CONTRIBUTIONS
FROM THE
CUSHMAN FOUNDATION
FOR
FORAMINIFERAL RESEARCH

VOLUME XIII, Part 3
July, 1962

Contents

No. 246. The Foraminiferal Genera Cibicides, Heterolepa, Planulina and Holmonella, new genus .......................... 71
No. 247. Faunal Studies of Recent Foraminifera from the Shore Sands of the State of Rio Grande do Sul in Southern Brazil .......................... 74
No. 248. Hantkenininae in the Tertiary Rocks of Tanganyika .................................................. 79
No. 249. Operculina and Associated Foraminifera from the Paleocene of the N. E. Fezzan, Libya .......................... 90
No. 250. The Type Specimens of Globigerina quadrilobata d'Orbigny, Globigerina secundifera Brady, Rotulina culttata d'Orbigny and Rotuvia menardii Parker, Jones and Brady .................................................. 98
No. 251. A Review of the Planktonic Foraminifera from the Upper Cretaceous of California ......................... 100
No. 252. Textularia carmenae nomen novum for Textularia compressa Obregon de la Parra, preoccupied by Jorge Obregon de la Parra ........ 110
No. 253. Quinqueloculina tenagos: new name for Quinqueloculina rhodiensis Parker, pre-occupied by Frances L. Parker .................................................. 110
Recent Literature on the Foraminifera .......................................................... 111

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 Cibicidiidae is restricted to genera with radially fibrous wall microstructure and bilamellid septa. Planulina is bivolute 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 Anomalinaidae 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. Pinnaela Brotzen, 1948 and Pseudotruncatulina Andrewes, 1884 are 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 Rhizopoda in which the families of the Foraminifera are based largely on wall composition, microstructure and lamellid character, as well as on life cycles and reproductive habits. When preparing this classification, the family Cibicidiidae was placed in the granular-walled superfamily Cassidulinacea, and the Anomalinaidae (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 refugens 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 the “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 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 Anomaliniidae are granular walled and bilamellid. A new generic name is required for Discorbinella valmontensis Kleinpell, as it has the wall structure of the Anomaliniidae, 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 CIBICIDIDAE 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.
Cymbicides Costa, 1839, p. 186 (nom. null.).
Truncatolina d’Orbigny, 1826, p. 278, type: Cibicides refulgens Montfort, 1808.
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, granular in structure, but this was later corrected by Wood and Haynes (1957, p. 46). Some species previously referred to Cibicides were included by Wood and Haynes (1957) and Reiss (1959) to be Pseudotruncatulina.

**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, nearlyplanispiral, 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 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.

**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. Pniaella 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. Pniaella 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 Anomalinidæ, as here restricted, rather than to the Cibicidæ.

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 north-west of end of breaker, 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


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).


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.


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, Porto Alegre, Brazil

ABSTRACT
Recent Foraminifera from shore sands off southern
Brazil show in the southern part of the area a relation­
ship 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 Torres (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, Al­
bardão, Cassino, São José do Norte, Mostardas, Soli­
dão, Quintão, Cidreira, Tramandaí, Atlântida, Cara­
murú, Rondinha, Torres (boundary of the State of
Santa Catarina) and Araranguá. Samples were taken
every 10 km. The faunal differences between neigh­
boring 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 Catarina. Most of the area is
composed of flat, sand beaches; only in the extreme
northern part (Torres) are there basaltic and arena­
ceous cliffs and hills.

Most of the samples were collected during the sum­
mer. Numerous samples from the stations at Barra do
Chuí, Cassino, Tramandaí and Torres 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 Interna­
tional 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 Torres, the variations are greater be­
cause fresh water from the rivers decreases the salinity.

Cordial thanks are given to Prof. Irajá Damiani
Pinto (Porto Alegre) and Mr. Emidio P. Martino
(Santa Vitória) for their helpful aid in the collection
of samples. The writers wish to express their grati­
tude to Dr. E. Boltovskoy (Buenos Aires) for gener­
ously supplying material for comparison and for stimu­
lating 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 import­
ant work by Boltovskoy (1959a) describes 260 Bra­
zilian species. Both of these studies were of offshore
areas.

The most common forms off our coast are: Elphidium
discoidale (d’Orbigny), Buccella frigida (Cush­
man), B. peruvi ana campsi (Boltovskoy) small speci­
mens, Quinqueloculina seminulum (Linné) and Rotalia
beccarii ex gr. parkinsoniana (d’Orbigny). The domi­
nant form is Elphidium discoidale which is very abun­
dant 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 ex­
tremely 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 regu­
larly present: Pyrgo nasuta Cushman, Mastitina
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 "Con­
seilo Nacional de Pesquisas."
TEXT FIGURE 1
Map showing the area studied, with the localities mentioned in the text.
<table>
<thead>
<tr>
<th>SPECIES NAME</th>
<th>BARRA DO CHU</th>
<th>HERMENECULO</th>
<th>PASSO DA LAGOA</th>
<th>CASSINO</th>
<th>SÃO JOSÉ DO NORTE</th>
<th>MOSTARDA</th>
<th>TRAMANDAI</th>
<th>ATLÂNTIDA</th>
<th>CARANDU</th>
<th>RONDONIA</th>
<th>TORRES</th>
<th>ARARANCIO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEXTULARIA GRAMEN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TEXTULARIA CANDEIANA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>QUINQUELOCULINA SEMINULUM</strong></td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>QUINQUELOCULINA ISABELLEI</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>QUINQUELOCULINA ATLANTICA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>QUINQUELOCULINA AFFRIGIDA</strong></td>
<td>MR</td>
<td>R</td>
<td>MR</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>QUINQUELOCULINA POLYGONA</strong></td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>QUINQUELOCULINA LAMARCKIANA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MASSILINA SECANS</strong></td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TRILOCULINA TRIGONULA</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PYRO NASUTA</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>R</td>
<td>E</td>
<td>AR</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NODOSARIA CATESBYI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LAGENA SULCATA ELYELLII</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LAGENA LAEVIS F. TYPICA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LAGENA LAEVIS F. PERLUCIDA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OOLINA COSTATA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GLOBULINA CARIBEA</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GUTTULINA PROBLEMA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NONIONELLA ATLANTICA</strong></td>
<td>MR</td>
<td>MR</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>FF</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BULIMINA MARGINATA E TYPICA</strong></td>
<td>MR</td>
<td>MR</td>
<td>R</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>R</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BULIMINA MARGINATA E SUBALATA</strong></td>
<td>MR</td>
<td>MR</td>
<td>R</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BULIMINA MARGINATA E ACULEATA</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BULIMINA PATAGONICA E TYPICA</strong></td>
<td>MR</td>
<td>E</td>
<td>E</td>
<td>MR</td>
<td>R</td>
<td>E</td>
<td>E</td>
<td>R</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BULIMINA PATAGONICA E GLABRA</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BULIMINA PSEUDO-AFFINIS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VIRGULINA PAUCICLOCULATA</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BOLIVINA STRIATULA E TYPICA</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BOLIVINA PUSILLA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UVIGERINA PEREGRINA E PARVULA</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DISCORBIS WILLIAMSONI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>POROEPOIDES LATERALIS</strong></td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>E</td>
<td>F</td>
<td>R</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BUCCAPELLA FRIGIDA</strong></td>
<td>F</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>F</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BUCCAPELLA PERUVIANA CAMPSI</strong></td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>F</td>
<td>E</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ROTALIA BECCARI EX-GR PARKINSONIANA</strong></td>
<td>MR</td>
<td>MR</td>
<td>R</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>E</td>
<td>E</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rolshausenia Rolshausenii</strong></td>
<td>MR</td>
<td>R</td>
<td>R</td>
<td>E</td>
<td>E</td>
<td>F</td>
<td>R</td>
<td>E</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ELPHIDIUM DISCOIDALE</strong> (D)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CANCRIS SAGA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CIBICIDES BERTHELOTI E TYPICA</strong></td>
<td>R</td>
<td>F</td>
<td>R</td>
<td>E</td>
<td>MR</td>
<td>E</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CIBICIDES BERTHELOTI E BOUENEA</strong></td>
<td>R</td>
<td>E</td>
<td>R</td>
<td>E</td>
<td>F</td>
<td>E</td>
<td>R</td>
<td>MR</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ORBULINA UNIVERSA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GLOBIGERINOIDES RUBRA E TYPICA</strong></td>
<td>MR</td>
<td>MR</td>
<td>R</td>
<td>F</td>
<td>E</td>
<td>R</td>
<td>MR</td>
<td>E</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GLOBIGERINOIDES RUBRA E TRILoba</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GLOBIGERINOIDES RUBRA E PYRAMIDALIS</strong></td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GLOBOROTALIA MENARDII</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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 rolshausenii (Cushman and Bermúdez), Cibicides bertheloti (d’Orbigny) and Globigerinoides ruber (d’Orbigny).

Masilina 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 isabellei d’Orbigny, Q. aff. Q. frigida Parker, Lagena levis (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 Bolotovskoy (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 candeaana d’Orbigny, Quinqueloculina atlantica Bolotovskoy, 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,Discorhis williamsoni (Chapman and Parr), Orbutila 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 Chui to Albarão) 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 Bolotovskoy, 1959b, p. 33). Buccella frigida can be considered the dominant form although Elphidium discoideum 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 (Bolotovskoy, 1959a, p. 27), are also absent here.

b) From Cassino to Arranquá a change in the fauna is noted. The dominant species now is Elphidium discoideum, and Buccella frigida is less common. The great abundance of Elphidium was also noted by Bolotovskoy (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 (Bolotovskoy, 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 Bolotovskoy 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 Rondinha and can be considered, after Elphidium discoideum, 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 Tórrres show a greater tendency to vary from the normal characters. In addition, abnormal forms of such species as Elphidium discoideum, Nonionella atlantica and Rotalia beccarii were observed.

g) Samples from Tórrres, 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


———, 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.


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

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

248. HANTKENININAE IN THE TERTIARY ROCKS OF TANGANYIKA
W. 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 is 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, Loeblitch 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, 5, 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 Cribrorhantkenina 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 Cribrorhantkenina 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 erector 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 below.

**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 dumbiei 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. dumbiei 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. dumbiei 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 sutureal. 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. dumbiei, the type of Applinella, and species of Aragonella. Similarity, moreover, occurs in that the spines are never truly sutureal in H. dumbiei and separation of the chambers at the periphery occurs in the adult stages of both H. dumbiei 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 Hantkenina, 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: Cribrohantkeninella bermudezi Thalmann, 1942.

Specimens of Hantkenina, from Alabama, were described by Barnard (1954) as showing a trend towards the development of the cribate apertural condition from the typical triradiate aperture. He suggested that this showed a phylectic 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 cribate condition must be considered of fundamental genetic importance. Hence Cribrohantkenina is regarded in this work as a valid genus.

**Morphological Criteria for Genus 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 chamber 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:— apertural development, spine positioning and chamber separation.

1. Single aperture, not cribate.

**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.


(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


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 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.—Figure 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 spe-
cies.” 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


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 coiling is generally by prolongation along the chamber axis and is 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 aperture 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. liebwi 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 off 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


*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


---

**EXPLANATION OF PLATE 16**

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

<table>
<thead>
<tr>
<th>FIGS</th>
<th>LOCATION</th>
<th>DEPOSITORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hantkenina (Aragonella) mexicana Cushman. Lateral view.</td>
<td>81</td>
</tr>
<tr>
<td>2-5, 15</td>
<td>Hantkenina (Aragonella) lehneri Cushman and Jarvis</td>
<td>82</td>
</tr>
<tr>
<td>2.</td>
<td>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.</td>
<td>83</td>
</tr>
<tr>
<td>6, 7</td>
<td>Hantkenina (Aragonella) liebusi Shokhina. Lateral views.</td>
<td>84</td>
</tr>
<tr>
<td>8, 9</td>
<td>Hantkenina (Hantkenina) primitiva Cushman and Jarvis</td>
<td>84</td>
</tr>
<tr>
<td>8.</td>
<td>Lateral view. 9. Apertural view.</td>
<td>85</td>
</tr>
<tr>
<td>10.</td>
<td>Hantkenina (Hantkenina) australis Finlay. Lateral view.</td>
<td>84</td>
</tr>
<tr>
<td>11.</td>
<td>Cribrohantkenina bermudezi Thalmann, Apertural view.</td>
<td>85</td>
</tr>
<tr>
<td>12a.</td>
<td>Postero-lateral view showing backwardly pointing spine. 12b. Apertural view showing subdivided aperture. 13. Lateral view, penultimate spine end just showing.</td>
<td>86</td>
</tr>
<tr>
<td>14.</td>
<td>Apertural view of subdivided aperture just approaching that shown by fig. 18. 18. Apertural view, showing subdivided aperture. Apertural face cracked.</td>
<td>84</td>
</tr>
</tbody>
</table>
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


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. Rare.

(Range reported outside Tanganyika: Upper Eocene.)

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

Hantkenina (Hantkenina) brevispina

Chamber lengths. 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

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 0.25 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.
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.


Genus *Cribrohantkenina* Thalmann, 1942

*Cribrohantkenina bermudezi* Thalmann

Plate 16, figure 11


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


**Description.**—Only the worn remains of almost g l obular 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).

**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.) albemansis*; 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

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

**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


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 multisepata Silvestri and Operculina thouini in Silvestri's sense are considered synonymous. O. alpina multisepata 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. canallata d'Arcy. 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 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. multisepata 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. multisepata along the western scarp front of the Gebel Iddan 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. multisepata 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 multisepata. 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 dolomitized 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**

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Fauna</th>
</tr>
</thead>
<tbody>
<tr>
<td>64 Tan limestone</td>
<td>Cibicides sp.</td>
</tr>
<tr>
<td>Buf marl</td>
<td>Cibicides libya Leroy Paleocene, Egypt.</td>
</tr>
<tr>
<td>Yellow marl</td>
<td>Coleites cf. C. reticulatus (Plummer) Paleocene, Texas.</td>
</tr>
<tr>
<td>63 White limestone</td>
<td>Discorbis sp.</td>
</tr>
<tr>
<td>62 Yellow marl</td>
<td>Gaudryina pyramidata (Cushman) U. Cretaceous, Trinidad.</td>
</tr>
<tr>
<td>61 Buff limestone (leached)</td>
<td>Lockhartia diversa Smout Paleocene, Qatar.</td>
</tr>
<tr>
<td>Dolomitised remnants only</td>
<td>Miliammina sp.</td>
</tr>
<tr>
<td>59 Yellow marl</td>
<td>Nonionella insecta (Schwager) Paleocene, Egypt.</td>
</tr>
<tr>
<td>58 Yellow marl</td>
<td>Operculina thouni d'Orb. in Silvestri’s sense.</td>
</tr>
<tr>
<td>57 Green shale</td>
<td>Quinqueloculina sp.</td>
</tr>
<tr>
<td>56 Black shale</td>
<td>Rotalia calcariformis (Schwager) Paleocene, Egypt.</td>
</tr>
<tr>
<td>55 Limestone</td>
<td>Rotalia hensoni Smout Paleocene, Qatar.</td>
</tr>
<tr>
<td>54 Chalk</td>
<td>Rotalia trochiformis Lamarck Paleocene to Lutetian.</td>
</tr>
<tr>
<td>53 Green grey</td>
<td>Rotalia tuberculifera Reuss Maestrichtian, Netherlands.</td>
</tr>
<tr>
<td>52 Chalk</td>
<td>Textularia midwayana Lalicker Paleocene, Texas.</td>
</tr>
<tr>
<td>51 Shale</td>
<td>Valvulina nammalensis Haque Paleocene, Pakistan.</td>
</tr>
</tbody>
</table>

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

_Cibicides_ sp.
_Cibicides_ libyca
_Lockhartia_ oblonga
_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 ovoides - 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 Bescesim 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. siddensis_ Davies of the Ranikot here considered a subspecies of _O. canalifera_ d’Archiac.

SYSTEMATIC PART

**Genus Operculina d’Orbigny, 1826**

**Operculina canalifera siddensis** (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.


**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 canalicate; ornament includes um-
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**

<table>
<thead>
<tr>
<th>Specimen</th>
<th>6</th>
<th>12</th>
<th>13</th>
<th>5</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation</td>
<td>Microspheric</td>
<td>Megalospheric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total whorl number</td>
<td>6½</td>
<td>5</td>
<td>6</td>
<td>3½</td>
<td>3½</td>
</tr>
<tr>
<td>Chambers visible on exterior</td>
<td>56</td>
<td>30</td>
<td>40</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>whorl 1</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>21</td>
<td>19</td>
<td>20</td>
<td>15½</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>30</td>
<td>30</td>
<td>26</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>54</td>
<td>+3</td>
<td>40</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>+8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>whorl 1</td>
<td>.1</td>
<td>.1</td>
<td>.1</td>
<td>.6</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>.3</td>
<td>.31</td>
<td>.3</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>.7</td>
<td>1.0</td>
<td>.9</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3.3</td>
<td>2.6</td>
<td>2.1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5.5</td>
<td>5.1</td>
<td>4.3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>8.5</td>
<td>-</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8.5</td>
<td>5.1</td>
<td>7</td>
<td>4.2</td>
</tr>
</tbody>
</table>

---

**EXPLANATION OF PLATE 17**

1-5. *Operculina canalifera sindensis* (Davies) These figures represent *Operculina thouini* in Silvestri’s sense, from El Fogaha. 1. X 8. Stereopair 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. X 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. X 24. Detail of axial section showing the radiate structure of the massive, canaliculate marginal cord. 4. X 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. X 8. Stereopair showing irregular specimen.
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 megaspheric 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. canaliifera* 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. canaliifera* 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 *canaliifera - sindensis* plexus. However, as no type figure was published until 1904 (by Fornasini) and whereas *O. canaliifera* was well established in 1853 it is thought correct and less confusing to refer the Libyan population (considered as a subspecies) to *O. canaliifera 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. canaliifera sindensis* the test is evolve, except for the initial whors in the microspheric generation, with a few whors 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 whors 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. planulatus* Lamarck. Although this view is not followed here, it is probable that *O. canaliifera* 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. canaliifera sindensis* appears to be the most advanced member of a plexus that also includes *R. sahnis* Davies, 1952, and Operculinoides bermudesi 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. canaliifera 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**

<table>
<thead>
<tr>
<th>Figs.</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-7. Operculina canaliifera sindensis (Davies)</td>
<td>92</td>
<td></td>
</tr>
</tbody>
</table>
ASSOCIATED FAUNA

Genus Cibicides Montfort, 1808
Cibicides libyca LeRoy

Genus Coleites Plummer, 1934
Coleites cf. C. reticulosis (Plummer)
See 1926, Palvinulina 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

Genus Nonionella Cushman, 1926
Nonionella insecta (Schwager)

Genus Nonionella Cushman, 1926
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.


Rotalia hensoni Smout

Rotalia trochidiformis Lamarck


Rotalia tuberculifera Reuss

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

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


In 1960 we published descriptions of lectotypic, syn-
typic and neotypic specimens of many species which are
deposited in the collections of the Museum Na-
tionale de l'Historie 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 prin-
cipal basis upon which currently published determina-
tions were being made. The descriptions of the care-
fully selected types (op. cit.) were as objective as we
could make them, and we kept our more subjective re-
marks 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 quadri-
lobata 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 con-
cept of the species which has grown amongst palaeon-
tologists over the last century or to d'Orbigny's origi-
nal description. It seems to us that d'Orbigny's original
diagnosis (1846, p. 164: "G. testa ovata-convexa, gib-
bosa, punctata, subitus umbilicata, loculis quatuor
sphaericis, subaequalibus, ultimo sphaeircon") is satis-
fied 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 sub-
equal spherical chambers (at least, in the last whorl)
in an ovate-convex, gibbous test, in any sample avail-
able to us from the Vindobonian of Nussdorf. Todd
(1961, p. 121) points out that d'Orbigny did not men-
tion 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 compar­
able 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 alto­
ger. We have no reason to doubt that the speci-
mens labelled "Globigerina quadrilobata d'Orb., Tor­
tonien, Nussdorf, Autriche" in the A. d'Orbigny collect
in Paris, are authentic syntypes, and it appears to
us untruly 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 rep­
resented by a lectotype. We believe that Globigeri­
nooides quadrilobatus (d'Orbigny) is morphologically
distinct from both Globigerinooides quadrilobatus sac­
culifer (Brady) and G. quadrilobatus trilobus (Reuss)
and that its recognition is important in the under­
standing of the phylogeny of these forms. The phylo-
geny of this group has already been covered in part
by us (loc. cit.), is dealt with in further detail in an­
other work (Eames, et al., 1962), and G. quadrilobatus
(s. i.) 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'Or-
bigny'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 diagnos­
sis "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 neo-
type (Banner and Blow, 1960, pp. 34-5). When d'Or-
bigny believed that a test was rugose he said so (d'Orbigny, 1839, p. 97, for Rosalina carneina: “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 Rosalina 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 Rosalina 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, subitus 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.)
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 CRETAEOUS 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 those 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. 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 Forami-

nifer first specifically identified from deposits of Cre-}

taceous age in California (J. A. Cushman and C. C. 
Church—Some Upper Cretaceous Foraminifera from 
ser., vol. 18, no. 16, pp. 497-530). These fossils—Glo-

botruncana area (Cushman) and Ventilabrella ornatis-

ima 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 North-
ern Petroleum Company well #19 in the Alcaide Hills, 
west of Coalinga. Thirteen years later, 1942, Thalm-
mann (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). Thal-
mann 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 "Francis-
can" 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 
Gumbelina sp. in a slightly siliceous "Franciscan" lime-
stone cropping out east of the Redwood Highway in the 
northern part of the state. He regarded the Lay-
tonville 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 equiva-

lents 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 Rotali-
pora-Schackoaina-Globigerina-Praeglobotruncana of the 
delrioensis type is "clearly and undoubtedly Ceno-
manian in age...[and] Other bodies of limestone 
neighboring, as well as the limestone near Laytonville, con-
tain tests of the genera *Ticinella* sp., *Thalmanninella* sp., and *Globigerina* sp., of the *washitenis* 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:


*Globotruncanca 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.


*Globotruncanca 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.


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


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


Four planktonic species are mentioned among the 67 Foraminifera recorded from various zones: *Globotruncanca arca* (Cushman), ranging from the D-1 zone to G-1 and with "characteristic occurrence" in zones D-2 and E; *Globotruncanca canaliculata* (Reuss), with an F-1 to G-2 zonal range and a "characteristic occurrence" in F-1, F'-1 and F-2; *G mouldifera 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.


*Globotruncanca 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.)


*Globigerina almadenensis*, *Globorotalia californica*, *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.)


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" *r F. Gandolfi, "Globorotalia" californica* Cushman and Todd to the group of *Globotruncanca ticinensis* Gandolfi, *Globotruncanca 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 cushioni* (Morrow) var. *evoluta* Sigal, and *Planomalina? almadenensis* Cushman and Todd to "Planulina" *bustum* of Gandolfi.


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


*Globotruncanca 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.

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


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. (See this paper for nomenclatural changes of several of the species listed by Church (1952) from the type locality of the Calera Limestone.


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


Globotruncana küpperi, new name, is proposed for Globotruncana (Praglobotruncana) rensi Gandolfo and Thalmann subsp. primitiva Küpper, 1956, from the Upper Cenomanian “Antelope shale.”


Globotruncana arca (Cushman), G. elevata stu­artiiformis 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.


Praglobotruncana 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 Gandolfo, G. schneeegansii Sigal, and Heterohelix globulosa (Ehrenberg) are recorded from middle Turonian, Coniacian, and Santonian outcrops in northern California.


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


“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.


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 no­curring in the middle to late Cenomanian strata of the Fresno County.

Fresno County.


"Globigerinella" aspera (Ehrenberg), Globotruncana fornicatea Plummer, G. lineicollis (d'Orbigny), G. lineicollis tricarinata (Quercou), 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 Pancho Formation, San Luis Creek Quadrangle, Merced County.

It is interesting to note that several planktonic foraminiferous 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.


5. Globotruncana arca (Cushman). Bandy, 1951, Jour. Paleontology, vol. 25, no. 4, p. 509, pl. 75, figs. 1a-c (Campanian).


[Non] Globotruncana canaliculata Reuss in Bandy, 1951, Jour. Paleontology, vol. 25, no. 4, p. 509, pl. 75, figs. 2a-c (Campanian).


?Globotruncana canaliculata (Reuss). Bandy, 1951, Jour. Paleontology, vol. 25, no. 4, p. 509, pl. 75, figs. 2a-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 |
|                 | In Almaden district, Santa Clara County | Clark Valley, Glenn and Contra Costa Counties | San Mateo County | Near Redding, Shasta County | Merced County | Carquinez Area, Solano County | Contra Costa County | Moreno Valley, Ventura County | Coalitions, Lake County |
| 1. Clavihedbergella simplex (Morrow) | 1 | 1 | 3 | 3 | 4 |
| 2. [?] Globigerina sp. Cushman and Todd | 2 | 1 | 5 | 4 |
| 3. "Globigerinella" azpera (Cushman) | 1 | 7 | 3 |
| 4. "Globotruncanella" (Cushman) | 1 |
| 5. Globotruncanella arca (Cushman) | 1 |
| 6. Globotruncanella calyculata (Reuss) | 18 |
| 7. Globotruncanella formiscata Plummer | 7 |
| 8. Globotruncanella helvetica Bolli | 17 |
| 9. Globotruncanella linneana (d'Orbigny) | 7, 17 |
| 10. Globotruncanella linneana tricornata (Quereau) | 7 |
| 11. Globotruncanella aff. G. paraventricosa Holker | 7 |
| 12. Globotruncanella renzi Gandolfi | 17 |
| 13. Globotruncanella rosetta (Carsey) | 1 |
| 14. Globotruncanella schneegasi Sigal | 17 |
| 15. Globotruncanella ventricosa White | 7 |
| 16. Gublerina ornattissima (Cushman and Church) | 3, 13 |
| 17. Hedbergella brittonensis Loeblieh and Tappan | 9, 11 |
| 18. Hedbergella trocoidea (Gandolfo) | 5, 11 |
| 19. Heterohelix globulosa (Ehrenberg) | 17 |
| 20. Heterohelix striata (Ehrenberg) | 1, 7 |
| 21. Heterohelix sp. | 6 |
| 22. Planomalina buxtorfi (Gandolfo) | 5, 9, 11 |
| 23. Praeglobotruncanella hansbolli Trujillo | 17 |
| 24. Praeglobotruncanella stephani (Gandolfo) | 2, 9, 10, 11 |
| 25. Pseudotextularia elegans (Rzehak) | 7 |
| 26. Rotalipora cushmani (Morrow) | 12 |
| 27. Rotalipora evoluta Sigal | 2, 5, 9, 11 |
| 28. Rotalipora greenhornensis (Morrow) | 5, 9, 10, 11 |
| 29. Rugoglobigerina kingi Trujillo | 17 |
| 30. Rugoglobigerina aff. R. ordinaria Subbotina | 7 |
| 31. Rugoglobigerina praeheletrica Trujillo | 17 |
| 32. Rugoglobigerina rugosa (Plummer) | 7 |
| 33. Schackoina multispinata (Cushman and Wickenden) | 10, 11 |
| 34. Ticinella aprica Loeblieh and Tappan | 11 |

* Numbers following species names refer to publications in Bibliography.
Giumbelina striata (Ehrenberg). Bandy, 1951, Jour. Paleontology, vol. 25, no. 4, p. 510, pl. 75, figs. 8-9a-b (Campanian).
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).
Globotruncana (Globotruncana) stephani Gandolfi var. truncata 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) stephani stephani (Gandolfi). Kupper, 1955, Contr. Cushman Found. Foram. Research, vol. 6, pt. 3, p. 116, pl. 18, figs. 6a-c (early or middle Cenomanian).
Globotruncana (Praeglobotruncana) renzi (Thalmann and Gandolfi) subsp. primitiva Kupper, 1956, Cushman Found. Foram. Research, vol. 7, pt. 2, p. 43, pl. 8, figs. 2a-c (late Cenomanian).
Globorotalia californica Cushman and Todd,
EXPLANATION OF PLATE 19
(figures reproduced from the original sources)

<table>
<thead>
<tr>
<th>FIGS.</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A-1B. Clavihedbergella simplex (Morrow) of LOEBLICH and TAPPAN, 1961</td>
<td>103</td>
</tr>
<tr>
<td>1Aa-c. &quot;Schackoina&quot; cf. S. gandolfi Reichel of KÜPFER, 1956. × 52.5. 1Aa, umbilical view; 1Ab, ventral view. Late Cenomanian, Glenn County.</td>
<td></td>
</tr>
<tr>
<td>1B. [?]Hastigerinella sp. of CUSHMAN and TODD, 1948. × 19. Side view. Middle to late Cenomanian, New Almaden district.</td>
<td></td>
</tr>
<tr>
<td>2. [?]Globigerina sp. CUSHMAN and TODD, 1948. × 19. Spiral view. Middle to late Cenomanian, New Almaden district.</td>
<td></td>
</tr>
<tr>
<td>3A-3B. &quot;Globigerinella&quot; aspera (Ehrenberg).</td>
<td></td>
</tr>
<tr>
<td>3Aa-c. Globigerinella aspera (Ehrenberg) of BANDY, 1951. × 60. 3Aa, dorsal view; 3Ab, edge view; 3Ac, ventral view. Campanian, Carlsbad area.</td>
<td></td>
</tr>
<tr>
<td>3Ba-c. &quot;Globigerinella&quot; aspera (Ehrenberg) of GRAHAM and CLARK, 1961. × 60. 3Ba, spiral view; 3Bb, edge view; 3Bc, umbilical view. Campanian, Merced County.</td>
<td></td>
</tr>
<tr>
<td>4. &quot;Globotruncana arca (Cushman)&quot; of CUSHMAN and CHURCH, 1929. × 30. 4a, umbilical view; 4b, edge view; 4c, spiral view. Campanian, near Coalinga.</td>
<td></td>
</tr>
<tr>
<td>5. Globotruncana arca (Cushman) of BANDY, 1951. × 25. 5a, spiral view; 5b, edge view; 5c, umbilical view. Campanian, Carlsbad area.</td>
<td></td>
</tr>
<tr>
<td>6. Globotruncana canaliculata (Reuss) of TRUJILLO, 1960. × 29. 6a, umbilical view; 6b, edge view; 6c, spiral view. Coniacian, Redding area.</td>
<td></td>
</tr>
<tr>
<td>7. Globotruncana fornicata Plummer of GRAHAM and CLARK, 1961. × 38. 7a, spiral view; 7b, edge view; 7c, umbilical view. Campanian, Merced County.</td>
<td></td>
</tr>
<tr>
<td>8. Globotruncana helvetica Bolli of TRUJILLO, 1960. × 29. 8a, umbilical view; 8b, edge view; 8c, spiral view. Middle Turonian, Redding area.</td>
<td></td>
</tr>
<tr>
<td>9A-9D. Globotruncana linnetiana (d'Orbigny).</td>
<td></td>
</tr>
<tr>
<td>9Aa-c. Globotruncana linnetiana (d'Orbigny) of TRUJILLO, 1960. × 31. 9Aa, umbilical view; 9Ab, edge view; 9Ac, spiral view. Campanian, Redding area.</td>
<td></td>
</tr>
<tr>
<td>9B-a-b. [?]Globotruncana canaliculata (Reuss) of CUSHMAN and GOUDKOFF, 1944. × 25. 9Ba, spiral view; 9Bb, umbilical view; ?Campanian, Moreno Gulch.</td>
<td></td>
</tr>
<tr>
<td>9Ca-c. [?]Globotruncana canaliculata (Reuss) of BANDY, 1951. × 25. 9Ca, spiral view; 9Cb, edge view; 9Cc, umbilical view. Campanian, Carlsbad area.</td>
<td></td>
</tr>
<tr>
<td>9Da-c. Globotruncana linnetiana (d'Orbigny) of GRAHAM and CLARK, 1961. × 37. 9Da, spiral view; 9Db, edge view; 9Dc, umbilical view. Campanian, Merced County.</td>
<td></td>
</tr>
<tr>
<td>10. Globotruncana linnetiana tricarinata (Quereau) of GRAHAM and CLARK, 1961. × 40. 10a, spiral view; 10b, edge view; 10c, umbilical view. Campanian, Merced County.</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>13. Globotruncana rosetta (Carsey) of BANDY, 1951. × 25. 13a, spiral view; 13b, edge view; 13c, umbilical view. Campanian, Carlsbad area.</td>
<td></td>
</tr>
<tr>
<td>14. Globotruncana schneegansi Sigal of TRUJILLO, 1960. × 31. 14a, umbilical view; 14b, edge view; 14c, spiral view. Middle Turonian, Redding area.</td>
<td></td>
</tr>
<tr>
<td>15. Globotruncana ventricosa White of GRAHAM and CLARK, 1961. × 40. 15a, spiral view; 15b, edge view; 15c, umbilical view. Campanian, Merced County.</td>
<td></td>
</tr>
<tr>
<td>16A-16C. Gublerina ornatisimia (Cushman and Church).</td>
<td></td>
</tr>
<tr>
<td>16A-16Ba-b. [Ventilabrella ornatisimia CUSHMAN and CHURCH, 1929] × 30. 16A and 16Ba, side views; 16Bb, end view; 16Bc, edge view.</td>
<td></td>
</tr>
<tr>
<td>16Ca-b. Gublerina ornatisimia (Cushman and Church) of MONTANARO, GALLITELLI, 1957. × 50. 16Ca, side view; 16Cb, (opposite side of 16Ca, etched), Campanian, near Coalinga.</td>
<td></td>
</tr>
<tr>
<td>17a-c. &quot;Globigerina&quot; sp. of KÜPFER, 1955. × 22.5. 17a, edge view; 17b, spiral view; 17c, umbilical view. Middle to late Cenomanian, New Almaden district.</td>
<td></td>
</tr>
<tr>
<td>18A-18B. Hedbergella trocoidea (Gandolfi) of LOEBLICH and TAPPAN, 1961</td>
<td></td>
</tr>
<tr>
<td>20A-20C. Heterohelix striata (Ehrenberg).</td>
<td></td>
</tr>
<tr>
<td>20Aa-b. Heterohelix striata (Ehrenberg) of GRAHAM and CLARK, 1961. × 56.5. 20Aa, side view; 20Ab, top view. Campanian, Merced County.</td>
<td></td>
</tr>
<tr>
<td>20B and 20C. Guembelina striata (Ehrenberg) of BANDY, 1951. × 40. 20Ba and 20Ca, side views; 20Bb and 20Cb, edge views. Campanian, Carlsbad area.</td>
<td></td>
</tr>
<tr>
<td>21. Heterohelix sp. GRAHAM and CLARK, 1961. × 37.5. 21a, side view; 21b, top view. Campanian, Merced County.</td>
<td></td>
</tr>
</tbody>
</table>
Graham: Planktonic Foraminifera, Upper Cretaceous, Calif.
Graham: Planktonic Foraminifera, Upper Cretaceous, Calif.
EXPLANATION OF PLATE 20
(figures reproduced from the original sources)

Figs. 22A-22B. Planomalina buxtorfi (Gandolfi).
22B-a. Planomalina buxtorfi (Gandolfi) of Küpper, 1955. X 22.5. 22Ba, side view; 22Bb, edge view. Middle to late Cenomanian, New Almaden district.


24A-24H. Praeglobotruncana stephani (Gandolfi).
24A-a. Praeglobotruncana stephani (Gandolfi) of Loeblich and Tappan, 1961. X 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. X 19. 24Bb, edge view. Middle to late Cenomanian, New Almaden district.
24Ea-c. "Globotruncana (Rotundina) australiensis (Sigal)" of Küpper, 1955. X 22.5. 24Ea, spiral view; 24Eb, edge view; 24Ec, umbilical view. Middle to late Cenomanian, New Almaden district.
24Fa-c. "Globotruncana (Rotundina) steppani steppani (Gandolfi)" of Küpper, 1955. X 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. X 52.5. 24Ga, umbilical view; 24Gb, edge view; 24Gc, spiral view. Late Cenomanian, Colusa County.
24Ha-c. "Globotruncana (Praeglobotruncana) rensi (Thalmann and Goudkoff) spp. primitiva" of Küpper, 1956. X 52.5. 24Ha, umbilical view; 24Hb, edge view; 24Hc, spiral view. Late Cenomanian, Colusa County.


26. Rotulipora cushmani (Morrow) of Loeblich and Tappan, 1961. X 30. 26a, umbilical view; 26b, edge view; 26c, spiral view. Middle to late Cenomanian, Glenn County.

27A-27D. Rotulipora evoluta Sigal.
27Aa-c. Globorotalia almadenensis Cushman and Todd, 1948. X 19. 27Aa, spiral view; 27Ab, umbilical view. Middle to late Cenomanian, New Almaden district.
27B. "Globorotalia (Rotulipora) apenninica var. typica Gandolfi" Bolli in Church, 1952. X ?. umbilical view. Late Cenomanian, San Mateo County.
27Ca-c. "Globorotalia (Rotulipora) apenninica apenninica (Renzi)" of Küpper, 1955. X 22.5. 27Ca, umbilical view; 27Cb, edge view; 27Cc, spiral view. Middle to late Cenomanian, New Almaden district.
27Da-c. "Globotruncana (Rotulipora) evoluta Sigal" of Küpper, 1955. X 22.5. 27Da, umbilical view; 27Db, edge view; 27Dc, spiral view. Middle to late Cenomanian, New Almaden district.

28A-a. Rotulipora greenhornensis (Morrow) of Loeblich and Tappan, 1961. 28Aa, spiral view; 28Ab, edge view; 28Ac, umbilical view. X 30. Middle to late Cenomanian, Glenn County.
28Ca-c. "Globotruncana (Rotulipora) globotruncanoides Sigal" of Küpper, 1955. X 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. X 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. X 52.5. 28Ea, umbilical view; 28Eb, edge view; 28Ec, spiral view. Late Cenomanian, Glenn County.

30. Rugoglobigerina aff. R. ordinaria Subbotina of Graham and Clark, 1961. X 42.5. 30a, spiral view; 30b, edge view; 30c, umbilical view. Campanian, Merced County.
31. Rugoglobigerina praehelvetica Trujillo, 1961. X 29. 31a, umbilical view; 31b, edge view; 31c, spiral view. Middle Turonian, Redding area.
32. Rugoglobigerina rugosa (Plummer) of Graham and Clark, 1961. X 56.5. 32a, umbilical view; 32b, edge view; 32c, spiral view. Campanian, Merced County.
33. Schackoina multispinata (Cushman and Wickenden) of Loeblich and Tappan, 1961. X 22.5. 33a-c. "Schackoina cenomaniana (Schacko) bicornis Reichel" of Küpper, 1956. X 52.5. 33a and 33c, side views; 33b, edge view. Late Cenomanian, Glenn County.
34a-c. "Globotruncana (Rotundina) californica (Cushman and Todd)" of Küpper, 1955. X 22.5. 34a, umbilical view; 34b, edge view; 34c, spiral view. Middle to late Cenomanian, New Almaden district.

*Globorotalia* *decorata* CUSHMAN and TODD, 1948, Contr. Cushman Found. Foram. Research, vol. 6, pt. 4, pp. 97-98, pl. 16, fig. 21 (Early Cretaceous).


LOCALITIES AND AGE REFERENCES


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

KUPFER, 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. KUPFER, 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) KUPFER, 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 Marlitt] — Panoche group)
(Panoche Quadrangle)
Cushman, J. A., and P. P. Goudkoff, 1944 — Late Cretaceous
(?Campanian age based on occurrence of Globotruncanala canaliculata
(Reuss) of Cushman and Goudkoff = ?Globotruncanala 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 “Globotruncanala arca
(Cushman)” of Cushman and Church, 1929, by Lewis
?Campanian Age based on data in Matsumoto,
1960, fig. 15, p. 116 (LSJU Loc. 3197). The latter
locality is in the NW ¼ SE ¼ 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 Cali­
fornia: Contr. Cushman Found. Foram. Re­
search, vol. 3, pt. 2, pp. 68-70, 2 text figs.
Upper Cretaceous Foraminifera from near Coa­
Ser., vol. 18, no. 16, pp. 497-530, pls. 36-41.
4. —— and P. P. Goudkoff, 1944: Some Forami­
nifera 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, Cali­
fornia: Contr. Cushman Lab. Foram. Research,
vol. 24, pt. 4, pp. 90-98, pl. 16, figs. 4-25.
6. Glaessner, M. F., 1949: Foraminifera of Fran­
ciscan (California): Am. Assoc. Petroleum Ge­
ologists, Bull., vol. 33, no. 9, pp. 1615-1617.
for the age of the “G-1 Zone” in the Upper Cretaceous of California: Contr. Cushman
8. Irwin, W. P., 1957: Franciscan group in Coast
Ranges and its equivalents in Sacramento
Valley, California: Am. Assoc. Petroleum Ge­
ologists, Bull., vol. 41, no. 10, pp. 2284-2297, 2 figs.
nifera from the “Franciscan Series” New Al­
maden district, California: Contr. Cushman
Found. Foram. Research, vol. 6, pt. 3, pp. 112-
118, 123, pl. 18.
10. —— 1956: Upper Cretaceous pelagic Forami­
nifera 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. Loeblitch, 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.
ammonites of California — Part 3: Mem. Fac­
ulty Sci., Kyushu Univ., Ser. D, Geol., Special
vol. 2, 204 p., 20 text-figs., 2 pls.
vision of the foraminiferal family Heterohelicidae in Studies in Foraminifera by A. R. Loeblitch, Jr. and collaborators: U. S. Nat. Mus.,
Bull. 215, pp. 133-154, pls. 31-34.
14. Thalmann, H. E., 1942: Globotruncanala in the
Franciscan limestone, Santa Clara County, Cali­
12, p. 1838 (Abs.).
15. —— 1943: Upper Cretaceous age of the “Fran­
ciscan” limestone near Laytonville, Mendocino
County, California: Geol. Soc. America Bull.,
vol. 54, no. 12, p. 1827 (Abs.).
16. —— 1959: New names for foraminiferal homo­
nynms IV: Contr. Cushman Found. Foram. Re­
nifera from near Redding, Shasta County, Cali­
290-346, 3 text-figs., pls. 43-50, 2 tables. [See p. 341 for comments on Globotruncanala arca
(Cushman) in Bandy, 1951, and in Cushman
and Goudkoff, 1944. These two species accord­
ing to Trujillo may belong to Globotruncanala
linneiana (d'Orbigny)].
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, PREOCCUPIED¹

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

1 Marine Foraminifera Laboratory Contribution No. 40.

*Quinqueloculina rhodiensis* (Wiesner) (originally *Miliolina rhodensis* 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. rhodensis* Parker.
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 Vaginulinoplis*), 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: *Cnibrobigerina* n. gen. (type species *C. parkerae* n. sp.) in the Textulariidae, *Alfredodiluvianus* 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, chart) .—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 quantitative analysis of planktonic/benthonic ratio.

Bergeren, 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.


Boll, H. M., Citta, 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.

Bolovskoy, 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 sub-species of Fissurina and new forma of Laguna.

Bomba, 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 bio-stratigraphic 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'Eocène inférieur en Pologne septentriionale 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 nihoculinoidea Plummer) is erected and Globigerina koslowskii n. sp. is described from the middle Paleocene.

Burnaby, N. 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, Inst. 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.


Cita, M. B., and Boll, H. M. Nuovi dati sull'eta Paleocenicca 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.


Conkin, James E. Mississippian smaller Foraminifera of Kentucky, southern Indiana, northern Tennessee, and southeastern Ohio.—Bull. Am. Paleontol., 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.

Corominseuf, 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 Globotruncan (1 new) and 1 of Rugoglobigerina.


Craig, G. Y., and Hoeg, 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.


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 Pétrolère (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 reexamination 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. Pseudorbitellina is recognized (through selection of Nummulina pristina Brady) and supercedes Operculina and Operculinoides. Ptilolepidina 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 Tinsonophella and Catapsydrax as synonyms. Turborotalita n. gen. (type species Truncatulina humilis Brady) is erected in the subfamily Globorotaliinae.

Flandrin, J., Moulade, M., and Porthault, B. Microfossiles caractéristiques du Crétacé Inférieur Vochontien.—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 Vochontian trough of France.


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


Hanzawa, Shoshirō. 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.


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. II. Bolivina (Loxostoma) selmaensis Cushman.—Natuurhist. Maandblad, 50° 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.


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.

Jeffries, R. P. S. The palaeoecology of the Actinocamax plenus Subzone (Lower Turonian) in the Anglo-Paris Basin.—Palaontology, v. 4, pt. 4, 1961 [Jan. 1962], p. 690-697, 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.


Kaaeschieter, 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 probable floating ability. Examples of increase of size with time. Illustrations and discussions of Globigerinatheca barri, Turborotalia centralis, and the genera Pseudohastigerina, Hastigerina, and Hanthenina.
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 RÉAT, D. Quelques nouveaux Foraminifères du Crétacé et du Tertiaire du Gabon (Afrique Equatoriale).—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. gumbeliformis n. sp.) and Allistoma nov. gen. (genotype D. circumtigens n. sp.) and Clavelloides nov. gen. (genotype C. tenuistriata n. sp.) in the Ellipsoidinidae.

KRAVA, E. JA. Foraminiferi Verkh'nonochnovikh ta Oligochnovikh Vidkladiv Pivnichnogo Krila Chornomorsk'koj Zapadini—Akad. Nauk Ukrain. Instyt. geol. Nauk Trudy, ser. strat. i paleo., vyp. 260, 1961, p. 1-65, pls. 1-7, tables 1, 2 (zonation chart, species range chart).—Includes a chart showing ranges between Cenomanian and Maastrichtian for about 260 species and varieties. Describes and illustrates 32 species (20 new and 1 indeterminate) and 2 varieties (both new).


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.


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., SÉRONTE-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.


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


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 Globoquadrinidae. Globorotalia quadriina is included in the Globorotaliidae and Globigerinita and Candeina are placed in Incertae Familiae.


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, L., 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 stratigrafiche 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 balitica is in Pleistocene.


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

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.


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. neoconiensis* 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.


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. nauch-no-issl. inst., 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.