga, umbilical view; 24Gb, edge view; 24Gc, spiral view. Late Cenomanian, Colusa County.

24Ha-c. "*Globotruncana* (*Praeglobotruncana*) *renzi* (Thalmann and Goudkoff) spp. *primitiva*" of KÜPPER, 1956. × 52.5. 24Ha, umbilical view; 24Hb, edge view; 24Hc, spiral view. Late Cenomanian, Colusa County.

25. *Pseudotextularia elegans* (Rzehak) of GRAHAM and CLARK, 1961. × 41. 25a, side view; 25b, top view. Campanian, Merced County. 105

26. *Rotalipora cushmani* (Morrow) of LOEBLICH and TAPPAN, 1961. × 30. 26a, umbilical view; 26b, edge view; 26c, spiral view. Middle to late Cenomanian, Glenn County 105

27A-27D. *Rotalipora evoluta* Sigal. 105

27Aa-c. [*Globorotalia almadenensis* CUSHMAN and TODD, 1948.] × 19. 27Aa, spiral view; 27Ab, umbilical view. Middle to late Cenomanian, New Almaden district.

27B. "*Globotruncana* (*Rotalipora*) *apenninica* var. *typica* Gandolfi" BOLLI *in* CHURCH, 1952. × ?. umbilical view. Late Cenomanian, San Mateo County.

27Ca-c. "*Globotruncana* (*Rotalipora*) *apenninica apenninica* (Renz)" of KÜPPER, 1955. × 22.5. 27Ca, umbilical view; 27Cb, edge view; 27Cc, spiral view. Middle to late Cenomanian, New Almaden district.

27Da-c. "*Globotruncana* (*Rotalipora*) *evoluta* Sigal" of KÜPPER, 1955. × 22.5. 27Da, umbilical view; 27Db, edge view; 27Dc, spiral view. Middle to late Cenomanian, New Almaden district.

28A-28E. *Rotalipora greenhornensis* (Morrow). 108

28Aa-c. *Rotalia greenhornensis* (Morrow) of LOEBLICH and TAPPAN, 1961. 28Aa, spiral view; 28Ab, edge view; 28Ac, umbilical view. × 30. Middle to late Cenomanian, Glenn County.

28B. [*Globorotalia decorata* CUSHMAN and TODD, 1948.] × 19. Spiral view. Middle to late Cenomanian, New Almaden district.

28Ca-c. "*Globotruncana* (*Rotalipora*) *globotruncanoides* Sigal" of KÜPPER, 1955. × 22.5. 28Ca, umbilical view; 28Cb, edge view; 28Cc, spiral view. Middle to late Cenomanian, New Almaden district.

28Da-c. "*Globotruncana* (*Thalmanninella*) sp." of KÜPPER, 1955. × 22.5. 28Da-c, umbilical view; 28Db, edge view; 28Dc, spiral view. Middle to late Cenomanian, New Almaden district.

28Ea-c. "*Globotruncana* n. sp. indet." of KÜPPER, 1956. × 52.5. 28Ea, umbilical view; 28Eb, edge view; 28Ec, spiral view. Late Cenomanian, Glenn County.

29. *Rugoglobigerina kingi* TRUJILLO, 1961. × 29. 29a, umbilical view; 29b, edge view; 29c, spiral view. Coniacian, Redding area. 108

30. *Rugoglobigerina* aff. *R. ordinaria* Subbotina of GRAHAM and CLARK, 1961. × 42.5. 30a, spiral view; 30b, edge view; 30c, umbilical view. Campanian, Merced County. 108

31. *Rugoglobigerina praehelvetica* TRUJILLO, 1961. × 29. 31a, umbilical view; 31b, edge view; 31c, spiral view. Middle Turonian, Redding area. 108

32. *Rugoglobigerina rugosa* (Plummer) of GRAHAM and CLARK, 1961. × 56.5. 32a, umbilical view; 32b, edge view; 32c, spiral view. Campanian, Merced County 108

33. *Schackoina multispinata* (Cushman and Wickenden) of LOEBLICH and TAPPAN, 1961 108

33a-c. "*Schackoina cenomana* (Schacko) *bicornis* Reichel" of KÜPPER, 1956. × 52.5. 33a and 33c, side views; 33b, edge view. Late Cenomanian, Glenn County.

34. *Ticinella aprica* Loeblich and Tappan, 1961. 108

34a-c. "*Globotruncana* (*Rotundina*) *californica* (Cushman and Todd)" of KÜPPER, 1955. × 22.5. 34a, umbilical view; 34b, edge view; 34c, spiral view. Middle to late Cenomanian, New Almaden district.

1948, Contr. Cushman Lab. Foram. Research, vol. 24, pt. 4, p. 98, pl. 16, figs. 24a-b (Early Cretaceous).

Globotruncana (*Rotalipora*) *apenninica* var. *typica* Gandolfi. BOLLI *in* CHURCH, 1952, Contr. Cushman Found. Foram. Research, vol. 3, pt. 2, p. 69, text-fig. 2 (early or middle Late Cretaceous).

Globotruncana (*Rotalipora*) *apenninica apenninica* (Renz). KÜPPER, 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, p. 114, pl. 18, figs. 2a-c (early or middle Cenomanian).

Globotruncana (*Rotalipora*) *evoluta* Sigal. KÜPPER, 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, p. 115, pl. 18, figs. 3a-c (early or middle Cenomanian).

28. *Rotalipora greenhornensis* (Morrow). LOEBLICH and TAPPAN, 1961, Micropaleontologist, vol. 7, no. 3, p. 299, pl. 7, figs. 7a-c (middle to late Cenomanian).

Globorotalia decorata CUSHMAN and TODD, 1948, Contr. Cushman Lab. Foram. Research, vol. 24, pt. 4, pp. 97-98, pl. 16, fig. 21 (Early Cretaceous).

Globotruncana (*Rotalipora*) *globotruncanoides* Sigal. KÜPPER, 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, pp. 113-114, pl. 18, figs. 1a-c (early or middle Cenomanian).

Globotruncana (*Thalmanninella*) sp. KÜPPER, 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, p. 115, pl. 18, figs. 4a-c (early or middle Cenomanian).

Globotruncana n. sp. indet. Küpper, 1956, Contr. Cushman Found. Foram. Research, vol. 7, pt. 2, p. 44, pl. 8, figs. 3a-c (late Cenomanian).

29. *Rugoglobigerina kingi* TRUJILLO, 1960, Jour. Paleontology, vol. 34, no. 2, pp. 339-340, pl. 49, figs. 5a-c (Coniacian).

30. *Rugoglobigerina* aff. *R. ordinaria* Subbotina. GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 111, pl. 5, figs. 2a-c (Campanian).

31. *Rugoglobigerina praehelvetica* TRUJILLO, 1960, Jour. Paleontology, vol. 34, no. 2, p. 340, pl. 49, figs. 6a-c (middle Turonian).

32. *Rugoglobigerina rugosa* (Plummer). GRAHAM and CLARK, 1961, Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, p. 111, pl. 5, figs. 1a-c (Campanian).

33. *Schackoina multispinata* (Cushman and Wickenden). LOEBLICH and TAPPAN, 1961, Micropaleontologist, vol. 7, no. 3, p. 271 (middle to late Cenomanian).

Schackoina cenomana (Schacko) *bicornis* Reichel. KÜPPER, 1956, Contr. Cushman Found. Foram. Research, vol. 7, pt. 2, p. 44, pl. 8, figs. 5a-c (late Cenomanian).

34. *Ticinella aprica* LOEBLICH and TAPPAN, 1961, Micropaleontologist, vol. 7, no. 3, p. 292 (middle to late Cenomanian).

Globotruncana (*Rotundina*) *californica* (Cushman and Todd). KÜPPER (not Cushman and Todd, 1948), 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, p. 116, pl. 18, figs. 7a-c (early or middle Cenomanian).

LOCALITIES AND AGE REFERENCES

I — New Almaden district, Santa Clara County ("Franciscan Series") (Los Gatos Quadrangle)

CUSHMAN, J. A., and RUTH TODD, 1948 — Early Cretaceous.

GLAESSNER, M. F., 1949 — Albian (late Early Cretaceous).

KÜPPER, KLAUS, 1955 — early or middle Cenomanian.

LOEBLICH, A. R., JR., and HELEN TAPPAN, 1959; 1961 — middle to late Cenomanian.

II — Clark Valley, Glenn County (Formation not designated) (Fruto Quadrangle)

LOEBLICH, A. R., JR., and HELEN TAPPAN, 1961 — middle to late Cenomanian.

III — San Mateo County (Type Calera Limestone) (Montara Mountain Quadrangle)

THALMANN, H. E., 1942 — Probably correlative with the Franciscan limestone at Permanente Quarry (Palo Alto Quadrangle), which is not older than Turonian and not younger than Santonian (early Senonian).

———, 1943 — Synchronous with the "Franciscan" limestone near Laytonville, Mendocino County, which is at least of Turonian Age.

CHURCH, C. C., 1952 — Somewhere close to the basal or middle Late Cretaceous.

KÜPPER, KLAUS, 1956 — Age equivalent to that of the "Antelope Shale" of Glenn and Colusa counties, which is late Cenomanian.

THALMANN, H. E., *in* IRWIN, W. P., 1957 — Statement is made that the Calera Limestone is Cenomanian rather than Turonian in age.

IV — Glenn and Colusa Counties ("Antelope Shale") (Lodoga Quadrangle)

KÜPPER, KLAUS, 1956 — late Cenomanian.

V — Near Redding, Shasta County (Formation not designated) (Millville Quadrangle)

TRUJILLO, E. F., 1960 — middle Turonian, Coniacian and Santonian.

VI — San Joaquin Valley, Merced County (Panoche Formation) (San Luis Creek Quadrangle)

GRAHAM, J. J., and D. K. CLARK, 1961 — Campanian (probably early).

VII — Carlsbad Area, San Diego County
(Formation not designated)
(San Luis Rey Quadrangle)

BANDY, O. L., 1951 — Campanian.

VIII — Moreno Gulch, Fresno County
(Formation not designated [?Upper Marlife] — Panoche group)
(Panoche Quadrangle)

CUSHMAN, J. A., and P. P. GOUDKOFF, 1944 — Late Cretaceous [?Campanian Age based on occurrence of *Globotruncana canaliculata* (Reuss) of Cushman and Goudkoff = ?*Globotruncana linneiana* (d'Orbigny) near LSJU Loc. 3323: see data in Matsumoto, 1960, fig. 10, p. 123].

IX — Near Coalinga, Fresno County
("Chico" shale — [?Alcalde] — Panoche Group)
(Coalinga Quadrangle)

CUSHMAN, J. A., and C. C. CHURCH, 1929 — Probably "uppermost Cretaceous corresponding rather closely with the Navarro of Texas and the Velasco of Mexico" [Santonian — Campanian Age based on assignment given to "*Globotruncana arca* (Cushman)" of Cushman and Church, 1929, by Lewis Martin in Ph.D. thesis, Stanford University, 1961; ?Campanian Age based on data in Matsumoto, 1960, fig. 15, p. 116 (LSJU Loc. 3197). The latter locality is in the NW¼SE¼ sec. 2, T. 21 S., R. 14 E., near the site of California Northern Petroleum Co. well no. 19 from which the Cushman and Church foraminiferal material was collected at a depth of 1135 feet].

BIBLIOGRAPHY

(does not include some references cited in full in text)

1. BANDY, O. L., 1951: Upper Cretaceous Foraminifera from the Carlsbad area, San Diego County, California: Jour. Paleontology, vol. 25, no. 4, pp. 488-513, pls. 72-75, 2 text-figs., 2 tables.
2. CHURCH, C. C., 1952: Cretaceous Foraminifera from the Franciscan Calera Limestone of California: Contr. Cushman Found. Foram. Research, vol. 3, pt. 2, pp. 68-70, 2 text figs.
3. CUSHMAN, J. A., and C. C. CHURCH, 1929: Some Upper Cretaceous Foraminifera from near Coalinga, California: Proc. Calif. Acad. Sci., Fourth Ser., vol. 18, no. 16, pp. 497-530, pls. 36-41.
4. ——— and P. P. GOUDKOFF, 1944: Some Foraminifera from the Upper Cretaceous of California: Contr. Cushman Lab. Foram. Research, vol. 20, pt. 3, pp. 53-64, pls. 9-10.
5. ——— and RUTH TODD, 1948: A foraminiferal fauna from the New Almaden district, California: Contr. Cushman Lab. Foram. Research, vol. 24, pt. 4, pp. 90-98, pl. 16, figs. 4-25.
6. GLAESSNER, M. F., 1949: Foraminifera of Franciscan (California): Am. Assoc. Petroleum Geologists, Bull., vol. 33, no. 9, pp. 1615-1617.
7. GRAHAM, J. J., and D. K. CLARK, 1961: New Evidence for the age of the "G-1 Zone" in the Upper Cretaceous of California: Contr. Cushman Found. Foram. Research, vol. 12, pt. 3, pp. 107-114, 2 text-figs., 1 pl.
8. IRWIN, W. P., 1957: Franciscan group in Coast Ranges and its equivalents in Sacramento Valley, California: Am. Assoc. Petroleum Geologists, Bull., vol. 41, no. 10, pp. 2284-2297, 2 figs.
9. KÜPPER, KLAUS, 1955: Upper Cretaceous Foraminifera from the "Franciscan Series" New Almaden district, California: Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, pp. 112-118, 123, pl. 18.
10. ——— 1956: Upper Cretaceous pelagic Foraminifera from the "Antelope Shale," Glenn and Colusa counties, California: Contr. Cushman Found. Foram. Research, vol. 7, pt. 2, pp. 40-47, pl. 8, 1 text-fig.
11. LOEBLICH, A. R., JR., and HELEN TAPPAN, 1961: Cretaceous planktonic Foraminifera: Part I — Cenomanian: Micropaleontologist, vol. 7, pt. 3, pp. 257-304, 8 pls., 3 text-figs.
12. MATSUMOTO, TATSURO, 1960: Upper Cretaceous ammonites of California — Part 3: Mem. Faculty Sci., Kyushu Univ., Ser. D, Geol., Special vol. 2, 204 p., 20 text-figs., 2 pls.
13. MONTANARO GALLITELLI, EUGENIA, 1957: A revision of the foraminiferal family Heterohelicidae *in* Studies in Foraminifera by A. R. Loeblich, Jr. and collaborators: U. S. Nat. Mus., Bull. 215, pp. 133-154, pls. 31-34.
14. THALMANN, H. E., 1942: *Globotruncana* in the Franciscan limestone, Santa Clara County, California: Geol. Soc. America Bull., vol. 53, no. 12, p. 1838 (Abs.).
15. ——— 1943: Upper Cretaceous age of the "Franciscan" limestone near Laytonville, Mendocino County, California: Geol. Soc. America Bull., vol. 54, no. 12, p. 1827 (Abs.).
16. ——— 1959: New names for foraminiferal homonyms IV: Contr. Cushman Found. Foram. Research, vol. 10, pt. 4, pp. 130-131.
17. TRUJILLO, E. F., 1960: Upper Cretaceous Foraminifera from near Redding, Shasta County, California: Jour. Paleontology, vol. 34, no. 2, pp. 290-346, 3 text-figs., pls. 43-50, 2 tables. [See p. 341 for comments on *Globotruncana arca* (Cushman) in Bandy, 1951, and in Cushman and Goudkoff, 1944. These two species according to Trujillo may belong to *Globotruncana linneiana* (d'Orbigny)].

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XIII, PART 3, JULY, 1962

NOMENCLATURAL NOTES

252. *TEXTULARIA CARMENAE* NOMEN NOVUM FOR *TEXTULARIA COMPRESSA* OBREGON DE LA PARRA, PREOCCUPIED

JORGE OBREGÓN DE LA PARRA
Juarez y Allende, Monterrey, N. L. Mexico

Hans Thalmann has informed me that *Textularia compressa* Obregón de la Parra, 1959, is preoccupied by *T. compressa* Roemer, 1838, and *T. tuberosa* d'Orbigny var. *compressa* de Amicis. The following new name is, therefore, proposed: *Textularia carmenae* nom. nov. for *T. compressa* Obregón de la Parra (1959, As. Mex. Geol. Petroleros, Bull. 11 (3-4), p. 141, 2, pl. 1, fig. 6); non *T. compressa* Roemer (1838, N. Jahrb. Min., p. 384, pl. 3, fig. 13; non *T. tuberosa* d'Orbigny var. *compressa* de Amicis (1893, Soc. Geol. Italiana, vol. 12, p. 336, pl. 3, fig. 4).

253. *QUINQUELOCULINA TENAGOS* NEW NAME FOR *QUINQUELOCULINA RHODIENSIS* PARKER, PREOCCUPIED[1]

FRANCES L. PARKER
Scripps Institution of Oceanography, La Jolla, California

Quinqueloculina rhodiensis Parker (*in* Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Research, Spec. Publ. 2, p. 12, pl. 2, figs. 15-17) was a new name for *Q. costata* Terquem, 1878 (part) (Mém. Soc. Géol. France, sér. 3, vol. 1, no. 3, p. 63, pl. 11, fig. 3 [not figs. 4, 5]). This name is preoccupied by *Q. rhodiensis* (Wiesner) (originally *Miliolina rhodiensis* Wiesner, 1912, Archv. Protistenk., bd. 25, p. 231). Wiesner's name was, in turn, a new name for *Quinqueloculina seminuda* Terquem (1878, Mém. Soc. Géol. France, sér. 3, vol. 1, no. 3, p. 76, pl. 9, fig. 8) which is a homonym of *Q. seminuda* Reuss, 1866. The new name *Quinqueloculina tenagos* is proposed for *Q. rhodiensis* Parker.

1 Marine Foraminifera Laboratory Contribution No. 40.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XIII, PART 3, JULY, 1962

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

ADAMS, C. G. *Alveolina* from the Eocene of England. —Micropaleontology, v. 8, No. 1, Jan. 1962, p. 45-54, pls. 1-3, text figs. 1, 2 (drawings), tables 1, 2.—All the alveolines are referred to *A. fusiformis* Sowerby, emended, and, with transitional forms, to *A.* cf. *elongata* d'Orbigny.

ANDERSEN, HAROLD V. Genesis and paleontology of the Mississippi River mudlumps. Part II. Foraminifera of the mudlumps, Lower Mississippi River Delta.—Louisiana Dept. Cons., Geol. Bull. No. 35, Part II, Sept. 1961, p. 1-208, pls. 1-29, text figs. 1, 2 (maps).—Two faunules are recognized, a sparse faunule (characterized by *Buliminella, Epistominella, Nonionella,* and *Streblus*) and a prolific faunule (characterized by *Textulariella, Liebusella,* and *Vaginulinopsis*), with all specimens considered to be Recent, although with the specimens from the prolific faunule having a greater relative age. Environmental implications, based on comparison with bottom sediments collected down to 380 feet, suggest the origin of the sparse faunule to have been the sediments of the delta front and the origin of the prolific faunule to have been clays from more than 400 feet. The illustrated systematic catalog of species includes 213 species and 8 subspecies. Twenty-one species and 3 genera are new: *Cribrobigenerina* n. gen. (type species *C. parkerae* n. sp.) in the Textulariidae, *Alfredosilvestris* n. gen. (type species *A. levinsoni* n. sp.) in the Nodosariidae, and *Oridorsalis* n. gen. (type species *O. westi* n. sp.) in the Discorbidae.

BARR, F. T. Upper Cretaceous planktonic Foraminifera from the Isle of Wight, England.—Palaeontology, v. 4, pt. 4, 1961 [Jan. 1962], p. 552-580, pls. 69-72, text-figs. 1-5 (map, columnar section, graph, distrib. table, outline drawings).—Descriptions and illustrations of 17 species and subspecies, 4 species new, found in about 1,000 feet of section. Interpretation of neritic or upper bathyal deposition is based on quantative analysis of planktonic/benthonic ratio.

BERGGREN, W. A. Some planktonic Foraminifera from the Maestrichtian and type Danian stages of southern Scandinavia.—Acta Univ. Stockholm., Stockholm Contrib. in Geol., v. 9:1, 1962, p. 1-106, pls. 1-14, text figs. 1-14 (map, range chart, phylogenetic diagram, evolution diagram, drawings).—Illustrations and descriptions of 21 Maestrichtian and 6 Danian species, none new, from Denmark and Sweden. The Cretaceous lineage of *Praeglobotruncana* (*Hedbergella*) appears to connect with certain lineages of *Globigerina* and *Globorotalia* in the Tertiary.

Stratigraphic and taxonomic-phylogenetic studies of Upper Cretaceous and Paleogene planktonic Foraminifera.—Acta Univ. Stockholm., Stockholm Contrib. in Geol., v. 9:2, 1962, p. 107-129, text figs. 1-3 (phylogenetic diagrams).—An interesting summary of speculations about lineages, evolutionary trends, and phylogenetic relationships.

BIGNOT, G., and NEUMANN, M. La structure des tests des Foraminifères. Analyse bibliographique.—Revue de Micropaléontologie, v. 4, No. 4, March 1962, p. 237-248, pls. 1, 2, text figs. 1, 2.—A summary of the subject.

BIZON, G. Contributions a l'étude micropaléontologique du Lias du Bassin de Paris. Deuxième partie: Lorraine, région de Nancy et Thionville: Foraminifères et Ostracodes.—Colloque sur le Lias Français, Bureau Recherches Géol. Min., Mém. No. 4, 1961, p. 433-436, table 2 (range chart).—Chart shows ranges of about 60 species between Rhétian and Toarcian.

Contributions a l'étude micropaléontologique du Lias du Bassin de Paris. Cinquième partie: Basse-Normandie (Régions d'Isigny et sud de Bayeux): Foraminifères et Ostracodes.—Colloque sur le Lias Français, Bureau Recherches Géol. Min., Mém. No. 4, 1961, p. 451-458, text fig. 3 (correl. table), table 5 (range chart).—Chart shows ranges of about 35 species of Foraminifera between Sinemurian and Toarcian.

BIZON, G., and OERTLI, H. Contributions a l'étude micropaléontologique du Lias du Bassin de Paris. Septième partie: Conclusions: Foraminifères-Ostracodes.—Colloque sur le Lias Français, Bureau Recherches Géol. Min., Mém. No. 4, 1961, p. 107-119, text fig. 1 (map), table 7 (range chart).—Chart shows ranges of about 30 species of Foraminifera between Hettangian and Bajocian.

BOLLI, H. M., CITA, M. B., and SCHAUB, H. Il limite Cretaceo-Terziario nella Catena del Monte Baldo. —Mem. Soc. Geol. Ital., v. 3, 1962, p. 149-168, text figs. 1-5 (map, columnar section, correlation table).—A sequence containing both planktonics and nummulites in association, permitting direct correlation.

BOLTOVSKOY, ESTEBAN. Algunos Foraminiferos nuevos de las aguas Brasileñas.—Neotropica, v. 7, No. 24, Dec. 1, 1961, p. 73-79, 1 pl.—*Canepaia* n. gen. (genotype *C. brasiliensis* n. sp.), showing affinities with *Ammosphaerulina*, and a new subspecies of *Fissurina* and new forma of *Lagena*.

BOMBITA, GH. Révisions bio-stratigraphiques dans le flysch paléogène des Carpates Orientales (I) (French summary of Rumanian text).—Acad. Repub. Pop. Romîne, Sect. Geol. si Geog., Studii si cercetari de Geol., tom. 6, No. 3, 1961, p. 405-435, pl. 1 (photos), text figs. 1-86 (geol. maps, profile, outline drawings).—Based on 3 faunal associations of larger Foraminifera (chiefly nummulites).

BRETT, C. EVERETT, and WHEELER, WALTER H. A biostratigraphic evaluation of the Snow Hill member, Upper Cretaceous of North Carolina.—Southeastern Geology (Duke Univ., Dept. Geol.), v. 3, No. 2, Dec. 1961, p. 49-132, pls. 1-9, text figs. 1-23 (maps, tables, graphs, columnar sections, photographs, cross sections).—Includes lists and illustrations of Taylor age Foraminifera from several outcrops of Peedee and Black Creek formations. The Snow Hill "member" is recognized by its biology instead of its lithology, and is interpreted as an open lagoonal deposit.

BROTZEN, F., and POZARYSKA, K. Foraminifères du Paléocène et de l'Éocène inférieur en Pologne septentrionale remarques paléogéographiques.—Revue de Micropaléontologie, v. 4, No. 3, Dec. 1961, p. 155-166, pls. 1-4, text figs. 1, 2 (columnar section, diagram).—*Subbotina* n. gen. (genotype *Globigerina triloculinoides* Plummer) is erected and *Globigerina kozlowskii* n. sp. is described from the middle Paleocene.

BURNABY, T. P. The palaeoecology of the foraminifera of the Chalk Marl.—Palaeontology, v. 4, pt. 4, 1961 [Jan. 1962], p. 599-608, text-fig. 1 (distrib. chart), tables 1, 2.—By quantitative analysis of 27 samples from a 90-foot section it is interpreted that the depth increased from about 5 fathoms to 50-100 fathoms, then decreased again to about 5 fathoms. Frequencies of 44 benthonic species are recorded; 4 species possessing marked peaks or troughs are taken as being governed by environmental changes. Depth interpretations are based on recorded depth ranges of modern species of the same or comparable genera.

BYKOVA, E. V. Foraminifery Karodoka Vostochnogo Kazakhstana.—Akad. Nauk Kazakhsk. SSR, Instit. Geol. Nauk, 1961, p. 1-69, pls. 1-25, text figs. 1-32 (map, columnar sections, drawings).—Systematic descriptions and illustrations of species from Cambrian to Devonian rocks include one new family (Maylisoriidae) and 5 new genera. Forty-six species are described (42 new) and 24 forma and 1 variety; all are included in the Astrorhizida.

CATI, FRANCO. Due nuove forme Lituolidi del Senoniano Vicentino.—Giornale di Geol., Ann. Mus. Geol. Bologna, ser. 2, v. 28, 1958-59 (1960), p. 195-200, pl. 1.—*Recurvoides manfredii* and its var. *lobatulum*.

CHAMPEAU, H. Contributions a l'étude micropaléontologique du Lias du Bassin de Paris. Troisième partie: Étude de la microfaune des niveaux marneux du Lias dans le sud-est du Bassin de Paris.—Colloque sur le Lias Français, Bureau Recherches Géol. Min., Mém. No. 4, 1961, p. 437-443, table 3 (range chart).—Chart shows ranges of about 45 species of Foraminifera between Hettangian and Aalenian.

CITA, M. B., and BOLLI, H. M. Nuovi dati sull'eta' Paleocenica dello Spilecciano di Spilecco.—Riv. Ital. Pal. Stratig., v. 67, No. 4, 1961, p. 369-392, pls. 29, 30, text figs. 1, 2 (geol. section, drawing). —A change of age from lower Eocene to upper Paleocene is indicated by several species of *Globigerina* and *Globorotalia*.

CITA, MARIA BIANCA, and SCIPOLO, CARLA. *Chapmanina gassinensis* (Silvestri) dans l'Oligocène du Monte Baldo (Italie).—Revue de Micropaléontologie, v. 4, No. 3, Dec. 1961, p. 121-134, pls. 1-3, text figs. 1-6 (maps, geol. sections, columnar section, line drawing, graph).—Interpreted as redeposited specimens. Illustrations of free specimens.

CONKIN, JAMES E. Mississippian smaller Foraminifera of Kentucky, southern Indiana, northern Tennessee, and southcentral Ohio.—Bull. Am. Paleontology, v. 43, No. 196, Dec. 1, 1961, p. 129-368, figs. 1-43 (on 3 pls.), pls. 17-27, map 1, charts 1-23 (correl. charts, distrib. charts, range charts), columnar sections.—A monographic study having records of occurrence and abundance of species by individual beds at numerous localities. In the systematic part, 38 species (18 new) are described and illustrated with photographs and drawings.

CORMINBOEUF, PAUL. Association de *Belemnitella* et de Globotruncanidae dans le Campanien supérieur des Alpettes (Préalpes externes fribourgeoises).—Eclogae Geol. Helvetiae, v. 54, No. 2, Dec. 31, 1961, p. 491-498, pls. 1, 2, text fig. 1 (photo).—Five species of *Globotruncana* (1 new) and 1 of *Rugoglobigerina*.

COUSIN, N., ESPITALIER, J., and SIGAL, J. Contributions a l'étude micropaléontologique du Lias du Bassin de Paris. Première partie: Ardennes, région de Mézières (Département des Ardennes): Foraminifères.—Colloque sur le Lias Français, Bureau Recherches Géol. Min., Mém. No. 4, 1961, p. 423-427, text fig. 1 (maps), table 1 (range chart).—Chart shows ranges of the principal Foraminifera (51 species) between Sinemurian and Pliensbachian.

Contributions a l'étude micropaléontologique du Lias du Bassin de Paris. Quatrième partie: Sud du Bassin, Région d'Argenton-sur-Creuse et de La Châtre (Départements du Cher et de l'Indre): Foraminifères.—Colloque sur le Lias Français, Bureau Recherches Géol. Min., Mém. No. 4, 1961, p. 445-449, table 4 (range chart).—Chart shows ranges of the principal Foraminifera (53 species) between Sinemurian and Aalenian.

CRAIG, G. Y., and HOGG, J. A rapid sorting device for microfossils.—Micropaleontology, v. 8, No. 1, Jan. 1962, p. 107-108, text figs. 1, 2.—Suction tube leading to rotating chambered tray.

DELMAS, M., and DELOFFRE, R. Découverte d'un nouveau genre d'Orbitolinidae dans la base de l'Albien en Aquitaine.—Revue de Micropaléontologie, v. 4, No. 3, Dec. 1961, p. 167-172, pl. 1, text figs. 1, 2 (map, thin sections).—*Coskinolinella daguini* nov. gen. et nov. sp., possibly a good marker for basal Albian.

DUPEUBLE, P. A. Polymorphisme chez les Cibicidinae actuels de la région de Roscoff (Finistère).—Revue de Micropaléontologie, v. 4, No. 4, March 1962, p. 197-202, pls. 1, 2.—Illustrations of various-shaped tests of *Cibicides lobatulus* throw doubt on the validity of *Cibicidella* and *Dyocibicides* as genera.

DURAND, J.-G. Le Lias dans les sondages de la Compagnie d'Exploration Petrolière (ouest du Bassin de Paris).—Colloque sur le Lias Français, Bureau Recherches Geol. Min., Mém. No. 4, 1961, p. 543-562, pl. 1, tables 1, 2 (columnar sections, range and abund. charts).—Ranges of selected Foraminifera are indicated in two drill holes.

EAMES, F. E., BANNER, F. T., BLOW, W. H., and CLARKE, W. J. Fundamentals of mid-Tertiary stratigraphical correlation (with a contribution by L. R. Cox).—Cambridge Univ. Press, 1962, 163 p., 17 pls., 20 text figs. (correl. charts, range charts, maps, evolution diagrams, transition diagrams, drawings, diagrams).—A reëxamination of evidence from many parts of the world and from both smaller and larger Foraminifera as well as other fossils suggests that, except for a few occurrences, rocks formerly regarded as Oligocene in the Western Hemisphere should be included in the Aquitanian, and that the upper Bartonian and all of the Oligocene are missing from the well-known stratigraphical sections of the Central American region. *Palaeonummulites* is recognized (through selection of lectotype of *Nummulina pristina* Brady) and supercedes *Operculinella* and *Operculinoides*. *Pliolepidina* is revised and its range regarded as Aquitanian to Burdigalian. In "Part 2: The mid-Tertiary (upper Eocene to Aquitanian) Globigerinaceae," by BLOW and BANNER, are included the description of the lower middle Oligocene section in Tanganyika and the systematic description and illustration of 38 species (8 new) and 14 subspecies (11 new) of planktonics. Three new planktonic zones are proposed, 2 in upper Eocene and 1 in lower to middle Oligocene. Seven evolutionary lineages in the planktonics are indicated diagrammatically and illustrated by transitional forms. *Globigerinita* is emended to include *Tinophodella* and *Catapsydrax* as synonyms. *Turborotalita* n. gen. (type species *Truncatulina humilis* Brady) is erected in the subfamily Globorotaliinae.

FLANDRIN, J., MOULLADE, M., and PORTHAULT, B. Microfossiles caractéristiques du Crétacé Inférieur Vocontien.—Revue de Micropaléontologie, v. 4, No. 4, March 1962, p. 211-228, pls. 1-3, text figs. 1, 2 (map, columnar sections), table 1 (range chart).—Descriptions, illustrations, and ranges of 33 species and 5 subspecies, one subspecies new, in the Vocontian trough of France.

GEROCH, STANISLAW. *Pseudoreophax,* a new genus of Foraminifera from the Neocomian in the Flysch Carpathians (in Polish with English summary).—Ann. Soc. Geol. Pologne, v. 31, fasc. 1, Ann. 1961, p. 159-165, pl. 17, text figs. 1, 2 drawings, graph), tables 1, 2.—Species ranges from Valanginian to lower Barremian. Genus belongs in Verneuilinidae.

GORDON, W. A. Some Foraminifera from the Ampthill Clay, Upper Jurassic, of Cambridgeshire.—Palaeontology, v. 4, pt. 4, 1961 [Jan. 1962], p. 520-537, text-figs. 1, 2 (drawings).—Descriptions and illustrations of 17 species (1 new).

Problems of paleontological correlation, with particular reference to Tertiary.—Am. Assoc. Petroleum Geologists Bull., v. 46, No. 3, March 1962, p. 394-398.—An evaluation of the use of planktonic Foraminifera.

HANZAWA, SHOSHIRO. Upper Cretaceous and Tertiary three-layered larger Foraminifera and their allied forms.—Micropaleontology, v. 8, No. 2, April 1962, p. 129-186, pls. 1-8, text figs. 1-11, chart 1 (generic range chart).—A classification of 11 families (one with 2 subfamilies), 58 genera, and 7 subgenera, with ranges between Turonian and Helvetian shown for each. Features useful in classification are evaluated and illustrated by specific examples. *Pseudorbitella* n. gen. (type species *P. americana* n. sp. = *Lepidorbitoides (L.) nortoni* (Vaughan) of Cole 1941) is erected in the subfamily Pseudorbitellinae of the family Pseudorbitoididae.

HARTONO. *Hantkenina* in the Nanggulan area.—Republik Indonesia, Depart. Perindustrian Dasar/ Pertambangan Djawatan Geologi, Bandung, Publ. Teknik, ser. pal. No. 1, 1960, p. 3-8, text figs. 1, 2 (map, drawings).—From drill-core samples, a first occurrence for this area.

Collection of smaller Foraminifera at the Paleontology Section of the Geological Survey of Indonesia. —Republik Indonesia, Depart. Perindustrian Dasar/Pertambangan Djawatan Geologi, Bandung, Publ. Teknik, ser. pal. No. 1, 1960, p. 11-19.—Listing of about 110 specimens, the specimens illustrated by LeRoy, 1939.

HOFKER, J. The Foraminifera of the Upper Campanian-Maestrichtian boundary in South Limburg, Netherlands.—Publ. Natuurhist. Genootschap in Limburg, 1961, p. 46-54, text figs. 1-5 (drawings, range chart, diagram, check list, table).—Many species listed and their ranges shown crossing or failing to cross the boundary.

Foraminifera from the Cretaceous of South Limburg, Netherlands. LI. *Bolivina (Loxostoma) selmaensis* Cushman.—Natuurhist. Maandblad, 50e Jrg., No. 1-2, Feb. 24, 1961, p. 20-22, text figs. 1-7.—Evolution across the Maestrichtian-Danian boundary proceeds in the direction of a larger, slenderer test, more inflated chambers, and a more terminal aperture.

LII. Stratigraphy of the Gulpen Chalk in South-Limburg, established by means of the orthogenesis of *Bolivinoides*.—Natuurhist. Maandblad, 50e Jrg., No. 3-4, April 28, 1961, p. 37-40, diagrams 1, 2.—Based on the number of pustules.

LIII. Some smaller Rotaliid species from the holes in the hard ground over the Md in the quarry Curfs, near Houthem, West-side.—Natuurhist. Maandblad, 50e Jrg., No. 5-6, June 30, 1961, p. 63-67, text figs. 1-11.—Ten species, 1 new.

LIV. Some small Rotaliids in the Lower Paleocene above the Md in the quarry Curfs, near Houthem, South-Limburg.—Natuurhist. Maandblad, 50e Jrg., No. 7-8, Sept. 30, 1961, p. 85-87, text figs. 1, 2.—Two species, 1 new.

LV. The pore-increase of *Gavelinella danica* (Brotzen) in Danian, Lower Paleocene and Montian in Denmark and in Holland-Belgium, showing the Maestrichtian of Dumont's being of Danian age. —Natuurhist. Maandblad, 50e Jrg., No. 9-10, Oct. 30, 1961, p. 100-102, 2 tables.

LVI. Foraminifera of the highest "Post-Maestrichtian" outcropping above the Md in South Limburg and the Canal Albert region in North Eastern Belgium.—Natuurhist. Maandblad, 50e Jrg., No. 11-12, Dec. 30, 1961, p. 124-126, text figs. 1-7.—Illustrations of 7 species from basal Montian (Paleocene).

Studien an planktonischen Foraminiferen.—Neues Jahrb. Geol. Paläont., Abh., Band 114, heft 1, Jan. 1962, p. 81-134, text figs. 1-85.—Illustrations of various planktonic species and discussions of their probable floating ability. Examples of increase of size with time. Illustrations and discussions of *Globigerinatheca barri, Turborotalia centralis,* and the genera *Pseudohastigerina, Hastigerina,* and *Hantkenina.*

HOTTINGER, LUCAS. Acerca de las Alveolinas Paleocenas y Eocenas.—Notas y Comunic. Instit. Geol. Minero España, Trimestre IV, No. 64, Ano 1961, p. 37-86, pls. 1-21, text figs. 1-3 (drawings), table 1 (illustrated range chart).—Ranges are shown for many species in 16 biozones based on alveolines from Paleocene to Biarritzian of the Eocene. Illustrated by thin section photographs.

HOYT, JOHN H., and CHRONIC, JOHN. Atokan fusulinids from the Casper formation, east flank of the Laramie Mountains, Wyoming.—Jour. Paleontology, v. 36, No. 1, January 1962, p. 161-164, text-figs. 1-3 (map, columnar section, photographs of specimens).

HUANG, TUNYOW. *"Lagena"-x* from Taiwan (Formosa).—Micropaleontology, v. 8, No. 1, Jan. 1962, p. 111, text figs. 1-5 (fossil photo).—In warm shallow marine sediments of late Miocene age.

JEFFERIES, R. P. S. The palaeoecology of the *Actinocamax plenus* Subzone (Lowest Turonian) in the Anglo-Paris Basin.—Palaeontology, v. 4, pt. 4, 1961 [Jan. 1962], p. 609-647, pls. 77-79, text-figs. 1-13 (maps, columnar section, diagram, graphs). —Includes photographs of species of benthonic and planktonic Foraminifera characteristic of various parts of the section or indicative of warm or cold water or of neither. Graphs show varying frequencies of Foraminifera species from various levels at 4 British and 2 French localities.

JULIUS, CHARLES. Les Foraminifères du gisement burdigalien des Bougés (Gironde).—Compte Rendu Sommaire des séances Soc. Géol. France, fasc. 9, Dec. 4, 1961, p. 266-267.—List of species.

JURKIEWICZ, H. The foraminiferal fauna of the lower Czarnorzeki beds in the Central Carpathian Depression (English summary of Polish text).—Acta Geol. Polonica, v. 11, No. 4, 1961, p. 507-524, pls. 23, 24, table 1 (abundance chart).—Records and illustrates assemblages from 3 horizons, Campanian to Maestrichtian.

KAASSCHIETER, JOHANNES PAULUS HEIMEN. Foraminifera of the Eocene of Belgium.—Instit. Royal Sci. Nat. Belgique, Mém. No. 147, July 31, 1961, 271 p., pls. 1-16, text figs. 1-16 (correl. chart, columnar sections, geol. sections, maps, photograph), tables 1-8 (distrib. and abund. charts), 20 maps.—In this monograph are included an illustrated systematic catalog of species containing about 225 species and varieties with 6 species and 7 varieties new, and 2 species given new names. Study was based on more than 450 surface samples in addition to many well samples. Faunal compositions of the various local clays and sands are recorded.

DE KLASZ, I., and RÉRAT, D. Quelques nouveaux Foraminifères du Crétacé et du Tertiaire du Gabon (Afrique Équatoriale).—Revue de Micropaléontologie, v. 4, No. 4, March 1962, p. 175-189, pls. 1-3, 1 map.—Twelve species, all new; 4 from Senonian, 3 from Eocene, 5 from Miocene; and 1 new subspecies from Eocene and Miocene. Four new genera are erected: *Laterostomella* nov. gen. (genotype *L. gumbeliniformis* n. sp.) and *Altistoma* nov. gen. (genotype *A. scalaris* n. sp.) in the Buliminidae, *Daucinoides* nov. gen. (genotype *D. circumtegens* n. sp.) and *Clavelloides* nov. gen. (genotype *C. tenuistriata* n. sp.) in the Ellipsoidinidae.

KRAEVA, E. JA. Foraminiferi Verkhn'oeothenovikh ta Oligothenovikh Vidkladiv Pivnichnogo Krila Prichornomors'koj Zapadini.—Akad. Nauk Ukrain. RSR, Kiev, 1961, p. 1-95, pls. 1-11, map, tables 1-4.—Fifty species (8 new) and 4 varieties (all new) from upper Eocene and Oligocene from the north side of the Black Sea Depression.

KSIAZKIEWICZ, MARIAN. Life conditions in Flysch Basins.—Ann. Soc. Geol. Pologne, v. 31, fasc. 1, 1961, p. 3-21.—Speculations about paleoecologic significance of various kinds of assemblages of Foraminifera in flysch basins.

LE CALVEZ, YOLANDE. A propos d'*Amphistegina abrardi* Le Calvez.—Compte Rendu Sommaire des séances Soc. Géol. France, fasc. 9, Nov. 20, 1961, p. 247, 1 photo.—A synonym of *Nummulites variolarius* (Lamarck).

LE CALVEZ, Y., and LEFAVRAIS-RAYMOND, A. Lias des sondages de la bordure du Morvan.—Colloque sur le Lias Français, Bureau Recherches Géol. Min., Mém. No. 4, 1961, p. 503-534, pls. 1, 2, text figs. 1-9 (maps, columnar sections), tables 1-5.—Includes range charts of species between Pliensbachian and Toarcian and photographs of a few specimens (including holotypes of 4 Payard species).

LEHMANN, ROGER. Strukturanalyse einiger Gattungen der Subfamilie Orbitolitinae.—Eclogae Geol. Helvetiae, v. 54, No. 2, 1961, p. 597-667, pls. 1-14, text figs. 1-49 (photomicrographs, block diagrams, drawings, graph, map, columnar section).—Monographic study includes *Orbitolites, Sorites, Amphisorus, Marginopora, Yaberinella* and *Somalina.* Twelve species (3 new in *Orbitolites*) are described and illustrated.

LIPNIK, O. S. Foraminifery i stratigrafija verkhn' okreidovykh vidkladiv Dniprovs'ko-Doneth'koj zapadini.—Akad. Nauk Ukrain. RSR, Kiev, Instyt. geol. Nauk Trudy, ser. strat. i paleo., vyp. 35, 1961, p. 1-65, pls. 1-7, tables 1, 2 (zonation chart, species range chart).—Includes a chart showing ranges between Cenomanian and Maestrichtian for about 260 species and varieties. Describes and illustrates 32 species (20 new and 1 indeterminate) and 2 varieties (both new).

LOEBLICH, ALFRED R. JR., and TAPPAN, HELEN. Six new generic names in the Mycetozoida (Trichiidae) and Foraminiferida (Fischerinidae, Buliminidae, Caucasinidae, and Pleurostomellidae), and a redescription of *Loxostomum* (Loxostomidae, new family).—Proc. Biol. Soc. Washington, v. 75, March 30, 1962, p. 107-114.

Type localities of some American Cretaceous foraminiferal genotype species described by Ehrenberg. —Jour. Paleontology, v. 36, No. 2, March 1962, p. 352-354.—Probable localities for 4 of the samples sent by Bailey to Ehrenberg.

LUTERBACHER, HANSPETER. Über Thuramminen aus dem Oberen Malm der Bohrung Altishofen.—Eclogae Geol. Helvetiae, v. 54, No. 2, 1961, p. 581-586, pl. 1.—Seven varieties (none new) of the Jurassic species, *Thurammina papillata.*

MACFADYEN, W. A. *Ammodiscus* Reuss, 1862 (Foraminifera); proposed designation of a type-species under the plenary powers (with addendum by TOM BARNARD, Note on *Spirillina arenacea* Williamson, 1858, proposed as type-species of the genus *Ammodiscus* Reuss, 1862).—Bull. Zool. Nomenclature, v. 19, pt. 1, Feb. 2, 1962, p. 27-34, pls. 1, 2.—Includes description and illustration of *Ammodiscus arenaceus,* a small (½ mm.) Recent species having a wall built of quartz fragments set in noncalcareous cement. The proloculus is followed by a thin tube that bends back upon itself through 2 right angles before increasing to normal size and initiating normal planispiral coiling.

MAGNÉ, J., SÉRONIE-VIVIEN, R. M., and MALMOUSTIER, G. Le Toarcien de Thouars (Deux-Sèvres).—Colloque sur le Lias Français, Bureau Recherches Géol. Min., Mém. No. 4, 1961, p. 357-397, pls. 1-15, text figs. 1-5 (columnar sections, range charts). —Range and abundance of about 45 species of Foraminifera are shown in 7 ammonite zones; most are illustrated.

MCCRONE, A. W., ELLIS, B. F., and CHARMATZ, R. Preliminary observations on Long Island Sound sediments (with a section, Paleontology of Long Island Sound sediments, by RICHARD CHARMATZ and A. W. MCCRONE).—Trans. New York Acad. Sci., ser. II, v. 24, No. 2, Dec. 1961, p. 119-129, text figs. 1-3 (maps, graph), table 1.—Species of Foraminifera reported from several cores.

MIKLUKHO-MACLAY, A. D. Stratigrafija Kamennougol'nykh Otlozhenij Srednej Azii (with English

summary).—Vestnik Leningrad. Univ., ser. geol. geogr., No. 6, vyp. 1, 1960, p. 20-30, tables 1, 2.—Biostratigraphic scale of the Carboniferous of middle Asia as based on Foraminifera.

Miller, Halsey W., Jr., and Breed, William J. A Guadalupian *Parafusulina* from a Shinarump conglomerate pebble in Arizona.—Jour. Paleontology, v. 36, No. 2, March 1962, p. 349-351, text fig. 1.

Montanari, Loris. Das Nummulitikum von Sciacca (Sizilen).—Eclogae Geol. Helvetiae, v. 54, No. 2, 1961, p. 570-579, pls. 1-3, text figs. 1-4 (map, section, columnar section, phylogenetic diagram).—Three species (one with a subspecies) from middle Oligocene rocks previously thought to be Eocene.

Moullade, M. A propos de *"Coskinolina maynci."*—Revue de Micropaléontologie, v. 4, No. 3, Dec. 1961, p. 173-174.—Placed in synonymy with *C. sunnilandensis elongata* Moullade.

Murata, Shigeo. Paleogene microbiostratigraphy of North Kyushu, Japan.—Bull. Kyushu Instit. Technology (Math., Nat. Sci.), No. 8, June 1961, p. 1-90, pl. 1, text figs. 1-3 (map, correl. charts), tables 1-25 (distrib. and abund. tables).—Qualitative and quantitative analysis of the small Foraminifera in many formations (and many samples) from 4 stages ranging in age from middle Eocene to lower Miocene as correlated with known stages in the United States and elsewhere. The stages are subdivided into 11 zones and many faunules on the basis of their smaller Foraminifera. Seven species and one subspecies are described as new.

Nyholm, Karl-Georg. A study of the foraminifer *Gypsina.*—Zool. Bidrag från Uppsala, Band 33, 1962, p. 201-206, pls. 1, 2, text figs. 1, 2.—An important paper presenting more biological evidence in support of the already-presented general thesis that *Cibicides lobatulus* exists in various "generic" forms. *Gypsina* is a resting stage of *Cibicides.*

Papp, A. Die systematische Stellung von *Silicotextulina* Deflandre 1934 (Foraminifera).—Verhandl. Austria Geol. Bundes., heft 1, 1961, p. 83-88, text figs. 1-8.—Interpreted as internal castings of small specimens of *Bolivina.*

Parker, Frances L. Planktonic foraminiferal species in Pacific sediments.—Micropaleontology, v. 8, No. 2, April 1962, p. 219-254, pls. 1-10.—Thirty-two species (3 new) and 1 subspecies. The presence or absence of long slender spines in living species is used as an additional factor to distinguish between the families Globigerinidae and Globorotaliidae. *Globoquadrina* is included in the Globorotaliidae and *Globigerinita* and *Candeina* are placed in *Incertae Familiae.*

Pavlovec, Rajko. A contribution to the study of Eocene and Oligocene Nummulites in Yugoslavia (English summary of Yugoslavian text).—Acad. Sci. Art. Slovenica, Cl. IV, Hist. Nat. Med., Ljubljana, Razprave, VI, 1961, p. 367-416, pls. 1-7, text figs. 1-15 (maps, drawings), tables 1-7.

Phleger, Fred B, and Ewing, Gifford C. Sedimentology and oceanography of coastal lagoons in Baja California, Mexico.—Geol. Soc. America Bull., v. 73, No. 2, Feb. 1962, p. 145-181, pls. 1-6, text figs. 1-11 (maps, graphs, cross sections, distrib. tables, occurrence chart), tables 1-9.—Quantitative analysis of living and dead populations in several facies (near-shore open-ocean, dune, lower lagoon, inner lagoon, and marsh). About 50 species of Foraminifera are involved.

Premoli Silva, I., and Palmieri, V. Osservazioni stratigrafiche sul Paleogene della Val di Non (Trento).—Mem. Soc. Geol. Ital., v. 3, 1962, p. 191-212, text figs. 1-6 (maps, columnar sections, range charts).—Recognition in the Upper Cretaceous to upper Eocene section of many of the planktonic zones described in Trinidad.

Ruggieri, G. Alcune zone biostratigrafiche del Pliocene e del Pleistocene Italiano.—Riv. Ital. Pal. Stratig., v. 67, No. 4, 1961, p. 405-417, text fig. 1 (diagram).—Two zones, each having 2 subzones, are recognized with zonal boundaries based on both presence and absence of species. *Globorotalia hirsuta* is in lower and middle Pliocene. *Anomalina balthica* is in Pleistocene.

Saidova, H. M. Ekologija Foraminifer i Paleogeografija Dal'nevostochnykh Morej SSSR i Severo-Zapadnoj Chasti Tikhogo Okeana.—Akad. Nauk SSSR, Instit. Okean., 1961, p. 1-232, pls. 1-31, text figs. 1-45 (maps, graphs), tables 1-13.—Quantitative analysis based on nearly 650 bottom samples and cores. Occurrence and abundance of species in selected samples from 60 deep-sea cores are tabulated. Table shows occurrence in NW Pacific, NW Bering Sea, Okotsk Sea, and Japan Sea, with columns indicating upper and lower limits of occurrence and favored depth range. Illustrated systematic catalog includes over 200 species and subspecies (17 species and 16 subspecies new).

Kolichestvennoe Raspredelenie Donnykh Foraminifer v Antarktike.—Doklady Akad. Nauk SSSR, tom 139, No. 4, 1961, p. 967-969, text figs. 1-3 (maps, graph).—Quantitative distribution of benthonics plotted areally and by depth.

Quantitative distribution of bottom Foraminifera of north-eastern Pacific (in Russian with English abstract).—Trudy Instit. Okean., Akad. Nauk SSSR, tom 45, 1961, p. 65-71, text figs. 1-3 (maps, graph), tables.—Calcareous Foraminifera are characteristic of the bathyal zone and peripheral parts of the ocean. Arenaceous Foraminifera characterize the abyssal zone, below 3,000-3,500 meters.

Zoogeography of bottom Foraminifers during the latest epochs of the Quaternary and their paleogeographic significance (in Russian with English abstract).—Trudy Instit. Geol. Akad. Nauk Estonskoj SSR, VIII, 1961, p. 197-206, text figs. 1, 2 (maps), table 1.—Comparison of species found in deep-sea cores with living species indicates lesser ocean depths during Illinois and Wisconsin times. Nature of water masses is also interpreted from deep-sea cores from the northwest Pacific.

SASTRI, V. V., and PANT, S. C. A note on the direction of coiling in *Streblus beccarii* (Linn.) (abstract).—Indian Sci. Congress Assoc., Proc. 47th Sess., Bombay, 1960, pt. III, Abstracts, p. 275.—About 80% sinistral in Pleistocene to Sub-Recent and random coiling in Recent beach sands.

SCHAUB, HANS. Über die Genusnamen der Nummulitidae: *Nummulites, Assilina* und *Operculina*.—Eclogae Geol. Helvetiae, v. 54, No. 2, 1961, p. 566-569.—In opposition to the suggestions of replacing the name *Nummulites* by *Camerina* and of combining *Operculina, Planocamerinoides* and *Camerina* within the same genus.

SMOUT, A. H., and SUGDEN, W. New information on the foraminiferal genus *Pfenderina*.—Palaeontology, v. 4, pt. 4, 1961 [Jan. 1962], p. 581-591, pls. 73-76, text-fig. 1 (drawings).—The genus is restricted to Middle and Upper Jurassic in the Middle East but to Lower Cretaceous in Europe. Redescription of *P. neocomiensis* is based on free specimens, and a new species is described. The genus *Kurnubia* is emended. Pfenderinidae new family is erected to include *Pfenderina, Kurnubia,* and *Meyendorffina*.

SOUAYA, F. J. Contribution to the study of *Miogypsina* s. l. from Egypt.—Proc. Kon. Nederl. Akad. Wetenschappen, ser. B, v. 64, No. 5, 1961, p. 665-705, pls. 1-4, text pls. 1-9 (map, columnar sections, diagrams, graphs), tables 1-14.—Occurrence of 3 species, with statistical analysis.

VILLA, F. Su alcune microfacies dell'Afghanistan Occidentale.—Riv. Ital. Pal. Stratig., v. 67, No. 4, 1961, p. 393-404, pls. 31, 32, text fig. 1 (map).—Thin sections of rocks from Carboniferous to Paleogene.

VOLOSHINOVA, N. A. The studies in the internal structure of some Foraminifera (in Russian).—Trudy Vses. neft. nauchno-issl. instit., 1960, p. 48-63, pls. 1-12.

YOSHIDA, SABURO. The Cretaceous-Tertiary boundary in eastern Hokkaido, Japan.—Jour. Hokkaido Gakugei Univ., v. 12, No. 1, Aug. 1961, p. 14-38, text figs. 1, 2 (geol. map, index map), charts 1, 2, tables 1-3.—Planktonic Foraminifera suggest Danian age for the Nemuro group otherwise considered uppermost Cretaceous.

RUTH TODD
U. S. Geological Survey
Washington 25, D. C.