Foraminifera from Carter Creek Northeastern Alaska

By RUTH TODD

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 294-F

A report on the discovery of a late Tertiary Foraminifera fauna from the northeastern coast of Alaska

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1957

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C.

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FORAMINIFERA FROM CARTER CREEK, NORTHEASTERN ALASKA

By Ruth Todd

ABSTRACT

A meager fauna of Foraminifera, probably of Miocene or Pliocene age, occurs on the northeastern Arctic coast of Alaska. Comparisons with Recent Arctic faunas and with the Tertiary faunas nearest geographically in both Eastern and Western Hemispheres are made. No evidence is found that would favor either a Pacific or Atlantic origin for the fauna.

INTRODUCTION AND ACKNOWLEDGMENTS

This paper reports the discovery of a late Tertiary Foraminifera fauna from the northeastern coast of Alaska, the farthest north occurrence of fossil Foraminifera so far reported.

I am indebted to R. H. Morris, collector of the material, and to Harlan R. Bergquist, who discovered the fauna. Helen Tappan Loeblich and Harlan R. Bergquist made numerous helpful suggestions regarding the manuscript, and George Switzer, of the United States National Museum, made determinations of the structure of the calcareous wall in several species.

LOCATION AND STRATIGRAPHIC RELATIONS

A Foraminifera fauna was found in two samples collected by Robert H. Morris in July 1953 from an unconsolidated or slightly indurated clay shale and siltstone zone occurring between about 160 and 400 feet below the top of a section estimated to be about 7,400 feet thick and consisting for the most part of shale, sandstone, and conglomerate. The section is exposed along Carter Creek and some tributary streams where they traverse the south limb of an anticline, 1½ miles south of Camden Bay, in Mount Michelson quadrangle, Alaska. The area is on the northeast coast of Alaska, near the Arctic Ocean, at a latitude of approximately 70° N. (See fig. 81.)

The thick sequence of Tertiary sedimentary rocks is separated by an angular break of 10° measured and up to 50° estimated, from overlying conglomerate of Pleistocene (?) age that is composed of rounded cobbles and pebbles derived from the Sadlerochit formation of Permian age (fide, R. H. Morris).

The fauna was found by Harlan R. Bergquist, who first examined the samples. Of 8 samples examined from both the upper and the lower parts of this Tertiary sequence, only the 2 from the upper part yielded fossils. The remaining 6 samples, all from between 450 and 1,450 feet above the bottom of the section, were found to be barren of Foraminifera.

The two samples occur as follows: Sample 3 (USGS f11550) from clay shale 160–208 feet below the base of a fine-grained light-gray sandstone at the top of the Tertiary section. This sample was obtained from a bed of megafossils where mollusks had been collected by Leffingwell and the strata assigned to the Pliocene by Dall (Leffingwell, 1919, p. 130). The age of these strata has more recently been determined as upper Miocene or lower Pliocene on the basis of their molluscan fauna (MacNeil, 1957). Sample 8 (USGS f11551) from siltstone 210 feet below the base of the capping sandstone.

DESCRIPTION OF FAUNA

Specimens of the fauna from Carter Creek are mostly well preserved and characteristically stained reddish brown or occasionally black. Many of them have empty interiors.

Table 1 lists systematically the Foraminifera found in the two samples and indicates their abundance. In all, 38 species in 24 genera were found. Of these, 4 species are new; 25 are identified or compared to already known species; 7 are indeterminate as to species; and 2 are uncertain even as to genus. Sixteen species are found in both samples; these species constitute less than half the total number but include all the abundant species and all except four of the common ones. Of those remaining, 17 species, 13 rare and 4 common, occur in sample 3 only; and 5 species, all rare, occur in sample 8 only. Thus the 2 samples contain essentially the same fauna.

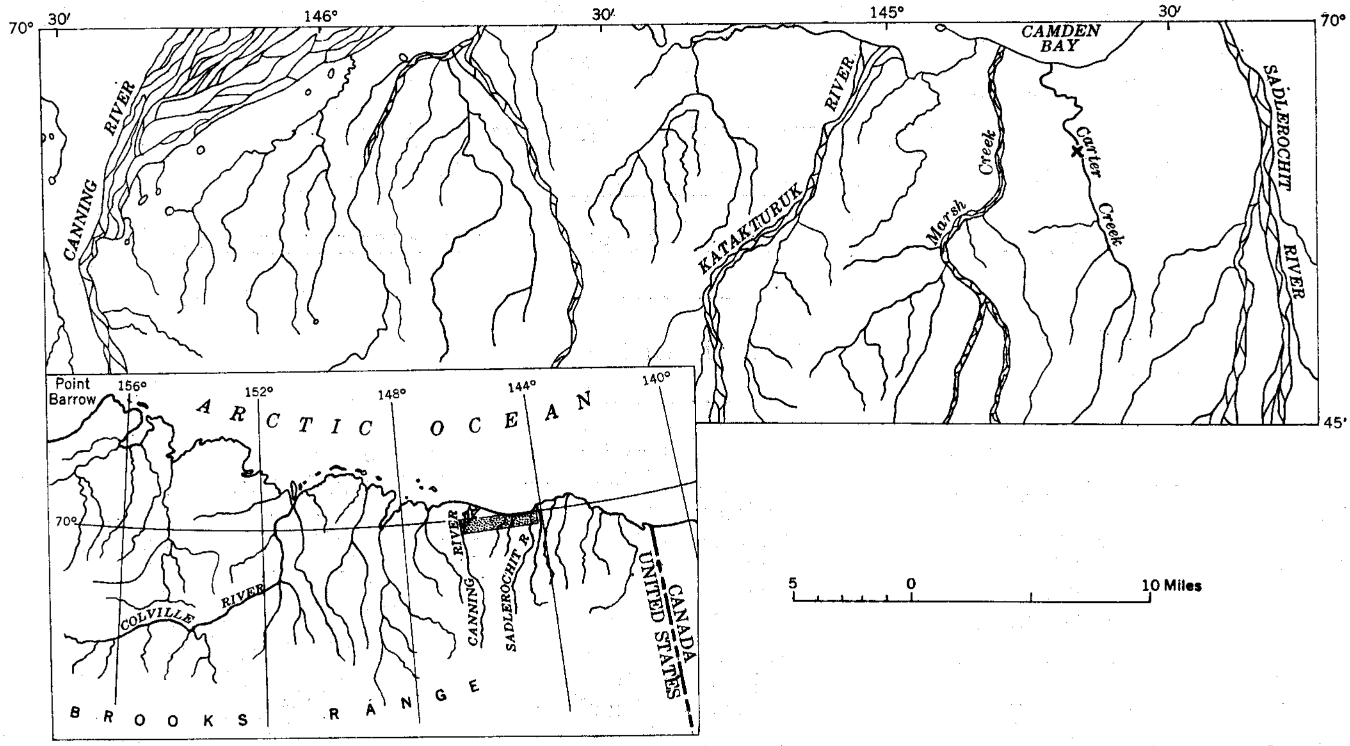

FIGURE 81.—Index map showing location of Carter Creek, northeastern Alaska, and locality (X) at which samples were collected.

TABLE 1.—*Occurrence and abundance of Foraminifera from Carter Creek*

[Key: A, abundant; C, common; R, rare]

	Sample 3	Sample 8
Family Tolypamminidae		
Involutina sp. (pl. 28, fig. 1)	R	--------
Family Lituolidae		
Haplophragmoides? sp. A (pl. 28, fig. 2)	R	--------
? sp. B	C	--------
Cyclammina sp. (pl. 28, fig. 3)	R	--------
Family Miliolidae		
Miliolinella circularis (Bornemann) (pl. 28, fig. 4)	R	C
Family Ophthalmidiidae		
Cornuspira sp. (pl. 28, fig. 5)	--------	R
Family Lagenidae		
Robulus cultratus Montfort (pl. 28, fig. 6)	C	R
Marginulina hantkeni Bandy (pl. 28, fig. 7)	R	--------
Dentalina soluta Reuss (pl. 28, fig. 8)	R	--------
sp.	R	--------
Lagena hispidula Cushman (pl. 28, fig. 10)	R	--------
saccata Todd, n. sp. (pl. 28, fig. 12)	C	--------
semilineata Wright (pl. 28, fig. 9)	R	R
sesquistriata Bagg (pl. 28, fig. 11)	--------	R
Family Polymorphinidae		
Globulina inaequalis Reuss (pl. 28, fig. 13)	C	R
Family Nonionidae		
Nonion erucopsis Todd, n. sp. (pl. 28, fig. 15)	A	A
labradoricum (Dawson) (pl. 28, fig. 17)	R	R
Family Buliminidae		
Buliminella curta Cushman (pl. 28, figs. 19, 20)	A	A
Globobulimina affinis (D'Orbigny) (pl. 29, fig. 1)	C	C
Family Buliminidae—Continued		
Bolivina sp. (pl. 29, fig. 2)	--------	R
Angulogerina fluens Todd (pl. 28, figs. 21, 22)	A	A
Oolina apiopleura (Loeblich and Tappan)	R	--------
borealis Loeblich and Tappan (pl. 29, fig. 4)	R	--------
laevigata D'Orbigny (pl. 29, figs. 5, 8)	C	R
lineato-punctata (Heron-Allen and Earland)	R	--------
squamosa (Montagu) (pl. 29, fig. 3)	--------	R
Fissurina globosa Bornemann (pl. 29, fig. 7)	C	--------
semimarginata (Reuss) (pl. 29, fig. 6)	R	--------
Family Rotaliidae		
Gyroidina cf. *G. girardana* (Reuss) (pl. 29, fig. 11)	C	C
sp. (pl. 29, fig. 9)	R	--------
Family Miscellaneidae?		
Elphidiella? brunnescens Todd, n. sp. (pl. 28, fig. 18)	A	A
Family Elphidiidae		
Elphidium discoidale (D'Orbigny) (pl. 28, fig. 14)	C	R
Elphidium? ustulatum Todd, n. sp. (pl. 28, fig. 16)	A	A
Family Cassidulinidae		
Cassidulina cf. *C. subglobosa* Brady (pl. 29, fig. 14)	--------	R
Family Chilostomellidae		
Pullenia salisburyi R. E. and K. C. Stewart (pl. 29, fig. 10)	C	R
Sphaeroidina sp. (pl. 29, fig. 15)	R	--------
Family Anomalinidae		
Cibicides lobatulus (Walker and Jacob) (pl. 29, fig. 17)	C	--------
perlucidus Nuttall (pl. 29, figs. 12, 13, 16, 18)	A	A

Inasmuch as the fauna under discussion is represented by only two samples, conclusions based on it must necessarily be only tentative, pending discovery of additional occurrences which could change its overall aspect and hence its interpretation.

For the purpose of comparing the present fauna with other faunas and making interpretations of age and ecology, new and indeterminate species cannot be considered. Thus the interpretations to follow are based wholly on the 23 previously described species listed in table 2.

These 23 species are listed in table 2 in approximate order of decreasing abundance, the first 3 species comprising between 50 and 60 percent of the total number of specimens. The new and indeterminate species, not given in table 2, represent about 40 percent of the total number of specimens.

Omitting from consideration 3 species known to be cosmopolitan and all the rare and very rare species, 10 species are left upon which the age determination of the Carter Creek material is based. Recorded ranges of the previously described species are indicated in table 2.

AGE DETERMINATION

Various factors affect and qualify the recorded ranges as indicated on table 2: certain species, such as *Miliolinella circularis* (Bornemann), have been recorded elsewhere under several different specific and generic names. Further study, particularly of living material, is needed before the biologic, geographic, and stratigraphic limits of such species can be firmly established. Until this is done their geologic ranges must be regarded as only approximate. Certain other species, such as *Robulus cultratus* Montfort, have been used so loosely and apparently have included so many unrelated species that their real geologic and geographic range is so blurred as to be virtually useless. Certain other species, such as *Fissurina globosa* Bornemann,

TABLE 2.—*Stratigraphic ranges and ecologic implications of the already known species of Foraminifera from Carter Creek*

	Ecologic implications				Recorded ranges							
	Shallow	Deep	Cold	Warm	Pre-Tertiary	Paleocene	Eocene	Oligocene	Miocene	Pliocene	Pleistocene	Recent
Abundant:												
Cibicides perlucidus Nuttall							▲	▲	▲			
Angulogerina fluens Todd	×	×	×							?	?	▲
Buliminella curta Cushman	×	×							▲	▲	▲	▲
Common:												
Globobulimina affinis (D'Orbigny)		×							▲	▲	▲	▲
Globulina inaequalis Reuss [1]	?	?					▲	▲	▲	▲	▲	▲
Oolina laevigata D'Orbigny	?	?	×									▲
Fissurina globosa Bornemann								▲				
Pullenia salisburyi R. E. and K. C. Stewart		×					▲	▲	▲	▲	▲	▲
Miliolinella circularis (Bornemann)	×	×						▲	▲	▲	▲	▲
Robulus cultratus Montfort		×						?	▲	▲	?	▲
Elphidium discoidale (D'Orbigny)	×			×				▲	▲	▲	▲	▲
Cibicides lobatulus (Walker and Jacob) [1]	×	×					▲	▲	▲	▲	▲	▲
Rare:												
Nonion labradoricum (Dawson)	×	×	×						▲	▲	▲	▲
Lagena hispidula Cushman		×	×				▲	?	?	▲	▲	▲
semilineata Wright		×	×									▲
Fissurina semimarginata (Reuss)		×								▲	▲	▲
Very rare:												
Dentalina soluta Reuss [1]		×			▲	▲	▲	▲	▲	▲	▲	▲
Marginulina hantkeni Bandy							▲	▲	▲			
Oolina apiopleura (Loeblich and Tappan)	×		×									▲
lineato-punctata (Heron-Allen and Earland)	×		×									▲
squamosa (Montagu)	?	?						▲		▲	▲	▲
borealis Loeblich and Tappan	×		×									▲
Lagena sesquistriata Bagg		×							▲	▲	▲	▲

[1] Cosmopolitan.

either are so rare or have been misidentified so often, or both, that their actual geologic and geographic range is fragmentary or lost. Other species, such as those of the genus *Oolina*, seem to have been separated on the basis of ornamentation to such a degree that what appear to be different species are actually reflections of environmental differences, and the recorded ranges of them are of little or no significance. Others, possibly *Lagena hispidula* Cushman, may be polymorphic, the proof or disproof of which is beyond the scope of this paper. In the light of the above probabilities and possibilities, the geologic ranges as indicated in table 2 are at best only approximate. Such being the case, the nearest approximation to age of the Carter Creek material, that can be based on the Foraminifera, is Miocene or Pliocene.

ECOLOGIC INTERPRETATION

Only 3 of the 23 previously described species listed in table 2 are not known as Recent species. The ecologic interpretation is based, therefore, on the 20 remaining species.

There are what might be regarded as major size differences between the average sizes or size limits of the various Carter Creek species as compared to the average sizes or size limits of the type specimens of the corresponding species with which they are identified. In some species (for example, *Oolina laevigata*, *Fissurina globosa*, and *Globobulimina affinis*), the Carter Creek specimens are larger; in others (such as *Robulus cultratus*, *Globulina inaequalis*, *Nonion labradoricum*, *Oolina borealis*, and others), they are smaller. It is suggested that size variation is not a specific character but may be in part a result of environmental influences. Thus, specimens of a species occurring near the extremity of its ecologic tolerance would be expected to be smaller than specimens occurring under the optimum conditions for that species. It follows, therefore, that a species originally described from conditions less than optimum subsequently may be found to include larger specimens.

TEMPERATURE

As indicated in table 2, 1 abundant species, 1 common species, and 6 rare or very rare species are characteristically found in cold water, either in the Arctic or Antarctic Oceans, or in cold deep water from other oceanic regions. Only 1 species, *Elphidium discoidale* (D'Orbigny), appears to be characteristic of warmer water as a Recent species. Along the Atlantic coast it is not known farther north than Rhode Island (Cushman, 1944, p. 26). The 12 remaining species are not good indicators of temperature as they include both warm and cold areas in their known habitats.

DEPTH

Only 2 species, *Globobulimina affinis* (D'Orbigny) and *Pullenia salisburyi* R. E. and K. C. Stewart, are known only from moderately deep water. All but 1 of the other Recent species range from deep water to water shallower than 10 fathoms. One species, *Elphidium discoidale* (D'Orbigny), is characteristic of shallow and littoral areas.

Inasmuch as shallow-water species found at depth present less of a problem in interpretation than deep-water species found in shallow sediments, it follows that the best interpretation for the Carter Creek material is that it was deposited in moderately deep water, possibly between 10 and 100 fathoms. Absence of planktonic species suggests that the area of deposition may not have been within the area of circulation of oceanic currents. Complete absence of planktonic species is not surprising, however, as in only about one-third of the 48 Arctic samples studied by Phleger (1952b) were there any planktonic specimens found, and in only one sample did they occur abundantly.

COMPARISONS WITH OTHER FAUNAS

The fauna from Carter Creek has been compared with several groups of faunas, as plotted on figure 82. Comparisons with negative results are included where no faunas to which positive comparisons might be made are known.

RECENT ARCTIC AND COLD-WATER FAUNAS
(Fig. 82, nos. 1–14)

The fauna from Carter Creek seems to be rather closely related to Recent Arctic faunas of nearby areas. (See fig. 82, nos. 1, 2, 3, 4, 5, 6, 7, 10.) Resemblances are marked by the species *Angulogerina fluens* Todd and *Nonion labradoricum* (Dawson) and the genera *Elphidium*, *Lagena*, *Oolina*, and *Fissurina*.

Differences lie in the absence or rarity of arenaceous specimens (particularly species of *Haplophragmoides*, *Eggerella*, and *Trochammina*), miliolids, and species of the genera *Astrononion*, *Buccella*, and *Cassidulina*, all of which are to be expected as common or abundant constituents of Recent Arctic faunas and are known in Tertiary sediments.

Even the cold-water faunas of the northern Atlantic coast of North America, such as those described by Athearn (1954), Cushman (1944), Parker (1948, 1952a), and Phleger (1952a), still retain much of the Arctic flavor in their compositions.

At about the latitude of Cape Cod, which marks the point where the Labrador Current diverges from the Atlantic coast, there is a change in fauna marked by different species of the genera that occur in the Arctic,

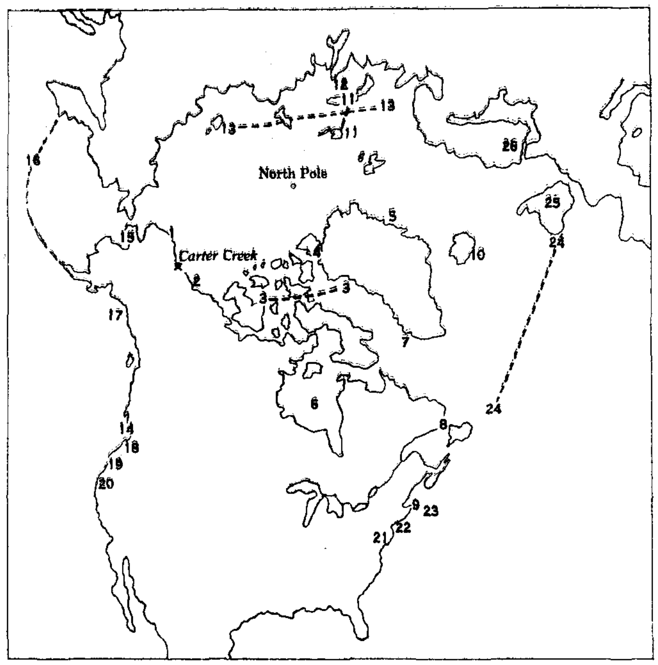

FIGURE 82.—Index map showing location of those faunas compared with the Carter Creek fauna.

Numerals represent areas containing faunas which have been compared with the fauna from Carter Creek, as follows:

1. Point Barrow, Alaska (Loeblich and Tappan, 1953)
2. Canadian-Arctic (Cushman, 1920, 1948a)
3. Canadian and Greenland Arctic (Phleger, 1952b)
4. Baffin Bay area (Parker and Jones 1865; Brady, 1878)
5. Northeastern Greenland (Cushman, 1948a)
6. Hudson Bay (Cushman, 1921, 1948a)
7. Southwestern Greenland (Parker and Jones, 1865; Norman 1876)
8. Labrador (Athearn, 1954)
9. Northern Atlantic coast (Cushman, 1944; Parker, 1948, 1952a, 1952b; Phleger, 1952a)
10. Iceland (Nørvang, 1945)
11. Novaya Zemlya and Franz Josef Land (Brady, 1881)
12. Kara Sea (Stschedrina, 1936, 1938; Awerinzew, 1911)
13. Nordenskjöld Sea–Barents Sea (Awerinzew, 1911)
14. British Columbia and Washington coasts (Cushman, 1925; Cushman and Todd, 1947a)
15. Nome, Alaska (Cushman, 1941)
16. Amchitka Island, Aleutians (Cushman and Todd, 1947b; Todd, 1953)
17. Middleton Island, Gulf of Alaska (Miller, 1953)
18. Washington (Cushman, Stewart, and Stewart, 1949; Beck, 1943; Rau, 1948a, 1951)
19. Oregon and Washington (Cushman, Stewart, and Stewart, 1948; Rau, 1948b; Cushman and Schenck, 1928; Detling, 1946)
20. Northern California (Stewart and Stewart, 1949)
21. Maryland (Cushman and Cole, 1930; Dorsey, 1948; Cushman, 1948b)
22. Atlantic continental slope (Cushman, Henbest, and Lohman, 1937; Phleger, 1939)
23. Georges Bank (Cushman, 1936)
24. North Atlantic (Cushman and Henbest, 1940)
25. England (Jones, Parker, and Brady, 1866; Jones, 1895–97; Millett, 1885, 1895, 1898; Reade and Wright, 1906)
26. Norway (Feyling-Hanssen, 1954)

and the addition of *Streblus beccarii* (Linné), *Poroeponides lateralis* (Terquem), and various species of *Rosalina.*

The Foraminifera faunas of the northern Pacific coast are less well known than those of the northern Atlantic coast, but it is probable that the Arctic elements predominate in the Recent coastal waters to a point at least as far south as they do on the Atlantic side. The faunas of the Puget Sound-British Columbia area (Cushman, 1925; Cushman and Todd, 1947a) seem predominantly Arctic in general aspect.

The few Recent faunas from the Asiatic side of the Arctic Ocean that have been described (Brady, 1881; Stschedrina, 1936, 1938; Awerinzew, 1911) appear not to differ in any essential way from the Arctic faunas of the Western Hemisphere.

Taking the several Recent Arctic and cold-water faunas listed above as a composite whole, there are few, if any, species common to every one, with the possible exception of *Eggerella advena* (Cushman). Instead, their qualitative unity rests in almost every case at a higher level; that is, in generic or even family similarity. Furthermore, their quantitative unity is almost nonexistent at the level of a single sample. A glance at an occurrence table, such as Phleger's (1952b, p. 84, table 1), makes clear the wide discrepancy in relative abundance from sample to sample of species defined (Phleger, 1952b, list p. 81) as being predominant in the region as a whole. Because of this qualitative and quantitative variation, which is further affected by bottom character and depth, only general statements can be made regarding the similarity or dissimilarity of the fauna from Carter Creek and other Recent or fossil faunas.

PLIOCENE AND PLEISTOCENE FAUNAS

(Fig. 82, nos. 15–18, 20–26)

In the northern Pacific area there are several recorded occurrences of Foraminifera faunas of Pliocene or Pleistocene age. Three from Alaska (see fig. 82, nos. 15, 16, 17) have few species in common with each other and even fewer in common with the fauna from Carter Creek. One of the abundant species, *Angulogerina fluens* Todd, occurs in both the Amchitka Island and Middleton Island faunas but was not recorded from the Nome fauna. The typical form of *Elphidiella*, as represented by *E. arctica* (Parker and Jones), is restricted to post-Miocene strata and is characteristic of cold climatic conditions. As typical representatives of this genus are present in each of the three already described Alaska faunas mentioned above, their absence here is supporting negative evidence pointing to a pre-Pliocene age for the fauna from Carter Creek.

Farther south along the Pacific coast, two Pliocene faunas (fig. 82, nos. 18, 20) provide additional comparisons. The Foraminifera of these two Pliocene sections in western Washington and northern California appear to lack any strong Arctic resemblances and have little if any similarity to the fauna from Carter Creek.

In the northern Atlantic area one surface occurrence and numerous submarine cores and outcrops provide a picture of the Foraminifera of this area during the Pliocene and Pleistocene. The Pleistocene fauna of Maryland (Cushman and Cole, 1930) differs but little from the Recent faunas now living along that coast. The submarine cores from along the continental slope (Cushman, Henbest, and Lohman, 1937; Phleger, 1939) and Georges Bank (Cushman, 1936) and from across the North Atlantic from Newfoundland to Ireland (Cushman and Henbest, 1940) are from sediments that are probably no older than Pleistocene. The species present in the cores are all living species and not distinguishable from Recent deepwater Foraminifera living in the Atlantic and Arctic. The alternations between cold- and warm-water faunas, corresponding to the glacial and interglacial stages, indicate the Pleistocene age of these sediments. Probably because of their deepwater habitat and predominantly planktonic specimens, they have very little in common with the Foraminifera from Carter Creek.

Outcrops from the submarine canyon walls of Georges Bank yield a late Tertiary Foraminifera fauna that is possibly as old as late Pliocene but includes no species known to be fossil elsewhere. In overall aspect it bears no resemblance to the fauna from Carter Creek.

On the European side of the North Atlantic, Pleistocene sediments on the Isle of Man (Reade and Wright, 1906) and near Oslo, Norway (Feyling-Hanssen, 1954), contain faunas very similar to the Recent Arctic faunas of the Western Hemisphere.

The Pliocene Coralline Crag of England and the Pliocene of Belgium and Italy (Jones, Parker, and Brady, 1866; Jones, 1895–97) contain faunas not much different from the Pleistocene faunas of those areas, but richer and more varied. Although these faunas are from warmer and shallower facies than that of the fauna from Carter Creek, a comparison is of interest. As well as may be determined, considering the changes in taxonomy between the time of publication of the Monograph of the Foraminifera of the Crag and the present, the following 12 species appear to occur in the fauna of the Crag and along Carter Creek given in order of abundance along Carter Creek.

Globobulimina affinis (D'Orbigny)	Common	
Globulina inaequalis Reuss	Common	Cosmopolitan.
Oolina laevigata D'Orbigny	Common	
Miliolinella circularis (Bornemann)	Common	
Robulus cultratus Montfort	Common	
Cibicides lobatulus (Walker and Jacob)	Common	Cosmopolitan.
Nonion labradoricum (Dawson)	Rare	
Lagena semilineata Wright	Rare	
Fissurina semimarginata (Reuss)	Rare	
Dentalina soluta Reuss	Very rare	Cosmopolitan.
Oolina squamosa (Montagu)	Very rare	
Oolina borealis Loeblich and Tappan	Very rare	

As indicated in the above, three of these species are cosmopolitan and thus not of value for correlation. Because over half of the remaining nine species are rare or very rare and none of the abundant species from Carter Creek are included, the correlation suggested is tenuous.

MIOCENE FAUNAS

(Fig. 82, nos. 19, 20)

The Foraminifera from along Carter Creek have been compared with the most northern known outcrops of Miocene strata from the Pacific coast (Rau, 1948b; Cushman, Stewart, and Stewart, 1948, pts. 1, 2) and from the Atlantic coast (Dorsey, 1948). These two groups of Miocene faunas are related, particularly in the genera *Nonion*, *Nonionella*, *Bulimina*, *Bolivina*, *Uvigerina*, *Siphogenerina*, and *Eponides*. The Maryland Miocene is further characterized by abundant specimens of the genera *Lagena*, *Virgulina* (*Virgulinella*), and *Valvulineria* and the families Textulariidae and Polymorphinidae; and the Oregon Miocene, by abundant specimens of the genus *Plectofrondicularia*.

The fauna from Carter Creek shows no close affinity to either the Oregon or the Maryland Miocene, and it is doubtful that the Foraminifera indicate any closer migratory connection with the Pacific than with the Atlantic. One of the abundant species from Carter Creek, *Buliminella curta* Cushman, occurs as a fossil on both coasts of North America but has not previously been recorded farther north than about latitude 45° N. (Cushman and Parker, 1947, p. 64–65; Dorsey, 1948, p. 303; Cushman, Stewart, and Stewart, 1948, p. 17).

EARLY TERTIARY FAUNAS

(Fig. 82, nos. 16, 18, 19, 21)

Several early Tertiary faunas of the northern Pacific coast (fig. 82, nos. 16, 18, 19) and one, the most northern of those known from the Atlantic coast, have been compared with the fauna from Carter Creek. The geographically nearest one is that from Amchitka Island in the Aleutians (Todd, 1953). Following are species of the two faunas that are very closely related, but identical in only one case:

Carter Creek	*Amchitka Island*
Dentalina soluta Reuss	*Dentalina soluta* Reuss.
Globulina inaequalis Reuss	*Globulina* sp.
Nonion erucopsis Todd, n. sp	*Nonion planatum* Cushman and Thomas
Gyroidina sp	*Gyroidina girardana* (Reuss).
Cassidulina cf. *C. subglobosa* Brady	*Cassidulina globosa* Hantken.

As the first two species are cosmopolitan, the third one is related by virtue of its position in an evolutionary series, and the last two are questionably identified, correlation seems impossible between the faunas from Carter Creek and Amchitka Island.

Foraminifera of Oregon from the Bastendorff formation of Eocene and Oligocene age (Cushman and Schenk 1928; Detling, 1946) and Oligocene Foraminifera of Washington (Rau, 1951) show no similarity to the fauna from Carter Creek. Likewise the fauna from Carter Creek shows little other than superficial resemblance to the Eocene Foraminifera of Washington (Beck, 1943; Rau, 1948a) and Oregon (Cushman, Stewart, and Stewart, 1948, pts. 3–5).

On the Atlantic side of North America, the most northern record of lower Tertiary Foraminifera seems to be a subsurface occurrence in eastern Maryland (Cushman, 1948b, p. 225–244, pls. 16–20). Of several Eocene (and possibly lowermost Oligocene—Cooper marl equivalent) faunas represented in the well section, none show evidence of close connection with the fauna from Carter Creek.

CONCLUSIONS

The Foraminifera from Carter Creek belong to a moderately deep-cold-water fauna that differs from Recent faunas known from the same region in the presence of a few southern species, particularly *Buliminella curta* Cushman and *Cibicides perlucidus* Nuttall, and in the absence of such typically Arctic genera as *Astrononion* and *Buccella* and scarcity of the various arenaceous, miliolid, and cassidulinid species that are usually common or abundant in the Arctic. As the various species of the fauna from Carter Creek that have southern extensions of their habitat are known along both the Atlantic and the Pacific coasts, it is probable that there was communication between the oceans across the northern part of the continent at the time of deposition of the material along Carter Creek.

In summary, I do not think conclusions regarding the probable or possible migratory connection of the Carter Creek area with either the Pacific or Atlantic side of the continent may be based upon present evidence of the Foraminifera. The chief tie, *Buliminella curta* Cushman, between the fauna from Carter Creek and Miocene faunas, is present both in California and in Maryland. The affinity of the fauna from Carter Creek seems no closer to one side than to the other. Moreover, it has a closer similarity to the geographically closer faunas, a likeness based on likeness of ecology and not of age.

The Foraminifera provide only approximate indications of age of the sediments; a Miocene or Pliocene age seems to be as close as can be determined.

SYSTEMATIC DESCRIPTIONS

In this section, in which genera are alphabetically arranged, are included only the descriptions of the four new species, one redescription, and brief notes on one other species and the genus *Oolina*. Illustrations of most of the remaining species and information regarding their abundance, ecologic implications, and recorded stratigraphic ranges elsewhere are provided by plates 28 and 29 and tables 1 and 2. For these remaining species, the original reference, or a reference to an easily available source wherein the species is well illustrated, is included in an alphabetical list at the end of this section.

Cibicides perlucidus Nuttall

Plate 29, figures 12, 13, 16, 18

Cibicides perlucida Nuttall, 1932, Jour. Paleontology, v. 6, p. 33, pl. 8, figs. 10–12.

The present material exhibits a wide range of characteristics and includes many gradational individuals between those which appear to be microspheric and others which appear to be megalospheric. The following description of the two types of individuals is based on the large suite of specimens from Carter Creek.

Test free, or megalospheric specimens possibly attached by the dorsal side; composed of about 2½ whorls in megalospheric specimens to about 4 whorls in microspheric specimens; microspheric specimens biconvex; megalospheric specimens biconvex or planoconvex with the dorsal side flattened; periphery entire, sometimes very slightly indented around the last few chambers in megalospheric specimens; periphery acute and carinate in microspheric specimens, angled or rounded in megalospheric specimens. Chambers rather indistinct, 12 to 14 constituting the adult whorl in microspheric specimens, 8 or 9 in the adult whorl in megalospheric ones, not inflated, very gradually increasing in size as added. Spiral sutures more distinct than radial ones; sutures slightly limbate, particularly in megalospheric specimens; radial ones gently curved on both dorsal and ventral sides; last several sutures slightly depressed. Wall calcareous, thick, translucent, distinctly perforate in megalospheric specimens; wall of the ventral umbilical area very thick with a few tubular perforations extending in toward the center as radiating oblique lines in megalospheric specimens. Aperture in microspheric specimens a low elongate slit at the base of the last-formed chamber on the ventral side, becoming shorter and higher and migrating toward and over the periphery in megalospheric specimens or becoming entirely peripheral and dorsal in the largest forms. Microspheric individuals: diameter 0.35–0.55 mm, thickness about 0.26 mm. Megalospheric individuals: diameter 1.00–1.75 mm, thickness 0.50–0.70 mm.

Microspheric and megalospheric specimens are about equally abundant. Contrary to the usual size distinctions between microspheric and megalospheric forms, the microspheric forms in this species are smaller than the megalospheric. The proloculum and initial chambers are clearly visible only in the microspheric specimens. In the megalospheric specimens their probable size is inferred from the size of the earliest chambers that are visible (contrast pl. 29, figs. 12 and 13 with figs. 16 and 18).

Cibicides perlucidus was described from the lower Oligocene of Mexico and has been recorded from strata ranging in age from Eocene to Miocene from many localities, as follows: Cuba, Puerto Rico, Barbados, Dominican Republic, Venezuela, Ecuador, Chile, California, Oregon, Washington, Italy, and Spain.

The types from Mexico, as well as most of the illustrated specimens referred to this species, are more similar to the specimens here considered megalospheric than to the microspheric ones. It is possible that microspheric forms have been separated and given different names. A possible, but not verified, example of this is *Eponides?* sp. (Rau, 1948b, p. 779, pl. 119, figs. 18–20) from the Astoria formation of southwestern Washington.

The genus *Cibicides* is one in which many species have been recognized and named. They may, however, be grouped as follows:

(*a*) Those similar to *C. lobatulus* (Walker and Jacob); that is, strongly planoconvex showing evidence of attachment, umbilicus closed, wall equally perforate on dorsal and ventral sides.

(*b*) Those similar to *C. pseudoungerianus* (Cushman); that is, flat and biconvex, with larger perforations on the dorsal than on the ventral side, umbilicus filled with clear shell material.

(*c*) Those similar to *C. floridanus* (Cushman); that is, flat and biconvex with acute periphery, limbate sutures, filled umbilicus, perforations equal and coarse on the dorsal and ventral sides.

(*d*) Those similar to *C. perlucidus* Nuttall and *C. mexicanus* Nuttall; that is, thick with rounded periphery, wall coarsely perforate on both sides.

(*e*) Those similar to *C. cicatricosus* (Schwager); that is, thick with rounded periphery and very coarsely perforate throughout, nearly involute, sutures obscured from wall thickening and perforations.

(*f*) Those similar to *C. refulgens* Montfort; that is, conical with fine perforations, closed umbilicus, and acute entire periphery.

Judging by already known foraminiferal faunas (Nørvang, 1945; Höglund, 1947; Loeblich and Tappan, 1953; Cushman, 1941; Cushman and Todd, 1947b), true *Cibicides*, except for the cosmopolitan species *C. lobatulus*, are absent or rare in Recent and late Tertiary sedimentary rocks of Alaska and other Arctic environments.

Elphidiella? brunnescens Todd, n. sp.

Plate 28, figure 18

Test free, planispiral, biconvex; periphery acute, limbate, entire; umbilical area raised and covered by a fine granulation. Chambers distinct, very slightly increasing in size as added, not inflated; about 11 constituting the adult whorl. Sutures distinct, limbate, slightly raised, radial from the umbilical area, becoming rather strongly curved backward toward the periphery. Wall calcareous with radial structure, finely perforate, smooth except for the limbate sutures and granulation over the umbilical area and in front of the terminal face. No aperture observed; possibly the areas covered by fine granulation or pustules provide communication with the interior of the test by means of pores obscured by the pustules. Diameter 0.60–0.90 mm, thickness about 0.37 mm.

Holotype (USNM 625443) from USGS f11551 (sample 8) from siltstone 210 feet below the base of a capping sandstone at the top of a thick Tertiary sequence exposed on the south limb of an anticline along Carter Creek, 1½ miles south of Camden Bay, in Mount Michelson quadrangle, northeastern Alaska.

The species occurs abundantly also in sample 3.

The generic assignment of this species is questioned because no apertural openings could be recognized on the terminal face nor any rows of canal openings along the radial sutures. The biconvex shape seems to relate it to species of *Elphidiella* having a similar shape; *E. nitida*, *E. hannai*, and *E. groenlandica*, particularly the first mentioned; but no trace of retral processes or sutural pores, even incipient ones, was observed in any of the specimens. Superficially the species resembles the genus *Robulus*, but there is no radiate aperture.

Elphidium? ustulatum Todd, n. sp.

Plate 28, figure 16

Test small for the genus, compressed; umbilical area raised with a small depression in the center; no bosses or slits in the umbilical area; periphery angled but not carinate; margin entire or becoming slightly lobulated around the final chambers. Chambers distinct, about 9 in the adult whorl, not inflated. Sutures distinct, curved, marked by elongate slits, extending nearly from the umbilical region to the periphery but closed at both ends; no retral processes observed. Wall calcareous with radial structure, smooth. Aperture not observed; probably consists of small openings along the base of or in the apertural face. Greater diameter 0.45–0.57 mm, thickness 0.20–0.26 mm.

Holotype (USNM 625440) from USGS f11551 (sample 8) from siltstone 210 feet below the base of a capping sandstone at the top of a thick Tertiary sequence exposed on the south limb of an anticline along Carter Creek, 1½ miles south of Camden Bay, in Mount Michelson quadrangle, northeastern Alaska.

This species is found commonly in both samples. It seems related to *Elphidium incertum* (Williamson) in the long sutural slits but appears to lack any retral processes over the slit openings It differs further from *E. incertum* in the angled, not rounded, periphery.

Globobulimina affinis (D'Orbigny)

Plate 29, figure 1

Bulimina affinis D'Orbigny, 1839, *in* de la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères," v. 6, p. 105, pl. 2, figs. 25, 26.
Globobulimina affinis (D'Orbigny) Phleger, Parker, and Peirson, 1953, Repts. Swedish Deep-sea Exped., v. 7, Sediment cores from the North Atlantic Ocean, no. 1, p. 34, pl. 6, fig. 32.

Specimens referable to this species are common in the Carter Creek fauna.

In accordance with Höglund's (1947, p. 237–244) redescription of the genus, this species falls into a widely distributed and stratigraphically long-ranging (from at least Paleocene to Recent) group of species. The known Recent species of this genus are generally characteristic of deep water. The genus seems to have a worldwide distribution, and its presence at Carter Creek is to be expected. In the vicinity of Point Barrow, single specimens of a closely related, or possibly identical, species were obtained from depths between 37 and 223 meters (Loeblich and Tappan, 1953, p. 110–111).

Lagena saccata Todd, n. sp.

Plate 28, figure 12

Test free, unilocular, circular in section; base flattened; apertural end tapering into a long, slender tube. Body of test nearly equal in width and height; length of apertural neck about 1½ times the height of the body. Wall calcareous, hyaline, translucent, ornamented by about 9 distinct, nonserrate costae that extend from the lower part of the body of the test, leaving a bare circular area on the base of the test, up onto the apertural neck where 3 or 4 of the costae, reduced in size, continue to the end of the neck. Aperture a very small circular opening at the end of the neck, showing no suggestion of internal or external striations. Diameter of body of test 0.25–0.28 mm, maximum length observed 0.73 mm, smallest diameter of apertural neck observed 0.025 mm.

Holotype (USNM 625443) from USGS f11550 (sample 3) from clay shale 160–208 feet below the base of a capping sandstone at the top of a thick Tertiary sequence exposed on the south limb of an anticline along Carter Creek, 1½ miles south of Camden Bay, in Mount Michelson quadrangle, northeastern Alaska.

The species was found only in sample 3 and rather rarely there.

In the present material the costae range from 8 to 11 and vary in strength of development over the test, being highest and sharpest at the base where they terminate at the circumference of the smooth basal area.

In the nearly globular shape of the body chamber, this species suggests *Lagena isabella* (D'Orbigny) described from off the Falklands, but it differs in having fewer costae and in the tapering and very slender neck.

Nonion erucopsis Todd, n. sp.

Plate 28, figure 15

Test free, planispiral, compressed; umbilicus small and depressed; periphery rounded, entire. Chambers distinct, rather rapidly increasing in size but not in thickness as added, not inflated, 8 and a part of the 9th chamber constituting the adult whorl. Sutures distinct, slightly curved, narrow, limbate, neither raised nor depressed, with their inner ends fused into a narrow limbate ring that circles and overhangs the depressed umbilicus. Wall calcareous with granular structure, smooth, thickly and coarsely perforate. Aperture a very low opening extending from one umbilicus across the periphery to the other under the basal part of the last-formed chamber which has a very slightly protruding lip. Greater diameter 0.48–0.52 mm, lesser diameter 0.35–0.40 mm, thickness 0.20 mm.

Holotype (USNM 625438) from USGS f11551 (sample 8) from siltstone 210 feet below the base of a capping sandstone at the top of a thick Tertiary sequence exposed on the south limb of an anticline along Carter Creek, 1½ miles south of Camden Bay, in Mount Michelson quadrangle, northeastern Alaska.

The species is common in both samples.

It appears to be related to the following group of species, which further studies may confirm as an evolutionary series:

Nonion pacificum (Cushman)	Recent	Tropical Pacific.
N. barleeanum (Williamson)	Recent	British Isles.
N. zaandamae (Van Voorthuysen).	Pliocene to Recent.	Netherlands and Arctic.
N. formosum (Seguenza)	Late Tertiary	Italy.
	Recent	Atlantic and Gulf of Mexico.
N. nicobarense (Schwager)	Miocene	Kar Nicobar and Dominican Republic.
N. affine (Reuss)	Oligocene	Europe.
N. vicksburgense Todd	Oligocene	United States.
N. planatum Cushman and Thomas.	Eocene	United States.

It differs from *N. pacificum* in being not at all inflated. It differs from the second, third, and fourth species mentioned in having fewer chambers more distinctly set off by the limbate sutures. It seems to stand about midway between *N. nicobarense* and *N. affine* on the one hand and *N. vicksburgense* and *N. planatum* on the other hand in the nature of its umbilicus, not having the conspicuous limbate ring of the first two nor the umbilical flaps of the last two.

Genus OOLINA D'Orbigny, 1839

Oolina D'Orbigny, 1839, Voyage Am. Mérid., v. 5, pt. 5, Foraminiferes, p. 18.

Parr, 1947, Royal Soc. Victoria Proc., v. 58 (n. ser.), pts, 1–2, p. 119.

Representatives of this genus are abundantly represented in Arctic (Loeblich and Tappan, 1953, p. 67–75) and Antarctic (Parr, 1950, p. 302–305) waters. That the genus has not been recorded as frequently from warmer waters should not be taken as evidence of its scarcity there.

Because of its monothalamous test, there are few characters upon which specific separation may be based. These are shape of test; nature of tube, whether entosolenian or ectosolenian or both; and ornamentation. Experience suggests that ornamentation is a highly variable character, and degree of ornamentation may prove to be not of as much specific importance as type of ornament or number of costae. Hence both smooth and faintly costate specimens are included in *Oolina laevigata* D'Orbigny. (See pl. 29, figs. 5, 8.) Shape of the whole test except for the apertural end, the shape of which is probably diagnostic for species, is also a variable character. The nature of the entosolenian and ectosolenian tubes where present seems to be the least variable of the characters of *Oolina*. Even these tubes, however, may show considerable deviation from the normal for any particular species, such as longer or shorter, bent or straight, or flaring at the outer end. Lacking verification of the natural limits of species of *Oolina*, I have followed the conventional practice of separating them into what are probably artificial categories, based chiefly on ornamentation.

REFERENCES FOR ADDITIONAL IDENTIFIED SPECIES

Angulogerina fluens Todd, *in* Cushman and McCulloch, 1948, p. 288, pl. 36, fig. 1.

Buliminella curta Cushman, Cushman and Parker, 1947, p. 64, pl. 16, fig. 22.

Cassidulina cf. *C. subglobosa* Brady.
  Cassidulina subglobosa Brady, 1884, p. 430, pl. 54, fig. 17.

Cibicides lobatulus (Walker and Jacob), Cushman, 1931, p. 118, pl. 21, fig. 3.

Dentalina soluta Reuss, 1851, p. 60, pl. 3, fig. 4.

Elphidium discoidale (D'Orbigny).
  Polystomella discoidalis D'Orbigny, 1839b, p. 56, pl. 6, figs. 23, 24.
  Elphidium discoidale (D'Orbigny) Cushman, 1939, p. 56, pl. 15, figs. 5–7.

Fissurina globosa Bornemann, 1855, p. 317, pl. 12, fig. 4.

Fissurina semimarginata (Reuss).
  Lagena marginata Williamson var. *semimarginata* Reuss, 1870a, p. 468; 1870b, pl. 4, figs. 4–6, 10–12.

Globulina inaequalis Reuss, 1850, p. 377, pl. 48, fig. 9.

Gyroidina cf. *G. girardana* (Reuss).
  Rotalina girardana Reuss, 1851, p. 73, pl. 5, fig. 34.

Lagena hispidula Cushman, 1913, p. 14, pl. 5, figs. 2, 3.

Lagena semilineata Wright, 1886, p. 320, pl. 26, fig. 7.

Lagena sesquistriata Bagg, 1912, p. 50, pl. 13, figs. 12–14.

Marginulina hantkeni Bandy, 1949, p. 46, pl. 6, fig. 9.
  Marginulina subbullata Hantken, 1881 (not Gümbel, 1861), p. 46, pl. 4, figs. 9, 10; pl. 5, fig. 9.

Miliolinella circularis (Bornemann).
  Triloculina circularis Bornemann, 1855, p. 349, pl. 19, fig. 4.

Nonion labradoricum (Dawson).
  Nonionina labradorica Dawson, 1860, p. 191, fig. 4.

Oolina apiopleura (Loeblich and Tappan).
  Lagena apiopleura Loeblich and Tappan, 1953, p. 59, pl. 10, figs. 14, 15.

Oolina borealis Loeblich and Tappan, 1954, p. 384.
  Entosolenia costata Williamson, 1858 (not *Oolina costata* Egger, 1857), p. 9, pl. 1, fig. 18.

Oolina laevigata D'Orbigny, 1839a, p. 19, pl. 5, fig. 3.

Oolina lineato-punctata (Heron-Allen and Earland).
  Lagena globosa var. *lineato-punctata* Heron-Allen and Earland, 1922, p. 142, pl. 5, figs. 12–14.

Oolina squamosa (Montagu) Loeblich and Tappan, 1953, p. 73, pl. 13, figs. 9, 10.

Pullenia salisburyi R. E. and K. C. Stewart, 1930, p. 72, pl. 8, fig. 2.

Robulus cultratus Montfort, 1808, p. 215, 54th genre.

LITERATURE CITED

Athearn, W. D., 1954, Bottom sediments and Foraminifera from Labrador, *Blue Dolphin*—1951 and 1952: Woods Hole Oceanographic Inst., ref. no. 54-42, p. 1–17, text fig. 1.

Awerinzew, S., 1911, Zur Foraminiferen-Fauna des Sibirischen Eismeeres: Acad. Imp. Sci. St. Petersbourg Mem., ser. 8, v. 29, no. 3, p. 1–27, 1 pl.

Bagg, R. M., 1912, Pliocene and Pleistocene Foraminifera from southern California: U. S. Geol. Survey Bull. 513, p. 1–153, pls. 1–28, text figs. 1–3.

Bandy, O. L., 1949, Eocene and Oligocene Foraminifera from Little Stave Creek, Clarke County, Ala.: Bull. Am. Paleontology, v. 32, no. 131, p. 1–211, pls. 1–27, text figs. 1, 2, table 1.

Beck, R. S., 1943, Eocene Foraminifera from Cowlitz River, Lewis County, Wash.: Jour. Paleontology, v. 17, no. 6, p. 584–614, text figs. 1–4, pls. 98–109.

Bornemann, J. G., 1855, Die mikroskopische Fauna des Septarienthones von Hermsdorf bei Berlin: Deutsch. geol. Gesell. Zeitschr., v. 7, p. 307–371, pls. 12–21.

Brady, H. B., 1878, On the reticularian and radiolarian Rhizopoda (Foraminifera and Polycystina) of the North-Polar Expedition of 1875–76: Annals and Mag. Nat. History, ser. 5, v. 1, p. 425–440, pls. 20, 21, distrib. table.

——— 1881, On some Arctic Foraminifera from soundings obtained on the Austro-Hungarian North-Polar Expedition of 1872–1874: Annals and Mag. Nat. History, ser. 5, v. 8, p. 393–418, distrib. table.

——— 1884, Report on the Foraminifera dredged by H. M. S. *Challenger*, during the years 1873–1876: Reports of the Scientific Results of the Voyage of H. M. S. *Challenger*, v. 9 (Zoology), London, 814 p., 115 pls.

Cushman, J. A., 1913, A monograph of the Foraminifera of the North Pacific Ocean. Part 3. Lagenidae: U. S. Natl. Mus. Bull. 71, pt. 3, p. i–ix, 1–125, pls. 1–47.

——— 1920, Report of the Canadian Arctic Exped. 1913–18. Part M. Foraminifera: Canadian Arctic Exped. 1913–18 Rept., v. 9, pt. M, p. 1–13, pl. 1.

——— 1921, Results of the Hudson Bay Expedition, 1920. I. The Foraminifera: Contr. Canadian Biology, no. 9, p. 135–147.

——— 1925, Recent Foraminifera from British Columbia: Cushman Lab. Foram. Research Contr., v. 1, pt. 2, p. 38–47, pls. 6, 7.

——— 1931, The Foraminifera of the Atlantic Ocean. Part 8. Rotaliidae, etc.: U. S. Natl. Mus. Bull. 104, pt. 8, p. 1–179, pls. 1–26.

——— 1936, Geology and paleontology of the Georges Bank Canyons. Part IV, Cretaceous and Late Tertiary Foraminifera: Geol. Soc. America Bull., v. 47, p. 413–440, pls. 1–5.

——— 1939, A monograph of the foraminiferal family Nonionidae: U. S. Geol. Survey Prof. Paper 191, p. 1–100, pls. 1–20.

——— 1941, Some fossil Foraminifera from Alaska: Cushman Lab. Foram. Research Contr., v. 17, pt. 2, p. 33–38, pl. 9.

——— 1944, Foraminifera from the shallow water of the New England Coast: Cushman Lab. Foram. Research Special Pub. 12, p. 1–37, pls. 1–4.

——— 1948a, Arctic Foraminifera: Cushman Lab. Foram. Research Special Pub. 23, p. 1–79, pls. 1–8.

——— 1948b, Foraminifera from the Hammond well: Md. Dept. Geology, Mines, and Water Res. Bull. 2, p. 213–267, text figs. 25–27 (charts), pls. 15–26.

Cushman, J. A., and Cole, W. S., 1930, Pleistocene Foraminifera from Maryland: Cushman Lab. Foram. Research Contr., v. 6, pt. 4, p. 94–100, pl. 13.

Cushman, J. A., and Henbest, L. G., 1940, Geology and biology of North Atlantic deep-sea cores between Newfoundland and Ireland. Part 2, Foraminifera: U. S. Geol. Survey Prof. Paper 196–A, p. 35–56, text figs. 11–21 (charts), pls. 8–10.

Cushman, J. A., Henbest, L. G., and Lohman, K. E., 1937, Notes on a core-sample from the Atlantic Ocean bottom southeast of New York City: Geol. Soc. America Bull., v. 48, p. 1297–1306, pl. 1.

Cushman, J. A., and McCulloch, Irene, 1948, The species of *Bulimina* and related genera in the collections of the Allan Hancock Foundation: Allan Hancock Pacific Exped., v. 6, no. 5, p. 231–294, pls. 29–36.

Cushman, J. A., and Parker, F. L., 1947, *Bulimina* and related foraminiferal genera: U. S. Geol. Survey Prof. Paper 210–D, p. 55–176, pls. 15–30.

Cushman, J. A., and Schenck, H. G., 1928, Two foraminiferal faunules from the Oregon Tertiary: Calif. Univ., Dept. Geol. Sci. Bull., v. 17, no. 9, p. 305–324, pls. 42–45.

Cushman, J. A., Stewart, R. E., and Stewart, K. C., 1948, Five papers on Foraminifera from the Tertiary of western Oregon: Oreg. Dept. Geology and Min. Industries Bull. 36, pts. 1–5, p. 1–111, pls. 1–13, text figs. 1–4.

——— 1949, Quinault Pliocene Foraminifera from western Washington: Oreg. Dept. Geology and Min. Industries Bull. 36, pt. 7, p. 148–163, pls. 17, 18, text fig. 6.

Cushman, J. A., and Todd, Ruth, 1947a, Foraminifera from the coast of Washington: Cushman Lab. Foram. Research Special Pub. 21, p. 1–23, pls. 1–4.

——— 1947b, A foraminiferal fauna from Amchitka Island, Alaska: Cushman Lab. Foram. Research Contr., v. 23, pt. 3, p. 60–72, pls. 14–16.

Dawson, J. W., 1860, Notice of Tertiary fossils from Labrador, Maine, etc., and remarks on the climate of Canada in the newer Pliocene or Pleistocene period: Canadian Naturalist, v. 5, p. 188–200, illus.

Detling, M. R., 1946, Foraminifera of the Coos Bay Lower Tertiary, Coos County, Oreg.: Jour. Paleontology, v. 20, no. 4, p. 348–361, pls. 46–51.

Dorsey, Ann, 1948, Miocene Foraminifera from the Chesapeake group of southern Maryland: Md. Dept. Geology, Mines, and Water Res. Bull. 2, p. 268–321, text figs. 28, 29 (charts), 30 (map), pls. 27–39, table 20.

Feyling-Hanssen, R. F., 1954, Late-Pleistocene Foraminifera from the Oslofjord area, southeast Norway: Norsk geol. tidsskr., v. 33, pt. 1–2, p. 109–152, pls. 1, 2, text figs. 1–5.

Hantken, Max, 1881, Die Fauna der *Clavulina Szaboi* Schichten. I. Foraminiferen: Mitt. Jahrbuch K. Ungar. geol. Anstalt, v. 4, 1875 (1881), p. 1–93, pls. 1–16.

Heron-Allen, Edward, and Earland, Arthur, 1922, British Antarctic ("Terra Nova") Expedition, 1910. Protozoa. Part 2.—Foraminifera: British Mus. (Nat. History), Zoology, v. 6, no. 2, p. 25–268, pls. 1–8, 1 text fig.

Höglund, Hans, 1947, Foraminifera in the Gullmar Fjord and the Skagerak: Zool. Bidrag från Uppsala, Band 26, p. 1–328, 312 text figs., 32 pls., 2 maps, 7 tables.

Jones, T. R., 1895–97, A monograph of the Foraminifera of the Crag. Parts 2, 3, and 4: Palaeont. Soc., v. 39, p. 73–210, pls. 5–7; v. 40, p. 211–314; v. 41, p. 315–402.

Jones, T. R., Parker, W. K., and Brady, H. B., 1866, A monograph of the Foraminifera of the Crag. Part 1: Palaeont. Soc., v. 19 (for 1865), p. 1–72, pls. 1–4.

Leffingwell, E. de K., 1919, The Canning River region, northern Alaska; U. S. Geol. Survey Prof. Paper 109, p. 1–251, pls. 1–35, text figs. 1–33.

Loeblich, A. R., Jr., and Tappan, Helen, 1953, Studies of Arctic Foraminifera: Smithsonian Misc. Coll., v. 121, no. 7, p. 1–150, text fig. 1, pls. 1–24.

——— 1954, New names for two foraminiferal homonyms: Wash. Acad. Sci. Jour., v. 44, no. 12, p. 384.

MacNeil, F. S., 1957, Cenozoic megafossils of the Arctic coast of Alaska: U. S. Geol. Survey Prof. Paper 294–C.

Miller, D. J., 1953, Late Cenozoic marine glacial sediments and marine terraces of Middleton Island, Alaska: Jour. Geology, v. 61, no. 1, p. 17–40.

Millett, F. W., 1885, Notes on the fossil Foraminifera of the St. Erth clay pits: Royal Geol. Soc. Cornwall Trans., v. 10, pt. 7, p. 213–216.

——— 1895, The Foraminifera of the Pliocene beds of St. Erth: Royal Geol. Soc. Cornwall Trans., v. 11, pt. 9, p. 655–661, 1 pl.

——— 1898, Additions to the list of Foraminifera from the St. Erth clay: Royal Geol. Soc. Cornwall Trans., v. 12, pt. 3, p. 174–176, 1 pl.

Montfort, Denys de, 1808, Conchyliologie systematique et classification methodique des Coquilles: Paris, F. Schoell, v. 1, 409 p., illus.

Norman, A. M., 1876, Crustacea, Tunicata, Polyzoa, Echinodermata, Actinozoa, Foraminifera, Polycystina, and Spongida, *in* Jeffreys, J. G., Preliminary report of the biological results of a cruise in H. M. S. *Valorous* to Davis Strait in 1875: Royal Soc. London Proc., v. 25, p. 202–215.

Nørvang, Aksel, 1945, The zoology of Iceland, v. 2, pt. 2, Foraminifera: Copenhagen and Reykjavik, Ejnar Munksgaard, p. 1–79, text figs. 1–14.

Orbigny, A. D. D', 1839a, Voyage dans l'Amérique Méridionale, Foraminifères: Paris and Strasbourg, tome 5, pt. 5, p. 1–86, 9 pls.

——— 1839b, Foraminifères, *in* Ramon de la Sagra, Histoire physique, politique et naturelle de l'Ile de Cuba: Paris, p. xlviii, 1–224, 12 pls.

Parker, F. L., 1948, Foraminifera of the continental shelf from the Gulf of Maine to Maryland: Mus. Comp. Zoology Bull., v. 100, no. 2, p. 213–253, pls. 1–7, text figs. 1–4, tables 1–10.

——— 1952a, Foraminifera species off Portsmouth, N. H.: Mus. Comp. Zoology Bull., v. 106, no. 9, p. 391–423, pls. 1–6.

——— 1952b, Foraminiferal distribution in the Long Island Sound–Buzzards Bay area: Mus. Comp. Zoology Bull., v. 106, no. 10, p. 425–473, pls. 1–5, text figs. 1–4, tables 1–6.

Parker, W. K., and Jones, T. R., 1865, On some Foraminifera from the North Atlantic and Arctic Oceans, including Davis Straits and Baffin's Bay: Philos. Trans., 1865, p. 325–441, pls. 12–19, tables 1–12.

Parr, W. J., 1950, Foraminifera: B. A. N. Z. Antarctic Research Exped. 1929–31, Repts., ser. B (Zoology and Botany), v. 5, pt. 6, Foraminifera, p. 233–392, pls. 3–15, text figs. 1–8.

Phleger, F. B., Jr., 1939, Foraminifera of submarine cores from the continental slope: Geol. Soc. America Bull., v. 50, p. 1395–1422, figs. 1–4, pls. 1–3.

——— 1952a, Foraminifera ecology off Portsmouth, N. H.: Mus. Comp. Zoology Bull., v. 106, no. 8, p. 315–390, text figs. 1–26, tables 1–18.

——— 1952b, Foraminifera distribution in some sediment samples from the Canadian and Greenland Arctic: Cushman Found. Foram. Research Contr., v. 3, pt. 2, p. 80–89, pls. 13, 14, text fig. 1 (map), table 1.

Rau, W. W., 1948a, Foraminifera from the Porter shale (Lincoln formation), Grays Harbor County, Wash.: Jour. Paleontology, v. 22, no. 2, p. 152–174, pls. 27–31.

——— 1948b, Foraminifera from the Miocene Astoria formation in southwestern Washington: Jour. Paleontology, v. 22, no. 6, p. 774–782, pl. 119.

——— 1951, Tertiary Foraminifera from the Willapa River Valley of southwest Washington: Jour. Paleontology, v. 25, no. 4, p. 417–453, pls. 63–67.

Reade, T. M., and Wright, Joseph, 1906, The Pleistocene clays and sands on the Isle of Man: Liverpool Geol. Soc. Proc., 1905–1906, p. 103–117.

Reuss, A. E., 1850, Neue Foraminiferen aus den Schichten des österreichischen Tertiärbeckens: Akad. Wiss. Wien, Math.-naturwiss. Kl., Denkschr., Band 1, p. 365–390, pls. 46–51.

——— 1851, Ueber die fossilen Foraminiferen und Entomostraceen der Septarienthone der Umgegend von Berlin: Deutsch. geol. Gesell. Zeitschr., v. 3, p. 49–92, pls. 3–7.

——— 1870a, Die Foraminiferen des Septarien-Thones von Pietzpuhl: Akad. Wiss. Wien, Sitzungsber., v. 62, pt. 1, p. 455–493.

——— 1870b, *in* E. von Schlicht, Die Foraminiferen des Septarienthones von Pietzpuhl: Berlin, 38 pls.

Stewart, R. E., and Stewart, K. C., 1930, Post-Miocene Foraminifera from the Ventura quadrangle, Ventura County, Calif.: Jour. Paleontology, v. 4, no. 1, p. 60–72, pls. 8, 9.

——— 1949, Local relationships of the Mollusca of the Wildcat Coast section, Humboldt County, Calif.: Oreg. Dept. Geology and Min. Industries Bull. 36, pt. 8, p. 165–208, pls. 19–22, text fig. 7, table 1.

Stschedrina, Z. G., 1936, Zur kenntnis der Foraminiferenfauna der Arktischen Meere der USSR: Trans Arctic Inst., Leningrad, v. 33, p. 51–64, 1 distrib. table.

——— 1938, On the distribution of Foraminifera in the Kara Sea: Comptes rendus Acad. Sci. URSS, v. 19, no. 4, p. 319–322.

Todd, Ruth, 1953, Foraminifera from the Lower Tertiary of Amchitka Island, Aleutian Islands: Cushman Found. Foram. Research Contr., v. 4, pt. 1, p. 1–7, pls. 1, 2.

Williamson, W. C., 1858, On the Recent Foraminifera of Great Britain: Ray Soc., London, 1858, 107 p., 7 pls.

Wright, Joseph, 1886, Foraminifera of the Belfast Naturalists' Field Club's Cruise off Belfast Lough in the Steamtug *Protector*, June 1885; also, Foraminifera found by Dr. Malcolmson at Rockport, Belfast Lough: Belfast Nat. Field Club Proc., 1885–86 (1886), app. 9, p. 317–326, pl. 26.

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[Italic page numbers indicate descriptions]

PLATES 28 AND 29

PLATE 28

Specimens illustrated in figures 10, 16, 17, 21, 22 were whitened with an ammonium chloride spray in order to bring out surface detail, and hence have lost their natural luster.

FIGURE 1. *Involutina* sp. (p. 224).
USNM 625423, × 43. USGS f11550 (sample 3).

2. *Haplophragmoides?* sp. A (p. 224).
USNM 625424, × 80. USGS f11550 (sample 3). *a*, Side view; *b*, rear peripheral view.

3. *Cyclammina* sp. (p. 224).
USNM 625425, × 43. USGS f11550 (sample 3).

4. *Miliolinella circularis* (Bornemann) (p. 224).
USNM 625426, × 43. USGS f11550 (sample 3). *a*, Side view; *b*, front peripheral view.

5. *Cornuspira* sp. (p. 224).
USNM 625427, × 43. USGS f11551 (sample 8). *a*, Side view; *b*, peripheral view.

6. *Robulus cultratus* Montfort (p. 224).
USNM 625428, × 43. USGS f11551 (sample 8). *a*, Side view; *b*, peripheral view.

7. *Marginulina hantkeni* Bandy (p. 224).
USNM 625429, × 60. USGS f11550 (sample 3).

8. *Dentalina soluta* Reuss (p. 224).
USNM 625430, × 28. USGS f11550 (sample 3).

9. *Lagena semilineata* Wright (p. 224).
USNM 625432, × 43. USGS f11550 (sample 3).

10. *Lagena hispidula* Cushman (p. 224).
USNM 625431, × 43. USGS f11550 (sample 3).

11. *Lagena sesquistriata* Bagg (p. 224).
USNM 625435, × 43. USGS f11551 (sample 8).

12. *Lagena saccata* Todd, n. sp. (p. 231).
Holotype, USNM 625433, × 43. USGS f11550 (sample 3).

13. *Globulina inaequalis* Reuss (p. 224).
USNM 625436, × 43. USGS f11550 (sample 3). *a*, Side view; *b*, top view.

14. *Elphidium discoidale* (D'Orbigny) (p. 224).
USNM 625442, × 40. USGS f11550 (sample 3). *a*, Side view; *b*, peripheral view.

15. *Nonion erucopsis* Todd, n. sp. (p. 231).
Holotype, USNM 625438, × 80. USGS f11551 (sample 8). *a*, Side view; *b*, peripheral view.

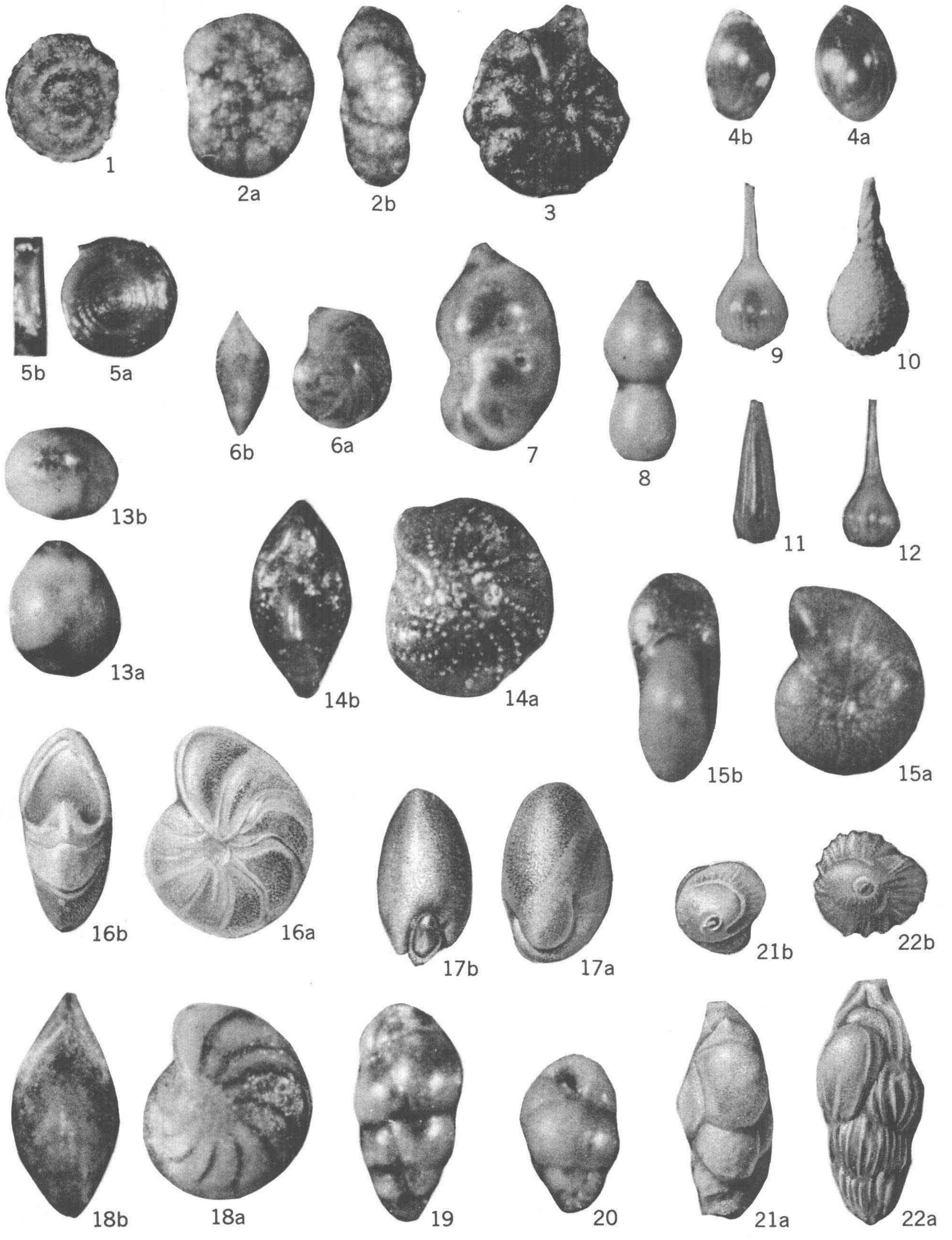
16. *Elphidium? ustulatum* Todd, n. sp. (p. 230).
Holotype, USNM 625440, × 80. USGS f11551 (sample 8). *a*, Side view; *b*, peripheral view.

17. *Nonion labradoricum* (Dawson) (p. 224).
USNM 625437, × 80. USGS f11550 (sample 3). *a*, Side view; *b*, peripheral view.

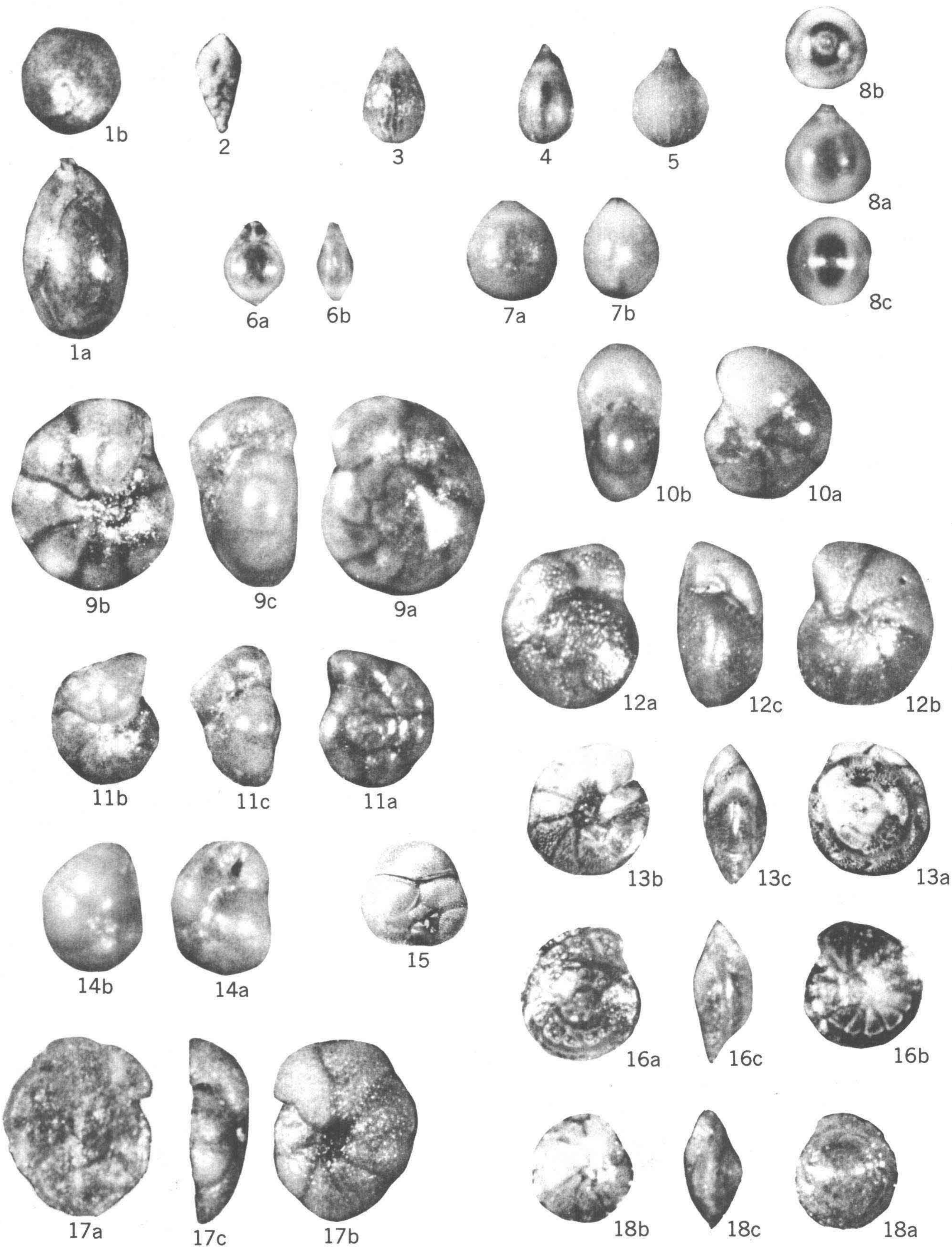
18. *Elphidiella? brunnescens* Todd, n. sp. (p. 230).
Holotype, USNM 625443, × 50. USGS f11551 (sample 8). *a*, Side view; *b*, peripheral view.

19, 20. *Buliminella curta* Cushman (p. 224).
19, USNM 625445; 20, USNM 625446. × 80. USGS f11551 (sample 8).

21, 22. *Angulogerina fluens* Todd (p. 224).
21, USNM 625449; 22, USNM 625450. × 80. USGS f11551 (sample 8). *a*, Side views; *b*, top views.



FORAMINIFERA FROM CARTER CREEK, NORTHEASTERN ALASKA



FORAMINIFERA FROM CARTER CREEK, NORTHEASTERN ALASKA

PLATE 29

Specimens illustrated in figures 2, 5, 15 were whitened with an ammonium chloride spray in order to bring out surface detail, and hence have lost their natural luster.

FIGURE 1. *Globobulimina affinis* (D'Orbigny) (p. 231).
USNM 625447, ×40. USGS f11550 (sample 3). *a*, Side view; *b*, top view.

2. *Bolivina* sp. (p. 224).
USNM 625448, ×80. USGS f11551 (sample 8).

3. *Oolina squamosa* (Montagu) (p. 224).
USNM 625454, ×60. USGS f11551 (sample 8).

4. *Oolina borealis* Loeblich and Tappan (p. 224).
USNM 625453, ×60. USGS f11550 (sample 3).

5, 8. *Oolina laevigata* D'Orbigny (p. 224).
5, USNM 625452, ×43; costate form. 8, USNM 625451, ×43; smooth form. USGS f11550 (sample 3). 8*a*, Side view; 8*b*, top view; 8*c*, basal view.

6. *Fissurina semimarginata* (Reuss) (p. 224).
USNM 625455, ×43. USGS f11550 (sample 3). *a*, Front view; *b*, side view.

7. *Fissurina globosa* Bornemann (p. 224).
USNM 625456, ×43. USGS f11550 (sample 3). *a*, Front view; *b*, side view.

9. *Gyroidina* sp. (p. 224).
USNM 625458, ×60. USGS f11550 (sample 3). *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

10. *Pullenia salisburyi* R. E. and K. C. Stewart (p. 224).
USNM 625460, ×80. USGS f11551 (sample 8). *a*, Side view; *b*, peripheral view.

11. *Gyroidina* cf. *G. girardana* (Reuss) (p. 224).
USNM 625457, ×60. USGS f11551 (sample 8). *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

12,13,16,18. *Cibicides perlucidus* Nuttall (p. 229).
12, USNM 625462, ×28; 13, USNM 625463, ×20; 16, USNM 625464, ×43; 18, USNM 625465, ×43. 12, 13, 16, USGS f11551 (sample 8); 18, USGS f11550 (sample 3). Series showing gradation from megalospheric (fig. 12) to microspheric (fig. 18) forms. *a*, Dorsal views; *b*, ventral views; *c*, peripheral views.

14. *Cassidulina* cf. *C. subglobosa* Brady (p. 224).
USNM 625459, ×80. USGS f11551 (sample 8). *a*, Apertural view; *b*, side view.

15. *Sphaeroidina* sp. (p. 224).
USNM 625461, ×60. USGS f11550 (sample 3).

17. *Cibicides lobatulus* (Walker and Jacob) (p. 224).
USNM 625466, ×43. USGS f11550 (sample 3). *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

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