

CONTRIBUTIONS
FROM THE
CUSHMAN FOUNDATION
FOR
FORAMINIFERAL RESEARCH

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Volume XVII (1966)

Editor

ZACH M. ARNOLD

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312. PLANKTONIC FORAMINIFERA
FROM THE TYPE AQUITANIAN-BURDIGALIAN OF FRANCE

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ABSTRACT

A systematic account, illustrations and a range chart of 30 species and subspecies of the planktonic Foraminifera, including one new species from the type Aquitanian-Burdigalian rocks, are given. The available data on the stratigraphic ranges of the planktonic Foraminifera suggest that the Oligocene-Miocene boundary should be placed between the *G. opima opima* Zone and the *G. eiperoensis eiperoensis* Zone and that the Aquitanian-Burdigalian boundary is between the *G. kugleri* Zone and the *C. dissimilis* Zone of Trinidad. *Globigerinoides bisphericus* Todd and later taxa of the *Orbulina universa* lineage were not found in the type Aquitanian-Burdigalian samples examined. This is supporting evidence for the records of the initial appearance of *Orbulina universa* d'Orbigny in the Helvetian-Tortonian rocks of Europe. A new species, *Globorotalia saginata* Jenkins, is described.

INTRODUCTION

A preliminary account of the type Aquitanian-Burdigalian planktonic Foraminifera was recently published by the writer (Jenkins, 1964a). Details of the localities of the 8 samples kindly provided by Mlle. Sourdillon and a preliminary list of the species obtained from the samples were given. The ages and locations were given in the section on Sample Localities (Jenkins, *ibid.*) but unfortunately sample 5 (GT 125) from Le Coquillat of Lower Burdigalian age was wrongly placed in the Table 1 under the heading Upper Aquitanian, and the Upper Burdigalian sample 6 (GT 136a) was wrongly placed under the Lower Burdigalian column.

The first part of this paper gives a detailed systematic account of the species and subspecies of planktonic Foraminifera obtained from the samples, including a further 8 species and subspecies which have been found on repicking the samples. All of the taxa have been illustrated (Plates 1-3) and a range chart is provided on which the actual numbers of specimens of each taxon and their test coiling ratios in each sample is recorded (Table 1). In the second part of this paper the correlation of the Aquitanian-Burdigalian type planktonic foraminiferal faunas is discussed. This has a direct bearing on three main topics: (a) the positioning of the Oligocene-Miocene boundary by means of planktonic Foraminifera; (b) the Aquitanian-Burdigalian Stage boundary; and (c) the entry of *O. universa* in the European Tertiary. A correlation of Bolli's Trinidad zones with the type Aquitanian-Burdigalian Stages is also discussed.

The types and figured specimens have been depos-

ited in the collections of the Bureau de Recherches Géologiques et Minières, Paris, France.

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SYSTEMATIC DESCRIPTIONS

The form of classification followed in this paper is similar to that produced by Reiss (1963), with the exception of *Cassigerinella* which he placed in the Family *Globigerinidae*.

Family CASSIDULINIDAE d'Orbigny, 1839
Sub-family CASSIDULININAE d'Orbigny, 1839
Genus *Cassigerinella* Pokorný, 1955
Cassigerinella chipolensis (Cushman and Ponton)

Plate 1, figures 1a, 1b

Cassidulina chipolensis CUSHMAN and PONTON, 1932, Florida Geol. Surv. Bull. 9, p. 98, pl. 15, fig. 2a-c.

Cassigerinella boudecensis POKORNÝ, 1955, Věstník, Ustréd. Úst. Geol. vol. 30, pp. 136-140, text-fig. 1-3.

Cassigerinella chipolensis (Cushman and Ponton), BOLLI, 1957, U. S. Nat. Mus. Bull. 215, p. 108, pl. 22, fig. 3a-c; HOFKER, 1963, Micropaleontology, vol. 9, no. 3, pp. 321-324, pl. 1; JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, Table 1.

Figured specimen.—The figured specimen obtained from the type Upper Aquitanian sample No. 4 (GV 184b); greatest diameter 0.16 mm.

Remarks.—Bolli, Loeblich and Tappan (1957) erected the sub-family *Cassigerinellinae* of the family *Hantkeninidae* to accommodate the genus *Cassigerinella*, and Reiss (1963) also followed this form of classification. The writer agrees, however, with the conclusions of Hofker (1963a) who has pointed out that *Cassigerinella* is better placed in the Family *Cassidulinidae* on aperture characteristics and wall structure.

The writer has obtained type specimens of *C.*

TABLE 1—Range chart of 30 species and subspecies of planktonic Foraminifera obtained from 7 type Aquitanian-Burdigalian samples and 1 Helvetian (?) sample from southwestern France.

Series		Miocene							
		Aquitanian				Burdigalian			Helvetian(?)
		Lower		Upper	Lower	Upper			
Planktonic Foraminifera	Sample numbers Sinistral/Dextral Coiling	GV 180a	GV 182a	GV 183a	GV 184b	GT 125	GT 136a	GT 183b	GT 130
		1	2	3	4	5	6	7	8
		S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D
<i>Globigerina woodi woodi</i> Jenkins		2/0	5/0	32/23	7/6	50/21	95/31	181/61	130/44
<i>Globorotalia continuosa</i> Blow		?2/0		10/9	2/3	11/9		7/12	?5/2
<i>Globigerina ciperoensis angustiumbilocata</i> Bolli		0/1	10/5	83/61	21/6	54/51	47/24	137/127	94/58
<i>Globigerina</i> sp.		1/2							
<i>Globigerina praebulloides</i> Blow			5/0	31/17	3/3	14/7	10/11	66/34	22/28
<i>Globigerina ciperoensis ciperoensis</i> Bolli			2/0	?2/0					
<i>Globigerina juvenilis</i> Bolli			2/1	10/4	12/4	2/2	2/7	5/7	3/6
<i>Globorotalia semivera</i> (Hornibrook)			1/1	4/7	1/3	1/2	13/4	15/22	12/13
<i>Globigerina bradyi</i> Wiessner			1/0	1/2				3/3	0/1
<i>Globigerina ouachitaensis</i> Howe and Wallace			1/0	4/2					
<i>Globoquadrina dehiscens</i> (Chapman, Parr and Collins)			?4/0	7/2			16/4	52/6	21/1
<i>Globigerinoides</i> cf. <i>G. primordius</i> Blow and Banner				7/3					
<i>Globigerina ciperoensis angulisuturalis</i> Bolli				0/1					
<i>Globorotalia</i> sp.				2/5	2/2				
<i>Catapsydrax</i> sp. 1				0/1					
<i>Globigerina woodi</i> cf. <i>G. woodi connecta</i> Jenkins					2/3				
<i>Globigerina leroyi</i> Blow and Banner					8/1				
<i>Globoquadrina larmeui</i> Akers					18/9		15/4	38/16	9/14
<i>Cassigerinella chipolensis</i> (Cushman and Ponton)					1				
<i>Globigerinoides trilobus</i> (Reuss) s.l.							40/31	109/66	89/40
<i>Globigerinoides altiapertura</i> Bolli						1/2			
<i>Catapsydrax</i> sp. 2						0/2	1/0	7/5	
<i>Globorotalia obesa</i> Bolli						1/7	3/1	62/34	40/32
<i>Sphaeroidinella cellata</i> Subbotina						2/0	3/1	1/8	0/2
<i>Globigerinoides apertasuturalis</i> Jenkins							2/1	1/0	4/1
<i>Globigerinoides trilobus trilobus</i> (Reuss)							0/1	14/10	7/2
<i>Globigerina foliata</i> Bolli								0/1	
<i>Globorotalia saginata</i> Jenkins, sp. nov.								8/5	3/5
<i>Globigerina eamesi</i> Blow								6/1	3/2
<i>Globigerinatella</i> (?) sp.								2/1	

boudecensis Pokorný from Dr. Pokorný and agrees with Blow and Banner (*in Eames et al.*, 1962) that it is a junior synonym of *C. chipolensis*.

C. chipolensis is currently classified as a planktonic foraminifer by many authors, but there is very little evidence to support the theory that this extinct species was planktonic.

Stratigraphic Range.—*C. chipolensis* occurs in only the type Upper Aquitanian sample No. 4 (GV 184b).

Recorded Stratigraphic Range.—Cushman and Ponton (1932) originally described *C. chipolensis* from the Lower Miocene rocks of Florida. Bolli (1957) recorded its range as *G. ampliapertura* Zone to *G. johsi robusta* Zone in the Ciperio formation of Trinidad. Blow and Banner (*in Eames et al.*, 1962) record its lowest range as being at the base of the Oligocene (*G. oligocaenica* Zone) in East Africa.

Family GLOBIGERINIDAE Carpenter, Parker and Jones, 1862

Sub-family GLOBIGERININAE Carpenter Parker and Jones, 1862

Genus *Catapsydrax* Bolli, Loeblich and Tappan, 1957
Catapsydrax sp. 1

Plate 1, figures 2a-c

Catapsydrax sp. 1, JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, Table 1.

Description.—Test free, small, trochospiral, low spired; periphery rounded; chambers subglobular, arranged in 2½ whorls with 5 chambers in the first whorl; sutures distinct, depressed; wall calcareous, distinctly perforate, umbilicus covered by an inflated elongate bulla with a single small infralaminar lipped aperture at the end of a tubelike structure, this aperture overlapping the end of the umbilical primary aperture. Largest diameter: 0.22 mm.

Remarks.—The distinctly perforate wall structure of *Catapsydrax* sp. 1 suggests a possible relationship between it and *Globigerina woodi* Jenkins.

Figured specimen.—Figured specimen obtained from the type Lower Aquitanian sample No. 3 (GV 183a).

Stratigraphic Range.—Only one specimen of *Catapsydrax* sp. 1 was found; this came from the type Lower Aquitanian sample No. 3 (GV 183a).

Catapsydrax sp. 2

Plate 1, figures 3a-c

Catapsydrax sp. 2, JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, table 1.

Description.—Test free, small trochospiral, low spired, periphery rounded; chambers subglobular, arranged in nearly 3 whorls, sutures distinct, slightly

depressed; wall calcareous, perforate; umbilicus covered by a small inflated bulla with a small infralaminar lipped aperture opening into the umbilicus. Largest diameter: 0.22 mm.

Figured specimen.—Figured specimen obtained from the Lower Burdigalian sample No. 5 (GT 125).

Stratigraphic Range.—Found in all 3 type Burdigalian samples examined.

Remarks.—*Catapsydrax* sp. 2 has a distinct small inflated bulla which is different from the elongate lemon shaped bulla of *Catapsydrax* sp. 1. In the Upper Burdigalian sample No. 7 there are two forms: one with a coarse wall similar to *Globigerina woodi* Jenkins and the other with a smooth wall similar to *Globigerina praebulloides* Blow. The figured specimen from the Lower Burdigalian sample is the smooth walled form.

Both *Catapsydrax* sp. 1 and *C. sp. 2* differ from *C. unicavus* Bolli, Loeblich and Tappan and *C. dissimilis* (Cushman and Bermudez) in not having a flattened bulla.

Genus *Globigerina* d'Orbigny, 1826

Globigerina bradyi Wiesner

Plate 1, figures 4, 5

Globigerina sp., BRADY, 1884, Rept. Challenger Zool., vol. 9, p. 603, pl. 82, figs. 8-9.

Globigerina bradyi WIESNER, 1931, Deutsche Südpolar-Exped. 1901-1903, vol. 20 (Zool., vol. 12) p. 133; BOLLI, 1957, U. S. Nat. Mus. Bull. 215, p. 110, pl. 23, fig. 5a-c; JENKINS, 1960, Micropaleontology, vol. 6, no. 4, p. 350, pl. 1, fig. 3a-b.

Globigerina cf. *G. bradyi* Wiesner, JENKINS, 1964, Cushman Found. Foram. Res. Contr. vol. 15, pt. 1, p. 29, Table 1.

Figured specimens.—Both the figured specimens were from the Upper Burdigalian sample No. 7 (GT 183b); greatest diameter of the tightly coiled specimen 0.23 mm.; greatest diameter of the loosely coiled specimen: 0.25 mm.

Remarks.—Three specimens obtained from the Upper Burdigalian sample No. 7 (GT 183b) have a coarse wall ornamentation and some of the specimens are more loosely coiled than the holotype (Pl. 1, fig. 5).

Stratigraphic Range.—Lower type Aquitanian to Helvetian (?).

Recorded Stratigraphic Range.—The lowest stratigraphic range of *G. bradyi* in Trinidad was given as *G. kugleri* Zone by Bolli (1957). Jenkins (1960) recorded its initial appearance in southeast Australia in the *G. dehiscens dehiscens* Zone, and recent work in New Zealand has yielded specimens from rocks slightly older than this, from the Upper Whaingaroan Stage.

Globigerina ciproensis angulisuturalis Bolli

Plate 1, figures 6a-c

Globigerina ciproensis angulisuturalis BOLLI, 1957, U. S. Nat. Mus. Bull. 215, p. 109, pl. 22, fig. 11a-c.

Globigerina ciproensis angustisuturalis (sic, = *angulisuturalis*) JENKINS, 1960, Micropaleontology, vol. 6, no. 4, p. 350, pl. 1, fig. 4a-c.

Globigerina angulisuturalis BOLLI, BLOW and BANNER (in Eames *et al.*, 1962) p. 84, PL. IX Aa-Cc.

Figured specimen.—The figured specimen from the Lower Aquitanian sample No. 3 (GV 183a); greatest diameter 0.17 mm.

Stratigraphic Range.—Only the figured specimen was found.

Recorded Stratigraphic Range.—Bolli (1957) gave its range as *G. opima opima* Zone to *G. ciproensis ciproensis* Zone in the Trinidad rocks and Jenkins (1960) gave it as *G. dehiscens dehiscens* Zone to *G. woodi woodi* Zone in a rock sequence from southeast Australia. Blow and Banner (in Eames *et al.*, 1962) did not record this subspecies in the two Aquitanian samples they examined from southwestern France.

Globigerina ciproensis angustiumbilocata Bolli

Plate 1, figures 7a-c

Globigerina ciproensis angustiumbilocata BOLLI, 1957, U. S. Nat. Mus. Bull. 215, p. 109, pl. 22, figs. 12a-13c; BOLLI, 1957, *ibid.*, p. 164, pl. 36, figs. 6a-b.

Globigerina angustiumbilocata (Bolli), BLOW, 1959, Bull. Amer. Paleont., vol. 39, no. 178, p. 172, pl. 7, figs. 33a-c, 34.

Globigerina angustiumbilocata Bolli, JENKINS, 1960, Micropaleontology, vol. 6, no. 4, p. 350, pl. 1, figs. 2a-c; JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, Table 1.

Figured specimens.—Figured specimen obtained from the type Upper Burdigalian sample No. 7 (GT 183b); greatest diameter 0.24 mm.; figured specimen of *G. ciproensis* cf. *angustiumbilocata* from the same sample; greatest diameter 0.27 mm.

Remarks.—Bolli (1957) stated that there was a complete gradation between *G. ciproensis ciproensis* and *G. ciproensis angustiumbilocata*; this gradation has also been seen by the writer in samples from southeast Australia (Jenkins, 1960) and in the New Zealand rocks of the same age. In the type Aquitanian-Burdigalian and in the Australasian rocks the central and more dominant form is *G. ciproensis angustiumbilocata*, which is also the precursor of *G. ciproensis ciproensis*.

Blow and Banner (in Eames *et al.*, 1962) illustrated a specimen of *G. ciproensis angustiumbilocata* from the Aquitanian of Escorneb eu, south-

western France, but the single figure does not indicate the presence of the lip that is a diagnostic feature of this subspecies (Bolli, 1957). To illustrate the difficulty involved in trying to separate these two subspecies, a specimen from the Upper Burdigalian sample no. 7 (GT 183b) has been illustrated (Plate 1, fig. 8). This specimen, referred to here as *G. ciproensis* cf. *angustiumbilocata*, is clearly closer in morphology to *G. ciproensis ciproensis* but is beyond the stratigraphic range of this subspecies and has a lipped aperture.

Stratigraphic Range.—*G. ciproensis angustiumbilocata* was found in all the type samples examined: Lower Aquitanian to Helvetian (?).

Recorded Stratigraphic Range.—*G. ciproensis angustiumbilocata* has a long stratigraphic range in the Tertiary. The lowest stratigraphic record of this species in the Trinidad rocks is from the upper part of the *Globorotalia cocoensis* Zone (Bolli, 1957). Blow and Banner (in Eames *et al.*, 1962) also recorded *G. angustiumbilocata* from the Upper Eocene of Lindi, Tanganyika.

Globigerina ciproensis ciproensis Bolli

Plate 1, figures 9a-c

Globigerina ciproensis BOLLI, 1954, Cushman Found. Foram. Res. Contr., vol. 5, pt. 1, p. 1.

Globigerina ciproensis ciproensis BOLLI, 1957, U. S. Nat. Mus. Bull. 215, p. 109, pl. 22, figs. 10a-b.

Globigerina ciproensis Bolli subsp. *ciproensis* Bolli, JENKINS, 1960, Micropaleontology, vol. 6, no. 4, p. 350, pl. 1, figs. 5a-c.

Globigerina ouachitaensis ciproensis (Bolli), BLOW and BANNER (in Eames *et al.*, 1962) pp. 90-91, Pl. IX, E-G; fig. 9 (i-iii).

Figured specimen.—Figured specimen from Lower Aquitanian sample No. 3 (GV 183a); greatest diameter 0.24 mm.

Remarks.—Further examination of the type Lower Aquitanian No. 2 sample (GV 182a) has yielded two specimens of *G. ciproensis ciproensis*, these in association with a large *G. ciproensis angustiumbilocata* population. Blow and Banner (in Eames *et al.*, 1962) record *G. ciproensis ciproensis* from the Lower and Middle Aquitanian of southwestern France.

Stratigraphic Range.—Recorded only from the upper two samples, Nos. 2 and 3 (GV 182a; GV 183a), of the type Lower Aquitanian.

Recorded Stratigraphic Range.—The stratigraphic range of *G. ciproensis ciproensis* in the Trinidad rocks was given by Bolli (1957) as *G. ampliapertura* Zone to the *G. ciproensis ciproensis* Zone.

Globigerina eamesi Blow

Plate 1, figures 10a-c

Globigerina eamesi BLOW, 1959, Bull. Amer. Pa-

leont., vol. 39, no. 178, pp. 176-177, pl. 9, figs. 39a-c; JENKINS, 1960, *Micropaleontology*, vol. 6, no. 4, pp. 350-351, pl. 1, figs. 7a-c.

Figured specimen.—Figured specimen from the Helvetian (?) sample No. 8 (GT 130); greatest diameter 0.24 mm.

Stratigraphic Range.—Upper Burdigalian-Helvetian (?).

Recorded Stratigraphic Range.—Blow (1959) recorded its range as *G. menardii menardii*/*G. nepenthes* Zone to the *S. seminulina* Zone, Pozón, Venezuela. Jenkins (1960) recorded a much longer range in southeast Australia, from the pre-*G. dehiscens dehiscens* Zone to the *O. universa* Zone.

Globigerina foliata Bolli

Plate 1, figures 11a-c

Globigerina foliata BOLLI, 1957, U. S. Nat. Mus. Bull. 215, p. 111, pl. 24, figs. 1a-c; BLOW, 1959, Bull. Amer. Paleont., vol. 39, no. 178, pp. 177-178, pl. 10, figs. 42a-c; JENKINS, 1960, *Micropaleontology*, vol. 6, no. 4, p. 351, pl. 1, figs. 9a-c.

Globigerina cf. *G. foliata* Bolli, JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, table 1.

Figured specimen.—Figured specimen from the Upper Burdigalian sample No. 7 (GT 183b); largest diameter 0.19 mm.

Stratigraphic range.—Only one specimen was found, in the Upper Burdigalian sample No. 7 (GT 183b).

Recorded Stratigraphic Range.—Bolli (1957) recorded its range as *C. dissimilis* Zone to the *G. fohsi robusta* Zone in Trinidad and Blow (1959) recorded its range as *C. stainforthi* Zone to the *S. seminulina* Zone in Venezuela. Jenkins (1960) recorded a much longer range in a southeast Australian sequence: pre-*G. dehiscens dehiscens* Zone to the *G. menardii miotumida* Zone.

Globigerina juvenilis Bolli

Plate 1, figures 12a-c

Globigerina juvenilis BOLLI, 1957, U. S. Nat. Mus. Bull. 215, p. 110, pl. 24, figs. 5a-b; BLOW, 1959, Bull. Amer. Paleont., vol. 39, no. 178, p. 178, pl. 10, figs. 43a-b; JENKINS, 1960, *Micropaleontology*, vol. 6, no. 4, pp. 351-352, pl. 1, figs. 10a-c, 11a-c; JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, table 1.

Figured specimen.—Figured specimen from the Upper Burdigalian sample No. 7 (GT 183b); largest diameter 0.23 mm.

Remarks.—In the upper Burdigalian sample no. 7 (GT 183b) there is a form similar to the variant figured by Jenkins (1960, pl. 1, fig. 11). It should

be noted that in the type Aquitanian samples *G. juvenilis* overlaps the ranges of *G. ciperoensis ciperoensis* and *G. ouachitaensis*.

Stratigraphic range.—Lower Aquitanian-Helvetian (?).

Recorded Stratigraphic Range.—Bolli (1957) records the lowest stratigraphic range in Trinidad of *G. juvenilis* in the *G. kugleri* Zone and it ranges up to the *G. menardii* Zone. In southeast Australia its initial appearance is stratigraphically lower than in Trinidad: it starts off in the pre-*Globoquadrina dehiscens dehiscens* Zone and ranges up to the *G. triloba triloba* Zone (Jenkins, 1960).

Globigerina leroyi Blow and Banner

Plate 1, figures 13a-c

Globigerina praebulloides leroyi BLOW and BANNER (in Eames et al., 1962), p. 93, pl. IX R-T; fig. 9 (v).

Figured specimen.—Figured specimen from the Upper Aquitanian sample No. 4 (GV 184b); largest diameter 0.23 mm.

Remarks.—Blow and Banner (in Eames et al., 1962) also record *G. praebulloides leroyi* in the Aquitanian rocks of Moulin de l'Église and Escornebéou, southwestern France.

Stratigraphic Range.—*G. leroyi* was recognized only in the Upper Aquitanian sample No. 4 (GV 184b).

Recorded Stratigraphic Range.—Upper Eocene to Lower Miocene in East Africa and *G. ampliapertura* Zone to the *G. insueta* Zone in Trinidad (Blow and Banner, *ibid.*).

Globigerina ouachitaensis Howe and Wallace

Plate 1, figures 14a-c

Globigerina ouachitaensis HOWE and WALLACE, 1932, Bull. Louisiana Conserv. Geol. no. 2, p. 74, pl. 10, figs. 7a-b.

Globigerina ouachitaensis ouachitaensis Howe and Wallace, BLOW and BANNER (in Eames et al., 1962), p. 90, pl. IXD, H-K, Fig. 9 (VI).

Figured specimen.—Figured specimen from the Lower Aquitanian sample No. 2 (GV 182a); largest diameter 0.20 mm.

Stratigraphic Range.—Lower Aquitanian.

Recorded Stratigraphic Range.—*G. ouachitaensis* was originally described from the Upper Eocene of Louisiana, U.S.A. Blow and Banner (in Eames et al., 1962) recorded its upper limit as *G. ampliapertura* Zone although their range chart (*ibid.* fig. 20) shows it dotted into the *G. opima opima* Zone. Blow and Banner (*ibid.*) also record *G. ouachitaensis* from the lower Aquitanian of Escornebéou in southwestern France.

Globigerina praebulloides Blow

Plate 1, figures 15a-c

Globigerina praebulloides BLOW, 1959, Bull. Amer. Paleont., vol. 39, no. 178, p. 180, pl. 18, figs. 47a-c; pl. 9, fig. 48; JENKINS, 1960, Micropaleontology, vol. 6, no. 4, p. 352, pl. 2, figs. 1a-c; JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, table 1.

Figured specimens.—Figured specimen from the Upper Burdigalian sample No. 7 (GT 183b); largest diameter 0.27 mm.

Stratigraphic Range.—Type Lower Aquitanian to Helvetian (?).

Recorded Stratigraphic Range.—Blow (1959) gave the range of *G. praebulloides* as *C. stainforthi* Zone to *G. menardii menardii*/*G. nepenthes* Zone in Venezuela and Jenkins (1960) a pre-*G. dehiscens dehiscens* Zone to *G. menardii miotumida* Zone range in a southeastern Australian sequence. Since then, Blow and Banner (in Eames *et al.*, 1962) have split up *G. praebulloides* into a number of subspecies, and the earliest appearance of *G. praebulloides* s.l. is recorded as Upper Eocene.

Globigerina sp.

Plate 1, figures 16a-c

Globigerina sp., JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, table 1.

Description.—Test small, free, low trochospiral, equatorial periphery lobate; wall calcareous, surface finely perforate; chambers subspherical, 9 forming the test, the last 3 chambers increasing rapidly in size; the final test chamber has been broken off; sutures distinct, slightly depressed, umbilicus small, umbilical aperture small, arched, with a thin lip.

Type specimen.—Figured specimen from the type Lower Aquitanian sample No. 1 (GV 180a); largest diameter 0.15 mm.

Remarks.—*Globigerina* sp. is possibly a juvenile form of *G. praebulloides*, but the preservation is not good enough to confirm this observation.

Stratigraphic Range.—Recorded only in the type Lower Aquitanian sample No. 1 (GV 180a).

Globigerina woodi cf. *G. woodi connecta* Jenkins

Plate 1, figures 17a-c

Globigerinoides trilobus (Reuss) s.l. (in part), 1964, JENKINS, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, table 1 (Sample 4 only).

Figured specimen.—Figured specimen from the Upper Aquitanian sample No. 4 (GV 184b); largest diameter 0.19 mm.

Remarks.—Unfortunately the preservation of the specimens from the Upper Aquitanian sample No. 4 (GV 184b) is poor, but there are 5 specimens of

G. woodi with lower arched apertures than *G. woodi woodi* and these have been referred to *Globigerina woodi* cf. *connecta* Jenkins (1964b).

Stratigraphic Range.—Occurs only in the Upper Aquitanian sample No. 4 (GV 184b).

Globigerina woodi woodi Jenkins

Plate 1, figures 18a-c

Globigerina woodi JENKINS, 1960, Micropaleontology, vol. 6, no. 4, p. 352, pl. 2, figs. 2a-c; TAKAYANAGI and SAITO, 1962, Tohoku, Univ. Sci. Rept., 2nd (Geol.), Spec. Vol. (5), pp. 91-92, pl. 25, figs. 6a-c; JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, table 1.

Figured specimen.—Figured specimen from the Upper Burdigalian sample No. 7 (GT 183b); largest diameter 0.36 mm.

Stratigraphic Range.—Lower Aquitanian-Helvetian (?).

Recorded Stratigraphic Range.—Jenkins (1960) recorded the range of *G. woodi* as being from the base of the *G. woodi* Zone to the *G. menardii miotumida* Zone. Recent work on New Zealand rocks has shown that *G. woodi* starts in the Waitakian Stage at the same level as in Australia.

Genus *Globoquadrina* Finlay, 1947*Globoquadrina dehiscens* (Chapman, Parr and Collins)

Plate 1, figures 19a-c

Plate 2, figure 1

Globorotalia dehiscens CHAPMAN, PARR and COLLINS, 1934, Linn. Soc. London, Journ. Zool., vol. 38, no. 262, p. 569, pl. 11, figs. 36a-c.

Globoquadrina dehiscens (Chapman, Parr and Collins) BOLLI, 1957, U. S. Nat. Mus. Bull. 215, p. 111, pl. 24, figs. 3a-4c; CARTER, 1958, Geol. Surv. Victoria, Bull. no. 55, p. 56, pl. 8, figs. 85-87.

Globoquadrina dehiscens dehiscens (Chapman, Parr and Collins), BLOW, 1959, Bull. Amer. Pal., vol. 39, no. 178, p. 182, pl. 8, figs. 49a-c.

Globoquadrina dehiscens (Chapman, Parr and Collins) subsp. *dehiscens* (Chapman, Parr and Collins), JENKINS, 1960, Micropaleontology, vol. 6, no. 4, pp. 354-355, pl. 3, figs. 3a-c.

Globoquadrina dehiscens Chapman, Parr and Collins, JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, table 1.

Figured specimens.—Two figured specimens: 1 from the Lower Aquitanian sample No. 3 (GV 183a); greatest diameter 0.25 mm. (Pl. 1, figs. 19a-c); 2 (from the type Upper Burdigalian sample No. 7 (GT 183b); greatest diameter 0.33 mm. (Pl. 2, fig. 1).

Remarks.—The lowest stratigraphic range of *G.*

dehiscens in Trinidad was given by Bolli (1957) as *Catapsydrax stainforthi* Zone. In the Australasian region *G. dehiscens*, which was originally described from Australia, appears stratigraphically earlier than in Trinidad (Jenkins, 1960): in New Zealand *G. dehiscens* starts at the base of the Waitakian Stage (Hornibrook, 1958) and in southeast Australia it starts at the base of the *G. dehiscens dehiscens* Zone. Both these occurrences are well before the appearance of *Globigerinoides trilobus* (Reuss) and within the range of *Globigerina eapertura* Jenkins and *Globigerina ciperensis ciperensis* Bolli.

The specimens of *G. dehiscens* from the type Lower Aquitanian are more quadrate in appearance than *Globoquadrina dehiscens praedeheiscens* Blow and Banner (*In Eames et al.*, 1962), which has been proposed as the ancestor of *G. dehiscens* by Blow and Banner (*ibid.*). The type specimen of *G. praedeheiscens* is from the *G. kugleri* Zone of Trinidad, but in the New Zealand rocks of the same age and slightly older than *G. kugleri* Zone *G. dehiscens* specimens are much more quadrate than *G. praedeheiscens*. It is therefore suggested that *G. praedeheiscens* cannot be the ancestor of *G. dehiscens* of the Australasian region. The ancestor of the Australasian *G. dehiscens* was figured by Jenkins (1960, pl. 3, figs. 1a-b) from the Lakes Entrance oil shaft, southeast Australia. It was wrongly named *Globoquadrina larmeui* Akers (see below under *G. larmeui*). The same ancestral species also occurs in the pre-Waitakian Stage rocks of New Zealand.

Further work has yielded 4 juvenile specimens of *G. dehiscens* with extra-umbilical apertures in the Lower type Aquitanian sample No. 2 (GV 182a). Definite quadrate forms are present in the type Lower Aquitanian of sample No. 3 (GV 183a) which is only a metre above the lower Aquitanian sample No. 2.

The dominant sinistral coiling ratio of the *G. dehiscens* tests in the samples examined is the same as in the Miocene rocks of southeast Australia and New Zealand.

Stratigraphic Range.—Lower Aquitanian-Helvetian (?).

Recorded Stratigraphic Range.—*G. dehiscens* was originally described from the Balcombian rocks of Victoria, Australia, by Chapman *et al.* (1934). Bolli (1957) recorded its range as *C. dissimilis* Zone to the *G. menardii* Zone in Trinidad. Jenkins (1960) recorded its range as *G. dehiscens dehiscens* Zone to the *G. menardii miotumida* Zone in southeast Australia.

Globoquadrina larmeui Akers

Plate 2, figures 2a-c; 3

Globoquadrina larmeui AKERS, 1955, Journ. Pa-

leont., vol. 29, no. 4, p. 661, pl. 65, figs. 4a-c.

Globoquadrina larmeui Akers, JENKINS, 1960 (part only). *Micropaleontology*, vol. 6, no. 4, p. 355, pl. 3, figs. 2a-c (not figs. 1a-c).

Globorotaloides sp. JENKINS, 1964, *Cushman Found. Foram. Res. Contr.*, vol. 15, pt. 1, p. 29.

Globoquadrina cf. *G. larmeui* Akers, JENKINS, 1964, *ibid.*

Figured specimens.—Both figured specimens from the type Upper Burdigalian sample No. 7 (GT 183b); largest diameter of the specimen without the bulla 0.35 mm.; largest diameter of the specimen with the bulla 0.28 mm.

Remarks.—The early stage tends to have an extra-umbilical aperture which becomes umbilical in larger specimens, with some specimens developing a bulla. For these reasons some of the specimens were thought by the writer to be a species of *Globorotaloides*, but they are now regarded as belonging to the *G. larmeui* population. A similar ontogeny has been illustrated for *Globoquadrina conglomerata* (Schwager) by Parker (1962).

Stratigraphic Range.—Upper Aquitanian to Helvetian (?).

Recorded Stratigraphic Range.—Akers (1955) first recorded *G. larmeui* from Louisiana, U.S.A., from the *Operculinoides* Zone, which appears to correspond with the lower part of the *G. insueta* Zone of Trinidad. Jenkins (1960) recorded two distinct and separate stratigraphic ranges for *G. larmeui* in a southeast Australian sequence. The lower form is the ancestor of *G. dehiscens* in the Australasian region and was wrongly named *G. larmeui*. *G. larmeui* s.s. has a stratigraphic range from the top of the *G. triloba triloba* Zone to the *O. universa* Zone.

Genus *Globigerinatella* Cushman
and Stainforth, 1945

Globigerinatella (?) sp.

Plate 2, figures 4a-c

Globigerinatella (?) sp. JENKINS, 1960, *Micropaleontology*, vol. 6, no. 4, p. 354, pl. 2, figs. 10a-c.

Figured specimen.—Figured specimen from the type Upper Burdigalian sample No. 7 (GT 183b); largest diameter 0.26 mm.

Remarks.—The small high-arched aperture of *Globigerinatella* (?) sp. is similar to those of *Globigerinoides apertasuturalis* Jenkins, and it is possible that the two forms are related.

Stratigraphic Range.—Only one occurrence in the type samples, this from the uppermost Burdigalian sample.

Recorded Stratigraphic Range.—Jenkins (1960) gave the range of *Globigerinatella* (?) sp. as *G. triloba triloba* Zone to the *G. menardii praemenardii* Zone in a southeast Australian sequence.

Genus *Globigerinoides* Cushman, 1927

Globigerinoides apertasuturalis Jenkins

Plate 2, figures 5a-c

Globigerinoides apertasuturalis JENKINS, *Micropa-leontology*, vol. 6, no. 4, pp. 352-353, pl. 2, figs. 3a-c; JENKINS, 1964, *Cushman Found. Foram. Res. Contr.*, vol. 15, pt. 1, p. 29, table 1.

Figured specimen.—Figured specimen from the Helvetian (?) sample No. 8 (GT 130); greatest diameter 0.26 mm.

Stratigraphic Range.—Upper Burdigalian to Helvetian (?).

Recorded Stratigraphic Range.—Jenkins (1960) gave the range of *G. apertasuturalis* as *G. dehiscens dehiscens* Zone to the *G. menardii miotumida* Zone.

Globigerinoides altiapertura Bolli

Plate 2, figures 6a-c

Globigerinoides triloba altiapertura BOLLI, 1957, *U. S. Nat. Mus. Bull.* 215, p. 113, pl. 25, figs. 7a-8; text-fig. 21, no. 3; BLOW, 1959, *Bull. Amer. Paleont.*, vol. 39, no. 178, pp. 187-188, pl. 10, figs. 61a-b.

Figured specimen.—Figured specimen from the Lower Burdigalian sample No. 5 (GT 125); greatest diameter 0.45 mm.

Remarks.—Topotype specimens of *G. altiapertura* have been kindly supplied by Dr. H. M. Bolli and a direct comparison has been made with the specimens from the type Lower Burdigalian sample No. 5.

Recorded Stratigraphic Range.—Bolli (1957) gave the range of *G. altiapertura* as *C. dissimilis* Zone to the *C. stainforthi* Zone in Trinidad, and Blow (1959) recorded its upper range as being in the lower part of the *G. insueta-G. triloba* Subzone in Venezuela. Jenkins (1960) recorded its stratigraphic range from rocks in southeast Australia as *G. woodi* Zone to the *G. menardii miotumida* Zone, but the specimens from the Lakes Entrance oil shaft have now been compared with the topotype *G. altiapertura* from Trinidad and they appear to be different species. The Australian species differs from *G. altiapertura* in having a high spired test with smaller apertures (Jenkins, 1960, pl. 2, fig. 6).

G. altiapertura also occurs in the New Zealand rocks, having been recorded in one sample (F14849) from Parengarenga Harbour, Northland. This sample is from a section and is positioned between samples containing *Globigerinoides* cf. *G. primordius* Blow and Banner and samples containing *Globigerinoides trilobus* (Reuss), a similar sequence to that found in the type Aquitanian-Burdigalian rocks.

Globigerinoides cf. *G. primordius* Blow and Banner

Plate 2, figures 7a-c

Globigerinoides trilobus (Reuss) s.l. (in part) JENKINS, 1964, *Cushman Found. Foram. Res. Contr.*, vol. 15, pt. 1, p. 29, Table 1 (sample no. 3 only).

Figured specimen.—Figured specimen from the type Lower Aquitanian sample No. 3 (GV 183a); greatest diameter 0.35 mm.

Remarks.—*G. primordius* was originally described from the *G. kugleri* Zone of Trinidad and its authors, Blow and Banner (*in Eames et al.*, 1962), also recorded it from Sicily and East Africa. They did not record it from the Aquitanian rocks of Escornebéou or Moulin de l'Église (southwestern France) which they examined.

In the type description of *G. primordius*, Blow and Banner (*ibid.*) state that both the umbilical and sutural apertures lack a distinct lip or rim. The specimens from the type Lower Aquitanian sample possess thin rims to the apertures. The apertures are higher arched and the wall structure is coarser than the type of *G. primordius*. The specimens of *G. cf. G. primordius* have been compared with topotype specimens of *Globigerinoides altiapertura* Bolli and seem to be intermediate between *G. primordius* and *G. altiapertura*. Unfortunately no topotype specimens of *G. primordius* have been available for direct comparison.

G. cf. G. primordius is related in general test morphology to the *G. woodi* population of sample No. 3 (GV 183a): *G. cf. G. primordius* specimens appear to be *G. woodi* with a supplementary aperture on the spiral side.

Stratigraphic Range.—Limited to the Lower Aquitanian sample No. 3 (GV 183a).

Recorded Stratigraphic Range.—Blow and Banner (*in Eames et al.*, 1962) state that *G. primordius* is limited to the *Globorotalia kugleri* Zone of Trinidad.

Globigerinoides trilobus (Reuss) s.l.

Plate 3

Globigerinoides trilobus (Reuss) s.l. (in part) JENKINS, 1964, *Cushman Found. Foram. Res. Contr.*, vol. 15, pt. 1, p. 29, Table 1.

Figured specimens.—Figured specimens from the Upper Burdigalian sample No. 7 (GT 183b).

Remarks.—Bolli (1957) in his work on the Trinidad rocks produced a working classification of the Miocene species of *Globigerinoides*. In order to show the genetic relationship of four of the forms, he used a trinomial nomenclature, with *G. trilobus* (Reuss) as the central form. Both Blow (1959), working on a similarly aged Venezuelan sequence, and Jenkins (1960), working on an Australian Miocene sequence, followed this pattern of nomencla-

ture. Banner and Blow (1960) resurrected the long forgotten species *Globigerina quadrilobata* d'Orbigny (1846) and in choosing the lectotype picked out a form with multiple apertures. Having done this they then decided that their *Globigerinoides quadrilobatus*, instead of *G. trilobus*, was the central type of the Miocene *Globigerinoides* species. Other workers have concluded that the lectotype of *G. quadrilobata* does not fit either the original figures or the type description by d'Orbigny (Todd, 1961). Bandy (1964) rejected it, but did not invoke the authority of the International Committee of Zoological Nomenclature to have the lectotype officially invalidated, so its status remains controversial. Nevertheless, the writer, having examined a type sample from Nussdorf, kindly donated by Dr. R. Grill, is in agreement with Todd and Bandy that the lectotype of *G. quadrilobata* should be rejected for the reasons they have already stated.

The "lectotype" was chosen from a tube of mixed species of planktonic Foraminifera; none of the specimens corresponds in any way with d'Orbigny's original type figure and description of *Globigerina quadrilobata*. According to Banner and Blow (*ibid.*) the label on the tube was "probably in Terquem's handwriting." The writer intends to submit a case to the I.C.Z.N. in an attempt to have the lectotype officially invalidated.

In the present paper, *G. trilobus* has not been split up into numerous subspecies. The only form which has been singled out is the stratigraphically important *G. trilobus trilobus*. The variation in the test morphology of *G. trilobus* s.l. has been illustrated (Plate 3). It can be seen that the size and position of the final chamber varies considerably.

Kaasschieter (*in* Drooger *et al.*, 1955) recorded and figured *Globigerinoides trilocularis* (d'Orbigny), and Drooger (1956) recorded and figured *Globigerinoides triloba* (Reuss) from the type area of the Aquitanian-Burdigalian. From the figured specimens it can be seen that these species are probably synonymous with *G. trilobus* s.l.

Globigerinoides trilobus trilobus (Reuss)

Plate 2, figures 8a-c

Globigerina triloba REUSS, 1850, K. Akad. Wiss. Wien, Math.-Nat. Cl., Denkschr., vol. 1, p. 374, pl. 47, figs. 11a-d (*vide* Ellis and Messina, 1940 *et seq.*).

Globigerinoides triloba (Reuss), BOLLI, 1957, U. S. Nat. Mus. Bull. 215, pp. 112-113, pl. 25, figs. 2a-c; text-fig. 21, no. 1a-b; BLOW, 1959, Bull. Amer. Pal., vol. 39, no. 178, p. 187, pl. 11, figs. 60a-b.

Globigerinoides triloba (Reuss) subsp. *triloba* (Reuss), JENKINS, 1960, Micropaleontology, vol. 6, no. 4, p. 353, pl. 2, figs. 5a-c.

Globigerinoides trilobus (Reuss) s.l. (in part) JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, Table 1.

Figured specimen.—Figured specimen from the type Upper Burdigalian No. 7 (GT 183b); greatest diameter 0.36 mm.

Remarks.—Two type samples of *G. trilobus* (Reuss) from Weiliczka, Poland, have been obtained from Professor M. Ksiakiewicz and Dr. S. Alexandrowicz of the Department of Geology, Jagellonian University, Cracow. Specimens that appear to be identical with the holotype figures have been picked out. The specimens of *G. trilobus trilobus* from the type Aquitanian-Burdigalian rocks have been compared with the topotypes of *G. trilobus*. There is a wide range of variation in the test morphologies of *G. trilobus* in the two type samples from Weiliczka.

Blow (1956) was the first fully to describe the *O. universa* lineage; he demonstrated that *G. trilobus trilobus* (Reuss) evolved gradually into *Globigerinoides bisphericus* Todd. Blow's interpretation has been supported by the works of Bolli (1957) in Trinidad, and by Jenkins (1960) and Hornibrook (*m.s.* in press).

A topotype sample of *Globigerinoides bisphericus* Todd from Saipan has been obtained from Miss R. Todd, and a direct comparison has also been made with the specimens of *Globigerinoides* from the type Aquitanian-Burdigalian. Not one specimen of *G. bisphericus* was obtained from the samples examined.

Stratigraphic Range.—Upper Burdigalian-Helvetian (?).

Recorded Stratigraphic Range.—Bolli (1957) gave its range as *C. dissimilis* zone to *G. menardii* Zone in the Trinidad rocks. Jenkins (1960), working on a southeast Australian sequence, gave its range as *G. triloba triloba* Zone to *G. mayeri* Zone. Blow and Banner (*in* Eames *et al.*, 1962) show its initial appearance in the top of the *G. kugleri* Zone.

Subfamily GLOBOROTALIINAE Cushman, 1927

Genus *Globorotalia* Cushman, 1927

Globorotalia continuosa Blow

Plate 1, figures 9a-c

Globorotalia opima continuosa BLOW, 1959, Bull. Amer. Paleont., vol. 39, no. 178, pp. 218-219, pl. 19, figs. 125a-c.

Globorotalia opima Bolli subsp. *continuosa* Blow, JENKINS, 1960, Micropaleontology, vol. 6, no. 4, p. 366, pl. 5, figs. 4a-c, 5a-c.

Globorotalia continuosa Blow, JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, Table 1.

Figured specimen.—Figured specimen from the type Lower Aquitanian sample No. 3 (GV 183a); greatest diameter 0.27 mm.

Remarks.—The four-chambered final whorl and the distinctive comma-shaped aperture of *G. continua* (Blow, 1959) distinguish it from *Globorotalia nana* Bolli. Inasmuch as *G. nana* has an upper stratigraphic range of *G. ciperoensis ciperoensis* Zone in Trinidad (Bolli, 1957), it should be noted that Blow and Banner (*in Eames et al.*, 1962) record *G. nana* (unfigured) from the Lower Aquitanian rocks of Escorneb  ou, southwestern France.

Recorded Stratigraphic Range.—Blow (1959) gave its range in Venezuela as *C. stainforthi* Zone to the *S. seminulina* Zone. Jenkins (1960) recorded its initial appearance at a much lower stratigraphic level, in the pre-*Globoquadrina dehiscens dehiscens* Zone; this has been confirmed by recent work on the New Zealand rocks, where it is seen to have its initial appearance in the upper part of the Whaingaroan Stage.

Globorotalia obesa Bolli

Plate 2, figures 10a-c

Globorotalia obesa BOLLI, 1957, U. S. Nat. Mus. Bull. 215, p. 119, pl. 29, figs. 2a-3; BLOW, 1959, Bull. Amer. Paleont., vol. 39, no. 178, p. 218, pl. 19, figs. 124a-c; JENKINS, 1960, Micropaleontology, vol. 6, no. 4, p. 364, pl. 5, figs. 2a-c.

Globorotalia cf. *G. obesa* Bolli, JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, Table 1.

Figured specimen.—Figured specimen from the Helvetian (?) sample No. 8 (GT 130); greatest diameter 0.31 mm.

Stratigraphic Range.—Burdigalian to Helvetian (?).

Recorded Stratigraphic Range.—Bolli (1957) gave its range as *C. dissimilis* Zone to the *G. menardii* Zone in Trinidad, and Blow (1959) recorded its range as *C. stainforthi* Zone to the *G. bulloides* Zone in Venezuela. Jenkins (1960), working on a southeastern Australian sequence, gave its range as pre-*G. dehiscens dehiscens* Zone to the *G. menardii miotumida* Zone.

Globorotalia saginata Jenkins, n. sp.

Plate 2, figures 11a-c

Description of Holotype.—Test free, trochospiral, biconvex, but with the spiral side the more flattened; umbilicus small, distinct; periphery rounded, peripheral outline quadrilobate; chambers inflated, spherical, compressed; 12 chambers in just over 2 whorls: 5 in the first whorl and the four in the final whorl increasing very rapidly in size; sutures on both umbilical and spiral sides distinct and curved; wall calcareous, distinctly perforate; aperture a low distinct arch, umbilical, extending a short way towards the periphery. Greatest diameter: 0.25 mm.

Type specimen.—Holotype and unfigured Para-

types from the Upper Burdigalian sample No. 7 (GT 183b).

Remarks.—*G. saginata* appears to be related to *Globorotalia obesa* but differs from this species in having a more rapid increase in size of the chambers of the final whorl and in having a more umbilical aperture.

Stratigraphic Range.—Upper Burdigalian to Helvetian (?).

Globorotalia semivera (Hornibrook)

Plate 2, figures 12a-c

Globigerina semivera HORNIBROOK, 1961, New Zealand Geol. Surv. Pal. Bull. no. 34, pt. 1, pp. 149-150, pl. 23, figs. 445-447.

Globorotalia aff. *G. mayeri* Cushman and Ellisor, JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29.

Figured specimen.—Figured specimen from the Upper Burdigalian sample No. 6 (GT 136a); greatest diameter 0.32 mm.

Remarks.—It is probable that the specimens from the lower part of the range of *G. mayeri*, as recorded by Bolli (1957) from Trinidad, are referable, at least in part, to *G. semivera*. *Globorotalia mayeri* Cushman and Ellisor differs from *G. semivera* in having slightly recurved sutures (Hornibrook, 1961).

Stratigraphic Range.—Lower Aquitanian to Helvetian (?).

Recorded Stratigraphic Range.—Hornibrook (*ibid.*) recorded the New Zealand range of *G. semivera* as Waitakian Stage to Waiuan (?) Stage. Further work by the writer has shown that its initial appearance is slightly lower and should now be stated as being in the Upper Whaingaroan Stage. This level can be broadly correlated with the upper part of the *G. opima opima* Zone to the lower part of the *G. ciperoensis ciperoensis* Zone of Trinidad. Bolli (1957) showed *G. mayeri* starting in the *G. opima opima* Zone of Trinidad.

G. semivera is here regarded as a *Globorotalia* species, because its aperture tends to be umbilical to extra-umbilical in position.

Globorotalia sp.

Plate 2, figures 13a-c

Globorotalia sp., JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, Table 1.

Description of figured specimen.—Test free, trochospiral, biconvex, with a small umbilicus; periphery rounded, peripheral outline lobulate; chambers formed in about 3 whorls, with 5 in the final whorl; sutures distinct, slightly recurved on both umbilical and spiral sides, appearing slightly incised at the periphery; wall calcareous, punctate; aperture small,

low-arched, lipped, umbilical-extraumbilical. Greatest diameter 0.21 mm.

Figured specimen.—Figured specimen from the Upper Aquitanian sample No. 4 (GV 184b).

Stratigraphic Range.—Aquitanian Stage.

Subfamily SPHAEROIDINELLINAE Banner and Blow, 1959

Genus *Sphaeroidinella* Cushman, 1927

Sphaeroidinella cellata Subbotina

Plate 2, figures 14a-c

Sphaeroidinella cellata SUBBOTINA, 1958, Microfauna, SSSR, vol. 9, pp. 59-60, pl. 11, figs. 4a-c; 5a-c.

Sphaeroidinella ? sp., JENKINS, 1964, Cushman Found. Foram. Res. Contr., vol. 15, pt. 1, p. 29, Table 1.

Figured specimen.—Figured specimen from the Upper Burdigalian sample No. 7 (GT 183b); greatest diameter 0.27 mm.

Remarks.—*S. cellata* appears to be a thick-walled form of *G. trilobus* (Reuss) and, like *S. disjuncta* Finlay, it seems to be intermediate in position between *Sphaeroidinella* and *Globigerinoides*. Banner and Blow (1960) preferred to place *S. cellata* in the latter genus, because it lacks the necessary cortex on which they based a redefinition of the genus *Sphaeroidinella* (Banner and Blow, 1959). Reiss (1963) has cast doubt on the validity of the cortex wall structure, which, according to Reiss, is merely an optical effect. Specimens of *S. cellata* have a glassy appearance because of their thickened test walls; because of this they have been placed in the genus *Sphaeroidinella*.

Stratigraphic Range.—Burdigalian to Helvetian (?).

Recorded Stratigraphic Range.—Banner and Blow (1960) have seen similar thick-walled specimens from deposits of probable Upper Vindobonian age, but they gave no localities from which the specimens had been observed.

OLIGOCENE-MIOCENE BOUNDARY

The Oligocene-Miocene boundary is one of the most difficult and most controversial boundaries in the Tertiary.

The Aquitanian Stage is here regarded as the lowest stage of the Miocene, although some stratigraphers regard it as the topmost Oligocene stage (Gignoux, 1955). The Chattian Stage is here regarded as the uppermost Oligocene stage, but, here, too, there seem to be differing opinions (Berggren, 1963).

Drooger (1956) is the only worker to have published a co-ordinated study of the planktonic Foraminifera from the European type Oligocene-Miocene stages. Unfortunately, the faunas obtained by him from the type Rupelian, Chattian and Aquitanian stages were poor and mainly undiagnostic.

He recorded the following species from the type rocks:

Aquitanian:

Globigerina bulloides, *Globigerinoides trilobus*.

Chattian:

Globigerina globularis Roemer.

Rupelian:

Globigerina cf. *G. increbescens* Bandy.

Kaasschieter (in Drooger *et al.*, 1955) had earlier recorded *Globigerina bulloides* d'Orbigny and *Globigerinoides trilobularis* (d'Orbigny) from the type Aquitanian-Burdigalian rocks.

Recently Hofker (1963b) recorded the following 6 taxa from Oligocene rocks of northwestern Europe: *Globigerina opima opima* (Bolli), *Globigerina ouachitaensis* Howe and Wallace, *Globigerina ampliapertura* Bolli, *Globigerina praebulloides* Blow, *Globigerina dissimilis* Cushman and Bermudez and *Globigerina leroyi* Blow and Banner. Hofker concluded that the listed species "prove that the *opima opima* zone of the Cipero Formation of Trinidad is of Oligocene age."

According to Eames *et al.* (1962) the Oligocene-Miocene boundary coincides with the base of the *G. ampliapertura* Zone, first defined in the Trinidad rocks by Bolli (1957); the base of the zone coincided with his Eocene-Oligocene boundary. The only evidence given by Eames *et al.* (1962) regarding the presence of the *G. ampliapertura* Zone in the Aquitanian was the occurrence of *G. ouachitaensis ouachitaensis* in an Aquitanian sample from Escorneb eu, south-western France (Blow and Banner in Eames *et al.*, 1962). They concluded: "Since *Globigerina ouachitaensis ouachitaensis* ranges from the Upper Eocene to about the lower part of the *Globorotalia opima opima* Zone in southern Trinidad as well as occurring in the lower Aquitanian of southwestern France, the occurrence of this form strongly suggests that the *Globigerina ampliapertura* Zone is equivalent to part of the lower Aquitanian." Yet another possible interpretation is that part of the lower Aquitanian is equivalent to part of the *G. opima opima* Zone, both these views based on the assumption that *G. ouachitaensis ouachitaensis* became extinct in the Aquitanian Basin and in Trinidad at the same time. The evidence provided by Eames *et al.* (1962) for placing the *G. ampliapertura* Zone in the Aquitanian was very slender.

Berggren (1963), in his review of the work of Eames *et al.* (1962), tentatively placed the Oligocene-Miocene boundary within the *G. opima opima* Zone, a conclusion supported to some extent by the work of Hofker (1963b), quoted above.

The evidence obtained from the study of the planktonic Foraminifera from the type Aquitanian-

Burdigalian rocks is in the main negative. Neither *Globigerina ampliapertura* Bolli or *Globorotalia opima opima* Bolli were found in the Lower Aquitanian samples examined; both have restricted stratigraphical ranges (Bolli, 1957). The absence of *G. opima opima* in the Lower Aquitanian supports Hofker's contention that the *G. opima opima* Zone is Oligocene in age.

The positive evidence for defining the Oligocene-Miocene boundary on planktonic Foraminifera must be based on the species obtained from the type Aquitanian rocks. Jenkins (1964a) suggested that the Lower Aquitanian rocks were equivalent to the *G. kugleri* Zone of Trinidad, but subsequent work has yielded further evidence. The presence of *Globigerina ciproensis ciproensis* Bolli and *Globigerina ciproensis angulisuturalis* Bolli in the Lower Aquitanian samples suggests that they are equivalent to the *G. ciproensis ciproensis* Zone of Trinidad (Bolli, 1957). Blow and Banner (*in Eames et al.*, 1962) also record *G. ciproensis ciproensis*, as *G. ouachitaensis ciproensis*, in two samples from the lower and middle Aquitanian of southwestern France. Thus, the positive evidence suggests that the Lower Aquitanian is equivalent to at least part of *G. ciproensis ciproensis* Zone of Trinidad. It is here suggested that the Oligocene-Miocene boundary be placed between the *G. opima opima* Zone and *G. ciproensis ciproensis* Zone as defined by Bolli (1957).

AQUITANIAN-BURDIGALIAN BOUNDARY

The presence of typical specimens of *Globigerinoides altiapertura* Bolli in the Lower Burdigalian sample No. 5 (GT 125) and its absence below suggest that this sample is equivalent to part of the *G. dissimilis*-lower *C. stainforthi* Zones of Trinidad (Bolli, 1957). It is therefore suggested that the Aquitanian-Burdigalian boundary be tentatively placed between the *G. kugleri* and *C. dissimilis* Zones as defined by Bolli (1957).

INITIAL APPEARANCE OF *ORBULINA UNIVERSA* D'ORBIGNY

In Europe there are two distinct schools of thought regarding the initial appearance of *Orbulina universa* in the European Tertiary rocks (Jenkins, 1964c). The "Continental school" has shown that *O. universa*, preceded by its natural precursors, occurs for the first time in the Helvetian-Tortonian rocks in Europe (Drooger, 1956; Cita and Elter *in* Cita and Premoli Silva, 1960; and Papp, 1963). On the other hand, the "British School" has advocated the entry of *O. universa* in the Upper Aquitanian. First suggested by Blow (1957) in his work on Sicilian rocks, this has been repeated in subsequent published works (Banner and Blow, 1959; Banner and Blow, 1960; Eames *et al.*, 1962). Eames

et al. (1962) have suggested that *O. universa* in the Vienna Basin was not preceded by its immediate ancestors, but this can no longer be held to be true (see Papp, 1963).

Finlay (1947) and LeRoy (1948) postulated that the first appearance of *O. universa* marked a datum line in the world Tertiary rocks. Since then it has been demonstrated in many parts of the world that where there are continuous marine middle Tertiary sequences, *Orbulina universa* was the end form of one evolutionary lineage. Only in Europe has there been contradictory evidence that the *Orbulina universa* lineage appeared at two well separated and distinct levels: the first in the Upper Aquitanian and the other in the Upper Helvetian-Tortonian. There are three possible explanations for the apparent double entry of *O. universa* in the European rocks: 1. The *O. universa* lineage appeared at two distinct stratigraphic levels. 2. *O. universa* appeared at but one level and the Upper Aquitanian is stratigraphically equivalent to the Helvetian-Tortonian. 3. The original Upper Aquitanian dating of the first appearance of *O. universa* in Sicily is wrong (Blow, 1957).

Bandy (1963) has suggested that the *O. universa* lineage appeared first in the tropical region and much later in the colder regions. The delayed entry of *O. universa* could have been influenced by a vital factor like sea temperature.

The two main islands of New Zealand extend for a thousand miles in a line SW-NE from 34°S to 47°S. The *O. universa* lineage has been identified by Hornibrook (*m.s.* in press) from the southern tip of the South Island and from the east coast of the North Island (Jenkins, *m.s.* in press). On the basis of the available data, there does not seem to be any evidence from the stratigraphic ranges of the other fossils to indicate a recognisable time delay in the appearance of *Orbulina* in the New Zealand southernmost rocks.

As previously stated (Jenkins, 1964a) the uppermost samples from the type Aquitanian-Burdigalian have not yielded any of the *O. universa* lineage above the *G. trilobus trilobus* level. Again, it could be argued that these taxa were kept out of the type Aquitanian area by some geographic barrier. Fortunately, the work of Sourdillon (1960) has demonstrated the presence of the *O. universa* at Frouas, about 100 k.m. southwest of the type Aquitanian-Burdigalian, which tends to support the idea that the taxa were in the Miocene seas of the Aquitanian Basin area. The absence of the lineage taxa *G. bisphericus* to *O. universa* from the type Aquitanian-Burdigalian rocks also tends to support the evidence from the Vienna Basin and other European areas that *O. universa* made its initial appearance in the Helvetian-Tortonian Stages.

Unfortunately, Sourdillon was not able to correlate the rocks at Frouas with the type Aquitanian-Burdigalian. The reason for this appears to have been the lack of data on the planktonic Foraminifera from the type Aquitanian-Burdigalian.

Eames *et al.* (1964) stated that the planktonic foraminiferal faunas obtained from the type Aquitanian-Burdigalian rocks are poor, but this has been refuted by Jenkins (1964c). An examination of Table 1 will indicate how many specimens of each species were picked out. In the higher samples abundant unsorted specimens are present in the washed residues.

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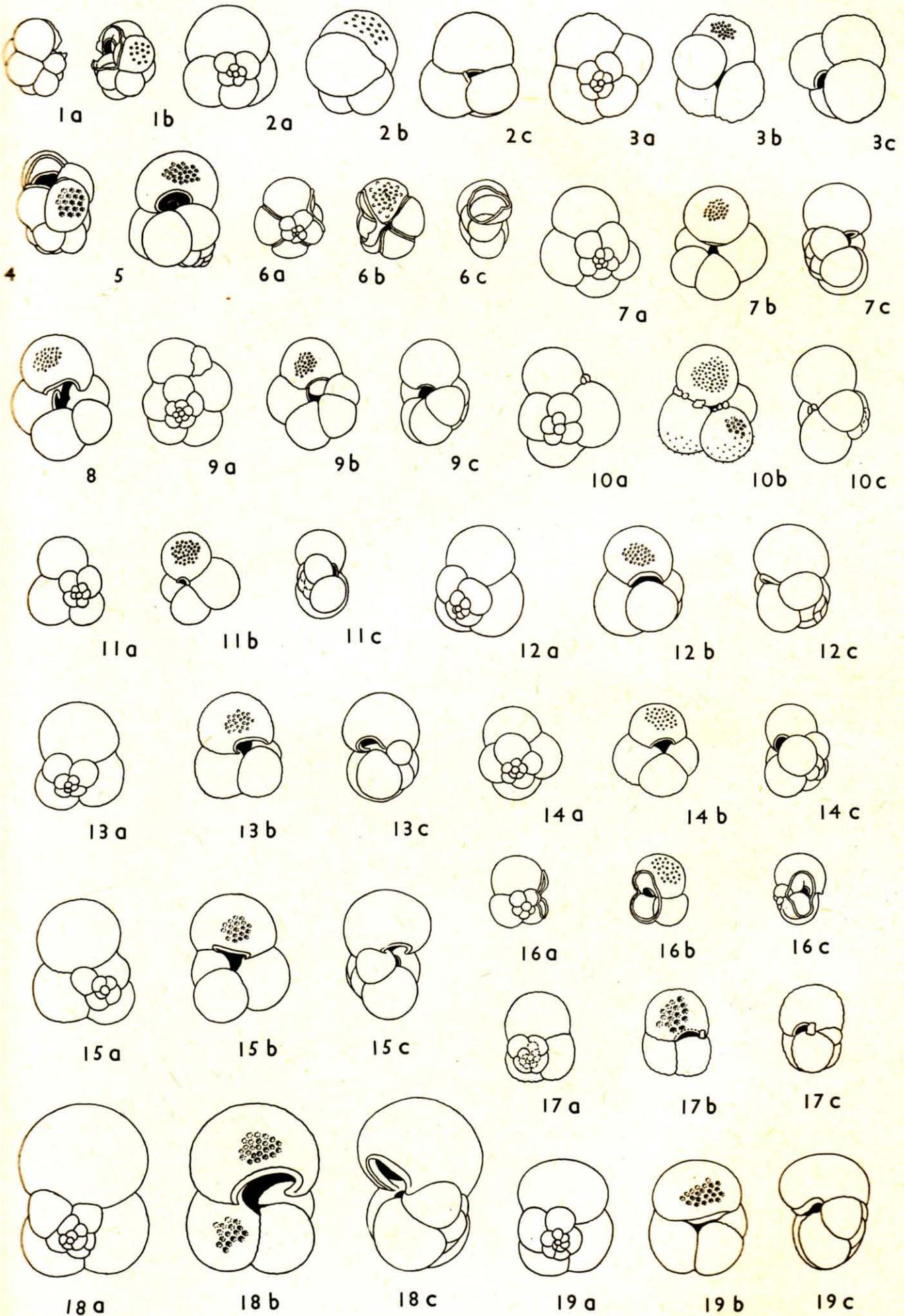
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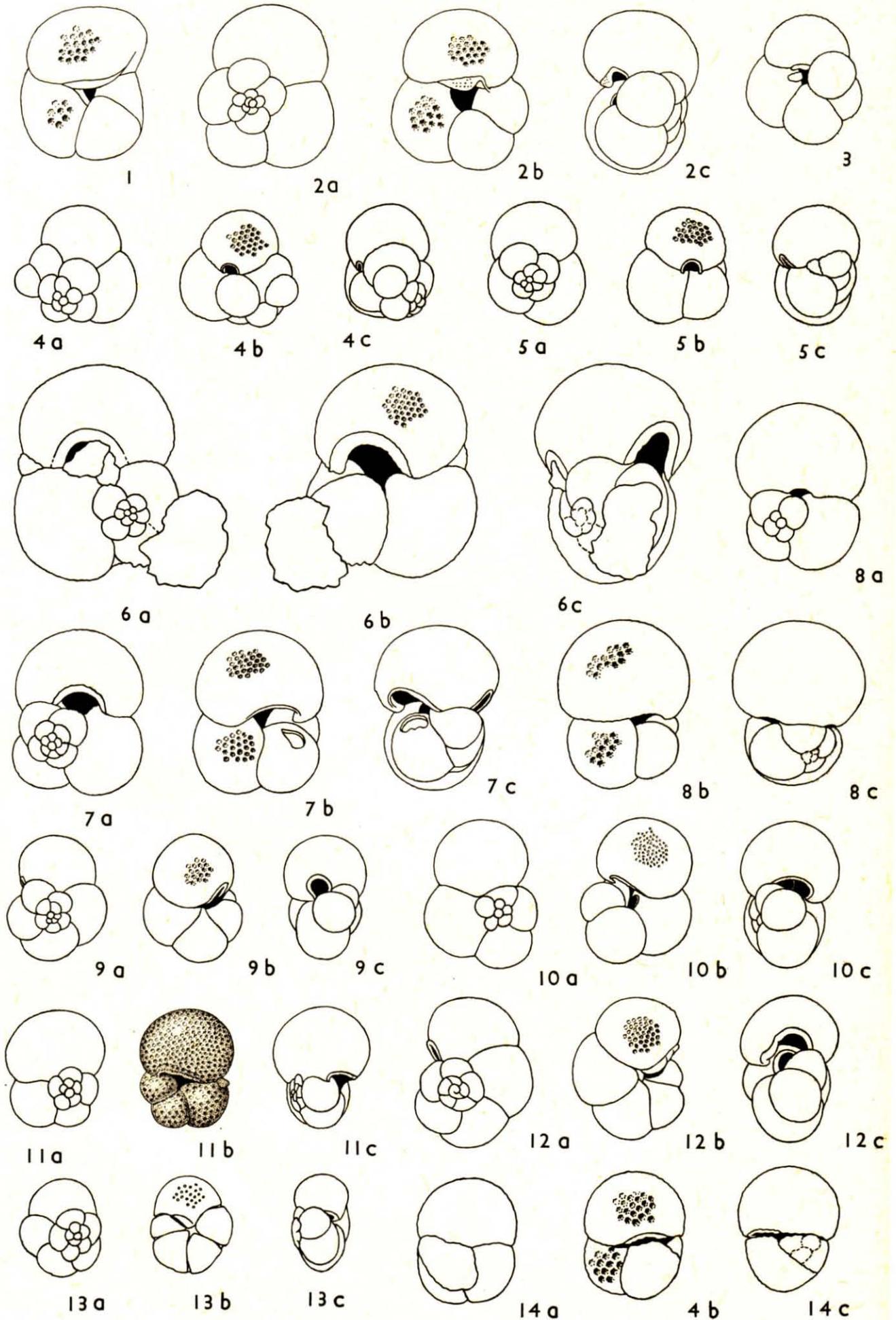
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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
 FOR FORAMINIFERAL RESEARCH
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 313. FORAMINIFERA FROM THE
 CRETACEOUS CARLILE SHALE OF COLORADO

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ABSTRACT

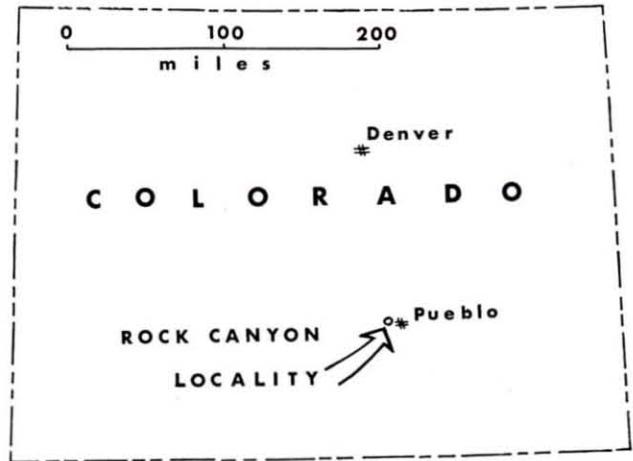
Twenty-six species of foraminifera have been recovered from the Carlile Shale of southern Colorado, including two new ones, *Ammobaculoides macellus* and *Ammomarginulina perimpexus*. The calcareous Fairport Shale Member contains dominantly calcareous planktonic specimens which are extremely abundant at the base and decrease markedly in abundance and variety upward. *Hedbergella delrioensis* (Carsey) dominates. *Praeglobotruncana renzi* (Thalmann) and *Globotruncana marginata* (Reuss) in the lower Fairport verifies the Middle Turonian age indicated by ammonites. Foraminifera of the overlying noncalcareous Blue Hill Shale Member are chiefly arenaceous, and they decrease in variety upward as the Blue Hill becomes increasingly silty. The overlying Codell Sandstone Member, with which the Blue Hill is gradational, contains numerous burrows suggestive of shallow water. The Codell is capped, however, by a two-foot dark marine shale containing a mixed calcareous and arenaceous foraminifer assemblage. Vertical changes in the Carlile Foraminifera are due to environmental changes and, with the exception of the uppermost two-foot shale bed, they indicate progressive shallowing of a regressive sea from open marine conditions at the base to extremely shallow conditions at the top.

INTRODUCTION

This report describes the foraminiferal faunas from a single section of the Carlile Shale at Rock Canyon Anticline, four miles west of Pueblo, Colorado (text figure 1). The Rock Canyon locality is on the Arkansas River a few miles southeast of the type area designated by Gilbert (1896, p. 565). The entire Carlile was measured at a single locality north of the river in NW¼ NW¼ Sec. 25, T. 20 S., R. 66 W. Samples were taken from good exposures both north and south of the Arkansas River as follows:

1. The intervals 152-171' above the base and 198-200' above the base of the Carlile were sampled on a cliff exposure in NW¼ NW¼ Sec. 30, T. 20 S., R. 65 W.
2. The interval 78-156' above the base of the Carlile was sampled in a roadcut and hillside immediately south of state highway 96 in SW¼ SW¼ Sec. 35, T. 20 S., R. 66 W.
3. The interval 45-85' above the base of the Carlile was sampled in gully and slope exposures in NW¼ NW¼ Sec. 25, T. 20 S., R. 66 W.

4. The interval 20-40' above the base of the Carlile was sampled in a roadcut immediately south of state highway 96 in SW¼ SE¼ Sec. 31, T. 20 S., R. 65 W.
5. The lower 20' of the Carlile and the upper 10' of the Bridge Creek Member of the underlying Greenhorn Formation were sampled in the ditch immediately south of state highway 96 in NW¼ NE¼ Sec. 2, T. 21 S., R. 66 W.
6. The lower 31' of the Bridge Creek was sampled in cliff exposures in SE¼ SW¼ Sec. 30, T. 20 S., R. 65 W.



TEXT FIGURE 1

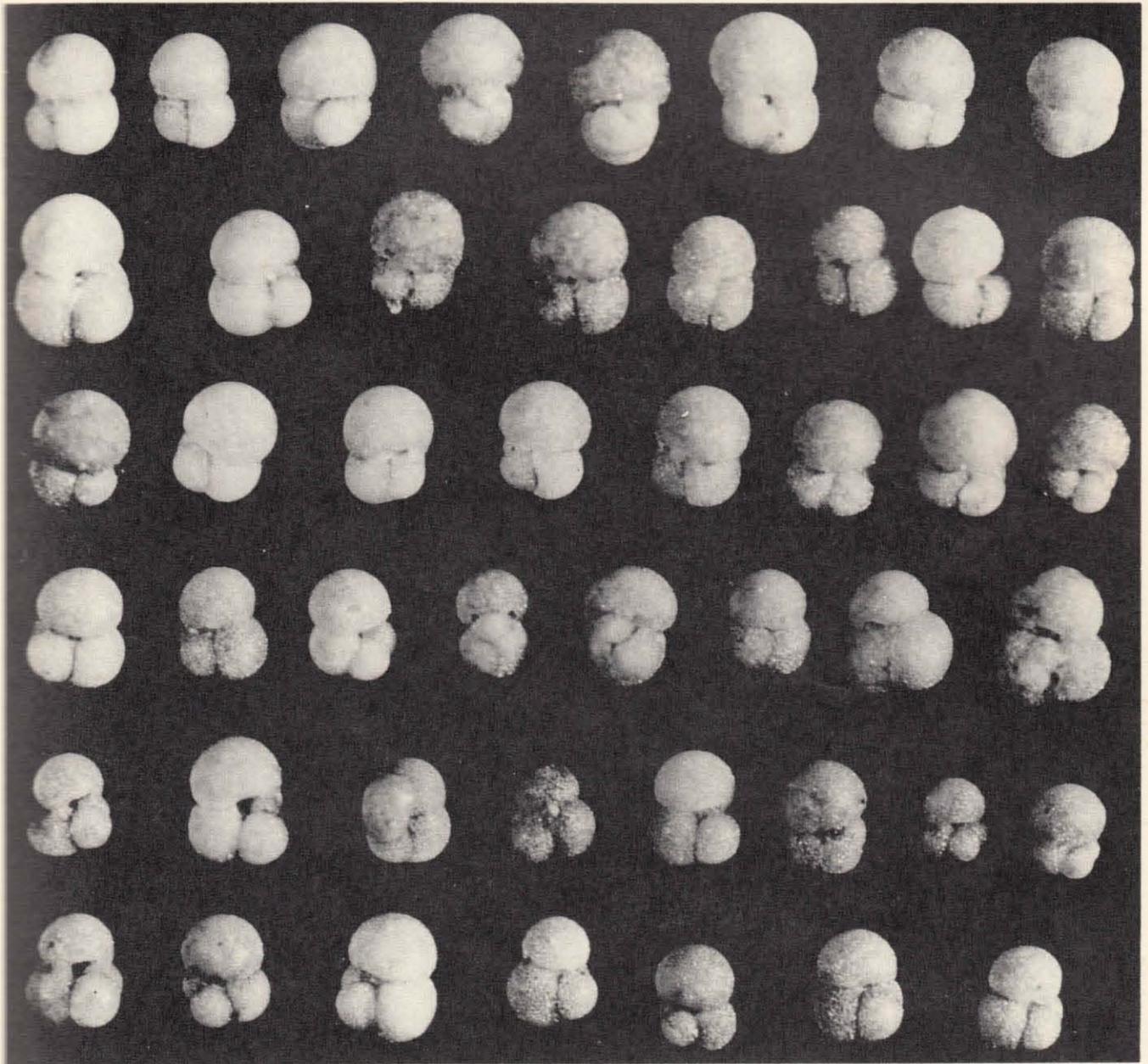
Index Map Showing Rock Canyon Locality

STRATIGRAPHY

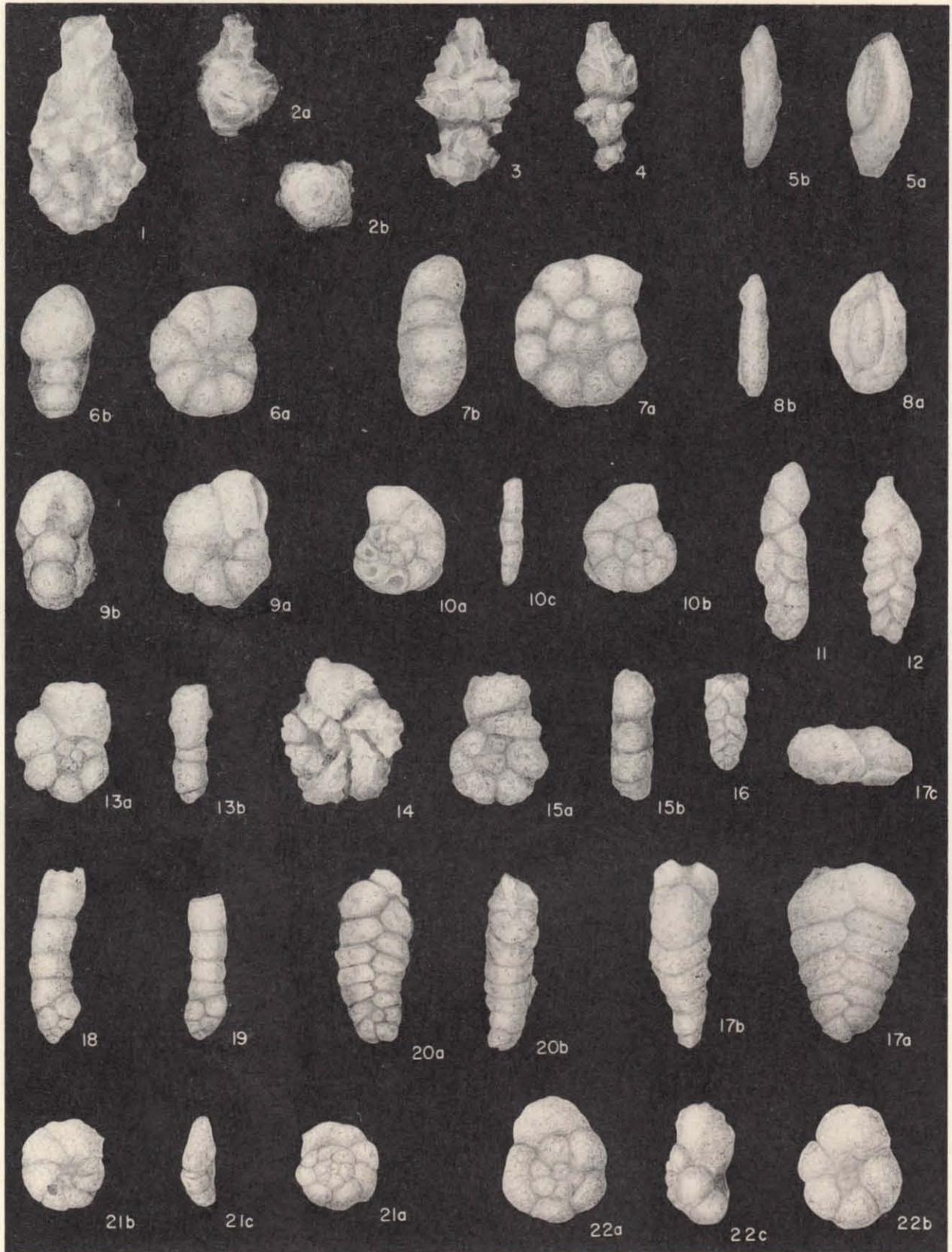
The Carlile is made up of three members. The Fairport Member at the base consists of 75 feet of light gray calcareous shale which becomes darker and less calcareous upward. The lower contact with the Bridge Creek Member of the Greenhorn Formation is gradational and conformable, and the Bridge Creek is distinguished only by containing numerous hard, resistant limestone beds interbedded with softer calcareous shales like those of the lower Fairport. The upper contact with the dark fissile, noncalcareous shale of the 96-foot Blue Hill Member is abrupt and it possibly represents a temporal break in sedimentation. The Blue Hill Shale becomes increasingly silty and less fissile upward, and it con-

EXPLANATION OF PLATE 3

Photograph showing the range of variation within *Globigerinoides trilobus* (Reuss) s.l. from the type Upper Burdigalian sample No. 7 (GT 183b). × c. 38.



Jenkins: Aquitanian-Burdigalian Planktonic Foraminifera



Eicher: Carlile Shale (Cretaceous) Foraminifera

tains three beds of very large calcareous septarian concretions in the middle part. The contact with the overlying Codell Sandstone Member is gradational, but it can be selected consistently at the base of the cliff-forming, massive-appearing sandstone interval which makes up the bulk of the 27-foot Codell unit. The sandstone of the Codell contains two or three brown-weathering, blocky, calcareous interbeds about one foot thick, and it is overlain by two feet of dark gray shale. This, in turn, is overlain abruptly and disconformably by the Fort Hays Limestone Member of the Niobrara Formation.

The Carlile of this area is Middle and Late Turonian in age (Kauffman and Pope, 1961, text fig. 2). The boundary between the Turonian and Coniacian Stages falls at the unconformable Codell-Ft. Hays contact, and the boundary between the Turonian and Cenomanian Stages falls within the underlying Greenhorn Formation, approximately at the base of the Bridge Creek Member (Cobban and Reeside, 1952, p. 1024).

Exact intervals which were channel-sampled for microfossils are located in the following lithologic descriptions:

NIOBRARA FORMATION

Ft. Hays Limestone Member	Thickness in feet
11. Limestone, gray, hard, beds to one foot thick; cross-sections of <i>Inoceramus</i> occur on joint surfaces.	not measured

CARLILE SHALE

Codell Sandstone Member	
10. Shale, dark gray, very silty lower portion, soft, poorly bedded	2
Interval sampled: 0-2 feet above base	
9. Sandstone, brown, hard, calcareous, weathers slightly blocky	1
8. Sandstone, tan, fine-grained, massive, riddled with numerous large burrows	4
7. Sandstone, brown, hard, calcareous, weathers to prominent, blocky ledge	1
6. Sandstone, tan, fine-grained, medium and thickly bedded in lower three feet, massive appearing above; riddled with numerous large burrows. This, together with the three units above, forms a vertical cliff beneath Niobrara	21
Total Codell Member 29	

Blue Hill Shale Member	
5. Sandstone, tan, fine-grained, thin to medium beds, soft and somewhat shaly in lower part; hard upper part; weathers tan, outcrop appears bedded in upper part, somewhat knobby in lower part; gradational with unit below	9
Interval sampled: 0-9 feet above base	
4. Shale, dark gray, very fissile in lower part, non-calcareous, silty and less fissile upward, finally becoming shaly siltstone in upper 20 feet of unit; three intervals of numerous, large, calcareous septarian concretions to 4 feet high and 5 feet wide have their bases at 39, 49, and 59 feet above base of unit; at 80 feet above base is a 0.5-foot gray, lenticular, concretionary limestone bed	87

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Intervals sampled in feet above base:	0-13
	13-18
	27-33
	33-43
	43-53
	53-63
	63-73
	73-81
	81-87

Total Blue Hill Member 96

Fairport Shale Member

3. Shale, light gray and tan, calcareous and hard in lower portion, becoming less calcareous and softer and darker in upper part; lower contact with Bridge Creek is gradational; upper contact with Blue Hill is abrupt 75

Intervals sampled in feet above base:	0-10
	10-20
	20-30
	30-40
	45-55
	55-65
	65-75

Total Fairport Member 75

Total Carlile Shale 200

GREENHORN FORMATION

Bridge Creek Limestone Member

2. Limestone, gray, weathers very light gray, hard, beds to one foot thick; and shale, light gray and tan, very calcareous, in beds to 1.5 feet thick; interbedded; limestone beds in upper 5 feet are darker and thinly laminated; contains *Ostrea* sp., *Inoceramus labiatus* 26

Intervals sampled in feet below top:	0-6
	6-16

1. Shale, gray, very calcareous; and limestone, gray, weathers very light gray; in 6 interbeds from 0.5 foot to 1.4 feet thick; thickest limestone bed is at base of unit; unit also contains 3 or 4 bentonite beds to 0.2 foot thick 15

Total Bridge Creek Member 41

FORAMINIFERA

The makeup of the Carlile Shale foraminiferal faunas is shown in the stratigraphic distribution of species illustrated in text figure 2. The assemblage from the Fairport Member comprises dominantly calcareous planktonic species, and the assemblages from the overlying Blue Hill Member and the upper two feet of the Codell Member comprise dominantly arenaceous benthonic species. The lower 20 feet of the Fairport member, which is the most productive interval in the Carlile, contains the following nine species:

- Neobulimina albertensis* (Stelck & Wall)
- Heterohelix globulosa* (Ehrenberg)
- Hedbergella delrioensis* (Carsey)
- Clavihedbergella simplex* (Morrow)
- Praeglobotruncana stephani* (Gandolfi)
- Globotruncana marginata* (Reuss)
- Praeglobotruncana renzi* (Thalman)

- Rugoglobigerina? aprica* (Loeblich & Tappan)
- Gavelinella dakotensis* (Fox)

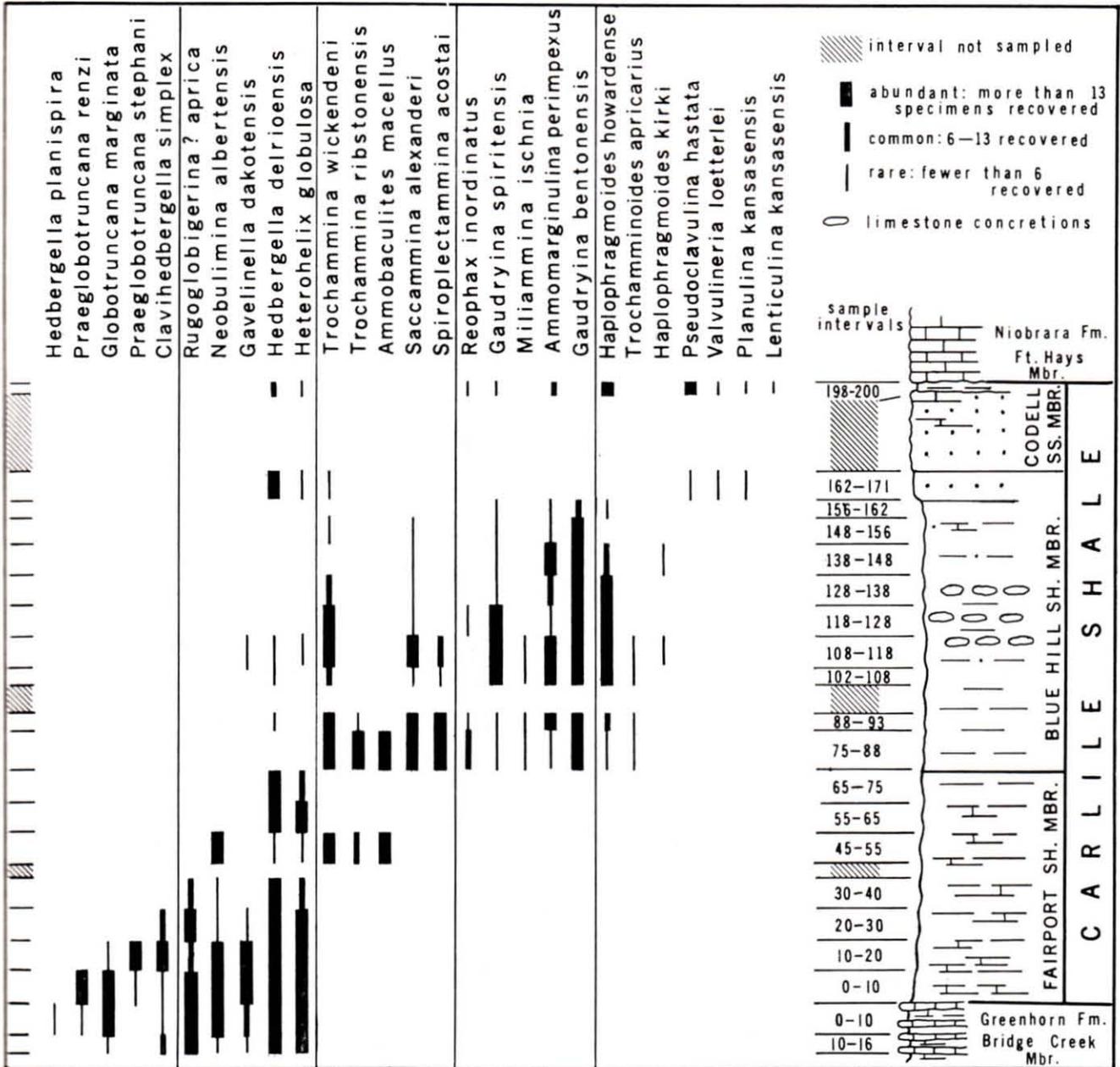
Eight of these species also occur in the upper part of the underlying Bridge Creek Limestone Member of the Greenhorn Formation and hence there is no significant faunal change at the contact. In both the Bridge Creek and Fairport, *Hedbergella delrioensis* is, by far, the most abundant species. The fauna of the Fairport becomes progressively more sparse upward, both in number of individuals and in number of species. Three arenaceous species, *Trochammina wickendeni* Loeblich, *Trochammina ribstonensis* Wickenden and *Ammobaculooides macellus* n. sp., occur in the sample interval 45-55 feet above the base of the Fairport, and constitute the only occurrence of arenaceous species in the Fairport. *Hedbergella delrioensis*, *Heterohelix globulosa*, and *Neobulimina albertensis* constitute the only calcareous species in the interval 20 to 40 feet below the top, and only *H. delrioensis* and *H. globulosa* occur in the upper 20 feet of the Fairport.

Twelve species of arenaceous foraminifers occur in the basal part of the Blue Hill Member:

- Saccamina alexanderi* (Loeblich & Tappan)
- Reophax inordinatus* Young
- Miliammina ischnia* Tappan
- Haplophragmoides howardense* Stelck & Wall
- Trochamminoides apricarius* Eicher
- Ammobaculooides macellus* n. sp.
- Spiroplectammina acostai* Tappan
- Ammomarginulina perimpexus* n. sp.
- Trochammina ribstonensis* Wickenden
- Trochammina wickendeni* Loeblich
- Gaudryina bentonensis* (Carman)
- Gaudryina spiritensis* Stelck & Wall

The most abundant half-dozen of these extend entirely throughout the Blue Hill, although they decrease in abundance in the upper silty portion. The sparsely represented half-dozen do not extend into the upper portion of the Blue Hill. In addition, two specimens of *Haplophragmoides kirki* Wickenden and a specimen of *Gavelinella dakotensis* (Fox) were found near the middle of the member. Specimens of *Hedbergella delrioensis* and *Heterohelix globulosa* occur sparsely in the lower portion and somewhat more abundantly in the uppermost sample, which came from the siltiest portion of the Blue Hill Member. Three other species appear, albeit very sparsely, in the uppermost Blue Hill sample: *Valvulineria loetterlei* (Tappan), *Pseudoclavulina hastata* (Cushman), and *Planulina kansasensis* Morrow.

The two-foot shale unit at the top of the Codell Member yielded ten species (text figure 2). All but one, *Lenticulina kansasensis* Morrow, occur in the underlying Blue Hill Member. *Pseudoclavulina hastata* is by far the most abundant species, and it lends a distinctive appearance to the upper Codell fauna



TEXT FIGURE 2

Stratigraphic distribution and relative abundance of foraminiferal species in Carlile Shale at Rock Canyon.

because it is represented in collections from the underlying Blue Hill Member by only one specimen.

FORAMINIFERAL ECOLOGY

The abundant and varied planktonic assemblage from the lower part of the Fairport Member indicates an open sea, normal marine environment, possibly of relatively deep water. Specimens of *Globotruncana* extend through a stratigraphic interval of only about 40 feet, beginning in the upper part of the Bridge Creek and extending upward into the lower Fairport. The Bridge Creek and the lower portion of the Fairport probably represent the maximum depth and extent of the sea during the Cenomanian-Turonian transgression, one of the most extensive Cretaceous transgressive episodes in the western interior. The decrease upward in variety, in average size of individuals, and in total forami-

niferal number within the Fairport probably indicates progressive regression of the sea and accompanying limiting environmental conditions. The concomitant decrease in calcareous content of the shale indicates influx of increasing quantities of terrigenous material.

The abrupt faunal and lithologic change between the Fairport and the overlying Blue Hill Member probably represents a disconformity, but the magnitude of the break is difficult to assess. The numerous arenaceous species in the lower Blue Hill indicate a pronounced change in environmental conditions from those of the Fairport. This may have included a substantial decrease in salinity, or an increase in turbidity of the water, or both. Rare calcareous planktonic specimens occur sporadically in the lower and middle Blue Hill and indicate that the interior sea was still physically connected to an

open sea of normal marine salinity, probably to the south, which intermittently contributed its faunal elements to the interior seaway when favorable currents permitted. But the sparsity of the normal marine planktonic faunas indicates that they were unable to proliferate in the interior seaway during deposition of the Blue Hill.

The upward coarsening of the Blue Hill and the simultaneous decrease in total foraminiferal number and in number of species indicates progressive regression of the sea and shallowing of the water. The numerous calcareous planktonic specimens in the uppermost and coarsest Blue Hill unit are anomalous. Possibly they were reworked from slightly older Turonian strata in central Colorado which had been deposited in more open marine environments and which are known to have been undergoing erosion while the upper Blue Hill beds were being deposited in the Rock Canyon area (Sharp, 1963).

The Codell Sandstone Member appears to culminate the regression. Abundant burrows, including *Ophiomorpha*, indicate shallow neritic and possibly even littoral environments. The two-foot black shale at the top of the Codell represents an entirely new regimen. It contains a diverse foraminiferal fauna which includes calcareous benthonic and planktonic species as well as arenaceous species. This fauna indicates a recurrence of marine environments which were accessible to planktonic as well as benthonic foraminifera. The disconformable contact with the overlying Niobrara may represent erosion prior to which the marine shale sequence in the uppermost Codell was considerably thicker.

In summary, the vertical changes in the Carlile Shale microfaunas can be attributed almost wholly to environmental changes. The overall pattern of change represents the progressive retreat of the interior sea from its maximum inundation in earliest Turonian time. With the exception of the two-foot shale unit at the extreme top, successive Carlile strata represent progressively shallower water, and increasingly limiting conditions for open sea, normal marine life.

Evolutionary as well as environmental factors may be responsible for the changes in populations of *Praeglobotruncana* and *Globotruncana* from the Bridge Creek Member of the underlying Greenhorn Formation upward into the lower part of the Fairport Member of the Carlile. The lowest occurrence of *Globotruncana* near the middle of the Bridge Creek may actually represent the initial dispersal of the genus after it evolved, because this is the approximate level of its initial worldwide appearance.

CORRELATION

Lateral microfaunal relationships with other areas in the western interior promise to be somewhat dif-

ficult to ascertain, chiefly because the bulk of the Carlile has been removed over a vast area of central and northern Colorado and adjacent areas in Wyoming and Utah (Sharp, 1963). Some of the foraminifer species from the apparently complete Carlile section in the northern Black Hills were reported by Fox (1954), but the Black Hills Carlile differs considerably from that of southern Colorado, both in lithologic sequence and microfauna. The Black Hills Carlile consists of the Pool Creek Shale Member at the base, the Turner Sandy Member, and the Sage Breaks Shale Member. From correlations based on ammonites, it appears that the southern Colorado Carlile correlates approximately only with the lower two members of the Black Hills Carlile. It is not clear where the Sage Breaks equivalents are in the southern Colorado sequence, but the Sage Breaks may be partly represented in the two-foot shale at the top of the Codell, in the disconformity at the Base of the Niobrara, and in the lowermost Niobrara beds. Fox (1954, p. 101) reported 16 species, most of which are arenaceous, from the unnamed and Turner Members in the Black Hills, and three calcareous species from the Sage Breaks Member. Of these, only three, *Lenticulina kansasensis* from the Turner, *Planulina kansasensis* from the Sage Breaks, and *Gaudryina bentonensis* from the unnamed and Turner Members have been identified in the Rock Canyon section.

The two species of *Praeglobotruncana* and one of *Globotruncana* from the lowermost 20 feet of the Carlile and the immediately underlying Greenhorn have been found in Turonian strata in various parts of the world. *Praeglobotruncana renzi* (Thalman) appears to be particularly diagnostic because of its short range. Together with *Globotruncana marginata*, an age of Middle Turonian is indicated for the Fairport, which corresponds to the age indicated by the ammonites. This assemblage does not appear to contain as many different species as Turonian planktonic assemblages from most other regions.

ACKNOWLEDGEMENTS

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SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERA

Family SACCAMMINIDAE Brady, 1884

Genus *Saccamina* M. Sars, 1869

Saccamina alexanderi (Loeblich and Tappan)

Plate 4, figures 1, 2

Proteonina alexanderi LOEBLICH and TAPPAN, 1950, Univ. of Kansas Paleontological Contr., Protozoa, art. 3, p. 5, pl. 1, figs. 1, 2.

Proteonina cf. *P. alexanderi* Loeblich and Tappan. STELCK and WALL, 1955, Research Council of Alberta Rept. 70, p. 52, pl. 1, figs. 5, 6.

Saccamina alexanderi (Loeblich and Tappan). EICHER, 1960, Peabody Museum of Natural History, Yale Univ., Bull. 15, p. 55, pl. 3, figs. 1, 2; CRESPIN, 1963, Australia Bureau of Mineral Resources, Geol. and Geophysics Bull. 66, p. 20, pl. 1, figs. 10-12.

Test consisting of one bulbous, somewhat elongate chamber with an elongate, tapering neck; wall arenaceous, of medium to coarse grains, some large specimens incorporating grains up to one-third their total length; aperture terminal, on prominent, tapering neck.

Length of large specimen in figure 1, 0.46 mm.; width, 0.24 mm. Length of small specimen in figure 2, 0.21 mm.; width, 0.13 mm.

Remarks.—Specimens from the Carlile Shale are more coarsely agglutinated than specimens from the Thermopolis and Skull Creek Shales of Wyoming. Especially large grains are commonly incorporated onto the neck. Grain size of the wall probably depends partly on particle sizes available in the sedimentary environment in which the animal lived.

Occurrence.—This species is common in the lower part and rare in the upper part of the Blue Hill Member of the Carlile Shale at Rock Canyon. Seventy-five specimens were picked and studied. It has previously been found in the Kiowa, Thermopolis, Skull Creek, and Graneros Shales in the western interior of the United States, in the Kaskapau Formation of western Canada, and in the Lower Cretaceous of Australia.

Figured specimens.—UCM 27000 and 27001.

Family HORMOSINIDAE Haeckel, 1894

Genus *Reophax* Montfort, 1808

Reophax inordinatus Young

Plate 4, figures 3, 4

Reophax inordinatus YOUNG, 1951, Jour. Paleontology, v. 25, p. 48, pl. 11, figs. 1, 2.

Test elongate, consisting of two or three uniserial chambers; chambers rounded in section in uncrushed specimens, increasing rapidly; sutures straight, distinct, depressed; wall coarsely arenaceous with little cement; aperture terminal, round, at the end of a prominent, tapering neck which constitutes the last third of the final chamber.

Length of uncrushed specimen in figure 4, 0.48 mm., width, 0.19 mm. Length of crushed specimen in figure 3, 0.53 mm. Other specimens range from 0.39 mm. to 0.57 mm. in length.

Remarks.—The specimens in hand are not quite so large as those described by Young (1951), but

they are similar in other respects. *Reophax* sp. of Peterson (1953, pl. 2, figs. 1, 2) appears to belong to this species.

Occurrence.—In the Carlile this species occurs sparsely in the lower two-thirds of the Blue Hill Member and in the Codell Member. Only about eight specimens have been found. It was previously reported from Greenhorn equivalents in southern Montana.

Figured specimens.—UCM 27002 and 27003.

Family RZEHAKINIDAE Cushman, 1933

Genus *Miliammina* Heron-Allen and Earland, 1930

Miliammina ischnia Tappan

Plate 4, figures 5, 8

Miliammina ischnia TAPPAN, 1957, U. S. National Museum Bull. 215, p. 211, pl. 67, figs. 25, 26; EICHER, 1960, Peabody Museum of Natural History, Yale Univ., Bull. 15, p. 71, pl. 5, figs. 11, 12.

Test small, sides gently convex, chamber arrangement quinqueloculine; chambers elongate; sutures generally faint, slightly depressed in some specimens; wall finely arenaceous, smoothly finished; aperture a simple opening at the end of the final chamber, without a neck.

Length of crushed specimen in figure 8, 0.20 mm., width 0.13 mm. Length of specimen in figure 5, 0.23 mm., width 0.11 mm. Other specimens range from 0.18 mm. to 0.33 mm. in length.

Occurrence.—Only 13 specimens were found in the lower part of the Blue Hill Member and most of these are crushed in preservation. This species has been reported from the Skull Creek, Thermopolis, Muddy, Shell Creek, and Graneros Formations in the western interior of the United States, and from the Grandstand Formation of northern Alaska.

Figured specimens.—UCM 27004 and 27005.

Family LITUOLIDAE de Blainville, 1825

Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides howardense Stelck and Wall

Plate 4, figures 6, 7

Haplophragmoides howardense STELCK and WALL, 1954, Research Council of Alberta Rept. 68, p. 25, pl. 1, fig. 20, pl. 2, figs. 5, 6.

Haplophragmoides howardense manifestum STELCK and WALL, 1954, Research Council of Alberta Rept. 68, p. 26, pl. 1, figs. 3, 4, 5, 18, pl. 2, figs. 1, 2.

Test planispiral, periphery broadly rounded, composed of two or more whorls, variably evolute, some specimens revealing nearly all of the preceding whorl, others nearly completely involute, umbilicus wide and very shallow in some specimens, narrow and moderately deep in others, umbilicus commonly partly filled with cement; commonly six

to eight and rarely up to nine and one-half chambers in last whorl, chambers inflated only very slightly, increasing very gradually; sutures distinct, thickened and typically clear, very slightly depressed to flush, faintly sinuous; wall of fine and medium grains, smoothly finished with much cement; aperture obscure, at base of apertural face.

Greatest diameter of specimen in figure 6, 0.23 mm., thickness, 0.10 mm. Greatest diameter of specimen in figure 7, 0.26 mm., thickness, 0.10 mm. Other specimens range up to 0.47 mm. in greatest diameter, but the majority fall between 0.19 mm. and 0.31 mm.

Remarks.—This species is similar to *Haplophragmoides gilberti* Eicher, but *H. gilberti* has more inflated chambers, less cement, and a coarser surface; the umbilicus is deeper and the coil somewhat more involute. *H. carlilensis* Fox appears somewhat similar, but it is larger (0.50 mm. to 0.90 mm. in greatest diameter), more involute, and it has ten chambers in the final whorl. *H. howardense* specimens from western Canada compare well in all characters with the Carlile species. The greatest difference is that the Canadian specimens are not quite so robust, but this is due partly to a degree of crushing in their preservation.

The Canadian species, *H. collyra* and *H. spiritense*, are extremely similar to *H. howardense*, but they are somewhat more involute and the chambers of the final whorl overlap more, creating sutures which reach farther into the center and cover a much greater portion of the preceding whorls.

Occurrence.—This species occurs throughout the Blue Hill Member of the Carlile. About 230 specimens have been recovered and studied. It was reported originally from the Kaskapau Formation of the Peace River area in western Canada.

Figured specimens.—UCM 27007 and 27006.

Haplophragmoides kirki Wickenden

Plate 4, figure 9

Haplophragmoides kirki WICKENDEN, 1932, Royal Soc. Canada Trans., v. 26, sec. 4, p. 85, pl. 1, fig. 1; CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 21, pl. 3, fig. 23; SHAW, 1953, Wyoming Geol. Assoc. Guidebook, 8th Ann. Field Conf., pl. 1, figs. 1-3; PETERSON, 1953, Utah Geol. and Miner. Survey Bull. 47, p. 31, pl. 1, fig. 5; STELCK and WALL, 1956, Research Council of Alberta Rept. 75, p. 36, pl. 4, figs. 12, 13; WALL, 1960, Research Council of Alberta Bull. 6, p. 18, pl. 3, figs. 11, 12; pl. 4, figs. 10, 11.

Test planispiral, involute, periphery rounded, four and one half to five and one-half chambers in last whorl; chambers inflated, expanding gradually; sutures distinct, fairly straight, gently depressed;

wall arenaceous, of fine grains, smoothly finished; aperture at the base of the apertural face.

Greatest diameter of figured specimen, 0.34 mm.; thickness, 0.19 mm. The only other specimen recovered is 0.23 mm. in diameter.

Occurrence.—The two Carlile specimens are from the Blue Hill Member. This species has been reported previously from the Fort St. John, Kaskapau, Puskwaskau, Lea Park, Bearpaw, Riding Mountain, and Pakowki Formations of Canada, and from the Allen Valley, Frontier, Carlile, Cody, and Adaville Formations in the United States.

Figured specimen.—UCM 27008.

Genus *Trochamminoides* Cushman

Trochamminoides apricarius Eicher

Plate 4, figure 10

Trochamminoides apricarius EICHER, 1965, Jour. Paleontology, v. 39, p. 894, pl. 103, figs. 7, 12.

Test small, strongly compressed, planispirally coiled and evolute, six to nine chambers in last whorl; chambers faintly inflated, increasing gradually; sutures very slightly depressed, straight or curving gently; wall finely arenaceous; aperture at the base of the apertural face, obscure in all specimens.

Greatest diameter of flattened figured specimen, 0.17 mm. Other Carlile specimens range from 0.14 mm. to 0.37 mm. in greatest diameter.

Occurrence.—Only 10 specimens were found in the Carlile, and these occur in the Blue Hill Member. These are of smaller average size than specimens from the Graneros Shale and its equivalents from which this species was initially described.

Figured specimen.—UCM 27009.

Genus *Ammobaculoides* Plummer, 1932

Ammobaculoides macellus, n. sp.

Plate 4, figures 11, 12, 16

Test slender, flattened, most specimens tapering gradually toward narrowly-rounded base from the greatest width near the penultimate chamber; early portion a tiny, obscure coil containing 5 or 6 chambers, later biserial portion containing up to 6 pairs of chambers; sutures indistinct in coil, distinct and slightly depressed in biserial portion, sutures between superadjacent chambers sloping steeply toward periphery; wall of very fine grains, smoothly finished; aperture terminal, on a distinct neck in some specimens, obscure in others.

Specimens in hand range from 0.21 mm. to 0.36 mm. in length. Length of the holotype in fig. 11, 0.29 mm., width, 0.09 mm. Length of paratype with coil broken off in fig. 12, 0.26 mm. Length of paratype with top broken off in fig. 16, 0.16 mm.

Remarks.—Many of the specimens in hand are crushed. The coil is commonly broken off or smashed due to the delicate nature of the early portion of the test.

This species is most similar to *Ammobaculooides phaulus* Loeblich and Tappan, but it is more slender, somewhat smaller, and the coil is proportionately smaller and not so distinct as in *A. phaulus*. Although one or two of the Carlile specimens become loosely biserial in late stages, none develops uniserial chambers.

Occurrence.—Fifty-five specimens of *Ammobaculooides macellus* were recovered from the sample interval 55-65' above the base of the Fairport Member, and in the lower 13' of the Blue Hill Member.

Holotype.—UCM 27010; paratypes, UCM 27011 and 27012.

Genus *Ammomarginulina* Wiesner, 1931

Ammomarginulina perimpexus, n. sp.

Plate 4, figures 13-15

Test planispiral, strongly compressed, evolute, comprised of less than two complete whorls followed in occasional specimens by one uniserial chamber, five to seven chambers in last whorl of coil, proloculus and from one to five chambers preceding last whorl; chambers increasing gradually, inflated peripherally in some specimens resulting in a lobate outline especially in crushed specimens; sutures of many specimens not distinctly separated in early portion, commonly slanted backward, thickened, and peripherally depressed in later portion, giving chambers a faintly imbricate appearance; aperture indistinct, at base of apertural face in coil, terminal on uniserial chambers; wall coarsely arenaceous.

Height of specimen in figure 13, 0.39 mm. Height of specimen in figure 14, 0.47 mm. Height of holotype in figure 15, 0.42 mm.; width of coil, 0.31 mm. Other specimens range up to 0.50 mm. in height.

Remarks.—Specimens vary greatly in slope of sutures and also in distinctness of sutures. The open coil and indistinctly separated early chambers are similar to *Ammobaculites impexus* Eicher from the Graneros Shale, and *A. impexus* may be ancestral to the species in hand. *Ammobaculites goodlandensis* Cushman and Applin differs from *Ammomarginulina perimpexus* in being much larger, more voluminous, and in having a saucer-like central depression and a greatly thickened periphery.

Occurrence.—Ninety-five specimens were found in samples from throughout the Blue Hill Member and from the uppermost part of the Codell Member of the Carlile at Rock Canyon.

Holotype.—UCM 27013; paratypes, UCM 27014 and 27015.

Family TEXTULARIIDAE Ehrenberg, 1838

Genus *Spiroplectammina* Cushman, 1927

Spiroplectammina acostai Tappan

Plate 4, figures 17, 20

Spiroplectammina acostai TAPPAN, 1943, Jour. Pa-

leontology, v. 17, p. 484, pl. 77, fig. 20; FRIZZELL, 1954, Texas Bureau of Econ. Geol., Rept. of Investigations 22, p. 66, pl. 4, fig. 16.

Test small, compressed, flaring moderately from rounded base, periphery sharply rounded, unevenly serrate; most specimens beginning with an early coil of four or five chambers followed by as many as eleven biserial chambers; some specimens beginning with a large proloculus followed immediately by up to fourteen biserial chambers; biserial chambers elongate, about twice as wide as high, sloping gently downward toward periphery, increasing very gradually in size; sutures fairly distinct, particularly in biserial portion where they are slightly depressed; wall finely arenaceous; aperture obscure, at the base of the apertural face.

Length of specimen in fig. 17, 0.29 mm.; width 0.21 mm.; thickness, 0.09 mm. Length of specimen in fig. 20, 0.27 mm.; width 0.12 mm.; thickness, 0.08 mm. Other specimens range in length from less than 0.18 mm. to 0.38 mm., but those exceeding 0.30 mm. are rare.

Remarks.—The taper of the test and the degree of flattening vary considerably. Tests without coiled early chambers may represent megalospheric individuals, and those with coils, microspheric individuals.

Occurrence.—*Spiroplectammina acostai* has been found in the lower portion of the Blue Hill Member of the Carlile from which 90 specimens were recovered. It has been reported previously from the Duck Creek Formation of Texas.

Figured specimens.—UCM 27016 and 27017.

Family TROCHAMMINIDAE Schwager, 1877

Genus *Trochammina* Parker and Jones, 1859

Trochammina ribstonensis Wickenden

Plate 4, figure 21

Trochammina ribstonensis WICKENDEN, 1932, Royal Soc. Canada Trans., v. 26, sec. 4, p. 90, pl. 1, fig. 12; CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 50, pl. 15, fig. 9; NAUSS, 1947, Jour. Paleontology, v. 21, p. 340, pl. 49, fig. 6; WALL, 1960, Research Council of Alberta Bull. 6, p. 26, pl. 5, figs. 7-12; TAPPAN, 1962, U. S. Geol. Survey Prof. Paper 236-C, p. 154, pl. 39, figs. 16, 17.

Test small, trochoid, comprising up to two and one-half whorls, dorsally gently convex to flat, ventral umbilicus small; chambers low, slightly inflated, increasing gradually in size, six to eight in last whorl; sutures distinct, depressed, gently curved dorsally; wall finely arenaceous, smooth; aperture obscure, at the ventral margin of the last chamber.

Maximum diameter of figured specimen, 0.15 mm.; thickness, 0.05 mm. Maximum diameter of other specimens in hand ranges from 0.10 mm. to 0.17 mm.

Remarks.—The Carlile specimens are rather small, even for this typically small species.

This species has been allowed an extraordinary amount of variation by some workers. Tappan (1962, pl. 39, fig. 15) assigned to it one specimen with only four chambers in the final whorl, which probably should be placed in another species. Wall (1960, p. 26) included in it specimens with as many as nine chambers in the final whorl.

Occurrence.—This species has previously been reported from the Lea Park and Puskwaskau Shales of Alberta, and from rocks of Turonian and Senonian age in northern Alaska. In Colorado it occurs in the lower portion of the Blue Hill Member of the Carlile. Specimens were also recovered from a single sample from the upper portion of the Fairport Member. Altogether 28 specimens were recovered.

Figured specimen.—UCM 27018.

Trochammina wickendeni Loeblich

Plate 4, figure 22

Trochammina wickendeni LOEBLICH, 1946 Jour. Paleontology, v. 19, p. 138, pl. 22, fig. 17; FRIZZELL, 1954, Texas Bureau of Econ. Geol. Rept. of Investigations 22, p. 79, pl. 7, fig. 24.

Test a very low trochoid spiral with a shallow ventral umbilicus, consisting of up to two complete whorls, periphery broadly rounded, four or five, rarely six chambers in last whorl; chambers inflated, increasing rapidly in size up to last three chambers, then more slowly; sutures distinct, depressed; wall finely arenaceous, smoothly finished; aperture obscure, apparently at the inner ventral margin of the last chamber, opening into the umbilicus.

Greatest diameter of figured specimen, 0.21 mm.; thickness, 0.10 mm. Other Carlile specimens range in greatest diameter from 0.14 mm. to 0.37 mm. and rarely larger, but most are between 0.20 and 0.30 mm.

Remarks.—This species appears very similar to *Trochammina wetteri* Stelck and Wall from the Kaskapau and Puskwaskau Formations of western Canada. The specimens in hand are generally smaller and typically have somewhat flatter spires than specimens of *T. wetteri*, but the distinction is not great.

Occurrence.—*Trochammina wickendeni* occurs in a single sample from the upper part of the Fairport Member, and from throughout the Blue Hill Member of the Carlile Shale. About 280 specimens were picked and studied. It also occurs in the Pepper Shale of Texas and in the Graneros Shale of Colorado.

Figured specimen.—UCM 27019.

Family ATAXOPHRAGMIIDAE Schwager, 1877

Genus *Gaudryina* d'Orbigny, 1839

Gaudryina bentonensis (Carman)

Plate 5, figures 3, 4

Spiroplectammina bentonensis CARMAN, 1929, Jour. Paleontology, v. 3, p. 311, pl. 34, figs. 8, 9.

Gaudryina bentonensis (Carman). CUSHMAN, 1932, Cushman Lab. Foram. Research Contr., v. 8, p. 96; 1937, Cushman Lab. Foram. Research Special Pub. 7, p. 42, pl. 6, figs. 21, 22; 1946, U. S. Geol. Survey Prof. Paper 206, p. 33, pl. 7, figs. 15, 16; CUSHMAN and DEADERICK, 1942, Cushman Lab. Foram. Research Contr., v. 18, p. 52, pl. 9, figs. 12, 13; SHAW, 1953, Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., pl. 1, fig. 4; FRIZZELL, 1954, Texas Bureau of Econ. Geol. Rept. of Investigations 22, p. 70, pl. 5, fig. 14.

Test elongate, rounded basally, slightly compressed, edges parallel to gently tapering in side view, early triserial portion about as high as wide, usually containing between two and three whorls, protruding slightly beyond side of test in front view, biserial portion usually slightly twisted; chambers increasing fairly rapidly in size in triserial portion, very gradually or not at all in biserial portion; sutures very distinct and fairly thick, especially in biserial part, becoming very slightly depressed late; wall of fine grains, smoothly finished; aperture a high, narrow opening rising from the base of the apertural face.

Length of specimen in figure 3, 0.39 mm.; width, 0.14 mm.; thickness, 0.11 mm. Length of specimen in figure 4, 0.50 mm.; width, 0.19 mm.; thickness, 0.15 mm. Other specimens range in length from 0.12 mm. for tiny, immature individuals to 0.70 mm. Those with lengths of about 0.50 mm. are most common.

Occurrence.—This species has previously been reported from throughout the Upper Cretaceous of the Gulf Coast area and from many Upper Cretaceous formations in the western interior of the United States. In this study it was found throughout the Blue Hill Member where it is one of the most abundant species. About 180 specimens were picked and studied.

Figured specimens.—UCM 27022 and 27023.

Gaudryina spiritensis Stelck and Wall

Plate 5, figures 1, 2

Gaudryina spiritensis STELCK and WALL, 1955, Research Council of Alberta Rept. 70, p. 43, pl. 2, figs. 9, 10; pl. 3, figs. 8-12.

Test elongate, tapering markedly to a very narrowly rounded base, early one-third to one-fourth of test closely triserial, rounded, later chambers in a biserial arrangement which may be slightly twisted, but which shows little gradation between the two portions; chambers slightly inflated, increasing gradually in size; sutures distinct, very slightly depressed; wall arenaceous, with fine to medium grains and

considerable cement; aperture a high arch in the apertural face.

Length of specimen in figure 2, 0.29 mm.; thickness, 0.10 mm.; length of specimen in figure 1, 0.47 mm., thickness, 0.14 mm. Other specimens range in length from 0.17 mm. to 0.52 mm., but most are between 0.24 mm. and 0.40 mm.

Remarks.—These specimens are placed in *Gaudryina* rather than *Verneuillinoides* because the later portion is distinctly biserial and only slightly twisted in all specimens in hand. Also, the change to the twisted biserial structure is sudden, involving no notable transition from the closely triserial structure in any of the specimens.

This species is similar in triserial and biserial proportions to *G. bentonensis*, but it is smaller, and it tapers much more strongly to a pointed base. It is also similar to *Gaudryina irenensis* Stelck and Wall, but the specimens in hand are smaller on the average and they are not so stout.

Occurrence.—*Gaudryina spiritensis* occurs throughout the Blue Hill Member and in the upper part of the Codell Member of the Carlile. About 80 specimens have been recovered. It has previously been recorded only from the Cenomanian Kaskapau Formation of Alberta and British Columbia. Specimens in hand are somewhat longer with more biserial chambers than those from the Kaskapau.

Figured specimens.—UCM 27020 and 27021.

Genus *Pseudoclavulina* Cushman, 1936

Pseudoclavulina hastata (Cushman)

Plate 4, figures 18, 19

Bigenerina hastata CUSHMAN, 1927, Royal Soc. Canada, Trans. 3rd ser., v. 21, sec. IV, p. 131, pl. 1, fig. 9; 1946, U. S. Geol. Survey Prof. Paper 206, p. 30, pl. 6, fig. 25.

Pseudoclavulina hastata (Cushman). TAPPAN, 1962, U. S. Geol. Survey Prof. Paper 236-C, p. 151, pl. 36, figs. 10, 11.

Test slender, elongate, early chambers in a compact, somewhat swollen triserial coil containing about two complete whorls, later portion uniserial, cylindrical, abruptly truncated, consisting of up to five chambers which increase very gradually in height and slightly or not at all in diameter, the later uniserial chambers about as high as broad; sutures distinct, thickened, but only very slightly depressed in uniserial portion; wall finely arenaceous, smooth; aperture in a large round terminal depression with a peripheral rim.

Length of specimen in figure 19, 0.46 mm.; width triserial portion, 0.13 mm.; width uniserial portion, 0.12 mm. Length of specimen with damaged final chamber in figure 18, 0.54 mm.; width 0.13 mm. Other specimens range from 0.26 mm. to 0.61 mm. in length.

Remarks.—Loeblich and Tappan (1964, p. 279) placed the genus *Pseudoclavulina* in synonymy with *Clavulina*, presumably because the type species of *Pseudoclavulina*, *Clavulina clavata* Cushman, possesses the distinguishing characteristic of *Clavulina*—an apertural tooth. However, the type specimen of *C. clavata* is a poorly preserved specimen with an obscure aperture which shows no tooth (J. F. Mello, U. S. Geological Survey, Washington, D. C., personal communication), and apparently no paratypes were designated, for none are in the collections of the U. S. National Museum. In the absence of information that any other specimens of *C. clavata* were studied in designating *Pseudoclavulina* a junior synonym of *Clavulina*, it would seem proper, for now, to continue to recognize the name *Pseudoclavulina* for those forms without apertural teeth.

The distinctive rim circling the apertural depression on the final chamber of the well-preserved specimens in hand conveys the false impression that the test has been broken.

Occurrence.—Fifty-five specimens were picked and studied, and all but one came from the two-foot shale at the top of the Codell Sandstone Member.

Figured specimens.—UCM 27024 and 27025.

Family NODOSARIIDAE Ehrenberg, 1838

Genus *Lenticulina* Lamarck, 1804

Lenticulina kansasensis Morrow

Plate 5, figure 15

Lenticulina kansasensis MORROW, 1934, Jour. Paleontology, v. 8, p. 189, pl. 30, fig. 23; LOETTERLE, 1937, Nebr. Geol. Survey, Bull. 12, p. 22, pl. 1, fig. 6; CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 56, pl. 18, fig. 15; SHAW, 1953, Wyoming Geol. Assoc. Guidebook, 8th Ann. Field Conf., pl. 1, fig. 11.

Test large, planispiral, involute, sides convex, thickness about one-third of greatest diameter, periphery keeled; chambers expanding gradually, 10 or 11 in last whorl, the final chamber with a narrow, high face; sutures smooth or elevated, curved, merging centrally into a distinct boss; wall calcareous, smooth; aperture indistinct, but apparently radially, at the peripheral angle.

Greatest diameter of figured specimen, 0.84 mm.

Occurrence.—Two large specimens recovered from the uppermost part of the Codell Member of the Carlile are referred to this species. It is known from the Turner Member of the Carlile in the Black Hills, from the Niobrara Formation, and from Niobrara equivalents in the Cody Shale of Wyoming and in the Funk Valley Formation of west-central Utah.

Figured specimen.—UCM 27026.

Family TURRILINIDAE Cushman, 1927

Genus *Neobulimina* Cushman and Wickenden, 1928*Neobulimina albertensis* (Stelck and Wall)

Plate 5, figures 5-8

Gumbelitria cretacea Cushman var. *albertensis* STELCK and WALL, 1954, Research Council of Alberta Rept. 68, p. 23, pl. 2, fig. 19.*Gumbelitria cretacea* Cushman var. *spiritensis* STELCK and WALL, 1955, Research Council of Alberta Rept. 70, p. 44, pl. 2, fig. 11.*Neobulimina albertensis* (Stelck and Wall). TAPPAN, 1962, U. S. Geol. Survey Prof. Paper 236-C, p. 184, pl. 48, figs. 3-6.

Test elongate, flaring moderately in the lower closely triserial portion, the upper loosely triserial portion relatively uniform in width, but more lobate in outline than early portion, some very small or medium-sized specimens consisting only of a closely triserial portion; chambers increasing regularly from a pointed or rounded base depending on proloculus size, chambers mildly inflated in early portion, strongly inflated in later portion; sutures distinct, depressed; wall calcareous, coarsely perforate; aperture a high loop in a pronounced depression in the apertural face.

The specimens in figures 5 through 8 are 0.12, 0.16, 0.45, and 0.39 mm. in length, respectively. Those in figs. 5 and 6 are magnified about twice as much as those in figs. 7 and 8. Other specimens range from 0.12 mm. to 0.58 mm. in length.

Remarks.—Specimens in hand are of larger average size than those which have been previously reported. Very small specimens commonly do not achieve the loose triseriality and show only the compact triserial arrangement which alone characterizes the genus *Praebulimina*.

The size of individuals decreases upward through the lower two-thirds of the Fairport Member, and the small specimens from the uppermost interval, 45-55' above the base, are triserial throughout. They appear much like *Praebulimina seabeensis* Tappan, but they are identical to the initial portions of the small *Neobulimina albertensis* specimens in the underlying 30-40' interval; they are interpreted as environmentally-caused variants of *N. albertensis*.

Occurrence.—About 180 specimens from the lower two-thirds of the Fairport Member of the Carlile Shale have been picked and studied. In Alaska and Canada *N. albertensis* occurs in the Seabee and Kaskapau Formations, respectively.

Figured specimens.—UCM 27027, 27028, 27030, and 27029.

Family DISCORBIDAE Ehrenberg, 1838

Genus *Valvulineria* Cushman, 1926*Valvulineria loetterlei* (Tappan)

Plate 5, figure 11

Pulvinulina sp. Margaret CARPENTER, 1925, Univ. Texas Bull. 2544, p. 17, figs. 11, 12.*Gyroidina nitida* (Reuss). PLUMMER, 1931, Univ. Texas Bull. 3101, p. 191, pl. 14, fig. 5 (not *Rotalina nitida* Reuss, 1844).*Gyroidina loetterlei* TAPPAN, 1940, Jour. Paleontology, v. 14, p. 120, pl. 19, fig. 10; 1943, Jour. Paleontology, v. 17, p. 512, pl. 82, fig. 9; FRIZZELL, 1954, Texas Bureau of Econ. Geol. Rept. of Investigations 22, p. 124, pl. 18, fig. 41.*Valvulineria loetterlei* (Tappan). TEN DAM and SCHIJFSMA, 1944, Soc. Geol. France, C. R. Sommaire, p. 143; TAPPAN, 1962, U. S. Geol. Survey Prof. Paper 236-C, p. 194, pl. 54, figs. 1-4.*Gyroidina* sp. A. WICKENDEN, 1951, Geol. Survey Canada Paper 51-16, p. 41, pl. IA, fig. 30.*Gyroidina* cf. *G. nitida* (Reuss). STELCK, WALL, BAHAN and MARTIN, 1956, Research Council of Alberta Rept. 75, p. 33, pl. 1, figs. 11-13, pl. 2, figs. 7-9 (not *Rotalina nitida* Reuss, 1844; not *Gyroidina nitida* (Reuss) Cushman, 1946).

Test small, thick, periphery broadly rounded, gently convex dorsally, ventral umbilicus covered by flap from final chamber; seven gradually increasing chambers in last whorl; sutures essentially flush, nearly straight ventrally, obscure but slightly curved dorsally; wall calcareous, smooth, finely perforate; aperture obscure.

The figured specimen, which is one of only two found, is 0.24 mm. in greatest diameter, and 0.11 mm. in thickness.

Occurrence.—One specimen was recovered from the topmost Blue Hill sample and another from the uppermost portion of the Codell. This species has been reported previously from the Washita and Woodbine Groups of Texas, and from Albian strata in western Canada and Alaska.

Figured specimen.—UCM 27031.

Family HETEROHELICIDAE Cushman, 1927

Genus *Heterohelix* Ehrenberg, 1843*Heterohelix globulosa* (Ehrenberg)

Plate 5, figures 9, 10

Textularia globulosa EHRENBERG, 1834, K. preuss. Akad. Wiss. Berlin Abh., p. 135, pl. 4, fig. 4B.*Gumbelina globulosa* (Ehrenberg) EGGER, 1899, K. Bayer. Akad. Wiss. Math. naturh. Abt., Abh. Kl. 2, v. 21, pt. 1, p. 32, pl. 14, fig. 43.*Heterohelix globulosa* (Ehrenberg). MONTANARO GALLITELLI, 1957, U. S. National Mus. Bull. 215, p. 137, pl. 31, figs. 12-15; TAPPAN, 1962, U. S. Geol. Survey Prof. Paper 236-C, p. 196, pl. 55, figs. 1, 2 (includes additional synonymy).

Test biserial, flaring moderately to rapidly from pointed or broadly rounded base, greatest width at

latest pair of chambers; chambers globular, increasing fairly rapidly, up to seven pairs in specimens beginning with a tiny proloculus, up to four pairs in specimens beginning with a large bulbous proloculus; sutures deeply depressed; wall calcareous, smooth, finely perforate; aperture a symmetrical arch at the base of the apertural face.

Length of specimen in figure 9, 0.28 mm.; width, 0.15 mm. Length of specimen in figure 10, 0.37 mm.; width, 0.24 mm. Other specimens range from 0.17 mm. to 0.42 mm. in length.

Remarks.—*Heterohelix globulosa* is a variable species, but collections in hand do not justify splitting into two or more species. Minute specimens are commonly found attached to tests of the other planktonic genera, *Hedbergella*, *Clavihedbergella*, and *Globotruncana*.

Occurrence.—This species is abundant throughout the Fairport Member of the Carlile Shale. It is also abundant in the underlying Greenhorn Formation. It occurs sparsely in a sample from the middle of the Blue Hill Member, in a sample from the uppermost Blue Hill Member, and in the sample from the uppermost Codell Member. It has a long range in the Cretaceous and has been reported widely from the western interior of the U. S. and from many other areas.

Figured specimens.—UCM 27032 and 27033.

Family ROTALIPORIDAE Sigal, 1958

Genus *Hedbergella* Bronnimann and Brown, 1958

Hedbergella delrioensis (Carsey)

Plate 5, figures 12, 13

Globigerina cretacea d'Orbigny var. *delrioensis* CARSEY, 1926, Texas Univ. Bull. 2612, p. 43.

Globigerina delrioensis Carsey. FRIZZELL, 1954, Texas Bureau of Econ. Geol. Rept. of Investigations 22, p. 127, pl. 20, fig. 1.

Praeglobotruncana (Hedbergella) delrioensis (Carsey). BANNER and BLOW, 1959, Palaeontology, v. 2, pt. 1, p. 8.

Hedbergella delrioensis (Carsey). LOEBLICH and TAPPAN, 1961, Micropaleontology, v. 7, p. 275, pl. 2, figs. 11-13 (includes additional synonymy).

Test trochospiral, flat to moderately convex dorsally, consisting of about two and one-half whorls, ventral umbilicus fairly deep; chambers globose, increasing moderately or rapidly in size, four to six in last whorl; sutures distinct, strongly depressed; wall calcareous, perforate, surface finely spinose; aperture a low interio-marginal arch extending into the umbilicus, bordered by a lip.

Greatest diameter of specimen in figure 12, 0.41 mm.; thickness, 0.22 mm. Greatest diameter of specimen in figure 13, 0.37 mm.; thickness, 0.20 mm. Other specimens range up to 0.50 mm. in greatest diameter.

Remarks.—Specimens from the lower 20 feet of

the Fairport Member are quite large, but specimen size decreases upward and those from the upper portion of the Fairport and from the overlying Blue Hill and Codell Members are comparatively small. Size differences are interpreted as resulting from ecologic rather than genetic factors, and hence the species is considered the same throughout.

Occurrence.—*Hedbergella delrioensis* occurs throughout the Fairport Member, and it is extremely abundant in the lower portion of the Fairport and in the underlying Greenhorn Formation. It occurs sparsely in the Blue Hill Member and in the uppermost portion of the Codell Member. This species occurs widely in strata ranging from Albian through Turonian in age.

Figured specimens.—UCM 27034 and 27035.

Genus *Clavihedbergella* Banner and Blow, 1959

Clavihedbergella simplex (Morrow)

Plate 6, figures 1-3

Hastigerinella simplex MORROW, 1934, Jour. Paleontology, v. 8, p. 198, pl. 30, fig. 6.—LOETTERLE, 1937, Nebr. Geol. Survey, 2nd ser., bull. 12, p. 46, pl. 7, fig. 5.—CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 148, pl. 61, fig. 10.—FRIZZELL, 1954, Texas Bureau of Econ. Geol. Rept. of Investigations 22, p. 127, pl. 20, fig. 13.

Clavihedbergella simplex (Morrow). LOEBLICH and TAPPAN, 1961, p. 279, pl. 3, figs. 11-14 (contains additional synonymy).

Test a low trochoid coil of up to three whorls, umbilicus wide and shallow, apparently filled with extensions of successive large apertural flaps, the final whorl generally with five to seven chambers; chambers expanding very gradually in last whorl, globular except for the final one or two chambers of many specimens which are strongly elongated; sutures distinct, depressed; wall calcareous, finely perforate, surface finely spinose; aperture interio-marginal, extending from the periphery onto the umbilical side, with a broad, prominent flap which extends commonly from well out on the final chamber into the umbilicus.

Length of broken specimen in figure 2, 0.35 mm. Greatest diameter of specimen in figure 1, 0.38 mm.; thickness, 0.14 mm. Greatest diameter of specimen in figure 3, 0.39 mm., thickness, 0.17 mm. Other specimens range from 0.23 mm. to 0.44 mm. in greatest diameter.

Remarks.—The degree of elongateness of the final chambers ranges from those in which the length of the final chamber is more than twice the width to specimens in which the final chamber remains nearly globular. The latter are clearly members of this species, however, as evidenced by the number of chambers in the final whorl, the distinc-

tive aperture which, because of the broad flap, appears somewhat forward of the normal interiomarginal position, and the presence of specimens showing every gradation with the specimens bearing elongate chambers.

Occurrence.—About 50 specimens were recovered from the lower half of the Fairport Member. This species also occurs in the underlying Greenhorn Formation and in the overlying Niobrara Formation, and it has been reported from the Eagle Ford and Austin Formations of Texas.

Figured specimens.—UCM 27037, 27038, and 27036.

Family ROTALIPORIDAE Sigal, 1958

Genus *Praeglobotruncana* Bermudez, 1952

Praeglobotruncana stephani (Gandolfi)

Plate 6, figure 4

Globotruncana stephani GANDOLFI, 1942, Riv. Ital. Pal., v. 48, Mem. 4, p. 130, pl. 3, figs. 4, 5, pl. 4, figs. 36, 37, 41-45, pl. 6, figs. 4, 6, pl. 9, figs. 5, 8, pl. 13, fig. 5, pl. 14, fig. 2.

Praeglobotruncana stephani (Gandolfi). BOLLI, LOEBLICH and TAPPAN, 1957, U. S. Nat. Mus., Bull. 215, p. 39, pl. 9, fig. 2; LOEBLICH and TAPPAN, 1961, Micropaleontology, v. 7, p. 284, pl. 6, figs. 1-8 (includes additional synonymy).

Test trochoid, dorsally convex, ventrally umbilicate, consisting of two and one-half whorls with five chambers in final whorl, lobate in outline, periphery sharpened into single peripheral keel which is beaded in the early chambers; chambers somewhat flattened dorsally, inflated ventrally; sutures distinct, dorsally gently curved and depressed, ventrally radial and depressed; wall calcareous, perforate, somewhat rough ventrally in early chambers of final whorl; aperture interiomarginal, bordered by a broad flap which in some well preserved specimens extends back into the umbilicus.

Greatest diameter of figured specimen, 0.44 mm.; thickness, 0.20 mm. Greatest diameter of other specimens ranges from 0.33 mm. to 0.50 mm.

Remarks.—A few of the single-keeled specimens provisionally included here have a relatively low degree of umbilical chamber inflation and broad umbilici with poorly preserved apertural detail. Possibly these particular specimens originally bore umbilical tegilla and belong in some other species such as *Globotruncana inornata* Bolli.

Occurrence.—The 40 Carlile specimens were recovered from the lower 20 feet of the Fairport Shale Member. All coil dextrally. *P. stephani* also occurs in the underlying Greenhorn Formation and Grangeros Shale. It has been reported widely from strata of Cenomanian and Turonian age.

Figured specimen.—UCM 27039.

Praeglobotruncana renzi (Thalmann)

Plate 6, figure 9

Globotruncana zwischenform appenninica — *linnei* RENZ, 1936, Eclogae Geol. Helv., v. 29, no. 1, p. 20, pl. 8, fig. 2.

Globotruncana renzi THALMANN, 1942, Am. Assoc. Petroleum Geologists 27th Ann. Convention Program, p. 51.

not *Globotruncana renzi* GANDOLFI, 1942, Riv. Ital. Pal., v. 48, Suppl., Mem. 4, p. 124, pl. 3, fig. 1, pl. 4, figs. 15, 16, 28, 29; pl. 10, fig. 2.

Globotruncana (Globotruncana) sp. aff. renzi Thalmann - Gandolfi. REICHEL, 1950, Eclogae Geol. Helv., v. 42, no. 2, p. 612, pl. 16, fig. 8; pl. 17, fig. 8.

Praeglobotruncana renzi (Thalmann). KLAUS, 1960, Eclogae Geol. Helv., v. 27, p. 795, pl. 6, fig. 4.

Test trochospiral, dorsally convex with relatively narrow ventral umbilicus, composed of up to three whorls, somewhat lobate particularly in final two chambers, five or six chambers in final whorl, two low, distinct, closely-spaced, beaded keels on early chambers of final whorl, coalescing into one, generally in penultimate chamber; chambers approximately equidimensional, partially flattened dorsally, inflated ventrally; sutures distinct, dorsally curved, slightly depressed or raised and lightly beaded, ventrally strongly depressed and nearly radial, ventral keel, where present, disappearing into the ventral suture; wall calcareous, perforate, typically rough ventrally early in last whorl; aperture interiomarginal, bordered in well-preserved specimens by a broad lip.

Greatest diameter of figured specimen, 0.52 mm.; thickness, 0.26 mm. Greatest diameter of other Carlile specimens ranges between 0.43 mm. and 0.54 mm.

Remarks.—Of 120 specimens examined from the basal Carlile, all but one coil dextrally. A few specimens have two keels on all but the final chamber, and these are similar to and apparently gradational with some specimens placed in *Globotruncana marginata* in which the final chamber is only weakly-keeled.

Most workers now appear to be following Klaus's (1959, p. 75) suggestions that *Globotruncana renzi* Thalmann, 1942, be considered a valid name, that this species now be placed in *Praeglobotruncana*, and that *Globotruncana renzi* Gandolfi, 1942, (later renamed *Globotruncana coldreiansis* by Gandolfi), is a different species and possibly conspecific with either *Praeglobotruncana schneegansi* (Sigal) or *Globotruncana sigali* Reichel.

Occurrence.—*P. renzi* (Thalmann) occurs only in the basal Fairport sample, but it is very abundant. It also occurs in the uppermost sample from the underlying Greenhorn Formation. It has been

reported in Europe from rocks of latest Cenomanian and Early and Middle Turonian age.

Figured specimen.—UCM 27040.

Family GLOBOTRUNCANIDAE Brotzen, 1942

Genus *Globotruncana* Cushman, 1927

Globotruncana marginata (Reuss)

Plate 6, figures 5, 6

Rosalina marginata REUSS, 1845, Boehmischen Kreide. Abt. 1, p. 36, pl. 13, fig. 68.

Globotruncana marginata (REUSS). THALMANN, 1934, *Eclogae Geol. Helv.*, v. 27, p. 414; HILTERMANN and KOCH, 1962, *Leitfossilien der Mikropaläontologie: Gebrüder Borntraeger, Berlin-Nikolassee*, p. 330, pl. 47, fig. 2.

Test trochospiral, dorsally slightly to moderately convex, ventrally umbilicate, composed of up to three whorls, five or six chambers in final whorl, two closely-spaced peripheral keels rimming the entire periphery but becoming lower and less distinct in final chamber; chambers inflated ventrally, flattened moderately to strongly dorsally; sutures curved, raised and beaded dorsally, strongly depressed and radial ventrally, the ventral keel disappearing into each ventral suture; wall calcareous, perforate, somewhat rough ventrally in early chambers of last whorl; aperture apparently umbilical, bordered by broad flaps which appear to be tegilla, but these not delineated clearly in Carlile material because of inadequate preservation.

Greatest diameter of specimen in figure 5, 0.63 mm.; thickness, 0.28 mm. Greatest diameter of specimen in figure 6, 0.46 mm.; thickness, 0.23 mm. Greatest diameter of most other specimens is between 0.44 mm. and 0.59 mm.

Remarks.—Of the 40 Carlile specimens recovered, only two coil sinistrally; one of these is the sole specimen from the 10-20' interval, the highest in which *G. marginata* occurs.

Klaus (1959, fig. 9) suggested that *Globotruncana marginata* might belong in the genus *Praeglobotruncana*, but his Alpine material included no specimens. His suggestion may have merit, inasmuch as *G. marginata* appears gradational with *Praeglobotruncana renzi* in Carlile material. Preservation of apertures in Carlile specimens is not adequate for a final determination, however, and so for the present *G. marginata* is retained in *Globotruncana*. Klaus (1959, pl. 7, fig. 2) did illustrate a specimen which appears very similar to those described here, which he labeled "*Praeglobotruncana*, form intermediate between *P. concavata* (Brotzen) and *P. ? ventricosa* (White)."

The specimens illustrated by Cushman (1946, pl. 62, figs. 1, 2) have raised and beaded umbilical sutures which are continuations of the ventral keel.

Hence they do not appear to belong to the same species as the specimen described here.

Occurrence.—In addition to its occurrence in the lower 20 feet of the Fairport Member of the Carlile, this species also occurs in the upper portion of the underlying Greenhorn Formation. It has been recorded from the Upper Cretaceous of the Gulf Coast area of the United States and Europe and elsewhere.

Figured specimen.—UCM 27041 and 27042.

Genus *Rugoglobigerina* Bronnimann, 1952

Rugoglobigerina? aprica (Loeblich and Tappan)

Plate 5, figure 14

Ticinella aprica LOEBLICH and TAPPAN, 1961, *Micro-paleontology*, v. 7, p. 292, pl. 4, figs. 14-16.

Test a low trochoid coil of two and one-half whorls, dorsally convex, periphery broadly rounded, ventrally broadly umbilicate; chambers globular, five and one-half to seven in final whorl, increasing gradually in final whorl; sutures distinct, strongly constricted; wall calcareous, perforate, surface coarsely hispid particularly in early chambers of last whorl; aperture umbilical, portions of broken or obscured flaps interpreted as tegilla visible in umbilicus of some Carlile specimens.

Greatest diameter of figured specimen, 0.60 mm.; thickness, 0.27 mm. Greatest diameter of other specimens ranges from 0.38 mm. to 0.65 mm.

Remarks.—The large, delicate umbilical cover plates of the holotype, which Loeblich and Tappan (1961, p. 292) interpreted as apertural lips, appear instead to be much like true globotruncanid tegilla. Were these structures interpreted as tegilla, this species would belong in the genus *Rugoglobigerina* rather than in *Ticinella*. In some Carlile specimens the umbilical plates are partly preserved, but in most they are entirely broken away or obscured, hence it is not possible to make the generic assignment unequivocally. However, none of the specimens examined exhibits backward-facing sutural accessory apertures like those which are typically clear and well-preserved in specimens of *Ticinella* from the underlying Greenhorn Formation. Also, the youngest known *Ticinella* species are of Cenomanian age. Known occurrences of the present species, including the type specimen, are exclusively Turonian except for *Globotruncana californica* Cushman and Todd of Kupper (1955, p. 116), from the Cenomanian of California, which Loeblich and Tappan (1961, p. 292) regarded as belonging in the present species.

This species appears much like *Rugoglobigerina rugosa* (Plummer) but there are no clear ridges on the last few chambers. Certain Carlile specimens resemble large specimens of *Hedbergella brittonensis*

Loeblich and Tappan or those specimens of *Clavibergella simplex* (Morrow) which have globular chambers throughout.

Occurrence.—In addition to the 75 specimens which were recovered from the lower 40 feet of the Fairport Member, specimens were also found in the underlying Bridge Creek Member of the Greenhorn Formation. This species was initially reported from the Turonian Arcadia Park Shale of the Eagle Ford Group of Texas.

Figured specimen.—UCM 27043.

Family CIBICIDIDAE Cushman, 1927

Genus *Planulina* d'Orbigny

Planulina kansasensis Morrow

Plate 6, figure 8

Planulina kansasensis MORROW, 1934, Jour. Paleontology, v. 8, p. 201, pl. 30, figs. 2, 12, 15; CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 157, pl. 64, fig. 12 (contains additional synonymy); BOLIN, 1952, So. Dak. Geol. Survey Rept. of Investigations 70, p. 62, pl. 4, fig. 10; FRIZZELL, 1954, Texas Bureau of Econ. Geol. Rept. of Investigations 22, p. 132, pl. 21, fig. 16; SHAW, 1953, Wyoming Geol. Assoc. Guidebook, 8th Ann. Field Conf., pl. 2, figs. 32-34; BOLIN, 1956, Jour. Paleontology, v. 30, p. 294, pl. 39, figs. 14-16, text-figs. 5-10, 14.

Test strongly compressed, evolute on spiral side, largely evolute on umbilical side, periphery very narrowly rounded, faintly lobate in side view; chambers increasing very gradually, 9 to 12 in final whorl; sutures distinct, flush, slightly thickened, gently curved; wall calcareous, smooth, coarsely perforate; aperture extending somewhat along um-

bilical margin from periphery, not well preserved in Carlile specimens.

Greatest diameter of figured specimen, 0.37 mm.; thickness, 0.08 mm. Other specimens range from 0.24 mm. to 0.38 mm. in greatest diameter.

Occurrence.—The seven specimens from the Carlile come from the uppermost Blue Hill interval and from the two-foot shale at the top of the Codell Member. None is very well preserved. *P. kansasensis* has been reported widely from upper Carlile, Niobrara, and Pierre Formations in the western interior of the United States, and also from Niobrara equivalents in the Gulf Coast and in Canada.

Figured specimen.—UCM 27045.

Family ANOMALINIDAE Cushman, 1927

Genus *Gavelinella* Brotzen, 1942

Gavelinella dakotensis (Fox)

Plate 6, figure 7

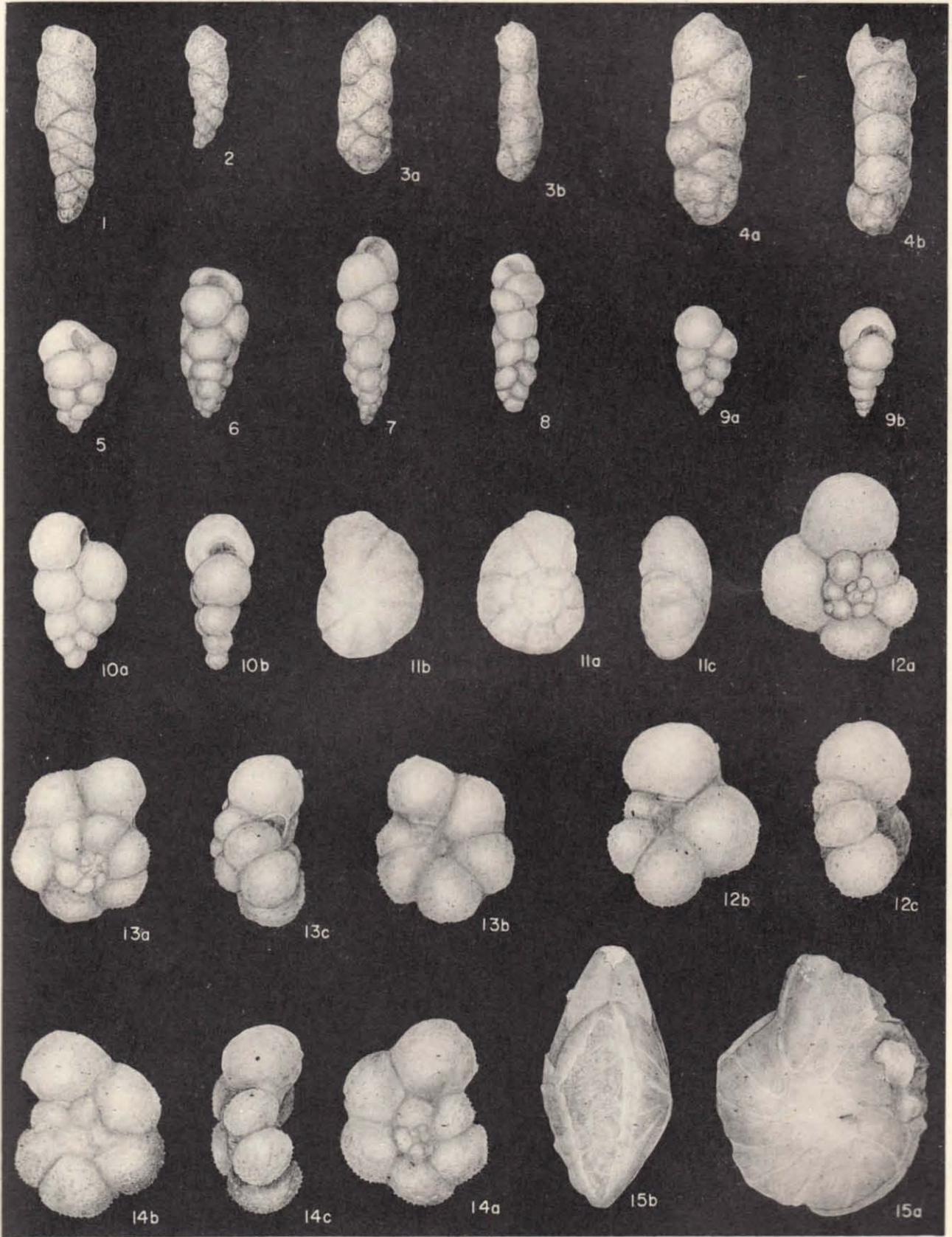
Planulina dakotensis Fox, 1954, U. S. Geol. Survey Prof. Paper 254-E, p. 119, pl. 26, figs. 19-21.

Test small, strongly compressed, spiral side evolute, ventral side almost entirely involute with only a small portion of preceding whorls showing in center, periphery narrowly rounded, later chambers of many specimens somewhat lobulate; chambers distinct, increasing gradually, 8 to 10 in final whorl; sutures distinct, very gently curved, limbate early in spiral side of some specimens, slightly depressed in later portion of final whorl; wall calcareous, smooth, perforate; aperture a low peripheral opening extending backward along the umbilical side where it is bordered by a delicate lip.

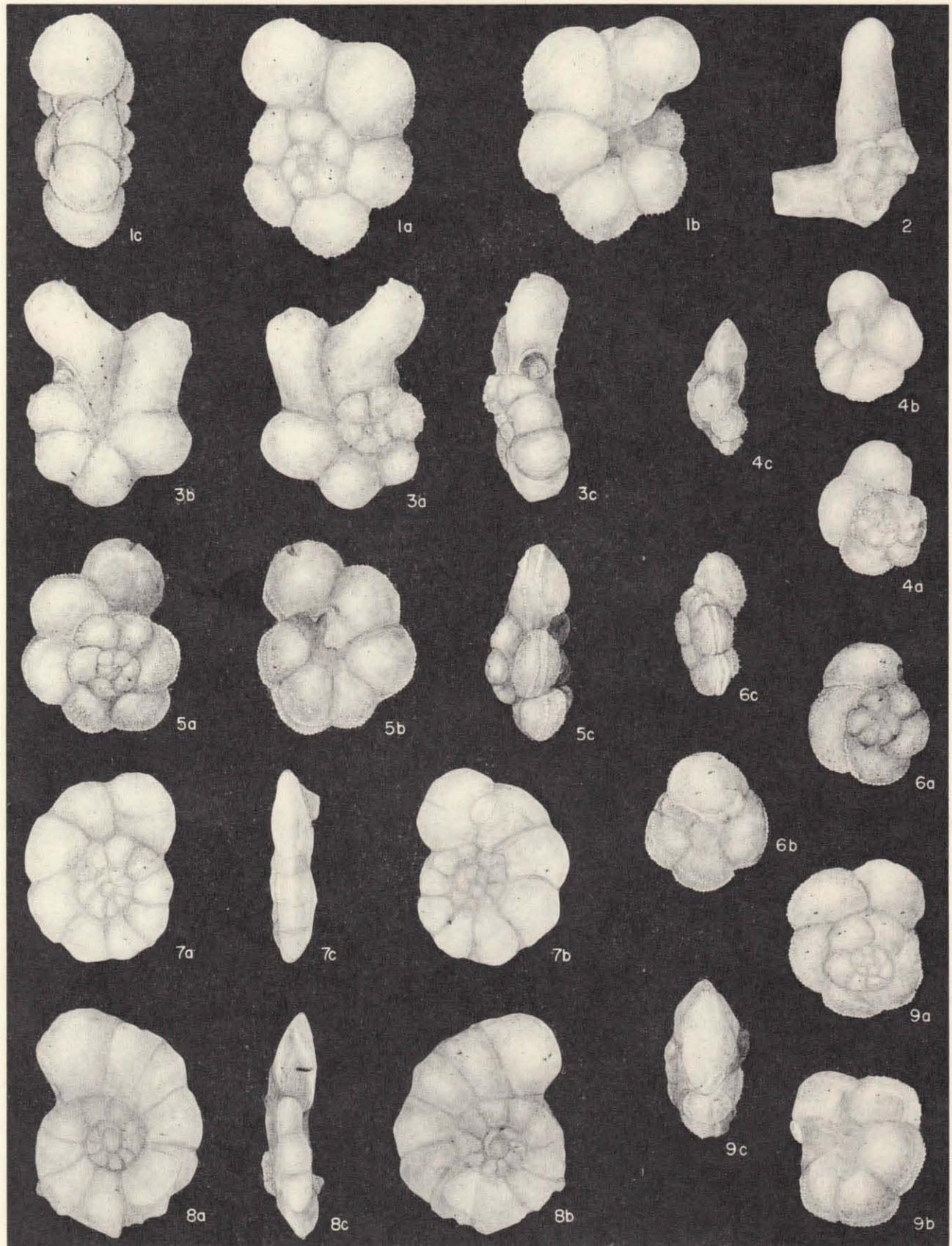
Greatest diameter of figured specimen, 0.32 mm.; thickness, 0.08 mm. Other specimens range from 0.14 mm. to 0.35 mm. in greatest diameter.

EXPLANATION OF PLATE 5

FIGS.		PAGE
1, 2.	<i>Gaudryina spiritensis</i> Stelck and Wall. 1, Side view of a large specimen, UCM 27020, × 64; 2, Side view of a small specimen, UCM 27021, × 64.	24
3, 4.	<i>Gaudryina bentonensis</i> (Carman). 3a, b, Side and edge views of small specimen with parallel sides, UCM 27023, × 64; 4a, b, Side and edge views of large specimen with gently tapering sides, UCM 27022, × 64.	24
5-8.	<i>Neobulimina albertensis</i> (Stelck and Wall). 5, 6, Side views of two small specimens without irregular late portions, UCM 27027 and 27028, × 144; 7, 8, Side views of two large specimens with typically developed irregular late portions, UCM 27030 and 27029, × 64.	26
9, 10.	<i>Heterohelix globulosa</i> (Ehrenberg). 9a, b, Side and edge views of specimen with tiny initial chambers and a pointed base, UCM 27033, × 64; 10a, b, Side and edge views of specimen with large initial chamber, UCM 27032, × 64.	26
11.	<i>Valvulineria loetterlei</i> (Tappan). 11a, b, c, Opposite sides and edge view of a specimen, UCM 27031, × 95.	26
12, 13.	<i>Hedbergella delrioensis</i> (Carsey). 12a, b, c, Opposite sides and edge view of a specimen, UCM 27034, × 70; 13a, b, c, Opposite sides and edge view of another specimen, UCM 27035, × 70.	27
14.	<i>Rugoglobigerina? aprica</i> (Loeblich and Tappan). 14a, b, c, Opposite sides and edge view of a specimen, UCM 27043, × 48.	29
15.	<i>Lenticulina kansasensis</i> Morrow. 15a, b, Side and edge views of a specimen, UCM 27026, × 48.	25



Eicher: Carlile Shale (Cretaceous) Foraminifera



Eicher: Carlile Shale (Cretaceous) Foraminifera

Remarks.—Most of the specimens from the Carlile are small, even for this small species. The holotype is 0.3 mm. in greatest diameter.

This species is placed in *Gavelinella* because the umbilical side is nearly entirely involute and the aperture clearly extends onto the umbilical side. The wall is assumed to be of perforate granular calcite, like *Gavelinella*, rather than of radially laminated calcite with double septa, like *Planulina*, but this has not been confirmed.

Occurrence.—Most of the 45 Carlile specimens studied occur in the lower portion of the Fairport Member, but one specimen was recovered from a single Blue Hill Sample. Specimens are also abundant in the upper portion of the underlying Greenhorn Formation. This species was initially described from the Greenhorn of the Black Hills of South Dakota.

Figured specimen.—UCM 27044.

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EXPLANATION OF PLATE 6

FIGS.	PAGE
1-3. <i>Clavhedbergella simplex</i> (Morrow). 1a, b, c, Opposite sides and edge view of a specimen without greatly elongated chambers, UCM 27037, $\times 95$; 2, Side view of broken specimen with greatly elongated chambers, UCM 27038, $\times 95$; 3a, b, c, Opposite sides and edge view of specimen with elongated final chambers, UCM 27036, $\times 95$.	27
4. <i>Praeglobotruncana stephani</i> (Gandolfi). 4a, b, c, Opposite sides and edge view of a specimen with a broad apertural flap reaching into umbilicus, UCM 27039, $\times 48$.	28
5, 6. <i>Globotruncana marginata</i> (Reuss). 5a, b, c, Opposite sides and edge view of specimen, UCM 27041, $\times 48$; 6a, b, c, Opposite sides and edge view of another specimen, UCM 27042, $\times 48$.	29
7. <i>Gavelinella dakotensis</i> (Fox). 7a, b, c, Opposite sides and edge view of a large specimen, UCM 27044, $\times 95$.	30
8. <i>Planulina kansasensis</i> Morrow. 8a, b, c, Opposite sides and edge view of a specimen, UCM 27045, $\times 95$.	30
9. <i>Praeglobotruncana renzi</i> (Thalman). 9a, b, c, Opposite sides and edge view of a specimen, UCM 27040, $\times 48$.	28

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XVII, PART 1, JANUARY, 1966

CORRECTIONS

The following changes should be made in the paper entitled "Further comments on planktonic foraminifera in the type Thanetian" by W. A. Berggren, which appeared in Vol. XVI, pt. 3, pp. 125-127 of this journal:

1. The last line (p. 126) before the references should read:

"This writer considers the evidence for the origin of Danian planktonic foraminiferal species

in the Thanetian of the eastern Kent area to be inconclusive."

2. The following should be added to the references:

Haynes, J. and El-Naggar, Z. R., 1964, Reworked Upper Cretaceous and Danian planktonic foraminifera in the type Thanetian: Micropaleontology, vol. 10, no. 3, pp. 354-356.

W. A. Berggren

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XVII, PART 1, JANUARY, 1966
RECENT LITERATURE ON THE FORAMINIFERA

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

- ADAMS, CHARLES GOEFFREY.** The Foraminifera and stratigraphy of the Melinau Limestone, Sarawak, and its importance in Tertiary correlation.—*Quart. Jour. Geol. Soc. London*, v. 121, Sept. 7, 1965, p. 283-338, pls. 21-30, text figs. 1-6 (maps, range chart, correl. diagrams). An uninterrupted faunal sequence extends from Tertiary *b* (upper Eocene) through Tertiary *c* and *d* into Tertiary *e* (lower Miocene), each fauna being characterized by associations of larger Foraminifera. Correlation is shown for 10 stratigraphic sections between Kirkuk and Eniwetok. Characteristic species of fore-reef and back-reef facies in 5 subdivisions from upper Eocene to lower Miocene of the Middle East and the Far East are listed. Restricted occurrences of 36 species of larger Foraminifera in the limestone are shown, and some species are illustrated in thin section. Three new species are described, one in the new genus *Wilfordia* (type species *W. sarawakensis* sp. nov.) belonging in the Acervulinidae.
- AKERS, W. H.** Pliocene-Pleistocene boundary, northern Gulf of Mexico.—*Science*, v. 149, No. 3685, Aug. 13, 1965, p. 741-742, text fig. 1 (diagram).—Extinctions and evolutionary changes in Discoaster and Foraminifera assemblages, already known in Atlantic and Pacific deep-sea cores, are also recognized in thick neritic deposits along the Gulf Coast. There the horizon of the changes is correlatable with alluvial terrace formations whose age is determinable as late Nebraskan glaciation or Aftonian interglaciation or later, not Pliocene/Pleistocene boundary.
- AOKI, NAOAKI.** Pliocene and Pleistocene uvigerinid Foraminifera from the Boso and Miura Peninsulas.—*Sci. Repts. Saitama Univ.*, ser. B (Biol. and Earth Sci.), v. 5, No. 1, 1965, p. 49-63, pl. 7, text figs. 1-6 (range chart, drawings).—Seventeen species (3 new), 1 new subspecies and 3 species and varieties left indeterminate.
- APPLIN, ESTHER R., and PAUL L.** Logs of selected wells in the coastal plains of Georgia.—*Georgia Geol. Survey, Bull. No. 74*, 1964, p. 1-229, text fig. 1 (map).—Includes records of larger and smaller Foraminifera in 31 wells.
- AZZAROLI, AUGUSTO, and REICHEL, MANFRED.** Alveoline e Crisalidine Neocretacee del "Calcere de Mola" in Terra di Bari.—*Boll. Serv. Geol. Italia*, v. 85, Anno 1964, p. 3-9, pl. 1.—From the upper Cenomanian and lower Turonian.
- BALAKHMATOVA, V. T.** Novye Predstaviteli Textulariidae iz Paleogena Severnoj Turkmenii, in *Paleontologija i Stratigrafija*.—*Russia Vses. geol. instit. Trudy*, n. ser., tom 93, 1964, p. 21-27, pl. 1.—Three species and 2 varieties, all new, in *Bolivinopsis* and *Spiroplectamina*.
- BANDY, ORVILLE L., INGLE, JAMES C., JR., and RESIG, JOHANNA M.** Foraminiferal trends, Hyperion outfall, California.—*Limnology and Oceanography*, v. 10, No. 3, July 1965, p. 314-332, text figs. 1-14 (distrib. maps), tables 1, 2.—Quantitative analyses of effects of pollution over an area of Santa Monica Bay down to about 80 meters. Water currents spiralling along the shore from the Santa Monica Canyon carry the sewage effluent from 3 outfalls over the shelf, both to the south and to the north. Number of total specimens is 5 to 50 times greater in the outfall area than elsewhere and live specimens are from 10 to 20 times more abundant. Diversity is higher away from than under the effluent field. Species whose productivity is favorably affected by the effluent field are *Bulimina marginata denudata*, *Buliminella elegantissima*, *Eggerella advena*, and *Trochammina pacifica*. *Nonionella* appears to be unfavorably influenced.
- BARBU, I. Z.** Un nouveau miliolidé, *Brebina transylvanica* n. g., n. sp., dans l'Éocène du N-O de la Transylvanie.—*Rev. Roumaine Géol., Géophys., et Géogr.*, ser. Géol., t. 9, No. 1, 1965, p. 9-12, pl. 1, text figs. 1, 2 (drawings).—From the Priabonian.
- BARKHATOVA, V. P.** The status of the *Schwagerina* beds in connexion with the problem of the boundary between the Carboniferous and the Permian.—*Cinquième Congrès Internat. de Stratigraphie et de Géologie du Carbonifère*, Paris, 9-12 Sept. 1963, *Compte rendu*, tome 1, 1964, p. 273-282, pls. 1, 2 (brachiopods).
- BARR, F. T., and BERGGREN, W. A.** Planktonic Foraminifera from the Thanet Formation (Paleocene) of Kent, England.—*Acta Univ. Stockholm., Stockholm Contrib. in Geol.*, v. 13:2, June 10, 1965, p. 9-26, text figs. 1-6 (maps,

- geol. section, drawings, correl. chart).—Re-examination of previously reported planktonic specimens indicates most of them are reworked from the Upper Cretaceous. Three other species, not previously reported from the Thanet, were found.
- BECKMANN, JEAN PIERRE, and KOCH, WILHELM. Vergleiche von *Bolivinooides*, *Aragonia*, und *Tappanina* (Foraminifera) aus Trinidad (Westindien) und Mitteleuropa.—*Geol. Jahrb.*, Hannover, Band 83, Oct. 25, 1964, p. 31-62, pls. 5-7, text figs. 1, 2 (range chart, phylogenetic diagram).—Descriptions, illustrations, and ranges of 8 species (1 new) and 6 subspecies (4 new).
- BERGGREN, W. A. The Maestrichtian, Danian and Montian Stages and the Cretaceous-Tertiary boundary.—*Acta Univ. Stockholm.*, Stockholm Contrib. in Geol., v. 11, Dec. 30, 1964, p. 103-176, tables 1-5 (correl. charts).—An historical review of problems and evaluation of alternative solutions.
- Paleocene—a micropaleontologist's point of view.—*Bull. Am. Assoc. Petr. Geologists*, v. 49, No. 9, Sept. 1965, p. 1473-1484, text fig. 1 (correl. table).—Correlation by planktonic Foraminifera, and a review of past and present usage.
- BIELECKA, WANDA. Callovian of the north-western area of Poland in the light of connexions of microfauna with facies (English summary of Polish text).—*Poland Instyt. Geol.*, *Kwart. Geol.*, no. 2, 1965, p. 281-289, text fig. 1 (check list), table 1.
- BIGNOT, G., and GUYADER, J. Quelques précisions sur *Neobulimina varsoviensis* Bielecka & Pozaryski 1954 et *Paleogaudryina magharaensis* Said & Barakat 1958.—*Revue de Micropaléontologie*, v. 8, No. 1, June 1965, p. 53-58, pl. 1, text figs. 1, 2 (drawings).—The 2 species, now both placed in *Paleogaudryina* (subfamily Verneuilininae), are distinguished. *P. magharaensis* is identified in the Upper Jurassic of France.
- BIK, E. TH. ARNOLD. An aberrant Nonionid from the Miocene of the Mayence basin.—*Notizblatt Hess. Landesamtes für Bodenforschung zu Wiesbaden*, Band 92, Oct. 30, 1964, p. 68-74, pl. 5, text figs. 1-3 (map, columnar section, drawings).—*Nonion demens* n. sp., a more globose-chambered relative of *N. granosum*, includes many aberrant individuals, and is believed to be the final response of *N. granosum* to decreasing salinity.
- BOLTOVSKOY, ESTEBAN. Los Foraminíferos recientes. Biología, métodos de estudio, aplicación oceanográfica.—*EUDEBA* (Editorial Universitaria de Buenos Aires), 1965, 510 p., 114 text figs. (drawings, diagrams, graphs, photomicrographs, maps, range charts, distrib. tables) (available from Librart S. R. L., Casilla Correo 5047, Buenos Aires, \$5.70).—A teaching manual in Spanish. Eighteen chapters include discussion of biology and culture of living specimens, morphology and classification, ecology and biogeography, oceanographic applications, methods of collection and study, treatment and preservation of samples, problems to be solved, and bibliography.
- BOSTWICK, DAVID A., and NESTELL, MERLYND K. A new species of *Polydiexodina* from central Oregon.—*Jour. Paleontology*, v. 39, No. 4, July 1965, p. 611-614, pl. 74, text fig. 1 (map), table 1.
- BRODNIOWICZ, IRENA. Recent and some Holocene Foraminifera of the southern Baltic Sea.—*Acta Palaeont. Polonica*, v. 10, No. 2, 1965, p. 131-236, pls. 1-11, text figs. 1-34 (maps, bottom profile, graphs, range and abund. chart, drawings), tables 1, 2.—Illustrated systematic catalog includes 55 species (3 new), predominantly arenaceous. The investigated area consists of a few deep basins separated by underwater ridges and in which salinity of bottom water decreases eastward. Study is based on 263 bottom samples, covering depths down to 215 meters and salinities between 110/00 and 220/00, and a boring through Holocene sediments of the glacial Littorina Sea, with only *Elphidium subarcticum* occurring in both Recent and Holocene. The Holocene fauna was a shallow, warmer, and more saline one than that of the present-day Baltic Sea. Sequence of faunas in the boring reflect maximum sea transgression into a shallow brackish bay, followed by decreasing salinity, and eventual overgrowing of the bay. The value of wet examination of samples (to avoid destruction of chitinous and some arenaceous specimens that results from the normal drying-soaking-washing process) is confirmed by laboratory experiments in which residual assemblages resulting from both methods are compared. Likelihood of preservation as fossils depends on kind of test wall in Foraminifera.
- BRYANT, WILLIAM R., and PYLE, THOMAS E. Tertiary sediments from Sigsbee Knolls, Gulf of Mexico.—*Bull. Am. Assoc. Petr. Geologists*, v. 49, No. 9, Sept. 1965, p. 1517-1518, table 1.—Tortonian planktonic Foraminifera from a submarine core.
- CARON, MICHÈLE. Les ouvertures chez le genre *Praeglobotruncana* (Foraminifères).—*C. R. Soc. Géol. France*, fasc. 7, June 21, 1965, p. 217-218, text fig. 1.—Umbilical plates.

- CARPENTER, W. R., PARKER, W. K., and JONES, T. R. Introduction to the study of the Foraminifera.—Reprinted by offset: McLean Paleontological Laboratory, Alexandria, Virginia, 319 p., 22 pls., 47 text figs. (\$37.50).
- CATI, FRANCO. Una microfauna Campaniana dei Monti Berici (Vicenza).—Ann. Museo Geol. Bologna, ser. 2, v. 32, fasc. 1, 1964, p. 199-271, pls. 34-42, text fig. 1 (map), range chart.—Illustrated systematic catalog includes 107 species (7 new).
- CEPEK, PAVEL. The arrangement of Protozoa in the collections of the Natur-Historisches Museum in Vienna. Problems of the determination of A. E. Reuss' foraminiferal material (in Czech with English abstract).—Casopis Narodni. Muzea. Odd. Prirod., roc. 134, cislo 1, 1965, p. 36-39, 1 text fig.
- CHALILOV, D. M. Danian stage Foraminifera of Azerbaijan in the light of specification between Cretaceous and Tertiary systems boundary (in Russian).—Akad. Nauk Azerbaidzhan. SSR, Baku, Essays on Geology of the Azerbaijan, 1964, p. 153-168, pls. 1-4, check list.—Illustrations and descriptions of 8 species and 6 subspecies of *Globorotalia*, *Acarinina*, and *Globigerina*, all new except 2 species.
- CHEN, S., and SHENG, J. C. The fusulinid zones in the Chinese Carboniferous.—Cinquième Congrès Internat. de Stratigraphie et de Géologie du Carbonifère, Paris, 9-12 Sept. 1963, Comptes rendus, tome 1, 1964, p. 321-324, table.
- CHRISTIANSEN, BENGT O. A bottom form of the planktonic foraminifer *Globigerinoides rubra* (d'Orbigny, 1839).—Pubbl. staz. zool. Napoli, v. 34, 1965, p. 197-202, text figs. 1-3.—In mud samples from 200 meters off Naples, specimens of *Globigerinoides rubra* were found living within *Pelosina*-like mud houses. Specimens dissected out of their mud houses were cultured: (a) those placed on the mud surface made no movement and showed no pseudopodia; (b) those placed within the mud built new mud houses in 2 days; (c) those cultured in darkness burrowed into the mud and built new houses. Some undissected mud houses were placed on the mud surface. After 5 days the living *G. rubra* had emerged through a hole on the lower side of the house, had burrowed into the underlying mud and had built a new mud house. The specimens from the mud houses are high-spired (equivalent to the form called *pyramidalis* Van den Broeck), have a smaller proloculus and larger test size than those taken from plankton hauls, and are multinucleate. Hence, they are interpreted as the microspheric generation of *G. rubra*.
- CHRISTODOULOU, G. Der Geologische Bau der Ebene von Thessaloniki-Jannitza nach den Ergebnissen der Mikropaleontologischen Untersuchungen am Bohrgut von Drei Tiefbohrungen (German summary of Greek text).—Bull. Geol. Soc. Greece, v. 6, No. 2, 1965, p. 249-296, pls. 8-13, text figs. 1-7 (map, columnar sections, geol. section).—Illustration of the Foraminifera.
- CHUVASHOV, B. I. Foraminifery i Vodorosli iz Verkhnedevonskikh Otlozhenij Zapadnogo Sklona Srednego i Juzhnogo Urala, in Foraminifery Devona i Permi Urala.—Akad. Nauk SSSR, Ural. filial, Sverdlovsk, Institut. geol., Trudy, vyp. 74, 1965, p. 3-93, pls. 1-29.—About 100 Upper Devonian species of Foraminifera (28 new).
- CICHA, IVAN. Die Stellung des Jungtertiärs der Westkarpaten im Lichte der Regionalen Entwicklung der Planktonischen Foraminiferen.—Geol. Sbornik, Geol. Carpathica, v. 16, pt. 1, June 1965, p. 19-31, tables 1-3.—Ranges of 24 well-known planktonics in the West Carpathians are shown between lower Oligocene and Tortonian.
- CICHA, IVAN, and ZAPLETALOVA, IRENE. Die Vertreter der Familie Textulariidae (Foraminifera-Protozoa) aus dem Miozän der Westkarpaten.—Sbornik Geol. Ved, Paleontologie, roda P, sv. 6, 1965, p. 99-148, pl. 1.—Descriptions and illustrations of 16 species and 7 subspecies (3 new). *Paravulvulina* n. gen. (type species *Plecanium serratum* Reuss) is erected.
- CIFELLI, RICHARD. Late Tertiary planktonic Foraminifera associated with a basaltic boulder from the Mid-Atlantic Ridge.—Jour. Marine Res., v. 23, No. 2, May 15, 1965, p. 73-87, pls. 1, 2, text fig. 1, table 1.—The boulder, having an altered surface and coated on one side by unconsolidated Quaternary ooze, lay on a surface of consolidated and partly silicified ooze. The older ooze is dated as probably late Miocene by planktonic species (18 are illustrated).
- CITA, M. B., PREMOLI SILVA, I., and ROSSI, R. Foraminiferi planctonici del Tortoniano-Tipo. Riv. Ital. Pal. Stratig., v. 71, No. 1, March 1965, p. 217-308, pls. 18-31, text figs. 1-9 (maps, columnar section, table, range chart, drawings).—Illustrated catalog includes 49 species (2 new) and 9 subspecies (1 new) from the type section of the Tortonian. Correlation with the West Indian section is made by planktonic species.
- CONIL, R., LYS, M., and MAUVIER, A. Critères micropaléontologique essentiels des formations-types du Carbonifère (Dinantien) du bassin Franco-Belge.—Cinquième Congrès Internat.

- de Stratigraphie et de Géologie du Carbonifère, Paris, 9-12 Sept. 1963, Compte rendu, tome 1, 1964, p. 325-332, pls. 1, 2 (correl. chart, range chart).
- CONKIN, JAMES E., and CONKIN, BARBARA M. Ordovician (Richmondian) Foraminifera from Oklahoma, Missouri, Illinois, and Kentucky.—Oklahoma Geology Notes, v. 25, No. 8, Aug. 1965, p. 207-221, pls. 1, 2, tables 1-3.—Descriptions and illustrations of 3 species, 2 indeterminate, found at 10 localities.
- CRESCENTI, U. Note biostratigrafiche sul Miocene medio del Molise occidentale.—Boll. Soc. Paleont. Ital., v. 3, No. 1, 1964, p. 13-19, fig. 1 (range chart).—Two planktonic zones, one with 2 subzones, in the Tortonian and Helvetian.
- CUSHMAN, JOSEPH A. Upper Cretaceous Foraminifera of the Gulf Coastal Region of the United States and adjacent areas.—Reprinted by offset: McLean Paleontological Laboratory, Alexandria, Virginia, 160 p., 66 pls. (\$21.80).
- DEBOO, PHILI B. Biostratigraphic correlation of the type Shubuta Member of the Yazoo Clay and Red Bluff Clay with their equivalents in southwestern Alabama.—Geol. Survey Alabama Bull. 80, 1965, 84 p., 28 pls. (1-10 range charts, 11-14 plates of ostracodes, 15-28 plates of Foraminifera), 11 text figs. (maps, correl. charts, graphs, cross-section).—Includes illustrations of about 165 species of Foraminifera from several formations just above the Jacksonian-Vicksburgian boundary (which boundary lies slightly below the Eocene-Oligocene boundary).
- EAMES, F. E., and CLARKE, W. J. Douvillé's *Lepidocyclina pustulosa*, *L. trinitatis* and *L. (Pliolepidina) tobleri*; a reconsideration.—Revue de Micropaléontologie, v. 8, No. 1, June 1965, p. 3-10, pls. 1-3.—Based on re-examination of original Douvillé material.
- EICHER, DON L. Foraminifera and biostratigraphy of the Graneros Shale.—Jour. Paleontology, v. 39, No. 5, September 1965, p. 875-909, pls. 103-106, text figs. 1-6 (map, diagram, correl. charts, drawings).—Thirty-five species (5 new) and 1 new subspecies in beds of Cenomanian age.
- ELIAS, MOJMIR, and HANZLIKOVA, EVA. A find of foraminiferal plankton in the Uplaz Brook bed near Horni Lomna (English summary of Czech text).—Vestnik Ustred. Ustavu Geol., roc. 40, cislo 4, 1965, p. 263-267, pl. 1.—Of late Danian age.
- ELLISON, R., NICHOLS, M., and HUGHES, J. Distribution of Recent Foraminifera in the Rappahannock River Estuary.—Virginia Instit. Marine Sci., Spec. Sci. Rept. No. 47, Jan. 1965, p. 1-35 (mimeographed), pl. 1, text figs. 1-12 (maps, graphs), tables 1-6.—Study based on over 150 samples in traverses across the estuary and up tributary creeks. Salinities range from 21‰ at the mouth to 1‰ upstream. Estuary fauna is dominated by arenaceous species and *Elphidium*, with an *Ammobaculites* facies living in the upper estuary (20 to 40 miles above the mouth) and an *Elphidium* facies in the deep lower reaches. The marsh fauna has a *Trochammina* facies bordering the lower bay and an *Ammoastuta* facies bordering the upper reaches and creeks.
- FUJIMOTO, HARUYOSHI, and TORIYAMA, RYUZO. A survey of the fossils from Japan illustrated in classical monographs. Part III, Conrad Schwaeger (1883); Carbonische Foraminiferen aus China und Japan.—Palaeont. Soc. Japan, Twenty-fifth Anniv. Vol., Sept. 16, 1963, p. 5-7, pls. 13-16.—New generic names for 8 Permian fusulinids.
- GERHARDT, HANS. Zur Taxionomie und Phylogenie von *Haplophragmium* und *Triplasia* (Foram., Unterkreide).—Senckenbergiana Lethaea, Band 46, No. 2/3, July 12, 1965, p. 183-186.
- GORDON, W. A. Foraminifera from the Corallian Beds, Upper Jurassic, of Dorset, England.—Jour. Paleontology, v. 39, No. 5, September 1965, p. 828-863, text figs. 1-11 (map, drawings), table 1.—Fifty-nine species; 4 new and 1 given a new name.
- HAMAOU, MAURICE. Sur la présence de *Gabonella* (Foraminiferida) en Israël.—Revue de Micropaléontologie, v. 8, No. 1, June 1965, p. 33-36, pl. 1, text fig. 1 (map).—In Cenomanian-Turonian.
- HANZLIKOVA, EVA. The Foraminifera of the Klentnice Beds (Malm).—Sbornik Geol. Ved, Paleontologie, rada P, sv. 5, 1965, p. 39-106, pls. 1-10, text figs. 1-4 (map, columnar section, geol. sections, diagram), tables 1-3.—Illustrated catalog of 84 species (2 species and 1 subspecies new).
- Stratigraphie der Kreide und des Paläogens der Flyschzone der Westkarpaten.—Geol. Sbornik, Geol. Carpathica, v. 16, pt. 1, June 1965, p. 33-64, text figs. 1-12 (drawings, graphs, distrib. tables).—Includes illustrations of evolution through time of species in *Bolivinoidea*, *Stensiöina*, *Aragonia*, *Cyclammina*, *Rzehakina*, *Hormosina*, and *Haplophragmoides*.
- HAUSMANN, HELLMUT E. Foraminiferenfauna und Feinstratigraphie des mittel-oligozänen

- Septarientones im Raum zwischen Magdeburg und Dessau—Teil I: Die Foraminiferenfauna.—Hercynia, Leipsig, v. 1, heft 3, 4, 1964, p. 314-419, pls. 1-8, text figs. 1-4, table 1.—Illustrated systematic catalog of about 125 species and subspecies (1 subspecies new).
- VAN HINTE, J. E. An approach to *Orbitoides*.—Proc. Kon. Nederl. Akad. Wetenschappen, ser. B, v. 68, No. 2, 1965, p. 57-71, pls. 1, 2, text figs. 1-4 (drawings).—Origin from heterohelicid ancestors.
- Remarks on the Kainach Gosau (Styria, Austria).—Proc. Kon. Nederl. Akad. Wetenschappen, ser. B, v. 68, No. 2, 1965, p. 72-92, pls. 1-4, text figs. 1-4 (map, columnar sections).—Illustrations of some middle to late Campanian Foraminifera, mostly planktonic.
- HOFKER, J. Foraminifera of the Cretaceous of South-Limburg, Netherlands. LXXIV. The evolution of the test wall of *Gyroidinoides*.—Natuurhist. Maandblad, 53° Jrg., No. 5, May 29, 1964, p. 72-74, text figs. 1-7.—Through time, an increase in thickness, a decrease in amount of agglutination, and the pores progressively denser and finer.
- LXXV. The Tuffeau de Cipluy in the quarry Curfs, Houthem, the Canal Albert near Vroenhoven, Belgium, and the mine-shaft Maurits III, near Geleen.—Natuurhist. Maandblad, 53° Jrg., No. 7-8, Aug. 26, 1964, p. 114-118, correl. table.—Correlation by Foraminifera of 11 European sections in the Danian and Paleocene.
- LXXVI. Some Foraminifera from the holes in the hard ground on top of the Md, Tuff Chalk, quarry Curfs, near Houthem.—Natuurhist. Maandblad, 54° Jrg., No. 1, Jan. 27, 1965, p. 6-7, 7 text figs.—Four lower Paleocene species.
- LXXVII. Arenaceous Foraminifera attached to the walls of holes in the hard grounds of the Lower Md in the quarry Curfs.—Natuurhist. Maandblad, 54° Jrg., No. 2, Feb. 24, 1965, p. 29-32, text figs. 1-10.—*Coscinophragma cribrorum*, *Placopsilina cenomana*, and *Bdelloidina vincentownensis*.
- LXXVIII. The occurrence of *Siphogenerinoides eleganta* (Plummer) as a time-marker in Holland and Belgium.—Natuurhist. Maandblad, 54° Jrg., No. 3, March 31, 1965, p. 40-41, 1 text fig.—A useful marker for the Cretaceous-Tertiary boundary.
- LXXIX. Planktonic Foraminifera in a sample taken from the holes in the hard ground on top of the Md in the quarry Curfs, near Houthem, South-Limburg, Netherlands.—Natuurhist. Maandblad, 54° Jrg., No. 4-5, May 26, 1965, p. 66-68, text figs. 1-8.—Four species from the lowermost Paleocene.
- HOFKER, J., JR. Some Foraminifera from the Aptian-Albian passage of northern Spain.—Leidse Geol. Meded., deel 33, 1965, p. 183-189, pls. 1-5, text figs. 1, 2 (drawings).—Ten species, 2 new and 3 indeterminate, studied in thin section, found in association with orbitolines.
- HORNIBROOK, N. DE B. A preliminary statement on the types of the New Zealand Tertiary Foraminifera described in the reports of the Novara expedition in 1865.—New Zealand Jour. Geol. Geophysics, v. 8, No. 3, June 1965, p. 530-536, table 1.—A progress report on re-study of the original collection in Vienna and comparison of topotype material. The original names of Karrer and Stache are listed, together with information regarding current generic name, number of specimens found, selection of lectotype, location of topotypes, and whether the species is valid or belongs in synonymy.
- HULME, S. G. Recent Foraminifera from Manukau Harbour, Auckland, New Zealand.—New Zealand Jour. Sci., v. 7, No. 3, Sept. 1964, p. 305-340, text figs. 1-6 (photo of dredge, map, harbor profiles, foram drawings), tables 1, 2.—Based on 64 samples, from the littoral to 16 fathoms, covering an extensive area of tidal flats and shallow channels, separated from the ocean by a deep and narrow entrance channel and subject to strong turbulence. Species living on the coastal shelf and planktonic species in the ocean water are brought into the harbor during the 8-12 foot tidal fluctuations. Over 150 species are recorded and 76 give a positive stain for protoplasm, but only 66 are believed to be autochthonous.
- IMBRIE, JOHN, and PHLEGER, FRED B. Analisis por vectores de los Foraminiferos bentonicos del area de San Diego, California.—Bol. Soc. Geol. Mexicana, tomo 26, No. 2, 1963, p. 103-105, text fig. 1 (graph).
- JEDNOROWSKA, A., and WECLAWIK, ST. Accumulation de Globorotalies et de Globigérines dans les couches de l'Éocène de la nappe de Magura de la région Ropki-Hanczowa (Bas Beskide).—Bull. Acad. Polonaise Sci., ser. sci. geol. geogr., v. 13, No. 1, 1965, p. 59-65, 1 pl., text figs. 1-4 (maps, columnar sections).—Photographs of assemblages interpreted as lower Eocene.
- JENKINS, D. GRAHAM. The genus *Hantkenina* in New Zealand.—New Zealand Jour. Geol. Geophysics, v. 8, No. 3, June 1965, p. 518-526, figs. 1-22 (on 2 pls.).—Redescription and illustration of *H. australis* which appears to be

- limited to the Bortonian and Kaiatan and is replaced by *H. alabamensis* in the Runangan.
- JOINT OCEANOGRAPHIC INSTITUTIONS' DEEP EARTH SAMPLING PROGRAM (JOIDES). Ocean drilling on the continental margin.—*Science*, v. 150, No. 3697, Nov. 5, 1965, p. 709-716, text figs. 1-4 (diagram, map, geol. section, seismic profiles), tables 1, 2.—Foraminifera used in dating beds of the Paleocene; lower, middle, and upper Eocene; Oligocene; and lower, middle, and upper Miocene penetrated by submarine drillings—2 on the continental shelf, 1 on the Florida-Hatteras slope, and 3 on the Blake Plateau.
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- KEIJ, A. J. Late Cretaceous and Palaeogene arenaceous Foraminifera from Flysch deposits in northwestern Borneo.—*Ann. Rept. Geol. Survey, Borneo Region, Malaysia, 1964 (1965), p. 155-158, pl. 59, text fig. 39 (geol. map).*—An assemblage similar to that of European flysch deposits.
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- KUSTANOWICH, S. Foraminifera of Milford Sound, in Studies of a southern fjord.—*New Zealand Dept. Sci. Industr. Res., Bull. 157, 1964, p. 49-63, text figs. 1-7 (bottom profile, graphs), tables 1-3.*—Study based on 7 stations shows 105 benthic and 12 planktonic species. Three faunal zones correspond with the 3 regions (entrance basin and sill, deep Stirling Basin, and delta at the head of the sound).
- LE CALVEZ, YOLANDE, and MARGEREL, JEAN-PIERRE. Un nouveau genre de Foraminifères des sables du Bois-Gouët (Loire-Atlantique).—*C. R. S. Soc. Géol. France, fasc. 6, June 14, 1965, p. 205-206, text figs.*—*Pseudocibicides occidentalis* n. gen., n. sp., having openings, both on the spiral and the umbilical side, along each suture where each succeeding chamber fails to completely join the previous one.
- LIDZ, LOUIS. Sedimentary environment and foraminiferal parameters: Nantucket Bay, Massachusetts.—*Limnology and Oceanography, v. 10, No. 3, July 1965, p. 392-402, text figs. 1-12 (maps, drawings).*—Quantitative analysis based on 25 samples within a shallow bay nearly enclosed by a sand bar shows arenaceous species most abundant in coarse sands and near beaches, hyaline species in fine sediments deeper than 2 meters, and porcelaneous species on sand flats and in intermediate depths. High concentrations of abnormal specimens are attributed to large seasonal changes in water conditions or to pollution, or to both.
- LINDENBERG, HANS GEORG. Problematica aus dem inneralpinen Tertiär *Pseudarcella* Spandel, emend. und *Bicornifera* n. g.—*Neues Jahrb. Geol. Paleont. Mh., Stuttgart, Band 1, Jan. 1965, p. 18-29, text figs. 1-6 (drawings, thin-section photomicrographs).*—Study of topotypes of *Pseudarcella* reveals a small tube projecting from one side of the cap-shaped chamber. *Bicornifera* appears as if it were a twinned *Pseudarcella*. Both these minute problematica (0.3-0.5 mm.) are found in the lower to middle Oligocene.
- LIPINA, O. A. Stratigraphie et limites du Tournaisien en U.R.S.S. d'après les Foraminifères.—*Cinquième Congrès Internat. de Stratigraphie et de Géologie du Carbonifère, Paris, 9-12 Sept. 1963, Compte rendu, tome 2, 1964, p. 539-551, text figs. 1-5 (maps, correl. table, evolution chart).*
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- MALAKHOVA, N. P. New genus of foraminifers from Ural Lower Viséan.—*Internat. Geol. Review, v. 7, No. 6, June 1965, p. 1121-1123, pl. 1.*—*Darjella monilis* gen. nov., sp. nov. in the Reophacidae.
- Foraminifery Permskikh Otlozhenij Vostochnogo Sklona Urala, in Foraminifery Devona i Permi Urala.—*Akad. Nauk SSSR, Ural. filial, Sverdlovsk, Instit. geol. Trudy, vyp. 74, 1965, p. 155-165, pls. 1-3, 1 text fig. (diagram).*—Fourteen Permian species, 1 new.
- MAMET, B. Remarques sur la microfaune du "Marbre Noir de Dinant."—*Ann. Soc. Géol.*

- Belgique, tome 88, 1964-65, Bull. No. 5, Sept. 1965, p. 187-219, pl. 1 (range chart), text figs. 1-5 (map, graphs, evolution diagrams, geol. section).—In the Tournaisian and Viséan.
- MAMGAIN, V. D., and JAGANNATHA RAO, B. R. Orbitolines from the limestone intercalations of Dras volcanics, Jammu and Kashmir State.—*Jour. Geol. Soc. India*, v. 6, 1965, p. 122-129, pls. 8-10, text fig. 1 (diagrams).
- MAYNC, WOLF. Some comments on C. D. Redmond's new lituolid Foraminifera from Saudi Arabia.—*Revue de Micropaléontologie*, v. 8, No. 1, June 1965, p. 37-40.—Several new species and genera are a result of too fine a separation made along lines of natural variability.
- MÉHES, KÁLMÁN. Beitrag zur stratigraphischen Verbeitung der Gattung *Orbitolina*.—*Neues Jahrb. Geol. Paläont. Mh.*, Stuttgart, v. 6, June 1965, p. 346-350, tables 1-3.
- MERIC, ENGIN. Sur deux nouvelles espèces de *Loftusia* et un nouveau genre, *Asterosomalina*. *Revue de Micropaléontologie*, v. 8, No. 1, June 1965, p. 45-52, pls. 1, 2, text fig. 1 (map).—*Asterosomalina dizeri* nov. gen., nov. sp. from the Lutetian of southeastern Anatolia, in the subfamily Orbitolitinae.
- MIKLUKO-MAKLAY, K. V. Kazanskije Lagenidy Russkoj Platformy, in *Paleontologija i Stratigrafija*.—*Russia Vses. geol. instit. Trudy*, n. ser., tom 93, 1964, p. 3-20, pls. 1, 2.—Twelve Permian species, none new.
- MORIKAWA, ROKURO. Solidgraphic study of Fusulinid Foraminifera (2)—Subfamily Verbeekinae in Japan.—*Sci. Repts. Saitama Univ.*, ser. B (Biol. and Earth Sci.), v. 5, No. 1, 1965, p. 15-27, pls. 2-5, text figs. 1-3.—One new *Misellina*.
- MURRAY, J. W. On the Foraminiferida of the Plymouth region.—*Jour. Marine Biol. Assoc. United Kingdom*, v. 45, No. 2, June 1965, p. 481-505, pl. 1, text figs. 1-8 (map, graphs, echograph, histograms), tables 1, 2.—Quantitative seasonal study of living and dead populations, based on 18 winter samples, 30 spring samples, and 32 summer samples taken from the inner part of Tamar estuary out across the offshore platform to the Eddystone lighthouse. Altogether 123 species are listed, but only 80 found living. Histograms show the different percentages in different parts of the traverse for the more abundant species and for family groups.
- NAKKADY, SAAD E., and EISSA, RAGI A. Biostratigraphy and correlation of two Lower Cretaceous subsurface sections at Oyoum Mousa, Sinai.—*Jour. Geol. United Arab Republic*, v. 4, No. 2, 1960, p. 1-15, pls. 1-5 (distrib. and abund. charts, columnar sections, drawings).—Occurrence and abundance of Foraminifera recorded in 2 well sections, and 2 new arenaceous species are described. *Ammovaginulina* n. gen. (genotype *A. aegyptiaca* n. sp.).
- NAYUDU, Y. R., and ENBYSK, B. J. Bio-lithology of northeast Pacific surface sediments.—*Marine Geol.*, v. 2, No. 4, Dec. 1964, p. 310-342, text figs. 1-15 (maps, photomicrographs, graphs), tables 1, 2.—In a large area (mapped in terms of relative abundances of 4 elements: planktonic Foraminifera, Radiolaria, diatoms, and lithic content), 7 bio-lithologic areas appear, generally parallel with the coastline. A *Globigerina*-rich area is present as an elongate band 300 miles off the Washington-British Columbia coast. Study is based on 200 gravity cores.
- NOGAMI, YASUO. Neu-Untersuchung der von Schwager beschriebenen Fusuliniden aus China und Japan, 1. Fusuliniden aus China.—*Paleont. Zeitschrift*, Band 39, No. 1/2, May 1965, p. 51-71, pls. 9-11.—Ten species, 3 of which are indeterminate, are described and illustrated.
- OMARA, S., and CONIL, R. Lower Carboniferous Foraminifera from southwestern Sinai, Egypt.—*Ann. Soc. Géol. Belgique*, tome 88, 1964-65, Bull. No. 5, Sept. 1965, p. 221-242, pls. 1-3, text fig. 1 (columnar section), geol. map.—Twelve lower Viséan species, 3 new and 2 indeterminate.
- OMARA, S., and STRAUCH, F. The foraminiferal genus *Nezzazata* Omara.—*Riv. Ital. Paleont. Stratig.*, v. 71, No. 2, June 1965, p. 547-562, pl. 65, text figs. 1-4 (graphs, map).—This rotaliform, granular-walled genus has 4 species, 2 with subspecies, and extends from Hauterivian to Turonian in the circumtethyan region.
- PAPP, A. Das Vorkommen von Grossforaminiferen in der Gams, in *Stratigraphie und Tektonik des Gosaubeckens von Gams (Steiermark, Österreich)*, by Heinz A. Kollmann.—*Jahrb. Geol. Bundesanstalt, Wien*, Band 107, August 1964, p. 118-125, text figs. 1-4 (columnar section, drawings).—Nine species.
- PARKER, FRANCES L. Irregular distributions of planktonic Foraminifera and stratigraphic correlation, in *Progress in Oceanography*, v. 3, M. Sears, Editor.—Pergamon Press, Oxford, 1965, p. 267-272.—Examples of pitfalls to be avoided in use of planktonics in correlation: changing latitudinal boundaries, species excluded or introduced by currents, small seas having irregular patterns, extinctions not strictly instantaneous (as exemplified by *Globoquadrina hexagona* and *G. conglomerata-venezuelana* extinct

in the Atlantic but still living in the Pacific and Indian Oceans), localized evolution (such as *Globigerinella adamsi* developing in the tropical part of the Pacific and Indian Oceans but prevented by the Panama barrier from spreading into the Atlantic), selective solution of CaCO₃ in surface sediments or water column, and coiling direction changing between provinces as well as across time lines.

PHLEGER, FRED B. Oceanografía física y ecología de los Foraminíferos del Golfo de California. —Bol. Soc. Geol. Mexicana, tomo 26, No. 2, 1963, p. 75-83, text figs. 1-4 (maps, graph).—Depth ranges are graphically illustrated for 13 species.

Patterns of living benthonic Foraminifera, Gulf of California, in Marine Geology of the Gulf of California, a symposium edit. by Tjeerd H. van Andel and George G. Shor, Jr.—Am. Assoc. Petr. Geologists, Tulsa, 1964, p. 377-394, pls. 1-3, text figs. 1-7 (maps, check list, range chart), table 1.—Quantitative study based on 76 stations between 6 and 1730 fathoms shows standing crops of living specimens ranging between a mean of 26 specimens per 10 sq. cm. below 500 fathoms and about 700 specimens in shallower water and near river mouths. Ratios of living to dead populations indicate slow deposition within the Gulf, except locally rapid deposition at a few stations near the coasts. About 220 living species were identified. Restricted distributions (deep limits and shallow limits) of 66 of the common species indicate 12 depth biofacies.

Depth patterns of benthonic Foraminifera in the eastern Pacific, in Progress in Oceanography, v. 3, M. Sears, Editor.—Pergamon Press, Oxford, 1965, p. 273-287, text figs. 1-3 (diagram, check list, range chart).—Quantitative analysis of 66 species (10 indeterminate) from 55 near-shore samples from between 7 and 594 meters (mostly shallower than 90 meters) from along the coasts of Nayarit, Sinaloa and Sonora, Mexico. Depth biofacies at 25, 35, 55, 75-85, 120, 180, 340, and 550 meters are recognized on the basis of shallow and deep limits of species.

RAINWATER, E. H. Regional stratigraphy of the Gulf Coast Miocene.—Trans. Gulf Coast Assoc. Geol. Soc., v. 14, 1964, p. 81-124, text figs. 1-36 (correl. chart, maps, geol. sections, columnar sections, range chart, check lists).—Includes summary of occurrences of Foraminifera, and ranges of important species.

RAJAGOPALAN, N. Late Cretaceous and early Tertiary stratigraphy of Pondicherry, South India. —Jour. Geol. Soc. India, v. 6, 1965, p. 108-121, text fig. 1 (geol. map), table 1 (correl. table).

—Planktonic Foraminifera zones of Trinidad are present.

ROSS, CHARLES A., and TYRRELL, WILLIS W., JR. Pennsylvanian and Permian fusulinids from the Whetstone Mountains, southeast Arizona.—Jour. Paleontology, v. 39, No. 4, July 1965, p. 615-635, pls. 75-78, text figs. 1-6 (maps, columnar sections), tables 1-3.—Thirty-five species, 8 new.

SCHROEDER, ROLF. *Neorbitolinopsis* n. gen. und ihre systematische Position innerhalb der Orbitoliniden (Studien über primitive Orbitolinidae II).—Eclogae Geol. Helvetiae, v. 58, No. 1, Sept. 1, 1965, p. 579-589, pl. 1, text fig. 1 (photomicrograph).—Generotype *Orbitolina conulus* H. Douvillé 1912.

SEIGLIE, GEORGE A. New and rare foraminifers from Los Testigos reefs, Venezuela.—Caribbean Jour. Sci., v. 4, No. 4, Dec. 1964, p. 497-512, pls. 1-5.—Seventeen species (16 new). Eight genera (6 new) are discussed, and a new subfamily, Ungulatellinae, of the family Spirillinidae is described.

SERPAGLI, E. Ritrovamento di flysch tipo M. Sporno nell'Appennino modenese: osservazioni geopaleontologiche.—Boll. Soc. Paleont. Ital., v. 3, No. 1, 1964, p. 20-37, pls. 5-8, text figs. 1, 2 (map, drawings), geol. map.—Lower Eocene Foraminifera illustrated as free specimens and in thin section.

SHENG, J. C., and LEE, H. H. Carboniferous-Permian boundary in China.—Cinquième Congrès Internat. de Stratigraphie et de Géologie du Carbonifère, Paris, 9-12 Sept. 1963, Compte rendu, tome 2, 1964, p. 775-779, tables 1, 2.—Based, in part, on fusulinid zones.

SKVORZOV, V. P. Novye Vizejskie Foraminifery Severnoj Fergany.—Akad. Nauk SSSR, Paleont. Zhurnal, No. 3, 1965, p. 23-32, pls. 3, 4.—Ten new Visean species.

SLITER, WILLIAM V. Laboratory experiments on the life cycle and ecologic controls of *Rosalina globularis* d'Orbigny.—Jour. Protozoology, v. 12, No. 2, May 1965, p. 210-215, text figs. 1-7, table 1.—Life cycle includes a floating stage, identified as *Tretomphalus bulloides*, resulting from schizogony and occurring less frequently than asexual reproduction and under conditions of higher temperature and increased salinity.

TAYLOR, D. J. Preservation, composition, and significance of Victorian Lower Tertiary 'Cyclammina faunas.'—Proc. Roy. Soc. Victoria, n. ser., v. 78, pt. 2, June 11, 1965, p. 143-160, text figs. 1-5 (map, drawings, range charts).—Several species formerly known as *Cyclammina* in the Upper Cretaceous, Paleocene, and Eo-

cene, all prove to belong in *Haplophragmoides*, the misidentifications having been due to results of chemical decay of the agglutinating cement of the test. The genus *Haplophragmoides* permits an interpretation of paralic environments, not bathyal depths as required by *Cyclammina*.

- TOOMEY, DONALD F. Upper Devonian (Frasnian) Foraminifera from Redwater and South Sturgeon Lake Reefs, Alberta, Canada.—Bull. Canadian Petr. Geol., v. 13, No. 2, June 1965, p. 252-270, pls. 1-4, text figs. 1-3 (map, columnar section, correl. table), table 1.—Studied in random sections; 5 species are distinguished but not specifically identified.
- WEAVER, D. W., and MOLANDER, G. E. The Eocene faunal sequence in the eastern Santa Rosa Hills, Santa Barbara County, California.—Univ. Calif. Publ. Geol. Sci., v. 41, No. 3, 1964 (Jan. 6, 1965), p. 161-211, pls. 1-18, text

figs. 1-4 (maps, columnar section, check list), tables 1, 2.—Illustrated systematic catalog includes 155 species and varieties, 1 species new. Five zonules based on Foraminifera assemblages are recognized in the Cozy Dell Formation and the undifferentiated Sacate-Gaviota.

- ZAGORSKAJA, N. G., JASHINA, Z. I., SLOBODIN, V. JA., LEVINA, F. M., and BELEVICH, A. M. Morskie Neogen(?)—Chetvertichnye Otlozhenija Nizhnego Techenija Reki Eniseja.—Nauchno-issl. instit. geol. arktiki gosud. geol. Komitet. SSSR, Trudy, tom 144, 1965, p. 1-91, text figs. 1-28 (maps, core diagrams, graphs), tables 1-21.—Foraminifera in Neogene?-Quaternary cores in the valley and estuary of the Yenisey River and offshore in the Kara Sea.

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