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Foraminifera from the Mancos Shale of East Central Utah*

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ABSTRACT.—The Upper Cretaceous foraminifera fauna of the Mancos Shale of east central Utah consists of 25 families, represented by 44 genera, and range in age from late Cenomanian to early Campanian. The fauna is characterized by three major assemblages: a lower nodosariid, buliminid, and planktonic assemblage which can be further subdivided into 3 biostratigraphic zones representing postulated water depths of 75 to 200 feet, with a connection to the open sea; a middle assemblage characterized by calcareous benthonic and agglutinate foraminifera, subdivided into four biostratigraphic zones representing postulated water depth of 75 to 400 feet; and a third faunal assemblage dominated by agglutinate forms indicative of water depth of 0 to 20 feet and decreased salinity.

The three major transgressive sequences are separated stratigraphically by two delta complexes which built from the west. The first transgressive event progressed over the area from the southeast, flooding the Henry Mountains area, and later the Woodside area. The second transgressive event proceeded from the north or northeast and flooded the Woodside area first, then spread along a fore-deep in the Castle Valley area and ultimately reached the Henry Mountains area much later. The third transgressive event does not appear to have been greatly affected by either the northern or southern extensions of the San Rafael Swell and has moved from east to west without significant interruption.

Of the two delta complexes the first, the Ferron Delta, was much more extensive spreading deposits over most of the study area. The later complex, the Emery Delta, produced extensive sandy deposits in western Castle Valley but thinned rapidly to the north and east. The sandstone beds do not extend into the Woodside or Henry Mountains area.

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INTRODUCTION

The Mancos Shale, of Late Cretaceous age, contains an abundant foraminifera fauna and is chiefly a dark gray marine shale containing two widespread sandy units—the Ferron and Emery Sandstone members. Hale (1972) regarded the Ferron and Emery units as formations in east central Utah and applied the earlier proposed Tununk Shale to the unit beneath the Ferron Sandstone, the Blue Gate Shale to the unit above it, and the Masuk Shale to the unit above the Emery Sandstone. The Tununk, Blue Gate, and Masuk shales are regarded as members of the Mancos Formation here, following usage of the U.S. Geological Survey. The Mancos Shale rests rather sharply, at times unconformably, on the Lower (?) and Upper Cretaceous Dakota Sandstone, and grades upward into and interfingers with the cliff-forming Upper Cretaceous Star Point Sandstone.

The Mancos Shale is less resistant to erosion than the overlying and underlying formations in eastern Utah and forms a series of valleys around the San Rafael Swell. Castle Valley is west of the San Rafael Swell and east of the Wasatch Plateau. Price Valley, named by Stokes in 1954, was formerly called Clark Valley (Clark, 1928) and wraps around the northern end of the San Rafael Swell. Blue Valley is situated between the southern flank of the San Rafael Swell and the Henry Mountains.

This study describes foraminifera recovered from the Mancos Shale in east central Utah, based upon a total of 2,564 samples. Of these samples 1,126 were examined for foraminifera. The study area is located on the outcrop belt of the Mancos Shale where the unit is exposed around three sides of the San Rafael Swell and along the west flank of the Henry Mountains (Text-fig. 1). Studied sections occur across the belt of Mancos Shale from the Book Cliffs near Woodside; on the western flank of the San Rafael Swell in Castle Valley; on the southeastern flank of the San Rafael Swell, just north of Utah Highway 24 between the communities of Hanksville and Caineville; and on the west flank of the Henry Mountains approximately 10 miles south of Utah Highway 24.

Acknowledgments

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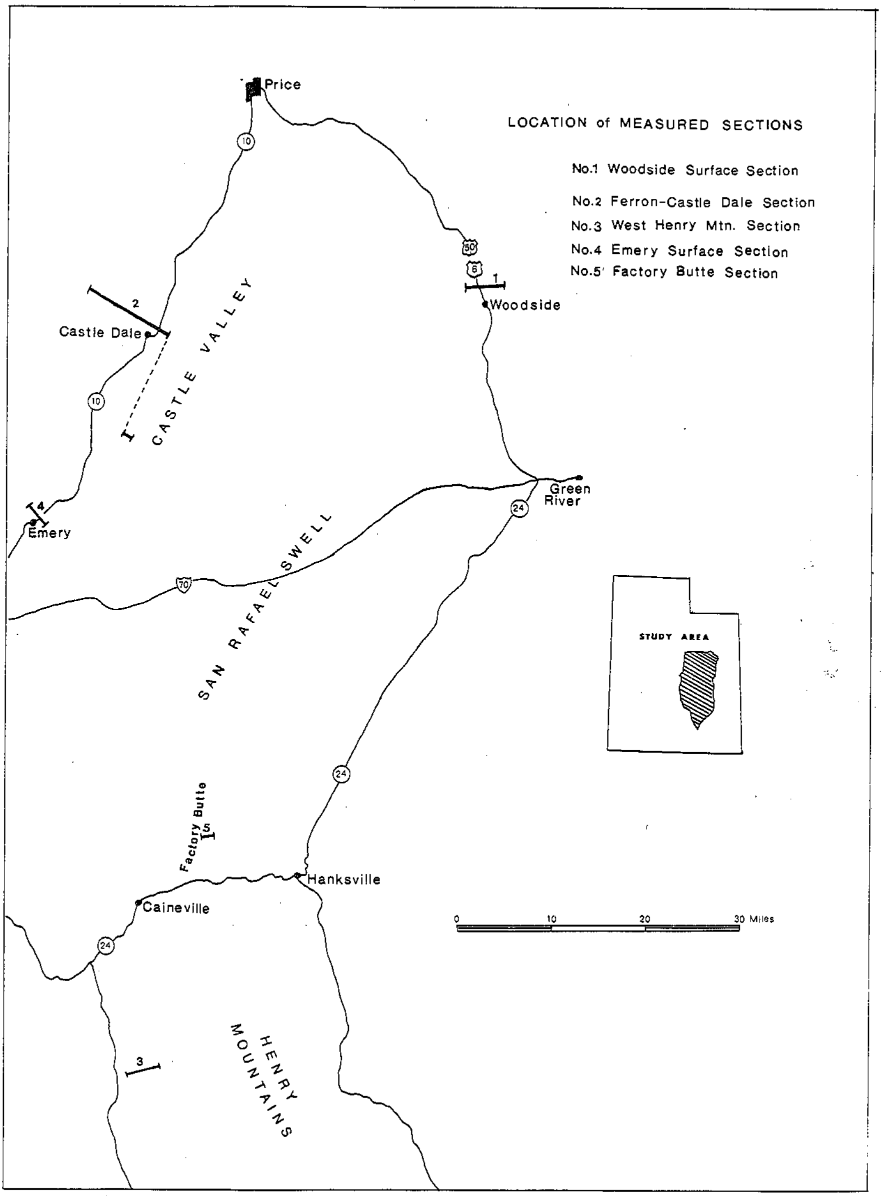


TEXT-FIGURE 1.—Index map showing location of measured sections in the east central Utah area.

comments during the study. Special thanks also to Dr. Morris Peterson of the thesis committee for his valuable assistance.

Previous Work

Previous microfaunal studies of the Mancos Shale in east central Utah were made by Lessard (1973), who studied the microfauna of the Tununk Member of the Mancos Shale and its paleoecological implications. He described 20 foraminifera species and 8 ostracoda species. Three unpublished theses were completed on the microfaunas of partially equivalent formations. Glissmeyer (1959) investigated the microfauna of the Funk Valley Formation in central Utah, and Green (1959) studied the microfauna of the Allen Valley Shale in the same general area. Rashel Nikravesh (1963) worked on the microfauna of the Allen Valley Shale in Sanpete County, Utah.

Stratigraphic studies of the Mancos Shale in central Utah have been numerous. A few of the more extensive and helpful studies are those of Spieker and Reeside (1925, 1926), Hunt, Averitt, and Miller (1953), and Katich (1954). More recent papers on portions of the Mancos Formation are those of Hale (1972) and Cleavinger (1974), both of which discussed the paleoenvironment and depositional history of the Ferron Sandstone.

Field and Laboratory Methods

Good exposures were found by reference to topographic maps and aerial photographs, by field reconnaissance, and by reference to previous field mapping by Shell Oil Company geologists. Main factors determining choice of sections to be measured and sampled were thickness of the exposure, freshness of the surface, and position with respect to other measured sections. Measurement was made by hand level and steel tape. Color, hardness, calcareous content, and silt-sand content of shale were noted, as were layers of concretions, bentonite beds, and other distinctive horizons. Lithologic samples were taken at five-foot intervals, except where special circumstances required closer spaced samples. Every effort was made to secure fresh, uncontaminated shale samples by using a post-hole shovel to dig through the weathered surface material.

In the laboratory the samples were crushed with a chipmunk crusher and divided by a sample splitter so that 100-gram samples could be obtained. The 100-gram samples were soaked in water with a wetting agent and rolled in pint jars for several hours until the samples were thoroughly disaggregated. The samples were finally washed on a Tyler-equivalent 200-mesh screen.

Samples were completely picked of foraminifera unless an individual species had an abundance of approximately 20 or more specimens per sample. If abundances were so great as to make picking and counting impractical, abundance was estimated from a random grid count of that particular species. Picked specimens were identified by use of a Wild binocular microscope. Other than reference and type material, all specimens were mounted on gum tragacanth-coated microfaunal slides and are retained in the Microfaunal Library of Shell Oil Company.

The type specimens selected for this study were mounted on scanning electron microscope stubs, were photographed by the scanning electron microscope at the Brigham Young University Botany Department laboratory, and are housed in the type collections of the Geology Department, Brigham Young University.

Measured Surface Sections

The Ferron-Castledale section, T. 18 & 20 S, R. 8 E, Emery County, Utah, was measured and sampled along the north side of the Horn Silver Gulch road, beginning at the top of the Dakota Sandstone in section 36, T. 20 S, R. 8 E, about 12 miles east of Ferron, Utah (Text-figs. 2A and 2 B). The Tununk member was sampled along a northwesterly traverse to the base of the first massive sandstone ledge in the Ferron Member in the SW¼, Sec. 26, T. 20 S, R. 8 E. Using the massive sandstone as a key bed, the section was offset to the north approximately 10 miles to the NW¼, Sec. 36, T. 18 S, R. 8 E, where Cottonwood Creek cuts through the Ferron Sandstone. From here the traverse continued in a general northwesterly direction, with numerous small offsets, passed along the north side of the communities of Castle Dale and Orangeville, and terminated at the base of the first massive sandstone ledge of the Star Point Sandstone in Sec. 6. T. 18 S, R. 7 E, about 7 miles northwest of Orangeville, Utah.

The Ferron-Castledale section was used as a control section; 415 of the 785 samples collected were analyzed, at each 5-foot interval wherever there appeared to be a change in fauna (Plate 18).

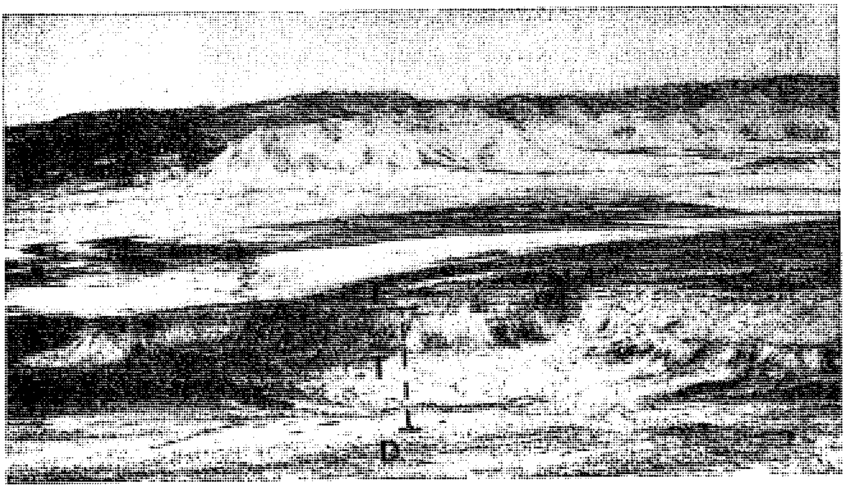
The Woodside section was measured and sampled beginning at the top of the Dakota Sandstone in Sec. 24, T. 17 S, R. 13 E, about one-half mile north of the Silvagni Ranch in Emery County, Utah. The section was measured and sampled along an easterly traverse to the base of the Castle Gate Sandstone in Sec. 13, T. 17 S, R. 14 E (Text-fig. 3).

Samples from the Woodside section were analyzed on the basis of one sample for each 25- to 30-foot interval, except in the Tununk Member where five-foot intervals were utilized. A total of 966 samples were taken, of which 211 were picked (Plate 17).

The West Henry Mountains section was measured and sampled, beginning at the top of the Dakota Sandstone in Sec. 6, T. 33 S, R. 8 E, Garfield County, Utah, and proceeding east to the base of the thick resistant sandstone ledge which caps a spur of Tarantula Mesa in Sec. 5, T. 33 S, R. 8 E (Text-fig. 4), which is the top unit of the Masuk Member as mapped by Hunt, Averitt, and Miller (1953).

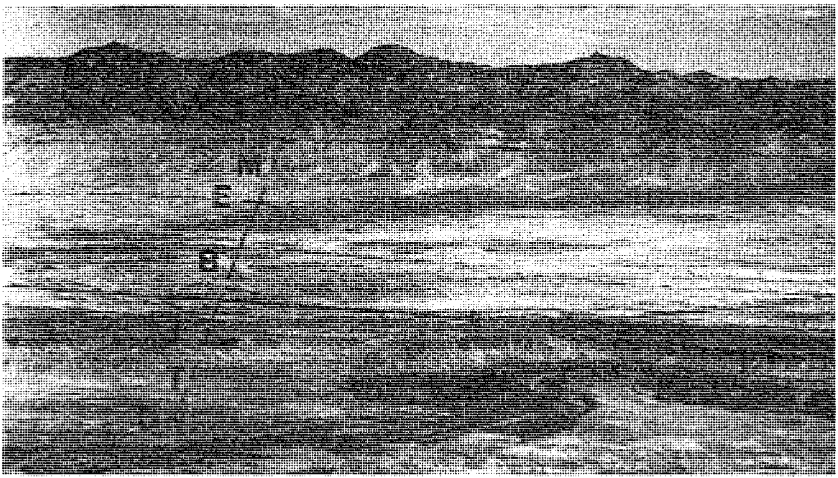
Because of the difference in faunal assemblage and distribution from that recovered from the Ferron-Castledale section, the West Henry Mountains section was also carefully studied. Of the 651 samples taken 428 were analyzed for foraminifera. Only one sample in each 50-foot interval was examined in the upper 1,100 feet of the section because no foraminifera were recovered. However, each 5-foot sample was examined wherever foraminifera were recovered (Plate 19).

Because of the change in faunal distribution between the Ferron-Castledale section and the West Henry Mountains section, two additional intervening sections were measured and sampled for additional control in the Blue Gate Member. The Emery surface section was measured and sampled near the town of Emery, beginning at the top of the Ferron Sandstone in Sec. 1, T. 22 S, R. 6 E, Emery County, Utah. The traverse followed a ridge extending northwest to the SE ¼ of Sec. 22, T. 21 S, R. 6 E, to the base of the first resistant sandstone of the Emery Sandstone (Text-fig. 5). The Factory Butte section was measured in Sec. 23, T. 27 S, R. 9 E, Wayne County, Utah, beginning at the top of the

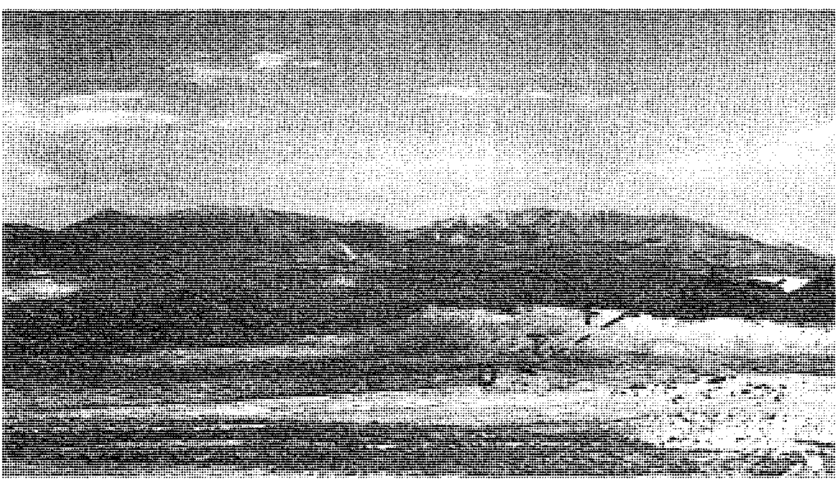


TEXT-FIGURE 2A.—View of the lower Ferron-Castledale section as seen from the air looking to the west, and showing the line of traverse of the measured section. D, (?) Dakota Sandstone; T, Tununk Shale; F, Ferron Sandstone.

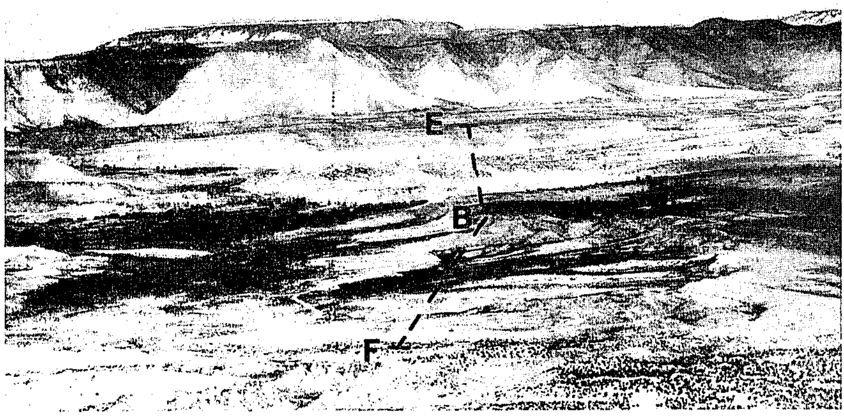
TEXT-FIGURE 2B.—View of the upper Ferron-Castledale section as seen from the air looking to the west, showing the line of traverse of the measured section. F, Ferron Sandstone; B, Blue Gate Shale; E, Emery Sandstone; M, Masuk Shale; S, Star Point Sandstone.



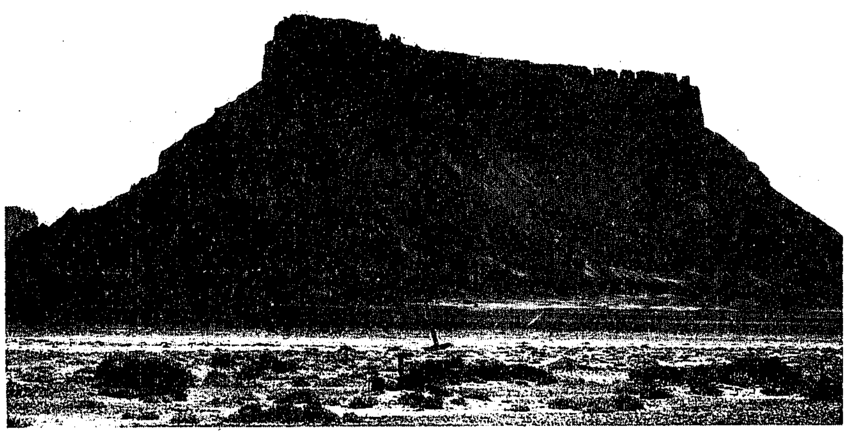
TEXT-FIGURE 3.—View of the Woodside section as seen from the air looking to the northeast showing the line of traverse of the measured section. D, (?) Dakota Sandstone; T, Tununk Shale; F, Ferron Sandstone; E, Emery Sandstone; M, Masuk Shale.



TEXT-FIGURE 4.—View of the West Henry Mountains section looking to the east, showing the line of traverse of the measured section. D, (?) Dakota Sandstone; T, Tununk shale; B, Blue Gate Shale; E, Emery Sandstone; M, Masuk Shale.



TEXT-FIGURE 5.—View of the Emery section as seen from the air looking to the west, showing the line of traverse of the measured section. F, Ferron Sandstone; B, Blue Gate Shale; E, Emery Sandstone.



TEXT-FIGURE 6.—View of the Factory Butte section as seen from the air, looking to the west, showing the line of traverse of the measured section. F, Ferron Sandstone; B, Blue Gate Shale.

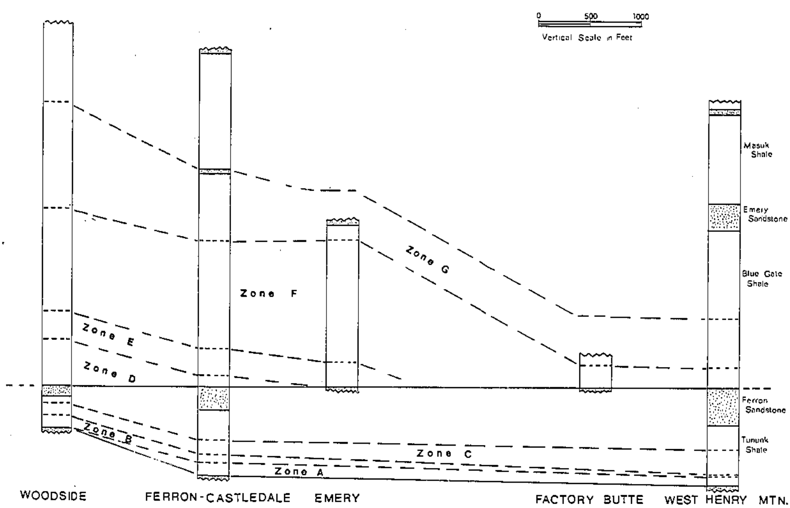
Ferron Sandstone and measuring the basal 230 feet of the Blue Gate Shale (Text-fig. 6). Both the Emery and Factory Butte sections were sampled at 5-foot intervals, but samples were analyzed at 25- to 30-foot intervals (Plates 20, 21).

STRATIGRAPHY

The Mancos Shale in the east central Utah area is divided into five members that total from 3,500 feet thick in the Henry Mountains area to 4,550 feet thick in the Woodside area. All the contacts, both between the members and at the top of the formation, are gradual and arbitrary. The bottom contact of the formation is gradational and arbitrary in the southern part of the area but is unconformable in the northeastern part of the area. In ascending order, the members are: Tununk Shale, Ferron Sandstone, Blue Gate Shale, Emery Sandstone, and Masuk Shale. Details of the stratigraphy and origin of the Mancos Shale and associated formations in east central Utah were discussed by Spieker and Reeside (1925; 1926), Hunt, Averitt, and Miller (1953), and Katich (1954).

Tununk Shale Member

The Tununk Shale Member is a dark gray, slightly fissile shale, and includes a few thin bentonite layers and, near the top and bottom, some sandstone beds. The Tununk Shale is gradational with the uppermost sandstone bed of the Dakota Sandstone, particularly in the southern San Rafael Swell and Henry Mountains area, but lies unconformably upon the Cedar Mountain Formation in the northeastern San Rafael Swell area. The shale member intertongues and intergrades with the overlying Ferron Sandstone Member. The Tununk Shale's thickness varies from 380 feet in the Woodside area to 610 feet in the Ferron-Castledale area. The range in thickness is largely because of intertonguing with the Ferron Sandstone. However, in the Woodside area, zonation based on foraminifera (Text-fig. 7) indicates a lack of equivalents



TEXT-FIGURE 7.—Biostratigraphic zonation chart.

to the basal Tununk sediments which accumulated elsewhere. This break also gives supporting evidence for the unconformable relationship of the Tununk Shale on the Cedar Mountain Formation in the area between Woodside and Green River.

Ferron Sandstone Member

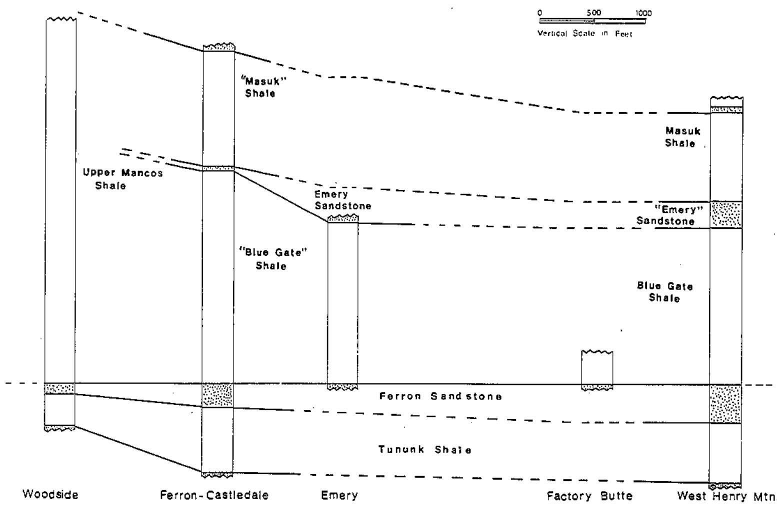
The Ferron Sandstone Member ranges in thickness from about 800 feet at the southern end of Castle Valley to 75 feet near Farnham, about 10 miles southeast of Price (Lupton, 1916). In measured sections of this study the Ferron Member ranges in thickness from about 380 feet in the Henry Mountains area to 90 feet in the Woodside area. The lower part of the Ferron Member is a regressive marine sandstone that contains sandstone concretions. The upper, and greater, part of the Ferron Sandstone consists of lenticular sandstone, mudstone, and carbonaceous beds, including coal beds as much as 22 feet thick. Depositional environments of the member vary from open marine to deltaic plain (Hale, 1972; Cleavinger, 1974).

Blue Gate Shale Member

The Blue Gate Shale Member in the Castle Valley area ranges in thickness from 1,540 feet near the town of Emery to 2,020 feet near Castle Dale. The range in thickness is largely due to intertonguing with the Emery and Garley Canyon Sandstones. In the Woodside area the Blue Gate Shale is not separated as a unit because the Emery Sandstone used elsewhere to delineate the upper boundary is absent. In the Henry Mountains area the Blue Gate Shale is approximately 1,470 feet thick. The Blue Gate Member is a dark bluish gray, finely laminated mudstone with a few beds of bentonite, shaly sandstone, and sandy limestone. The upper part of the member grades into the overlying Emery and Garley Canyon Sandstone members. The contact between the shale and these two sandstones was arbitrarily chosen. Zonation based on foraminifera (Text-fig. 8) indicates that the Blue Gate, as designated in the Henry Mountains area (Gilbert, 1877; Hunt, Averitt, and Miller, 1953), is correlative in the Castle Valley area to all the Blue Gate, Emery, and Masuk Members as designated by Spieker and Reeside (1955). Foraminiferal zonation indicates that only the lower 150 to 200 feet of the Blue Gate in the Henry Mountains area are equivalent to the Blue Gate in the Castle Valley area. Another indication of this unconformable relationship is a locally conglomeratic sandstone bed at the base of the Blue Gate Shale which rests on an eroded surface of the Ferron Sandstone Member in the area east and south of Swap Mesa, on the west flank of the Henry Mountains. Hunt, Averitt, and Miller (1953, p. 83) suggested that the sandstone is a transgressive beach deposit.

Emery Sandstone Member

The Emery Sandstone was named from exposures near the town of Emery. It is about 800 feet thick near Emery, but near the town of Ferron the member splits into two sandstone tongues (Spieker, 1931, p. 20). North of the town of Emery the Emery Sandstone thins rapidly to about 30 feet thick near Castle Dale, Utah. East of Price the Emery Member grades into shale, and the Sandstone does not extend into the Woodside area. Both the top and bottom contacts of the member are gradational and intertongue with the Masuk Shale above, the Blue Gate Shale below, and the contacts are somewhat arbi-



TEXT-FIGURE 8.—Lithologic correlation chart as correlated without reference to the biostratigraphic zonation.

trary. Along its outcrop in Castle Valley the Emery Member seems to be entirely of shallow-water marine origin, but in the subsurface, about 20 miles west of Price, thick coal beds are present in the middle and below the top of the sandstone tongue (Edson and Scholl, 1954, p. 90).

The Garley Canyon Sandstone Member of the Mancos Shale was proposed by Clark (1928, p. 112) for a conspicuous sandstone 160 feet thick in an area a few miles west and north of Price.

In the Henry Mountains area a sandstone mapped as Emery Sandstone and a sandstone mapped (by Hunt, Averitt, and Miller, 1953) as the basal sandstone of the Masuk were both included in the Emery Sandstone by Davidson (1967) and are 120-300 feet thick. Part of this thickness range is related to the difficulty in choosing the same lower contact. Foraminiferal zonation indicates that these sandstones are probably tongues of the Star Point Sandstone, as mapped in the Castle Valley area, and that the Emery Sandstone of Castle Valley is a deltaic deposit grading into shale before reaching as far east as the Henry Mountains (Text-fig. 7).

Masuk Shale Member

The Masuk Shale Member of the Mancos Shale was named by Gilbert (1877), with a type section in the Masuk Plateau in the Henry Mountains, where it is 700-900 feet thick. Lowermost beds of the Masuk Member grade upward from finely laminated gray mudstone to silty and sandy, coaly and carbonaceous mudstone.

In the Castle Valley area the Masuk Shale is 1,000 to 1,100 feet thick. It overlies the Emery Sandstone and resembles the Blue Gate Shale in general lithology. Masuk beds gradually become more silty upward and are gradational and intertonguing with the overlying Star Point Sandstone. Foraminiferal zonation indicates that the Masuk Member, as designated in the Castle Valley area, is correlative with the upper portion of the Blue Gate Shale, as that unit has been mapped in the Henry Mountains area (Text-fig. 7). The Masuk Shale of the Henry Mountains area is probably correlative to the Black Hawk Formation of the Castle Valley area.

FORAMINIFERIDA OF THE MANCOS SHALE

Foraminiferida of the Mancos Shale are represented by 25 families, eight of which are agglutinate. The other 17 families are calcareous. These 25 families are represented by 44 genera and 67 species.

The Nodosariidae are represented by the greatest number of genera (8) and species (15). They are the dominant family in the Tununk Member but are rather sparse in upper members in each section. Foraminiferal distribution in the various members of the Mancos Shale can be characterized as follows: The Tununk Member is dominated by calcareous forms, the Nodosariidae being particularly abundant, with agglutinate forms constituting a minor part of the total fauna (Plates 17, 18, 19). The Blue Gate Member contains mostly calcareous forms, but fewer than the Tununk Member. The Nodosariidae constitute a minor part of the calcareous fauna. Agglutinated forms constitute a large part of the total fauna, being only slightly less abundant than the calcareous forms (Plates 17, 18, 20). The Masuk Member is dominated by agglutinated forms, with calcareous forms constituting only a minor part of the total fauna, except for the species *Gavelinella nacatochensis,* which is abundant throughout most of the Masuk Member (Plates 17, 18, 19).

Most of the species recovered from the Mancos Shale are benthonic forms, strongly controlled by environmental conditions and having rather long stratigraphic ranges. Accurate correlation of thin units for great distances is difficult, but the few pelagic forms and the large variation of faunal association in the total fauna allow a fair zonation within a limited area.

Biostratigraphic Zonation

Seven biostratigraphic faunal assemblage zones are recognized in the Mancos Shale of east central Utah, based primarily on distribution of nine benthonic species and associated foraminifera. A potential pitfall in correlating benthonic assemblages is that of correlating rocks of like environment rather than of equivalent ages. However, with the combined few interspersed planktonic species and varied benthonic species, the proposed zonation should be useful if applied with some caution and within a limited area.

Zone A.—This zone occurs in the lower 90 feet of the Tununk Member in the Ferron-Castledale area. The base of the zone is not determinable because the Tununk Shale abruptly overlies Dakota Sandstone. The top of the zone is placed at the last appearance of *Citharina arguta.* Present within the zone but not restricted to the zone are *Planulina austinana, Gavelinella nelsoni,* and *Ammobaculites wenonahae*—all benthonic species that extend into Zone B. *Gumbelitria cretacea,* a planktonic species, is very abundant in Zone A but extends into Zone B where it occurs in decreased abundance.

Zone A is the basal zone of the Tununk Member which is a transgressive sequence. The zone is not present in the Woodside section but comprises the lower 90 feet of the Tununk Shale in the Ferron-Castledale section and the lower 80 feet of the same shale in the West Henry Mountains section (Text-fig. 7). The foraminiferal zone correlates with the *Sciponoceras gracile* ammonite zone as represented by the *Kanabiceras septenseriatum* of latest Cenomanian age (Cobban, 1975). Cobban also notes that one of the best guides to the zone of *S. gracile* is the pelecypod *Pycnodonte newberryi,* described originally as *Gryphaea newberryi* by Stanton (1893). *P. newberryi* was not observed by Katich (1954), in Castle Valley north of Emery nor in the Price-Woodside area (Katich, 1956)—but is present farther south and in the Henry Mountains area. Distribution of the oyster corresponds well with the area where foraminiferal Zone A is recognized.

Zone B.—Zone B is defined at the top by the last appearance of *Ammobaculites wenonahae* and *Gumbelitria cretacea. G. cretacea* is much less abundant in Zone B than in Zone A. *Dentalina utahensis* and *Vaginulinopsis austinana* first appear in the uppermost part of Zone A and are very abundant in Zone B and Zone C, as is *Gavelinella nelsoni.* Zone B is present in the lower Tununk Member in the Woodside section and in the middle Tununk Member in the Ferron-Castledale section but is somewhat indistinguishable as a zone in the West Henry Mountains section ((Text-fig. 7).

Zone C.—Zone C is defined, at the top, by the last appearance of *Dentalina utahensis* and *Vaginulinopsis austinana,* and at the base above the last appearance of *Ammobaculites wenonahae. D. utahensis* and *V. austinana* are both found in Zone B, but they are in association with *G. cretacea* and *A. wenonahae.* Zone C is present in the upper Tununk Member in all measured sections where the Tununk was sampled (Text-fig. 8). Cobban (1975) reports the ammonite zone of *Collegnoniceras woolgari*, of early middle Turonian, to be represented by specimens collected from shales of the upper Mancos Shale below the Ferron Sandstone in Castle Valley. Such occurrences are within foraminiferal Zone C.

Zone D.—Zone D is defined at both the top and bottom by the total stratigraphic range of *Planulina kansasensis.* This zone is recognized only in the Woodside and Ferron-Castledale sections (Text-fig. 7). The thickest development of Zone D is the Woodside section, but equivalent beds thin rapidly to the south. This rapid thinning appears to be due to a transgression of the Mancos Sea from the northeast over the Ferron Delta complex. Cobban (1975) has reported the ammonite *Prionocyclus hyatti* of late middle Turonian age from the lower sandstone tongue of the Ferron Sandstone, and specimens typical of *Scaphites warreni* indicative of late Turonian age were found near the top of the Ferron Sandstone Member in the Farnham Dome area and near the Woodside area. Zone D is considered to be late Turonian or early Coniacian age.

Zone E.—This zone is defined at the top by the last appearance of *Spiroplectammina navarroana* and at the base above the last appearance of *Planulina kansasensis*. The zone is characterized by the association of *Spiroplectammina mordenensis,* which first appears near the top of Zone D and ranges upward through Zones F and G, with *Lituola irregulariter,* which also first appears near the top of Zone D. Zone E is present in the Woodside, Ferron-Castledale, and Emery sections but is not present in the Factory Butte or West Henry Mountains sections. Thinning of included beds to the south appears to be related to the transgression of the Mancos Sea noted in Zone D. Reeside (1932) has reported the ammonites *Baculites mariasensis, Scaphites preventricosus, S. impendicostatus, Forresteria stantoni* and *Placenticeras pseudoplacenta* from the Mancos Shale, about 100 feet above the Ferron Sandstone, about 15 miles southwest of Emery. These ammonites are representative of early Coniacian age and appear to be within the upper part of Zone E.

Zone F.—Zone F is limited at the top by the last appearance of *Gavelinella nelsoni* and at the bottom by the last appearance of *Spiroplectammina navarroana. Bathysiphon brosgi* is rather common throughout much of the zone and is not found stratigraphically higher, although it does occur lower. Beds of Zone F thin markedly to the south, but the zone is represented in all measured sections (Text-fig. 7). According to Fisher, Erdmann, and Reeside (1960), a single ammonite, *Scaphites tetonensis* of late Coniacian age, was recovered from about 3,200 feet below the top of the Mancos Shale. This would be in Zone F.

Zone G.—This zone is limited at the top by the first appearance of *Citharina texana* and at the bottom above the last appearance of *Gavelinella nelsoni.* Zone G appears to be present in all measured sections (Text-fig. 7). Top of the zone is not defined in the Emery and Factory Butte sections because these sections were not sampled. Cobban (1975) reports ammonites from several fossil localities in the lower sandstone tongue of the Emery Sandstone, from the Garley Canyon Sandstone Member and from 150 feet below the base of the Garley Canyon Member. Species which he reports include: *Clioscaphites vermiformis, Baculites codyensis, B. asper, Placenticeras* (*Stantonoceras*) *sancarlosense,* and *P.* (*Stantonoceras*) *guadalupae,* all of middle Santonian age. Their occurrences would correlate with the upper 150 feet of Zone G and just above the zone.

The foraminiferal fauna above Zone G is predominantly agglutinated benthonic forms and no zonation was attempted. It should be noted, however, that Cobban (1975) reports the uppermost part of the Mancos Shale in the Price area probably lies in the zone of *Scaphites hippocrepis* of Campanian age.

Paleoecology

Because foraminifera are commonly abundant fossils found in many sedimentary sequences, they have been extensively used in interpreting paleoecology. Phleger (1960), in his discussion of depth distribution of Recent foraminifera, stated that the important ecological factors may be one, some, or all of the following: temperature, salinity, food supply, water chemistry, hydrostatic pressure, turbidity, turbulence, substrate, currents, biological competition, and disease. Due to a paucity of information available on the degree or manner in which these many factors affect species and because depth is a relatively easily determinable factor, most ecologists have expressed the distribution of modern species in terms of depth.

Modern distributional information is applied to fossil faunas with the inference that the fossils occupied an environment similar to that in which their modern representatives live. Only a few species of the Mancos Shale have living representatives, so the ecological conditions to which the majority of species were adapted cannot be inferred by reference to modern faunas. Modern patterns are thus considered to be a key to the past only on a familial level or by means of interpretations which do not depend upon genetic affiliations.

Comparison of fossil and Recent foraminiferal faunas can be most precisely done on the species level, but because very few of the species found in this study persist to the Recent, it is necessary to utilize less precise comparisons. Mello (1969), in his study on the foraminifera of the Upper Cretaceous Pierre Shale and Fox Hills Sandstone of north central South Dakota, noted that comparisons of fossil and Recent foraminiferal faunas on a generic level were not very successful. In his study several of the dominant benthonic genera and species remain dominant through nearly the entire thickness of rock examined, although most other species, including several particularly common ones, are more confined in vertical range. A similar distribution pattern shows in the Mancos Shale. This pattern and its poor comparability with patterns in the Recent Gulf of Mexico seem to have two possible explanations. First, Cretaceous foraminifera were adapted to conditions in an interior sea that may not have been analogous to conditions in the Gulf of Mexico. Second, the persistence of several species through a considerable length of time and their continuing dominance throughout the sections suggest that life conditions were fairly uniform over the study area. Thus, the faunal changes might indicate smaller scale fluctuations in this environment not comparable with Recent depth patterns.

Mello (1969, p. 26) stated that comparability becomes better at the familial level because most Cretaceous families are still represented in Recent seas, but that there is a concomitant loss of precision because of the large environmental ranges of most families. Some information may be obtained when the familial compositions of many different samples are considered together.

According to Phleger (1960), the use of families in foraminiferal paleoecology is of questionable value. Nevertheless, some of the patterns of Recent and ancient family-level distributions can be related to the Mancos Shale foraminiferal distributions. Lowman (1949) discussed the Recent depth-distribution of foraminifera in three traverses into the Gulf of Mexico and summarized some of his data, in part, at the family level. If genera and families represented in the Mancos Shale are related to Lowman's generalized Gulf Coast sequence, the agglutinate biofacies is assignable to his "bottom living, stagnant (?), brackish or marine" environment with a depth of 0 to 20 feet. That part of the Mancos Shale calcareous biofacies dominated by genera, species, and specimens of Buliminidae would seem to belong to Lowman's (1949) "upper part of continental slope (inner bathyal)" environment with a depth of 200 to 1,500 feet. The part of the Mancos Shale calcareous biofacies dominated by genera and species of Lagenidae (Nodosariidae) are interpreted to belong in Lowman's (1949) "outer continental shelf (outer neritic)" environment with a depth of 75 to 200 feet. Mello (1969) indicates that the close stratigraphic relationship between buliminid and lagenid faunas suggests that water depth approached the minimum depth of 200 feet rather than the maximum of 1,500 feet.

Loeblich and Tappan (1950), Stelck and Wall (1955), Mellon and Wall (1956), Skolnick (1958), and Eicher (1960, 1965) concluded from the foraminifers of the Cretaceous Thermoplis, Skull Creek, Kiowa, and Shell Creek Shales, and the Graneros Formation that these formations were all deposited in waters of less than normal marine salinity. These conclusions were based chiefly on patterns of distribution of modern foraminifers in which the greatest proportional concentration of agglutinated forms is usually found in environments where salinity is somewhat lower than that of the open ocean.

Living Recent planktonic foraminifers do not occur in water of less than normal marine salinity and are associated with open ocean environments, but the presence of planktonic foraminifers does not necessarily indicate greater depth. The sporadic occurrence of planktonic foraminifers in the Mancos Shale may indicate that they did not continually inhabit the interior seaway. The planktonic forms became temporarily common only when favorable currents brought them in from the normal marine, open ocean, but once in the restricted Mancos Seaway they did not survive and proliferate. Such a distribution indicates that the environment of the interior sea was indeed different from that of the open sea.

With the foregoing criteria as environmental indicators, environments of the various biostratigraphic zones may be reconstructed. Zone A is the basal transgressive zone dominated by a planktonic fauna with Nodosariidae and Buliminidae along with other calcareous species and a few agglutinate forms. This association indicates a fauna characteristic of the lower limits of Lowman's (1949) "outer continental shelf" with a postulated depth of 75 to 200 feet and with a connection to the open sea.

Zone B has a very abundant Nodosariidae and planktonic fauna with a weakened Buliminidae fauna, indicating a slight shallowing of the seaway but still an open sea connection. Zone C is still dominated by a Nodosariidae fauna. The planktonic and Buliminidae faunas are considerably less varied and abundant and there is a slight increase in agglutinated forms. This association is probably indicative of still further shallowing and also perhaps indicative of a slight decrease in salinity. The fauna is characteristic of one within the upper limits of Lowman's "outer continental shelf" near the depth of 75 feet.

The Ferron Sandstone occurs between the top of Zone C and the base of Zone D and was interpreted by Hale (1972) and Cleavinger (1974) as a deltaic complex consisting of regressive marine sandstone in the lower part, grading to deltaic plain deposits in the upper. Such an environmental interpretation would be consistent with the foraminifera faunal interpretation of the environment. The fauna changes from the top of Zone C to the base of Zone D from a calcareous benthonic and planktonic fauna to one of agglutinate forms with some samples processed where no foraminifera were recovered. Such a pattern is indicative of Lowman's (1949) "bottom living, stagnant (?), brackish or marine" environment of about 0 to 20 feet depth.

Zone D is a lithologic transgressive zone and contains significant agglutinate forms with a considerable planktonic and buliminid admixture. This combination probably indicates the lower part of Lowman's (1949) "outer continental shelf (outer neritic)" environment, with a depth of 75 to 200 feet.

Zone E, like Zone D, contains considerable agglutinate forms, with even more common planktonic and buliminid foraminifera, as well as an increase in the number of other calcareous benthonic species. Environmentally the zone probably represents a slightly deeper seaway than that of Zone D, as well as a connection to the open sea. The fauna appears to represent the upper limits of Lowman's (1949) "upper part of continental slope (inner bathyal)" environment with a depth of 200 to 300 feet.

Zone F has a mixed agglutinate and calcareous benthonic fauna and shows a definite decrease in planktonic and buliminid forms from that present in Zone E. This probably is indicative of a shallowing of the sea, but still with at least frequent connection to the open sea. Using Lowman's (1949) criteria the fauna of Zone F is representative of the "outer continental shelf" with a depth of 75 to 200 feet. From the top of Zone F to the top of the section there is a gradual increase in dominance of agglutinate forms over calcareous benthonic forms, with only a rare sample containing planktonic forms. Such a pattern is indicative of gradual shallowing of the seaway, with a decrease in salinity, probably due to the close proximity of the shore line.

CONCLUSIONS

Twenty-five foraminifera families, represented by 44 genera, were recovered from the Mancos Shale of east central Utah. These faunas can be grouped into three major assemblages: (1) a lower nodosarid, buliminid, and planktonic foraminifera assemblage which can be further subdivided into 3 biostratigraphic zones—zones A, B, and C—on the basis of distribution of key species; (2) an assemblage characterized by a calcareous benthonic and agglutinate foraminifera fauna which can be subdivided into Zones D, E, F, and G; (3) the third major faunal assemblage, dominantly of agglutinate forms and rocks, not subdivided into biostratigraphic zones.

Lithologic and biologic data suggest that vertical changes of foraminifera in the Mancos Shale are analogous, in general, to changes of faunas that occur from inner continental-shelf depths to near-shore in some areas of Recent deposition.

Sediments and faunas of the Tununk Shale (upper Cenomanian) record the first invasion of a Cretaceous sea in Utah, and show rather rapid deepening of the basin of accumulation to approximately a depth of 200 feet, followed by a gradual filling.

The initial transgression is represented by a change in lithology from a basal sandstone to shale and mudstone, the latter fine clastic rocks containing high percentages of benthonic and planktonic foraminifera. Variations in percentages of planktonic foraminifera are thought to be caused by distance from shore and not changes in depth of water. The initial transgression appears to have moved in from the southwest, across the Henry Mountains and Castle Valley areas, before reaching the Woodside locality. Distribution of biostratigraphic zones suggests that the northern San Rafael Swell was slightly positive during the initial transgression.

The regression that followed was marked by a decrease in foraminiferal numbers and a change from a fauna dominated by the Buliminidae to one dominated by the Nodosariidae, followed by one dominated by agglutinate foraminifera. The lithology changes vertically from laminated argillaceous rocks to cross-laminated and sandy sediments into sediments of the Ferron delta complex (Cleavinger, 1974; Hale, 1972). Lithologic evidence indicates that deltaic construction was at least partially responsible for the local regression.

A second transgression began in late Turonian time and a different pattern of marine invasion is evident from faunal distribution. The second transgression moved into the area from the northeast while the southern part of the San Rafael Swell and the Henry Mountains areas remained slightly positive. A fore-deep, formed along the western side of the present San Rafael

Swell, received sediments from the west until 1,600 to 1,900 feet had accumulated in the Castle Valley area. The sea was then able to transgress southward once more over the Henry Mountains area in early Coniacian time. During Coniacian time faunas indicate a gradual shallowing, probably due to the filling of the fore-deep. The maximum depth of water probably was never more than 300 to 400 feet.

During middle Santonian time another delta complex, the Emery delta, began to build from the west. Sandstone deposits of the Emery complex did not reach as far east as the former Ferron delta and failed to reach into the Henry Mountains area.

A third transgression of the Mancos Sea is indicated by a dominantly agglutinate fauna in argillaceous rocks above the Emery delta complex. This transgression resulted in accumulation of a predominantly agglutinate fauna and sediments which are interpreted to have been deposited in very shallow near-shore environments. Final regression of the Mancos Sea is recorded by eastward spread of sandstones of the Star Point Formation in Campanian time.

SYSTEMATIC PALEONTOLOGY

The classification followed here is that of Loeblich and Tappan (1964). Large populations have been studied whenever possible to determine intraspecific variation and dimorphism.

All illustrated specimens are deposited in the foraminiferal collection of the Department of Geology, Brigham Young University, Provo, Utah.

Subphylum SARCODINA Schmarda, 1871

Class RHIZOPODEA von Siebold, 1845
Subclass LOBOSIA Carpenter, 1861
Order FORAMINIFERIDA Eichwald, 1830
Suborder TEXTULARIINA Delage and Herouard, 1896
Superfamily AMMODISCACEA Reuss, 1862
Family ASTRORHIZIDEA Brady, 1881
Subfamily RHIZAMMININAE Rhumbler, 1895
Genus BATHYSIPHON M. Sars in G. O. Sars, 1872
BATHYSIPHON BROSGEI Tappan, 1957

Pl. 1, fig. 1

Bathysiphon brosgei Tappan 1957, U.S. Nat. Mus. Bull. 215, p. 202, pl. 65, figs. 1-5; Trujillo 1960, Jour. Paleont., v. 34, no. 2, p. 302, pl. 43, fig. 3; Tappan 1962, U.S. Geol. Survey Prof. Paper 236-C, p. 128, pl. 29, figs. 1-5; Sliter 1968, Univ. Kansas Paleont. Contr., ser. 49, art. 7, pp. 39-40, pl. 1, fig. 1; Mello 1969, U.S. Geol. Survey Prof. Paper 611, p. 40, pl. 4, fig. 1; Morris 1971, Micropaleont., v. 17, no. 3, pp. 263-64, pl. 1, figs. 1-3.

Description.—Test free, elongate, consisting of an undivided tubular chamber, commonly straight but rarely somewhat irregularly bent or curved, usually somewhat compressed; wall finely agglutinated, with considerable cement, rather smoothly finished; surface may have transverse growth wrinkles, irregularly spaced; aperture rounded at the open end of the tubular chamber. Dimensions of average-sized specimens: length, about 1.2 mm; breadth, about 0.3 mm.

Remarks.—Specimens occur in all measured sections, but in large numbers in only two zones, both in the Blue Gate Shale. The species was not found below the top of the Ferron Sandstone in any section. Most specimens have a very high proportion of amorphous cement similar to those described by Tappan (1957) and Mello (1969) although the amount of cement is highly variable. The species shows considerable range in size, with the average of the Blue Gate specimens slightly larger than those described by Tappan (1957). This species has been reported from shale of Coniacian and Santonian ages in the Redding area, Shasta County, and of Late Turonian to early Campanian ages in the Santa Ana Mountains of California, in the Pierre Shale and Lower Fox Hills Sandstone of north central South Dakota, and in the Upper Mancos Formation in northwestern Colorado. The species was originally described from the Colville and Nanunkuk groups of the Cretaceous of Alaska (Tappan; 1957, 1962).

Type specimens.—Figured specimen BYU 2319; reference specimen BYU 2391.

Family SACCAMMINIDAE Brady, 1884

Subfamily SACCAMMININAE Brady, 1884
Genus SACCAMMINA M. Sars in Carpenter, 1869
SACCAMMINA ALEXANDERI (Loeblich and Tappan, 1950)
Pl. 1, fig. 4

Proteonina alexanderi Loebich and Tappan 1950, Univ. Kansas, Paleont. Contr., ser. 6, art. 3, p. 5, pl. 1, figs. 1-2.

Proteonina cf. *P. alexanderi* Loeblich and Tappan, Stelck and Wall 1955, Alberta Res. Council, Bull. no. 70, p. 52, pl. 1, figs. 5-6.

Saccammina alexanderi (Loeblich and Tappan) Eicher 1960, Yale Univ., Peabody Mus. Nat. Hist., Bull. no. 15, p. 55, pl. 3, figs. 1-2; Crespin 1963, Australia Bur. Min., Res. Geol. and Geophys., Bull. no. 66, p. 20, pl. 1, figs. 10-12; Eicher 1966, Jour. Paleont., v. 39, no. 5, p. 891, pl. 103, fig. 1; Eicher 1966, Cushman Found. Foram. Res. Contr., v. 17, pt. 1, p. 20, pl. 4, figs. 1-2; Eicher 1967, Jour. Paleont., v. 41, no. 1 p. 180, pl. 17, fig. 1; Wall 1967, Alberta Res. Council, Bull. no. 20, p. 40, pl. 8, figs. 16-17; pl. 14, figs. 17-18; Morris 1971, Micropaleont., v. 17, no. 3, p. 264, pl. 1, figs. 4-5.

Description.—Test free, consisting of a bulbous chamber, flask shaped, slightly elongate, tapering to a distinct neck, usually round in cross section but may be flattened during compaction of the sediments; wall agglutinated, composed of medium-sized to coarse grains; aperture round, terminal on tapering neck. Dimensions of average-sized specimens: length, about 0.4 mm; breadth, about .25 mm.

Remarks.—The species occurs in all measured sections with the exception of the Factory Butte section, and occurs sporadically throughout all sections but in larger numbers in the more arenaceous portions of the sections. Specimens found in these sections average slightly larger and are coarser grained than those described by Loeblich and Tappan (1950). This species has been reported previously from the Lower Cretaceous Kiowa, Thermopolis, and Skull Creek shales in the western interior of the United States and from the Cenomanian Kaskapau Formation of Alberta, Canada, as well as from the Upper Cretaceous of Australia. The species was originally described from the Lower Cretaceous Kiowa Shale of Kansas (Loeblich and Tappan, 1950).

Type specimens.—Figured specimen BYU 2320; reference specimen BYU 2321.

SACCAMMINA COMPLANATA (Franke, 1912)
Pl. 1, fig 2

Pelosina complanata Franke 1912, Ver. Preuss. Rhinelande Westfalens, Verh., v. 32, pt. 2, p. 107, pl. 3, figs. 1a, b; 1928 Preuss. Geol. Landesanstalt Abh., new ser., v. 111, p. 10, pl. 1, fig. 6; Cushman and Jarvis 1932, U.S. Nat. Mus. Proc., v. 80, art. 14, p. 5, pl. 1, figs. 4-6; Renz 1942, 8th Am. Sci. Congress Proc., p. 528 (list); Frizzell 1943, Jour. Paleont., v. 17, p. 336, pl. 55, fig. 4; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 15, pl. 1, figs. 9-11; Takayanagi 1960, Tohoku Univ. Sci. Repts., ser. 22 (geol.), v. 32, p. 65, pl. 1, fig. 6; Martin 1964, Geol. Bundesanstalt Wien, Jahrb., Sonderbd. 9, p. 44, pl. 1, fig. 6.

Saccammina scruposum White 1928, (not *Haplophragmium scruposum* Berthelin), Jour. Paleont., v. 2, p. 183, pl. 27, fig. 5.

Pelosina scruposa Frizzell 1943, Jour. Paleont., v. 17, p. 337, pl. 55, fig. 3.

Saccammina complanata (Franke) Sliter 1968, Univ. Kansas Paleont. Contr., ser. 49, art. 7, p. 42, pl. 1, fig. 7.

Description.—Test free, consisting of a single bulbous chamber, invariably crushed; wall very fine-grained sand particles, or replaced by amorphous silica; aperture single, round, with short neck. Dimensions of average-sized specimens: breadth, about 0.25 mm.

Remarks.—The species occurs sporadically throughout the Ferron-Castledale and Emery sections. Specimens found in these sections are generally much smaller and not as smoothly finished as those described by Cushman (1946). The species has previously been reported from the Upper Cretaceous of Germany; Velasco Shale, Mexico; Hobson Clay, Trinidad; Mal Paso Shale, northwestern Peru; Hokkaido, Japan; Fresno County, California; southern California, and northwestern Baja California; and from the Taylor Marl and Austin Chalk, Texas. The species was originally described from the Upper Cretaceous of Germany (Franke, 1912).

Type specimens.—Figured specimen BYU 2323; reference specimen BYU 2322.

EXPLANATION OF PLATE 1

FIG. 1.—*Bathysiphon brosgei* Tappan. Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2319)

FIG. 2.—*Saccammina complanata* (Franke). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X273. (BYU 2323)

FIG. 3.—*Ammodiscus glabratus* Cushman and Jarvis. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X275. (BYU 2325)

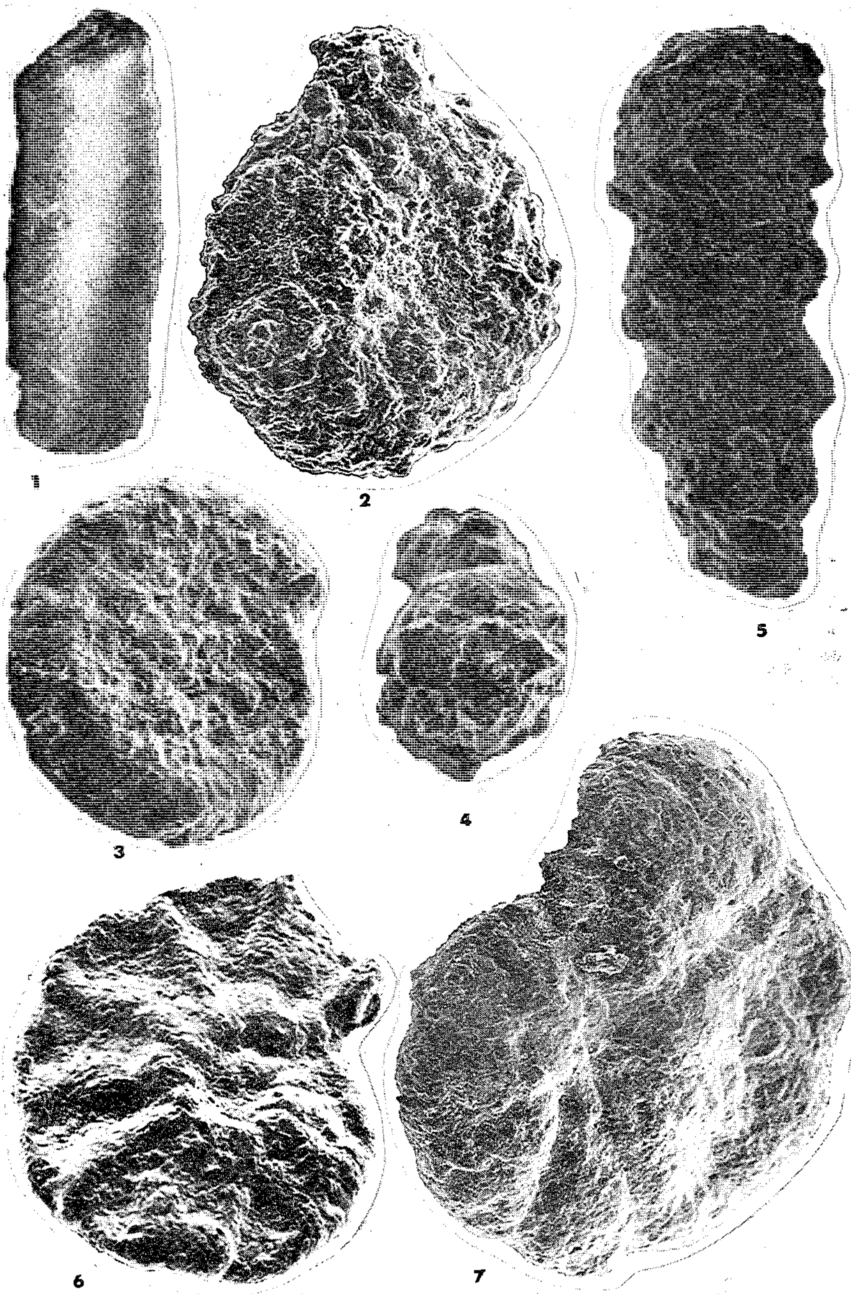
FIG. 4.—*Saccammina alexanderi* (Loeblich and Tappan). Middle part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X108 (BYU 2320)

FIG. 5.—*Reophax pepperensis* Loeblich. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X283. (BYU 2328)

FIG. 6.—*Haplophragmoides excavata* Cushman and Waters. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X70, (BYU 2556)

FIG. 7.—*Haplophragmoides excavata* Cushman and Waters. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X109. (BYU 2331)

PLATE 1



Family AMMODISCIDAE Reuss, 1862

Subfamily AMMODISCINAE Reuss, 1862
Genus AMMODISCUS Reuss, 1862
AMMODISCUS GLABRATUS Cushman and Jarvis, 1928
Pl. 1, fig. 3

Ammodiscus glabratus Cushman and Jarvis 1928, Cushman Lab. Foram. Research Contr., v. 4, p. 86, pl. 12, figs. 6a-b; Cushman 1932, U. S. Nat. Mus. Proc., v. 80, art. 14, p. 8, pl. 2, fig. 1; Renz 1942, 8th Am. Sci-Congress Proc., v. 4, pp. 528-29 (list); Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 17, pl. 1, fig. 32; Sliter 1968, Univ. Kansas Paleont. Contr., ser. 49, art. 7, p. 42, pl. 1, fig. 9.
Involutina glabratus (Cushman and Jarvis) Martin 1964, Geol. Bundesanstalt Wien, Jahrb., Sonderbd. 9, p. 45, pl. 1, figs. 10-11.

Description.—Test free, planispiral, compressed, consisting of a small proloculus and a nonsegmented tubular chamber, increasing gradually in size, sutures distinct, depressed, wall finely agglutinated, surface smoothly finished; aperture at open end of tube. Dimensions of average-sized specimens: breadth, about 0.20 mm.

Remarks.—Specimens occur in all measured sections except the Factory Butte section and occur sporadically throughout the Masuk Shale and Blue Gate Shale, but occur in larger numbers in the more arenaceous portions. Specimens are generally much smaller than those described elsewhere. The species has been reported previously from the Upper Cretaceous of Fresno County, California, southern California, and northwestern Baja California. The species was originally described from the Upper Cretaceous of Trinidad (Cushman and Jarvis, 1928).

Type specimens.—Figured specimen BYU 2325; reference specimen BYU 2324.

Superfamily LITUOLACEA de Blainville, 1825

Family HORMOSINIDAE Haeckel, 1894
Subfamily HORMOSININAE Haeckel, 1894
Genus REOPHAX Montfort, 1808
REOPHAX INORDINATUS Young, 1951
Pl. 2, fig. 1

Reophax inordinatus Young 1951, Jour. Paleont., v. 25, p. 48, pl. 11, figs. 1-2; Eicher 1966, Cushman Lab. Foram. Research Contr., v. 17, pt. 1, p. 21, pl. 4, figs. 3-4.

Description.—Test elongate, consisting of three or four uniserial chambers; chambers rounded in section in uncrushed specimens, increasing rapidly; sutures straight, distinct, depressed; wall coarsely agglutinated with little cement; aperture terminal, round, at end of a prominent, tapering neck which constitutes the last third of the final chamber. Dimensions of average-sized specimen: length, about 0.5 mm; width, about 0.2 mm.

Remarks.—Specimens occur sporadically throughout all sections with the exception of the section at Factory Butte. The greater numbers of specimens are concentrated in the more arenaceous portions of the sections, particularly near and in the Ferron Sandstone member. Specimens found in these sections average slightly smaller than those described by Young (1951). The species has been reported previously from the Carlile Shale of Colorado and from the Frontier Formation of Montana. The species was originally described from the Frontier Formation of Montana (Young, 1951).

Type specimens.—Figured specimen BYU 2326; reference specimen BYU 2327.

REOPHAX PEPPERENSIS Loeblich, 1946
Pl. 1, fig. 5

Reophax pepperensis Loeblich 1946, Jour. Paleont., v. 20, no. 2, p. 133, pl. 22, figs. 1a-b; Frizzell 1954, Univ. Texas Bur. Econ. Geol. Rept. Invest., no. 22, p. 58, pl. 1, figs. 12a-b; Tappan 1962, U.S. Geol. Survey Prof. Paper 236-C, p. 133, pl. 30, fig. 14; Eicher 1965, Jour. Paleont., v. 39, p. 892, pl. 105, fig. 8; 1967, Jour. Paleont., v. 41, no. 1, p. 180, pl. 17, fig. 8.

Description.—Test free, tiny, narrow, elongate, uniserial and rectilinear; subcylindrical chambers, closely appressed, of slightly greater breadth than height; sutures distinct, slightly depressed; wall finely agglutinated; aperture rounded, terminal. Dimensions of average-sized specimens: length, about 0.3 mm; width, about 0.1 mm.

Remarks.—The species occurs in all measured sections, occurring throughout the Masuk Shale and in the upper half of the Blue Gate Shale, but not in the lower half of the Blue Gate Shale or stratigraphically lower. Specimens are consistently replaced by hematite and are poorly preserved. This species has been reported previously from the Graneros Shale of southeastern Wyoming, Colorado, and Kansas, from the Belle Fourche Shale of Wyoming and Montana, and from Turonian beds in northern Alaska. The species was originally described from the Pepper Shale of Texas.

Type specimen.—Figured specimen BYU 2328.

Family LITUOLIDAE de Blainville, 1825

Subfamily HAPLOPHRAGMOIDINAE Maync, 1952
Genus HAPLOPHRAGMOIDES Cushman, 1910
HAPLOPHRAGMOIDES EXCAVATA Cushman and Waters, 1927
Pl. 1, figs. 6, 7

Haplophragmoides excavata Cushman and Waters 1927, Cushman Lab. Foram. Research Contr., v. 2, pt. 4, p. 82, pl. 10, figs. 3a-b; Cushman 1927, Royal Soc. Canada Trans., 3d ser., v. 21, sec. 4, p. 128, pl. 1, fig. 1,; Cushman and Jarvis 1932, U.S. Nat. Mus. Proc., v. 80, art. 14, p. 12, pl. 3, fig. 1; Cushman and Hedberg 1941, Cushman Lab. Foram. Research Contr., v. 17, p. 82, pl. 21, figs. 1a-b; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 21, pl. 2, figs. 13-17; Peterson 1953, Utah Geol. and Min. Survey, Bull. 47, pt. III, p. 30, pl. 1, figs. 3-4; Frizzell 1954, Univ. of Texas, Bur. Econ. Geol., Rpt. Invest. 22, p. 60, pl. 1, fig. 30; Morris 1971, Micropaleont. v. 17, no. 3, pp. 266-67, pl. 2, figs. 3-9.

Description.—Test free, planispiral, involute, biumbilicate; peripheral outline rounded to slightly lobate; peripheral margin rounded in uncrushed specimens to narrowly rounded or angular in crushed specimens; six to eight chambers in the outer whorl, varying from slightly inflated to depressed and concave and gradually increasing in size; inner portions toward umbilicus may be pointed or slightly lobate; sutures usually distinct, highly variable, curved to almost straight, thin to quite thick, slightly depressed; wall finely agglutinated, variable from extremely small grains and large amount of cement to larger grains and moderate amount of cement, with a moderately smooth glassy finish; aperture usually indistinct, a low arch at base of last chamber extending across the periphery. Dimensions of average-sized specimens: diameter, about 0.8 mm to 0.6 mm.

Remarks.—The species occurs in all measured sections and sporadically throughout each section but occurs in largest numbers in the more arenaceous portions. It occurs most consistently and in greatest abundance in the Masuk Shale. The average diameter of the specimens found is considerably less than those described by Cushman (1946). This species has a very wide distribution, occurring in Trinidad, Colombia, and the Gulf Coastal region of the United States and western Canada. It has been reported from the Kemp Clay, Corsicana Marl, Arkadelphia Marl, the middle part of the Selma Chalk, and from the Taylor Marl. The species was originally described from the Upper Cretaceous of Texas (Cushman and Waters, 1927).

Type specimens.—Figured specimens BYU 2331, 2556; reference specimens BYU 2329, 2330.

HAPLOPHRAGMOIDES RUDIS Bolin, 1956
Pl. 2, fig. 3

Haplophragmoides rudis Bolin 1956, Jour. Paleont., v. 30, no. 2, p. 285-86, pl. 37, figs. 3-6.

Description.—Test medium size; periphery subacute, slightly lobulate in later portion; shallowly umbilicate; umbilicus of one or both sides sometimes filled with a matrix of foreign material; planispirally coiled, tending to become evolute in later stages; chambers distinct, numerous, six to eight in final whorl,

EXPLANATION OF PLATE 2

FIG. 1.—*Reophax inordinatus* Young. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X110. (BYU 2326)

FIG. 2.—*Lituola irregulariter* Cushman. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X60. (BYU 2361)

FIG. 3.—*Haplophragmoides rudis* Bolin. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X105. (BYU 2332)

FIG. 4.—*Trochamminoides coronus* Loeblich and Tappan. Middle part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X170. (BYU 2333)

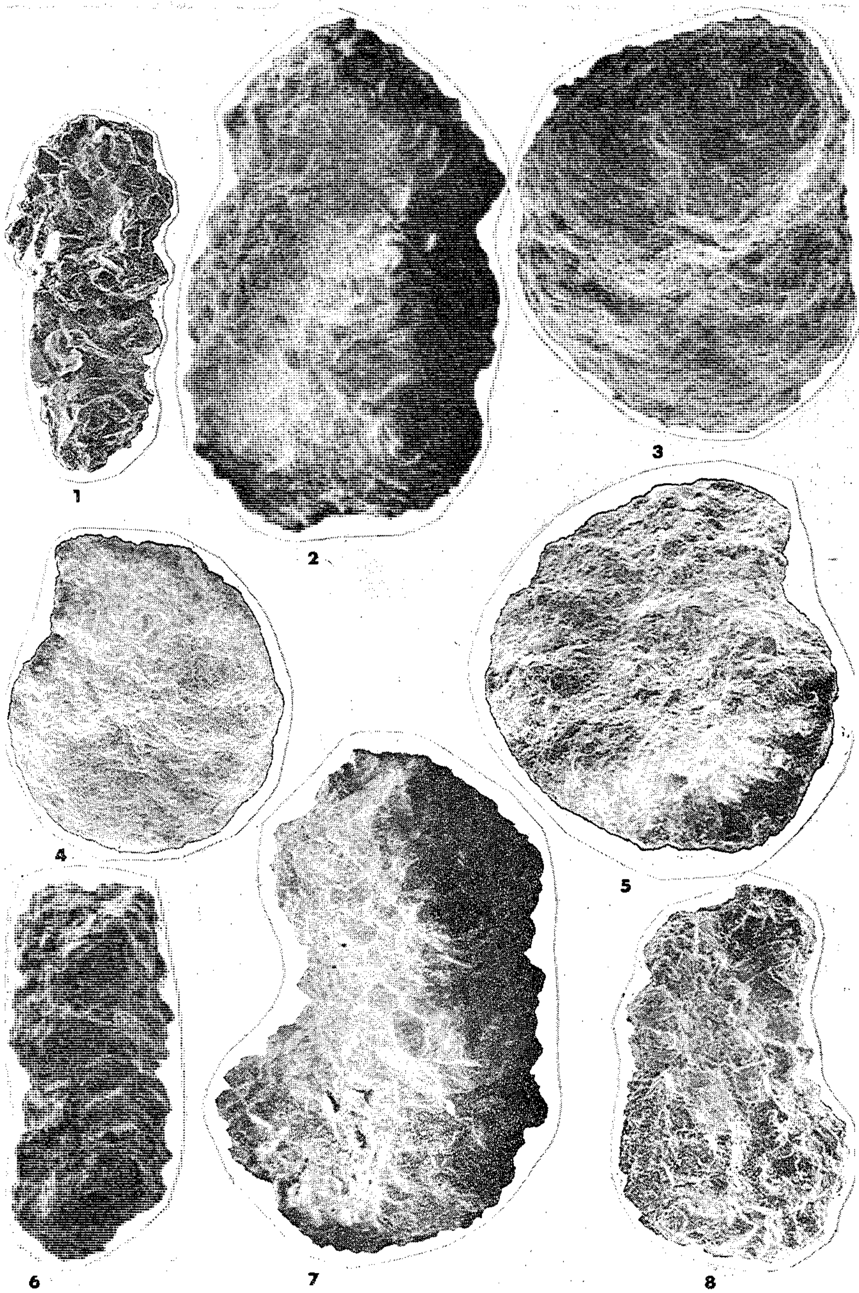
FIG. 5.—*Trochamminoides coronus* Loeblich and Tappan. Middle part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X110. (BYU 2334)

FIG. 6.—*Ammobaculites fragmentarius* Cushman. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X110. (BYU 2351)

FIG. 7.—*Lituola irregulariter* Cushman. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X53. (BYU 2355)

FIG. 8.—*Ammobaculites stephensoni* Cushman. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X110. (BYU 2350)

PLATE 2



increasing rather irregularly in size as added; sutures distinct, very slightly depressed, straight to slightly arched backwards; wall finely agglutinated and smoothly finished; aperture a crescentric opening at base of final chamber. Dimensions of average-sized specimens: diameter, about 0.5 mm; thickness, about 0.2 mm.

Remarks.—Specimens occur in all measured sections with the exception of the one at Factory Butte. The species is found sporadically throughout each section. Specimens average somewhat smaller than those described by Bolin (1956). This species was originally described from Aitkin County, Minnesota, from beds thought to be closely related to the Cenomanian Pepper Shale of Texas (Bolin, 1956).

Type specimen.—Figured specimen BYU 2332.

Genus TROCHAMMINOIDES Cushman, 1910

TROCHAMMINOIDES CORONUS Loeblich and Tappan, 1946

Pl. 2, figs. 4, 5

Trochamminoides coronus Loeblich and Tappan 1946, Jour. Paleont., v. 20, no. 3, p. 243, pl. 35, figs. 3a-c; 1949, Jour. Paleont., v. 23, no. 3, p. 248, pl. 46, figs. 2a-b.

Description.—Test free, discoidal, planispirally coiled and evolute, periphery angular; chambers numerous and small, twelve to fourteen in last whorl; as many as three complete whorls may be seen; sutures distinct, depressed, straight, somewhat thickened; wall finely agglutinated, occasionally iron stained; aperture a low arch at the base of the last-formed chamber, on the periphery. Dimensions of average-sized specimens: diameter, about 0.4 mm. to 0.5 mm; thickness, about 0.2 mm.

Remarks.—The species occurs in all measured sections and is abundant in nearly all samples throughout the Masuk Shale and Blue Gate Shale, but does not appear below the top of the Ferron Sandstone in any of the measured sections. Specimens found are slightly larger and have a more acute periphery than those described by Loeblich and Tappan (1946). The species was originally described from the Walnut Formation of northern Texas and southern Oklahoma (Loeblich and Tappan, 1946).

Type specimens.—Figured specimens BYU 2333, 2334; reference specimens BYU 2585, 2586, 2587.

Subfamily LITUOLINAE de Blainville, 1825

Genus LITUOLA Lamarck, 1804

LITUOLA IRREGULARITER Cushman, 1939

Pl. 2, figs. 2, 7

Lituola irregulariter Cushman 1939, Cushman Lab. Foram. Research Contr., v. 15, pt. 4, p. 89, pl. 16, figs. 9-10; 1946, U.S. Geol. Survey Prof. Paper 206, p. 26, pl. 5, figs. 7-8.

Description.—Test large, the early portion closely coiled and broadly rounded, later becoming uncoiled, uniserial; chambers fairly distinct in some specimens, very indistinct in others, with the early portion closely coiled, planispiral, later uncoiled and much inflated; sutures somewhat depressed, in many specimens obscure; wall coarsely agglutinated, composed of large angular fragments embedded in finer material with a considerable amount of cement; aperture simple in the young, with several openings in many adults. Dimensions of average-sized specimens: length, about 1.3 mm; width, about 0.8 mm.

Remarks.—Specimens were found only in the northwestern sections (Woodside, Ferron-Castledale, and Emery), and were found only in the lower portion of the Blue Gate Shale. As reported (Cushman, 1946) this species appears to be a useful stratigraphic index species. The wall is solid and firmly cemented, so that it is not easily broken. Specimens found in these sections are somewhat smaller than those described by Cushman and have less cementing material. This species has been reported previously from the Taylor Marl of Texas, where it was originally described from the lower part of the unit from Ellis County, Texas (Cushman, 1939).

Type specimens.—Figured specimens BYU 2355, 2361; reference specimen BYU 2356.

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES COPROLITHIFORMIS (Schwager, 1868)
Pl. 3, fig. 1

Haplophragmium coprolithiformis Schwager 1868, Beneck's Geogn.-paleont. Beitrage, v. 1, p. 654, pl. 34, fig. 3.

Ammobaculites coprolithiformis (Schwager) Cushman 1927, Royal Soc. Canada Trans., 3d ser., v. 21, sec. 4, p. 130, pl. 1, figs. 6-7; Cushman and Jarvis 1932, U.S. Nat. Mus. Proc., v. 80, art. 14, p. 13, pl. 3, figs. 4-5; Wickenden 1932, Jour. Paleont., v. 6, no. 2, p. 204, pl. 29, fig. 2; Cushman 1933, Cushman Lab. Foram. Research Special Pub. 5, pl. 5, fig. 10; Cushman and Deaderick 1942, Cushman Lab. Foram. Research Contr., v. 18, pt. 3, p. 51, pl. 9, fig. 9; Cushman and Todd 1943, Cushman Lab. Foram. Research Contr., v. 19, pt. 3, p. 50; Cushman and Deaderick 1944, Jour. Paleont., v. 18, no. 4, p. 328, pl. 50, fig. 2; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, pp. 22-23, pl. 3, fig. 7-9; Gauger 1953, Utah Geol. and Min. Bull. 47, pt. III. B, p. 55, pl. 5, figs. 1-8; Frizzell 1954, Univ. Texas Bur. Econ. Geol. Rept. Invest. 22, p. 61, pl. 2, figs. 15a-b.

Description.—Test elongate, early portion closely coiled, later chambers rectilinear and of uniform width, generally circular in section; sutures depressed; wall agglutinated but smoothly finished; aperture circular, terminal. Dimensions of average-sized specimens: length, about 0.3 mm; breadth, about 0.2 mm.

Remarks.—Specimens occur sporadically and in small numbers in the Woodside, Ferron-Castledale, and Emery sections. Specimens are much smaller than those described by Cushman (1946). This species has been reported previously from the Eagle Ford Shale to the Navarro Group of the Gulf Coast region of the United States, the Hilliard Formation of southwestern Wyoming, western Canada, the Upper Cretaceous of Trinidad, and the Velasco Shale of Mexico. The species was originally described from the Cretaceous of Europe (Schwager, 1868).

Type specimens.—Figured specimen BYU 2349; reference specimen BYU 2348.

AMMOBACULITES FRAGMENTARIUS Cushman, 1927
Pl. 2, fig. 6

Ammobaculites fragmentarius Cushman 1927, Royal Soc. Canada Trans., 3d ser., v. 21, sec. 4, p. 130, pl. 1, fig. 8; 1931, Tennessee Div. Geol. Bull. 41, p. 18, pl. 1, figs. 4a-b; Cushman and Deaderick 1944, Jour. Paleont., v. 18, pl. 50, fig. 4; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 23, pl. 3, figs. 10-16; Gauger 1953, Utah Geol. and Min. Survey Bull. 47, p. 56, pl. V, figs. 11-18; Frizzell 1954, Univ. Texas Bur. Econ. Geol., Rpt. Invest. 22, p. 62, pl. 2, figs. 16-18; Stelck et al. 1956, Alberta Res. Council Rpt. no. 75, p. 21, pl. 5, figs. 18-19; Eicher 1960, Yale Univ., Peabody Mus. Nat. Hist. Bull., no. 15, p. 61, pl. 4, fig. 11; Wall 1967, Alberta Res. Council Bull., no. 20, p. 55, pl. 1, figs. 7-9, pl. 7, figs. 18-20; Morris 1971, Micropaleont., v. 17, no. 3, p. 269, pl. 3, figs. 1-2.

Ammobaculites cf. *fragmentarius* Cushman 1946, Cushman and Applin, Cushman Lab. Foram. Research Contr., v. 22, p. 74.

(NOT) *Ammobaculites fragmentarius* Cushman 1962, Tappan, U.S. Geol. Survey Prof. Paper 236-C, pp. 136-37, pl. 32, figs. 8-11.

Description.—Test large, compressed, early portion planispiral, later and larger portion uniserial, rectilinear; chambers distinct; sutures distinct, depressed; wall of coarse sand in flat flakes, rather neatly cemented; aperture elliptical, terminal. Dimensions of average-sized specimens: length, about 0.5 mm; breadth, about 0.2 mm.

Remarks.—The species occurs in all measured sections with the exception of the Factory Butte section, and occurs sporadically throughout each section. Specimens are slightly smaller than those described by Cushman (1946) or Gauger (1953). This species has previously been reported from the Austin Chalk of Texas, the Hilliard Formation of southwestern Wyoming, the Thermopolis Shale of Wyoming, and the upper Mancos Shale from northwestern Colorado. The species was originally described from the Upper Cretaceous of western Canada (Cushman, 1927).

EXPLANATION OF PLATE 3

FIG. 1.—*Ammobaculites coprolithiformis* (Schwager). Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X275. (BYU 2349)

FIG. 2.—*Spiroplectammina mordenensis* Wickenden. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X149. (BYU 2347)

FIG. 3.—*Ammobaculites texanus* Cushman. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X35. (BYU 2358)

FIG. 4.—*Spiroplectammina mordenensis* Wickenden. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X140. (BYU 2373)

FIG. 5.—*Spiroplectammina mordenensis* Wickenden. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X140. (BYU 2344)

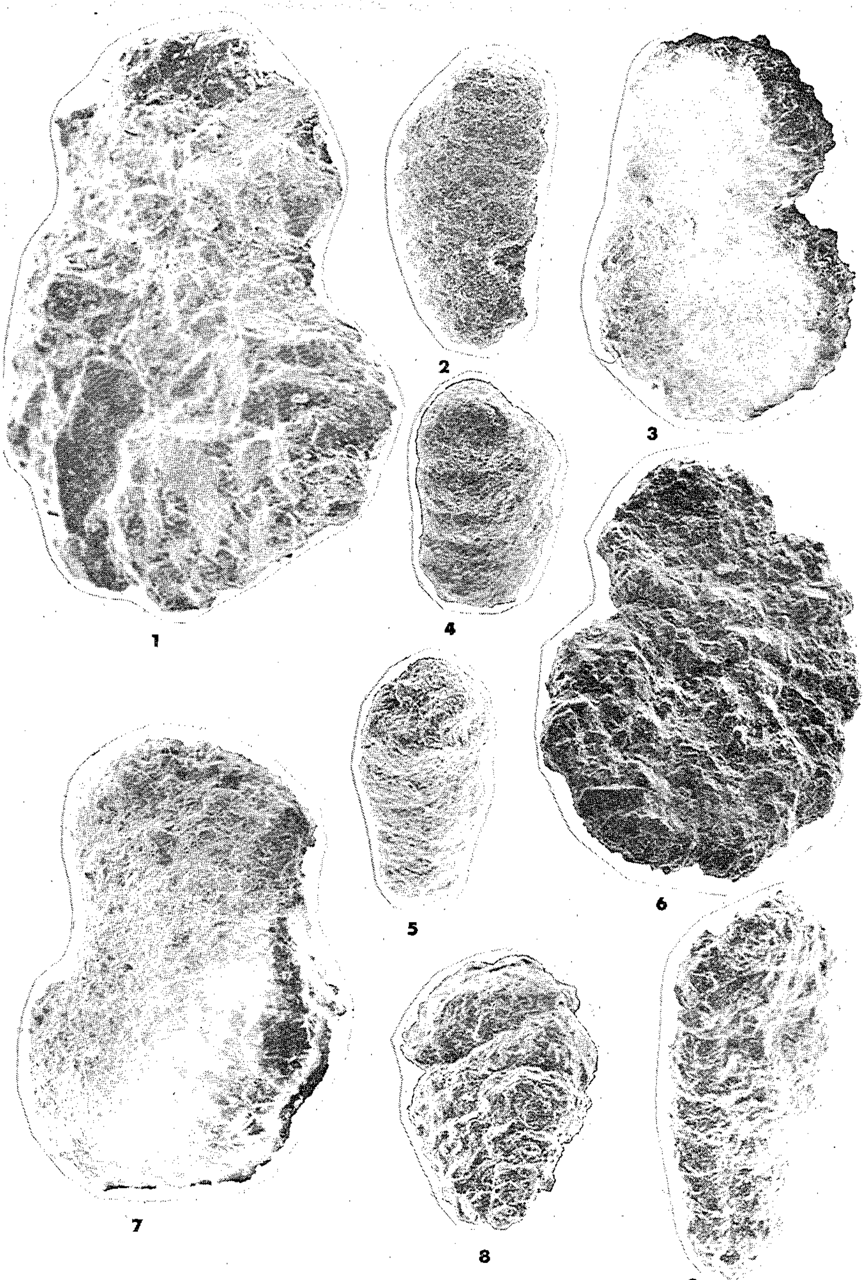
FIG. 6.—*Ammobaculites texanus* Cushman. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X55. (BYU 2354)

FIG. 7.—*Ammobaculites wenonahae* Tappan. Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X109. (BYU 2362)

FIG. 8.—*Spiroplectammina navarroana* Cushman. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X140. (BYU 2370)

FIG. 9.—*Spiroplectammina navarroana* Cushman. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X109. (BYU 2343)

PLATE 3



Type specimen.—Figured specimen BYU 2351.

AMMOBACULITES STEPHENSONI Cushman, 1933
Pl. 2, fig. 8

Ammobaculites stephensoni Cushman 1933, Cushman Lab. Foram. Research Contr., v. 9, pt. 3, p. 49, pl. 5, figs. 2a-b; 1944 idem., v. 20, pt. 1, p. 2, pl. 1, fig. 3; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 329, pl. 50, fig. 3; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 24, pl. 3, fig. 17; Gauger 1953, Utah Geol. and Min. Survey Bull. 47, p. 57, pl. 5, figs. 9-10; Frizzel 1954, Univ. Texas Bur. Econ. Geol., Rpt. Invest. 22, p. 62, pl. 2, figs. 26a-b.

Description.—Test very much compressed, the earlier portion closely coiled and somewhat involute, later portion uncoiled, periphery rounded; chambers rather indistinct, comparatively few, four or five in a coil; sutures indistinct, nearly straight; wall rather coarsely agglutinated but with a large proportion of cement and with fairly smooth finish. Dimensions of average-sized specimens: length, about 0.5 mm; breadth, about 0.3 mm; thickness, about 0.15 mm.

Remarks.—The species occurs in all measured sections with the exception of the Factory Butte section, and occurs sporadically throughout each section. Specimens average slightly smaller than those described by Cushman (1946) or Gauger (1953). This species ranges from Eagle Ford through Austin and Taylor Marl of Texas. It was also recovered from the Hilliard Formation of southwestern Wyoming. The species was originally described from the Taylor Marl of McLennon County, Texas (Cushman, 1933).

Type specimen.—Figured specimen BYU 2350.

AMMOBACULITES TEXANUS Cushman, 1933
Pl. 3, figs. 3, 6

Ammobaculites texanus Cushman 1933, Cushman Lab. Foram. Research Contr., v. 9, pt. 3, p. 50, pl. 5, fig. 3; Cushman and Todd 1943, Cushman Lab. Foram. Research Contr., v. 19, pt. 3, p. 50; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 23, pl. 3, figs. 22-23; Gauger 1953, Utah Geol. and Min. Survey Bull. 47, p. 57, pl. 5, fig. 19; Frizzell 1954, Univ. Texas Bur. Econ. Geol., rpt. invest. 22, p. 63, pl. 3, fig. 3.

Description.—Test large, compressed, periphery lobulated and rounded, the umbilical region somewhat excavated and the test becoming somewhat evolute in the adult; chambers fairly distinct, especially in the adult; usually five or six in the coil in the younger stages, slightly inflated, especially in the later development; sutures indistinct, very slightly depressed; wall very coarsely agglutinated, compressed. Dimensions of average-sized specimens: length, about 1.5 mm; diameter of coil, about 0.9 mm; thickness, about 0.6 mm.

Remarks.—The species occurs in all measured sections with the exception of the Factory Butte section. Specimens occur in large numbers in the Masuk Shale portion of the sections but only sporadically and in fewer numbers in the Blue Gate Member. The species was not found in the Tununk Shale of any of the sections. Specimens appear to be slightly smaller than those described from the Texas and Wyoming areas. This species has been reported previously

from the Hilliard Shale of southwestern Wyoming and was originally described from the Navarro-age Corsicana Marl, Texas (Cushman, 1933).
Type specimens.—Figured specimens BYU 2358, 2354; reference specimens BYU 2359, 2360.

AMMOBACULITES WENONAHAE Tappan, 1960
Pl. 3, fig. 7

Ammobaculites tyrrelli Nauss (not Nauss, 1947), Tappan 1951, Cushman Found. Foram. Research, Contr., v. 2, pt. 1, p. 3, pl. 1, figs. 12-14; Tappan 1951, in Payne et. al., U.S. Geol. Survey., Oil and Gas Invest. Map OM-126, sheet 3, fig. 21 (11).
Ammobaculites wenonahae Tappan 1960, Am. Asso. Petro. Geol. Bull., v. 44, no. 3, p. 291, pl. 1, figs. 3-6; 1962, U.S. Geol. Survey Bull. 236-C, p. 138, pl. 32, figs. 1-7.

Description.—Test free, elongate, slightly compressed; early portion close-coiled, with five to seven chambers in the coil and a large umbilicus; later portion uniserial with nearly parallel sides, early uniserial portion of equal or less breadth than the coil, peripheral margin broadly rounded; chambers numerous, inflated in the coil, ranging from subrounded to low and broad in the uniserial portion; uniserial chambers increasing very little in diameter as added; sutures distinct, straight and depressed; wall agglutinated, texture varying with the type of enclosing sediments, aperture terminal rounded. Dimensions of average-sized specimens: length, about 0.6 mm; diameter of coil, about 0.4 mm; thickness, about 0.3 mm.

Remarks.—Specimens occur in all measured sections in which the Tununk Shale was sampled. The species occurs in the lower part of the Tununk Shale in each of these sections and appears to be useful as a marker species. Mancos specimens are slightly smaller and have less distinct chambering than those described by Tappan (1960). This species was originally described from the Upper Cretaceous of the North Slope of Alaska (Tappan, 1951).

Type specimens.—Figured specimen BYU 2362; reference specimen BYU 2363.

Genus FLABELLAMMINA Cushman, 1928

FLABELLAMMINA COMPRESSA (Beissel, 1891)
Pl. 4, figs. 1, 2

Haplophragmium compressum Beissel 1891, Preuss. Geol. Landesanstalt abh., new ser., v. 3, p. 16, pl. 4, figs. 11-23.
Ammobaculites compressa Franke 1928, Preuss. Geol. Landesanstalt abh., new ser., v. 11, p. 166, pl. 15, fig. 10.
Flabellammina compressa Alexander and Smith 1932, Jour. Paleont., v. 6, p. 305, pl. 46, figs. 2-3, 5-9; Brotzen 1936, Sveriges Geol. Undersökning, v. 30, no. 3, ser. C, no. 396, p. 32, pl. 1, figs. 9a-b; Cushman 1946, U.S. Geol. Survey Prof. Paper, no. 206, p. 25, pl. 4, figs. 3-6.

Description.—Test strongly compressed, the flat surface rounded or elongate, elliptical or ovoid, periphery bluntly rounded; chambers few, somewhat indistinct; sutures fairly distinct, slightly depressed, curved; wall coarsely agglutinated, composed of angular fragments. Dimensions of average-sized specimens: length, about 1.1 mm; breadth, about 0.8 mm.

Remarks.—The species occurs in the Woodside, Ferron-Castledale, and Emery sections. This species occurs only in the Masuk Shale and Blue Gate Shale and very sporadically in these members. Specimens found are slightly smaller than those previously described elsewhere. Tests are formed almost exclusively of angular fragments with quantitatively somewhat less ground mass. This species has been reported from the Navarro-age Saratoga Chalk and Taylor-age Ozan Formation of Arkansas, from the Upper Cretaceous of Texas, and from the Upper Cretaceous of northern and central Germany. This species was originally described from the Upper Cretaceous Aachen Chalk of Germany (Geissel, 1891).

Type specimens.—Figured specimens BYU 2352, 2353.

Family TEXTULARIIDAE Ehrenberg, 1838

Subfamily SPIROPLECTAMMININAE Cushman, 1927
Genus SPIROPLECTAMMINA Cushman, 1927
SPIROPLECTAMMINA MORDENENSIS Wickenden, 1932
Pl. 3, figs. 2, 4, 5

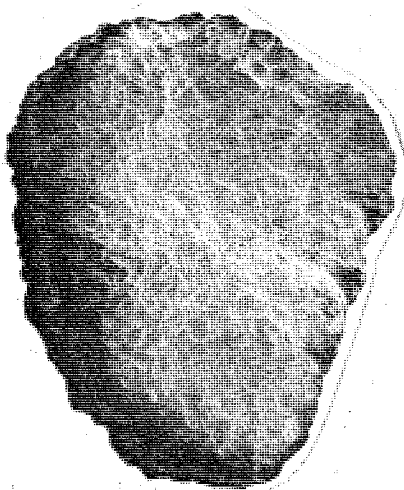
Spiroplectammina mordenensis Wickenden 1932, Royal Soc. Canada Trans., ser. 3, v. 26, sec. 4, p. 86, pl. 1, figs. 4a-b; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 28, pl. 6, fig. 4; Tappan 1951, Cushman Found. Foram. Research, contr., v. 2, pt. 1, p. 5, pl. 1, figs. 20a-b; 1957, in Payne et. al., U.S. Geol. Survey Oil and Gas Invest. Map. OM-126, sheet 3, fig. 21 (5); 1962, U.S. Geol. Survey Prof. Paper 236-C, p. 140, pl. 33, fig. 6; Mello 1969, U.S. Geol. Survey Prof. Paper 611, p. 45, pl. 4, figs. 8a-d.

Description.—Test initially planispiral, later becoming biserial, elongate in larger specimens, compressed; $1\frac{1}{4}$ to 2 times as long as broad, broadest and thickest at apertural end; apertural end rhomboidal in outline, slightly convex, composed of the upper surfaces of the last and penultimate chambers which

EXPLANATION OF PLATE 4

FIG. 1.—*Flabellammina compressa* (Beissel). Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X55. (BYU 2352)
FIG. 2.—*Flabellammina compressa* (Beissel). Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X55. (BYU 2353)
FIG. 3.—(?) *Bolivinopsis* sp. Middle part of the Upper Mancos Shale, Woodside section, Emery County, Utah. Side view, X268. (BYU 2580)
FIG. 4.—*Textularia ripleyensis* W. Berry. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X268. (BYU 2577)
FIG. 5.—*Textularia ripleyensis* W. Berry. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X140. (BYU 2573)
FIG. 6.—*Trochammina wickendeni* Loeblich. Middle part of the Upper Mancos Shale, Woodside section, Emery County, Utah. Dorsal view, X140. (BYU 2557)
FIG. 7.—*Trochammina wickendeni* Loeblich. Middle part of the Upper Mancos Shale, Woodside section, Emery County, Utah. Ventral view, X110. (BYU 2558)
FIG. 8.—*Textularia ripleyensis* W. Berry. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X140. (BYU 2575)
FIG. 9.—*Trochammina wickendeni* Loeblich. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X54. (BYU 2345)

PLATE 4



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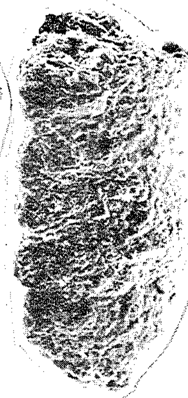

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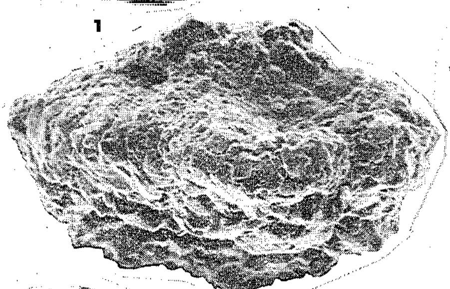

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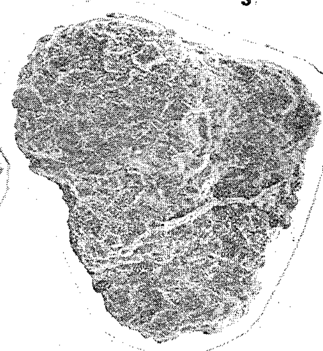

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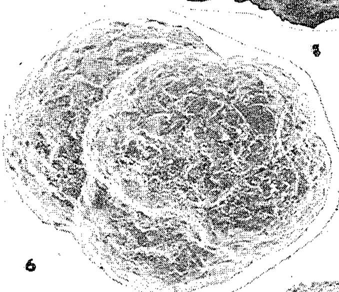

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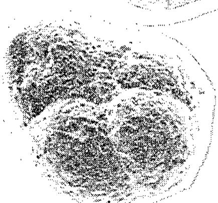

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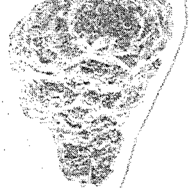

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meet at an acute angle in the midline of the test; planispiral part composed of four to seven chambers in addition to the proloculus; diameter of the initial end dependent upon the size of the coil, apparenty not directly related to the size of the proloculus; biserial part composing most of the test in all but the smallest specimens; usually composed of four to five pairs of chambers, but some specimens have as many as seven pairs; chambers oblique to axis of elongation, usually not inflated, two to three times as broad as high, regularly increasing in size as added, slightly overlapping; in all longer specimens the final few pairs of chambers become nearly as high as broad; sutures usually flush with the surface, indistinct, occasionally slightly depressed, oblique to the axis of elongation, straight or slightly convex toward the apertural end; wall agglutinated, composed of either calcareous or noncalcareous particles; particle size ranges from relatively coarse grained to fine grained, amount of cement variable, finer-grained particles and more cement characteristic of calcareous specimens; aperture a low-arched interiomarginal opening at the midline of the test, located in a slight invagination at the base of the low rounded apertural face. Dimensions of average-sized specimens: length, about 0.27 mm; maximum breadth, about 0.15 mm.

Remarks.—Specimens occur abundantly in all measured sections. This species appears to be a good marker for it is found only in the Blue Gate Shale and is distinct and abundant in most samples. It is slightly smaller than described by Cushman (1946) but well within the range given by Mello (1969). This species has been reported from the Upper Cretaceous of the North Slope of Alaska, and from the Fox Hills Sandstone, north central South Dakota. It was originally described from the Upper Cretaceous Morden beds of Manitoba, Canada (Wickenden, 1932).

Type specimens.—Figured specimens BYU 2344, 2347, 2373; reference specimens BYU 2371, 2372.

SPIROPLECTAMMINA NAVARROANA Cushman, 1932
Pl. 3, figs. 8, 9

Spiroplectammina navarroana Cushman 1932, Cushman Lab. Foram. Research Contr., v. 8, pt. 4, p. 96, pl. 11, figs. 14a-b; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 329, pl. 50, fig. 5; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 27, pl. 5, figs. 13-14; Gauger 1953, Utah Geol. and Min. Survey, bull. 47, p. 58, pl. 5, figs. 20-24; Frizzell 1954, Univ. Texas Bur. Econ. Geol., rpt. invest. 22, p. 67, pl. 4, figs 29a-b.

Description.—Test elongate, initially planispiral, later becoming biserial, very slightly if at all tapering in the adult portion; chambers nearly as high as broad, rounded at the periphery, somewhat inflated; sutures distinct, slightly depressed, nearly at right angles to the periphery; wall rather coarsely agglutinated, with large fragments but with fairly smooth finish; aperture somewhat oblique, consisting of a narrow arched opening at the inner margin of the apertural face. Dimensions of average-sized specimens: length, about 0.4 mm; breadth, about 0.2 mm; thickness, about 0.1 mm.

Remarks.—Specimens occur in the Woodside, Ferron-Castledale, and Emery sections. This species was found only in the Blue Gate Shale and, in large numbers, only in the lower portion. In conjunction with other species it forms a rather distinct faunal zone near the base of the Blue Gate Shale. Specimens are slightly shorter but are about the same breadth and thickness as those reported by Cushman (1932). They appear to be not quite as smoothly finished. This species has previously been reported from Navarro-age Kemp Clay of Texas, Taylor-age Marlbrook Marl of Arkansas, and the Hilliard Shale of southwestern Wyoming. The species was originally described from the Kemp Clay of the Navarro Group, Navarro County, Texas.

Type specimens.—Figured specimens BYU 2343, 2370; reference specimens BYU 2342, 2369.

Genus BOLIVINOPSIS Yakovley, 1891

(?) BOLIVINOPSIS sp.
Pl. 4, fig. 3

Description.—Only fragments were found, none showing large planispiral coil; walls calcareous, agglutinated fine-grained calcareous particles; test elongate, somewhat compressed, thickest along the median line, sides parallel; chambers distinct, biserial, low and broad; sutures distinct, slightly depressed, distinctly limbate, forming very low angle with the horizontal. Fragments present in samples very closely compare with *Bolivinopsis (?) clotho* (Grzybowski) Cushman, as illustrated by Cushman (1946); without, however, the diagnostic initial coil, generic placement is questionable. Dimensions of averaged-sized specimens: length, about 0.2 mm; breadth, about 0.1 mm.

Type specimens.—Figured specimen BYU 2480; reference specimen BYU 2581.

Subfamily TEXTULARIINAE Ehrenberg, 1838

Genus TEXTULARIA Defrance in de Blainville, 1824
TEXTULARIA RIPLEYENSIS W. Berry, 1929
Pl. 4, figs. 4, 5, 8

Textularia ripleyensis W. Berry, 1929, in W. Berry and Kelley, U.S. Nat. Mus. Proc., v. 76, art. 19, p. 4, pl. 2, fig. 2; Cushman 1931, Tennessee Div. Geol. Bull. 41, p. 19, pl. 1, figs. 6-7; 1931, Cushman Lab. Foram. Research Contr., v. 8, p. 96, pl. 11, figs. 12-13; 1932, Jour. Paleont., v. 6, p. 332; Sandidge 1932, Jour. Paleont., v. 6, p. 267, pl. 41, figs. 6-8; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 329, pl. 50, figs. 7-8; Cushman 1944, Cushman Lab. Foram. Research Contr., v. 20, p. 2, pl. 1, fig. 5; 1946, U.S. Geol. Survey Prof. Paper 206, p. 29, pl. 6, figs. 17-20.

Description.—Test compressed, slightly longer than broad; the apertural end broadly rounded, greatest width slightly above the middle, periphery subacute, serrate or only slightly lobed; chambers distinct, the outer end raised and depressed below, sutures made distinct by the depressed areas but the sutural lines indistinct; wall roughened at the outer edge, smoother toward the base, distinctly agglutinated; aperture a very low opening in the median portion of the inner margin of the chamber with an elongate lobe at each side. Dimensions of average-sized specimens: length, about 0.25 mm; breadth, about 0.23 mm.

Remarks.—The species occurs rather sparsely in the Tununk Shale of the Woodside and Ferron-Castledale sections. Specimens from the Mancos Shale appear to be slightly shorter than those reported from the Gulf Coast area. This species is reported to have wide distribution in upper Taylor-age beds of the Gulf Coastal Plain region of the United States and is described as an excellent index fossil for the upper and middle parts of the Taylor Marl (Cushman, 1946). However, distribution and abundance of the species appear to be rather limited in the area of the present study.

Type specimens.—Figured specimens BYU 2573, 2476, 2577; reference specimen BYU 2575.

Family TROCHAMMINIDAE Schwager, 1877

Subfamily TROCHAMMININAE Schwager, 1877
Genus TROCHAMMINA Parker and Jones, 1859
TROCHAMMINA WICKENDENI Loeblich, 1946
Pl. 4, figs. 6, 7, 9

Trochammina wickendeni Loeblich 1946, Jour. Paleont., v. 20, no. 2, p. 138, pl. 22, fig. 17; Frizzell 1954, Univ. Texas Bur. Econ. Geol., rpt. invest. 22, p. 79, pl. 7, figs. 24a-b; Eicher 1965, Jour. Paleont., v. 39, no. 5, p. 900, pl. 105, fig. 13; 1966, Cushman Found. Foram. Research, contr., v. 17, p. 24, pl. 4, fig. 22.

Description.—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 agglutinated, smoothly finished; aperture obscure, apparently at the inner ventral margin of the last chamber opening into the umbilicus; specimens very commonly crushed, giving the last three or four chambers a flared lobate form. Dimensions of average-sized specimens: greatest diameter, about 0.3 mm; crushed specimens' greatest diameter up to 1.0 mm.

Remarks.—Specimens occur in all measured sections and are distributed throughout most samples in each section. But the greatest abundances occur in the more arenaceous rocks. The largest diameters of uncrushed specimens are well within the reported ranges of 0.14 to 0.37 for the species; however, most Mancos specimens are crushed and therefore flare, ranging up to 1.0 mm. This species has previously been reported from the Upper Cretaceous of Texas, and from the Graneros and Carlile shales of Colorado. The species was originally described from the Pepper Shale of Texas.

Type specimens.—Figured specimens BYU 2345, 2557, 2558; reference specimen BYU 2346.

Family ATAXOPHRAGMIIDAE Schwager, 1877

Subfamily VERNEUILININAE Cushman, 1811
Genus GUADRYINA d' Orbigny in De La Sagra, 1839
GAUDRYINA BENTONENSIS (Carman, 1929)
Pl. 5, figs. 2, 3

Spiroplectammina bentonensis Carman 1929, Jour. Paleont., v. 3, p. 311, pl. 34, figs. 8-9.
Gaudryina bentonensis (Carman) Cushman 1932, Cushman Lab. Foram. Research Contr., v. 8, pt. 4, p. 96; 1937. Cushman Lab. Foram. Research Special Pub. 7, p. 42, pl. 6, figs. 21-22; Cushman and Deaderick 1942,

Cushman Lab. Foram. Research Contr., v. 18, p. 52, pl. 9, figs. 12-13; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 33, pl. 7, figs. 15-16; Frizzell 1954, Univ. of Texas Bur. of Econ. Geol., Rpt. Invest. no. 22, p. 70, pl. 5, fig. 15; Graham and Church 1963, Stanford Univ. Pub. Geol. Sci., v. 8, p. 19, pl. I, fig. 3; Sliter 1968, Univ. of Kansas Paleont. Contr., ser. 49, p. 48, pl. 3, fig. 10.

Description.—Test small, elongate, narrow early portion apparently triserial, later and much the larger portion biserial, easily distorted in fossilization and usually twisted, the biserial portion with the chambers somewhat inflated, high, rather regularly increasing in size as added; the sides of the biserial portion nearly parallel; sutures more or less indistinct, usually nearly horizontal; wall rather coarsely agglutinated, with much cement, somewhat roughly finished; aperture at the inner margin of the last formed chamber, low, narrow. Dimensions of average-sized specimens: length, about 0.6 mm; breadth, about 0.2 mm.

Remarks.—Specimens occur in all measured sections and are distributed throughout each section with the greatest abundances in the more arenaceous portions. Specimens appear to average slightly larger than those described by Cushman (1932). This species has previously been reported from the Taylor-age upper Taylor Marl, Pecan Gap Chalk, Wolfe City Sand, Annona Chalk, and lower Taylor Marl of Texas; the Austin-age Brownstown Marl, Blossom Sand, Selma Chalk, and Eagle Ford Shale of Texas; the Marlbrook Marl of Arkansas; and Upper Cretaceous beds of northern and southern California and northwestern Baja California. The species was originally described from the Benton Shale of Wyoming (Carmen, 1929).

Type specimens.—Figured specimens BYU 2338, 2339.

GAUDRYINA FAUJASI (Reuss, 1861)
Pl. 5, figs. 1, 5, 6

Textilaria faujasi Reuss 1861, Akad. Wiss. Wien, Math-naturwiss. Kl., Sitzungsber., v. 44, pt. 1, p. 320, pl. 3, figs. 9a-b.

Gaudryina faujasi Cushman 1932, Cushman Lab. Foram. Research Contr., v. 8, p. 91; 1937, Cushman Lab. Foram. Research Special Pub. 7, p. 39, pl. 5, figs. 17-20; pl. 6, figs. 1-2; Cushman and Deaderick 1942, Cushman Lab. Foram. Research Contr., v. 18, p. 53, pl. 9, fig. 14.

Gaudryina faujasi (Reuss) Cushman 1946, U.S. Geol. Survey Prof. Paper 206, pp. 32-33, pl. 7, fig. 14; Frizzell 1954, Univ. of Texas Bur. Econ. Geol., rpt. invest. 22, p. 70, pl. 5, figs. 12a-b.

Description.—Test large, elongate, the earliest portion triserial, triangular in transverse section, sides flattened or slightly concave, angles somewhat rounded; later and much the larger portion biserial, increasing gradually in breadth as added, periphery broadly rounded, sides somewhat flattened; chambers except those of the last-formed portion indistinct, latest somewhat inflated sutures indistinct except toward the apertural end, where they are slightly depressed, nearly horizontal or very slightly oblique; wall agglutinated, somewhat roughly finished; aperture a rectangular opening at the inner margin of the last-formed chamber. Dimensions of average-sized specimens: length, about 0.5 mm; breadth, about 0.35 mm; thickness, about 0.25 mm.

Remarks.—Specimens were recovered from all measured sections except for the West Henry Mountain section. The species is distributed sporadically throughout the other four sections. Specimens are considerably smaller and somewhat more roughly finished than those described and illustrated by Cushman (1946). This species has been previously reported from Upper Cretaceous beds of New Jersey, Arkansas, and Texas. The species was originally described from the Upper Cretaceous Maastrichtian stage of Maastricht, Holland (Reuss, 1861). It occurs elsewhere in the Senonian.

Type specimens.—Figured specimens BYU 2335, 2336, 2337; reference specimens BYU 2583, 2584.

GAUDRYINA RUDITA Sandidge, 1932
Pl. 5, figs. 4, 8

Textularia agglutinans W. Berry (not d'Orbigny) in Berry and Kelley 1929, U.S. Nat. Mus. Proc., v. 76, art. 19, p. 3, pl. 2, fig. 1.

Gaudryina rugosa Cushman (not d'Orbigny) 1931, Tennessee Div. Geology, bull. 41, p. 20, pl. 1, figs. 9-10.

Gaudryina minima Cushman (?) (not Egger) 1931, Jour. Paleont., v. 5, p. 301, pl. 34, figs. 5a-b.

Gaudryina rudita Sandidge 1932, Am. Midland Naturalist, v. 13, p. 342, pl. 31, figs. 19-20; Cushman 1937, Cushman Lab. Foram. Research, special pub. 7, p. 46, pl. 7, figs. 8-10; Cushman and Todd 1943, Cushman Lab. Foram. Research Contr., v. 19, p. 51, pl. 9, fig. 4; Cushman 1944, Cushman Lab. Foram. Research Contr., v. 20, p 84; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 329, pl. 50, figs. 9-10; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 34, pl. 7, figs. 23-24; pl. 8, fig. 1.

Description.—Test elongate, slightly compressed, broad at the apertural end, initial end bluntly pointed; triserial portion small, short; biserial portion much

EXPLANATION OF PLATE 5

FIG. 1.—*Gaudryina faujasi* (Reuss). Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X110. (BYU 2337)

FIG. 2.—*Gaudryina bentonensis* (Carman). Top of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X109. (BYU 2339)

FIG. 3.—*Gaudryina bentonensis* (Carman). Top of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X109. (BYU 2338)

FIG. 4.—*Gaudryina rudita* Sandidge. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X70. (BYU 2340)

FIG. 5.—*Gaudryina faujasi* (Reuss). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X110. (BYU 2335)

FIG. 6.—*Gaudryina faujasi* (Reuss). Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Oblique view, X140. (BYU 2336)

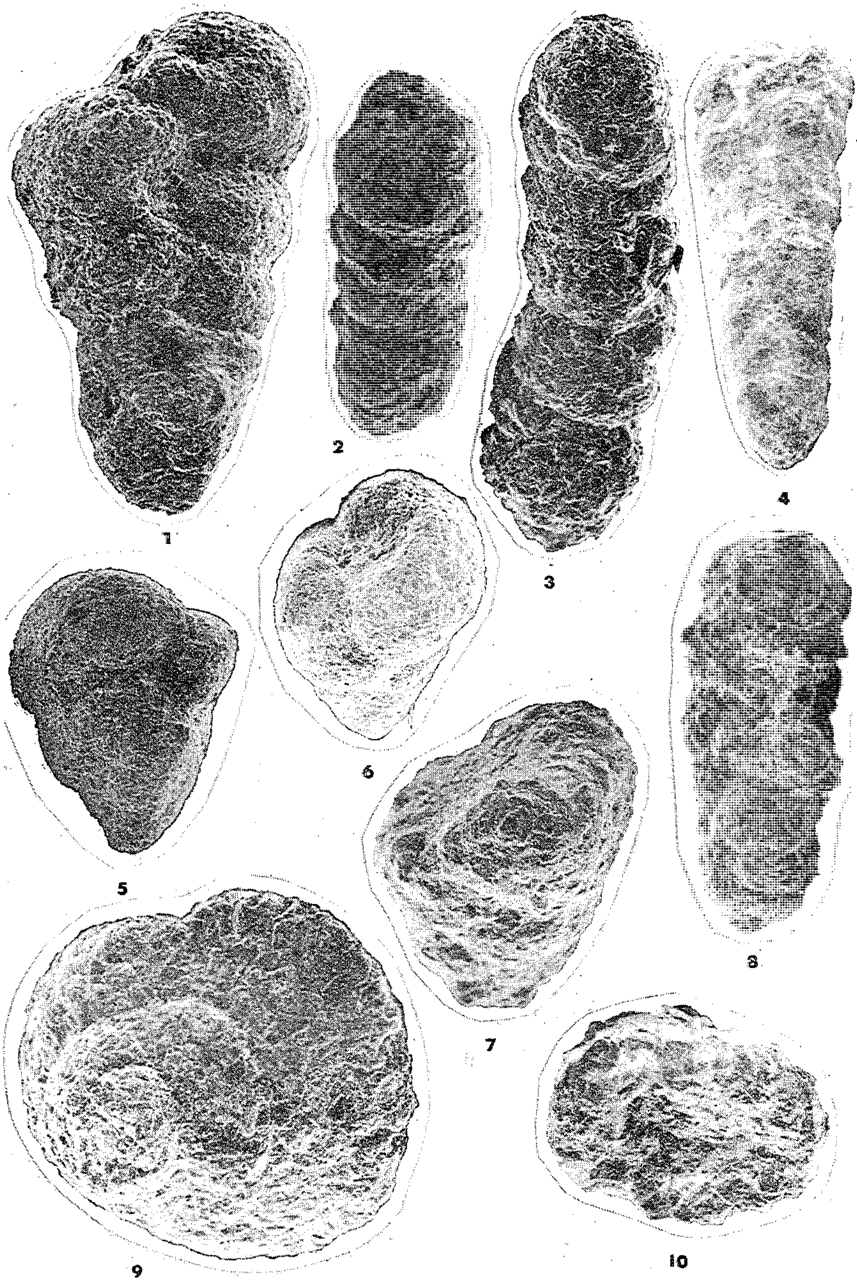
FIG. 7.—*Dorothia oxycona* (Reuss). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X140. (BYU 2366)

FIG. 8.—*Gaudryina rudita* Sandidge. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side View, X110. (BYU 2340)

FIG. 9.—*Dorothia oxycona* (Reuss). Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X114. (BYU 2364)

FIG. 10.—*Dorothia oxycona* (Reuss). Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X140. (BYU 2364)

PLATE 5



longer, slightly inflated; chambers gradually increasing in size as added, rounded, overlapping; sutures somewhat depressed, sometimes partially concealed by the rough coating of sand; wall finely agglutinated, exterior covered with coarse sand grains, surface rough; aperture in a rounded depression extending from the inner margin well into the face of the last chamber. Dimensions of specimens: length, 0.20 to 0.90 mm; breadth 0.15 to 0.35 mm.

Remarks.—The species occurs in all measured sections and is distributed sporadically throughout each section. Specimens from the Mancos Shale have a wide range of sizes, as reported, but are more smoothly finished and have thick limbate sutures which show clearly in transmitted light. This species has been previously reported from the Navarro-age Corsicana Marl, Texas, Owl Creek Formation, Mississippi, Prairie Bluff Chalk, Alabama, Ripley Formation, Tennessee, Selma Chalk, Tennessee, and Neylanville Marl, Texas; from the Taylor-age Taylor Marl, Texas, and the Marlbrook Marl, Arkansas; and from the Austin-age Austin Chalk, Texas, and Selma Chalk, Mississippi. The species was originally described from the Ripley Formation of Alabama (Sandidge, 1932).

Type specimens.—Figured specimens BYU 2340, 2341; reference specimens BYU 2583, 2584.

Subfamily GLOBOTEXTULARIINAE Cushman, 1927

Genus DOROTHIA Plummer, 1931

DOROTHIA OXYCONA (Reuss), 1860

Pl. 5, figs. 7, 9, 10

Textularia trochus d'Orbigny 1840, Mém. Soc. Géol. France, tome 4, fasc. 1, p. 45, pl. 4, figs. 25-26.

Texularia turris d'Orbigny 1840, Mém. Soc. Géol. France, tome 4, fasc. 1, p. 46, pl. 4, figs. 27-28.

Gaudryina oxycona Reuss 1860, K. Akad. Wiss. Wien, Math-naturwiss. Kl., Sitzungsber., v. 40, p. 229, pl. 12, fig. 3; 1862, Akad. Wiss. Wien, Math-naturwiss. Kl., Sitzungsber., v. 46, pt. 1 (1863); Karrer 1870, K. k. Geol. Reichsanstalt Jahrb., v. 20, p. 166; Marsson 1878, Naturw. ver. Neu-Vorpommern u. Rügen Mitt., Jahrb., v. 10, p. 158; Schacko 1896, Ver. Freunde Nat. Mecklenburg Archiv, v. 50, p. 156 (list), (1897); Egger 1899, K. bayer. Akad. Wiss., Math-naturh. Abt., abh. kl. II, v. 21, p. 28, pl. 4, figs. 1-3; Franke 1912, Naturh. Ver. preuss. Rheinlande u. Westfalens Verh., 69 Jahrb., v. 59, p. 263 (1913); 1925, Griefswald Univ., Geol.-palaeont. Inst. abh., v. 6, p. 15, pl. 1, figs. 20a-b; 1928, Preuss. Geol. Landesanstalt Abh., new ser., v. 111, p. 143, pl. 13, figs. 8a-b; Cushman and Church 1929, Calif. Acad. Sci., proc., ser. 4, v. 18, p. 501, pl. 36, fig. 3-4; Cushman 1931, Jour. Paleont., v. 5, p. 300, pl. 34, figs. 6a-b; 1932, idem., v. 6, p. 332; Wickenden 1932, idem., v. 6, p. 205, pl. 29, figs. 3a-b; Sandidge 1932, Jour. Paleont., v. 6, p. 268, pl. 41, figs. 2-3; Cushman and Jarvis 1932, U.S. Nat. Mus. Proc., v. 80, art. 14, p. 18, pl. 5, figs. 1-2.

Marssonella oxycona (Reuss) Cushman 1933, Cushman Lab. Foram. Research Contr., v. 9, p. 36, pl. 4, figs. 13a-b; 1933, Cushman Lab. Foram. Research Special Pub. 4, pl. 12, fig. 7; idem., special pub. 5, pl. 8, fig. 23; Jennings 1936, Bull. Am. Paleont., v. 23, no. 78, p. 14, pl. 1, fig. 11;

Cushman 1937, Cushman Lab. Foram. Research special pub. 8, p. 56, pl. 5, figs. 27-29; pl. 6, figs. 1-17; Loetterle 1937, Neb. Geol. Survey Bull., 2d ser., bull. 12, p. 59, pl. 10, figs. 7 a-b; Frizzell 1943, Jour. Paleont., v. 17, p. 340, pl. 55, fig. 15; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 43, pl. 12, figs. 3-5a-b; Bandy 1951, Jour. Paleont., v. 25, p. 492, pl. 72, fig. 8; Frizzell 1954, Univ. Texas Bur. Econ. Geol., rpt. invest. 22, p. 75, pl. 6, figs. 17a-b; Martin 1964, Geol. Bundesanstalt Wien, jahrb., sonderbl. 9, p. 56, pl. 3, fig. 14; Morris 1971, Micropaleont., v. 17, no. 3, p. 275, pl. 5, fig. 11.

Marssonella conica Gauger 1953, Utah Geol. and Min. Survey, bull., no. 47, p. 62, pl. 6, figs. 14-16.

Marssonella trochus (d'Orbigny) Hagn 1953, Palaeontographica, bd. 104, abt. A, p. 24, pl. 1, fig. 30.

Dorothia oxycona (Reuss) Loeblich and Tappan 1964, Treatise on Invert. Paleont., protista 2, pt. C., v. 1, p. C275, fig. 184; Morris 1971, Micropaleont., v. 17, no. 3, p. 275, pl. 5, fig. 11.

Description.—Test conical, either gradually tapering or broadly flaring; earliest whorl with four or five chambers, later reduced to three, then two in a whorl in the adult; rounded in transverse section; chambers distinct but not inflated; sutures distinct, usually flush with the surface; wall coarsely or finely agglutinated with larger quartz grains at the surface, smoothly finished or slightly roughened; aperture a broad, low opening at the inner margin of the last formed chamber. Dimensions of average-sized specimens: length, about 0.30 mm; diameter, about 0.28 mm. Crushed specimens' diameter up to 0.55 mm.

Remarks.—Specimens recovered from the Mancos Shale are considered to be distorted forms of *Dorothia oxycona* (Reuss), a variable and widespread Upper Cretaceous species. *Marssonella conica* Gauger is similar and distorted in the same manner. In agreement with Wall (1967, p. 84) and Morris (1971, p. 275), *Marssonella conica* is here considered probably to be a distorted form of *Dorothia oxycona* (Reuss). Specimens occur at all the Mancos measured sections. The species is distributed sporadically and in rather small numbers throughout the Masuk and Blue Gate shales but occurs in only the uppermost Tununk Shale. This species has been previously reported from the Upper Cretaceous of Europe, Mal Paso Shale of northwestern Peru, Navesink Marl and Mt. Laurel Sand of New Jersey, Navarro-age Prairie Bluff Chalk of Alabama, and the Saratoga Chalk of Arkansas; from the Taylor-age Taylor Marl and Pecan Gap Chalk of the Taylor Marl and the Annona Chalk from Texas; and from the Austin-age Gober and Ector tongues of the Austin Chalk from Texas, the Hilliard Formation of southwestern Wyoming, and the Upper Mancos Formation of northwestern Colorado. The species was originally described from the Upper Cretaceous of Europe.

Type specimens.—Figured specimens BYU 2364, 2365, 2366.

Suborder ROTALIINA Delage and Herouard, 1896

Superfamily NODOSARIACEA Ehrenberg, 1838
Family NODOSARIIDAE Ehrenberg, 1838
Subfamily NODOSARIINAE Ehrenberg, 1838
Genus NODOSARIA Lamarck, 1812
NODOSARIA BIGHORNENSIS Young, 1951
Pl. 6, figs. 1, 2

Nodosaria bighornensis Young 1951, Jour. Paleont., v. 25, no. 1, p. 58, pl. 12, figs. 17, 19; Eicher and Worstell 1970, Micropaleont., v. 16, no. 3, p. 287, pl. 3, figs. 21-22.

Description.—Test straight to slightly curved, long, slender, ornamented with seven or eight raised costae that do not spiral around the test; costae first appearing just distal to the proximal spine, dying out on the last chamber, evenly spaced, consistent in size throughout their length, extending the full length of the test; sutures may be depressed or invisible; last chamber tapering aperturally and drawn out into a neck; aperture terminal, radiate. Dimensions of average-sized specimens: length, about 0.41 mm; breadth, about 0.12 mm.

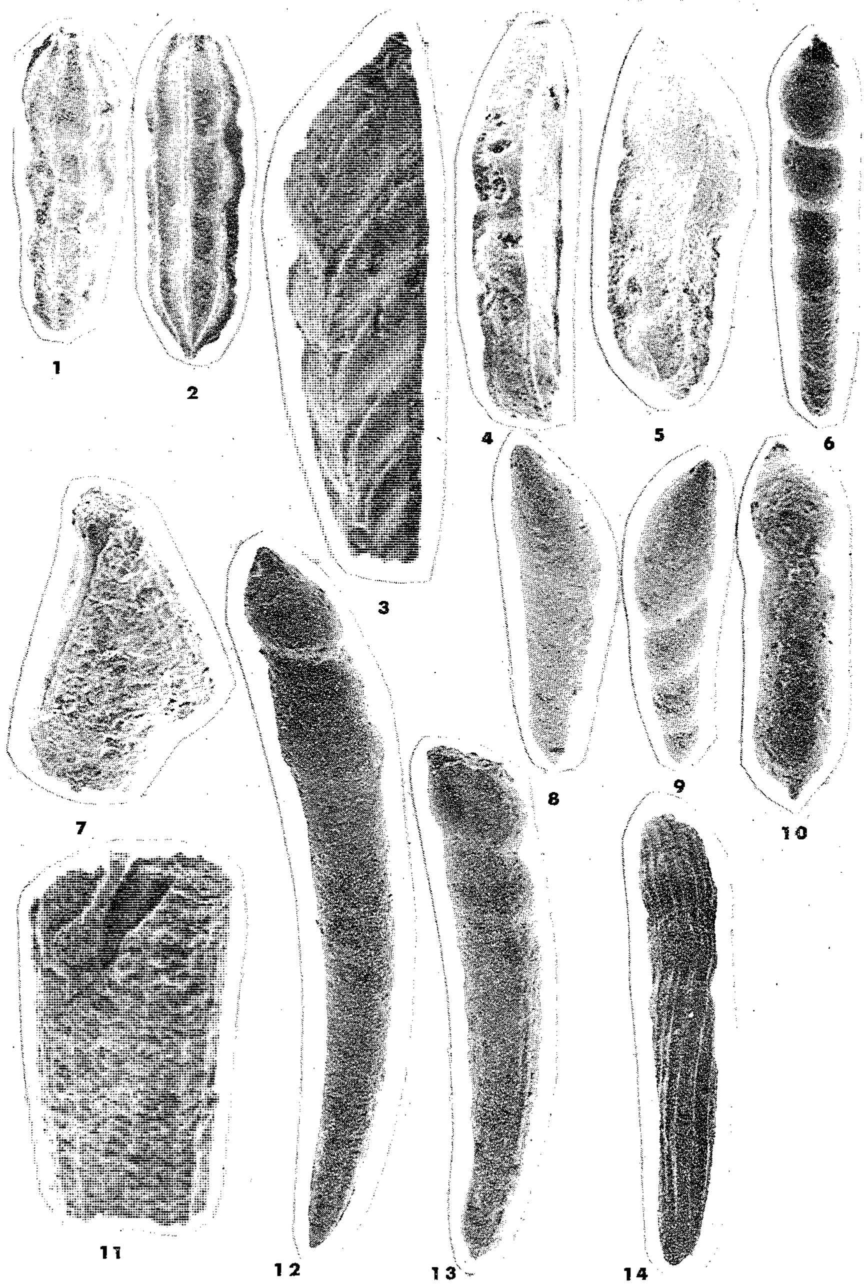
Remarks.—This species varies somewhat from the types in the depression of sutures, and varies widely in the degree of taper of the test. Mancos specimens show both sexual and asexual generations, for some expand rapidly from a pointed base while others have a large proloculus and broadly rounded base and remain essentially parallel sided throughout. Both have widely spaced costae and a low apertural neck. Specimens occur at all measured sections with the exception of the Factory Butte section, but are distributed rather sporadically. This species has previously been reported from the Cenomanian and Turonian of the Great Plains, United States. It was originally described from the Frontier Formation of southern Montana (Young, 1951).

Type specimens.—Figured specimens BYU 2455, 2457; reference specimen BYU 2456.

EXPLANATION OF PLATE 6

FIG. 1.—*Nodosaria bighornensis* Young. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X110. (BYU 2457)
FIG. 2.—*Nodosaria bighornensis* Young. Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X114. (BYU 2455)
FIG. 3.—*Citharina arguta* (Reuss). Lower part of the Blue Gate Shale, West Henry Mtns. section, Garfield County, Utah. Side view, X70. (BYU 2579)
FIG. 4.—*Citharina arguta* (Reuss). Lower part of the Tununk Shale, West Henry Mtns. section, Garfield County, Utah. Edge view, X110. (BYU 2572)
FIG. 5.—*Citharina arguta* (Reuss). Lower part of the Blue Gate Shale, West Henry Mtns. section, Garfield County, Utah. Side view, X110. (BYU 2578)
FIG. 6.—*Dentalina basiplanata* Cushman. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X55. (BYU 2451)
FIG. 7.—*Citharina texana* (Cushman). Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2470)
FIG. 8.—*Dentalina legumen* (Reuss). Lower part of the Blue Gate Shale, West Henry Mtns. section, Garfield County, Utah. Side view, X110. (BYU 2563)
FIG. 9.—*Dentalina legumen* (Reuss). Lower part of the Blue Gate Shale, West Henry Mtns. section, Garfield County, Utah. Side view, X110. (BYU 2562)
FIG. 10.—*Dentalina basiplanata* Cushman. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X110. (BYU 2449)
FIG. 11.—*Citharina texana* (Cushman). Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2469)
FIG. 12.—*Dentalina utahensis* Peterson. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X35. (BYU 2464)
FIG. 13.—*Dentalina utahensis* Peterson. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X35. (BYU 2465)
FIG. 14.—*Dentalina utahensis* Peterson. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X35. (BYU 2463)

PLATE 6



Genus CITHARINA d'Orbigny in De La Sagra, 1839

CITHARINA ARGUTA (Reuss, 1860)
Pl. 6, figs. 3, 4, 5

Vaginulina arguta Reuss 1860, K. Akad. Wiss., Math-naturw. cl., p. 202, pl. 8, fig. 4.
Vaginulina bicostulata Reuss 1860, K. Akad. Wiss., Math-naturw. cl., p. 202, pl. 8, fig. 5.
Vaginulina n. sp. Young 1951, Jour. Paleont., v. 25, no. 1, p. 58, pl. 13, figs. 13-14.
Vaginulina sp. Fox 1954, U.S. Geol. Survey Prof. Paper 254-E, p. 116, pl. 25, fig. 21.
Citharina arguta (Reuss) Lessard 1973, Utah Geol. and Min. Survey, special studies 45, p. 45, pl. 1, fig. 5.

Description.—Test flattened, calcareous; dorsal wall straight or very slightly convex; ventral wall slightly concave; noninflated chambers intersect dorsal wall at approximately 45° angles; chambers vary in number from four to nine; chambers increase rapidly in size in megalospheric forms and more gradually in microspheric; keeled on both sides; aperture radiate at terminus of dorsal side. Dimensions of average-sized specimens: length, about 0.75 mm; breadth, about 0.18 mm; thickness, about 0.07 mm.

Remarks.—Specimens occur only in the lower portion of the Tununk Shale in the Ferron-Castledale and West Henry Mountains sections. The species does not appear in the Tununk Shale in the Woodside section. It forms, in conjunction with other species, a rather distinct faunal zone near the base of the Tununk Shale. This species has previously been reported from the Greenhorn Formation of Wyoming, from the Frontier Formation of southern Montana, and from the Tununk Shale of Utah. It was initially described from the Cretaceous of Germany (Reuss, 1860).

Type specimens.—Figured specimens BYU 2572, 2578, 2579; reference specimens BYU 2570, 2571.

Genus CITHARINA d'Orbigny in De La Sagra, 1839

CITHARINA TEXANA (Cushman), 1930
Pl. 6, figs. 7, 11

Vaginulina simondsi Carsey, Moreman 1927, Jour. Paleont., v. 1, p. 98, pl. 16, fig. 1.
Vaginulina texana Cushman 1930, Cushman Lab. Foram. Research Contr., v. 6, p. 30, pl. 4, figs. 2-3; Morrow 1934, Jour. Paleont., v. 8, p. 192, pl. 29, fig. 10; Cushman and Deaderick 1942, Cushman Lab. Foram. Research Contr., v. 18, p. 59, pl. 12, figs. 1-6; Cushman 1944, Cushman Lab. Foram. Research Contr., v. 20, p. 88; 1946, U.S. Geol. Survey, Prof. Paper 206, pp. 77-78, pl. 28, figs. 7-22.
Vaginulina sp. Cushman 1930, Cushman Lab. Foram. Research Contr., v. 6, p. 30, pl. 4, figs. 12-13.
Vaginulina regina Plummer 1931, Texas Univ. Bull. 3101, p. 162, pl. 10, fig. 22.
Citharina texana (Cushman) Frizzell 1954, Univ. Texas Bur. Econ. Geol., rpt. invest. 22, pp. 95-96, pl. 11, figs. 29-32.

Description.—Test very variable in size and shape, distinctly compressed, the sides nearly parallel or tapering, with the ventral side becoming somewhat convex toward the apertural end; periphery rounded, initial end with a slight spine; chambers few to numerous, enlarging in size as added; chamber height about equal at the opposite ends, the upper and lower sides nearly parallel, usually not inflated and usually obscured by the ornamentation; sutures oblique, straight or very slightly curved, usually not depressed, obscured by the surface ornamentation; wall longitudinally costate, the smaller specimens with five or six costae on each side, increasing gradually to many in the larger specimens, the costae bifurcating to fill the area as the test broadens; aperture radiate, somewhat produced, at the dorsal margin. Dimensions of average-sized specimens: length, about 0.95 mm; breadth, about 0.48 mm.

Remarks.—Specimens occur rather abundantly in the Masuk Shale in the Ferron-Castledale section, but only a single specimen was noted in both the Woodside and West Henry Mountains sections. The species is rather robust and easily recognized but only fragments of it were found in the present study. As a consequence accurate measurements of dimensions were not possible. This species has previously been reported from the Austin-age Burditt Marl, Gober Tongue of the Austin Chalk, Austin Chalk, Brownstown Marl, and Bonham Clay, all of Texas. It also has been reported from the Selma Chalk of Mississippi. It was originally described from the Eagle Ford beds of northern Texas (Moreman, 1927).

Type specimens.—Figured specimens BYU 2469, 2470; reference specimen BYU 2468.

Genus DENTALINA Risso, 1826

DENTALINA BASIPLANATA Cushman, 1938
Pl. 6, figs. 6, 10

Dentalina annulata Cushman (not Reuss) 1931, Tennessee Div. Geol., bull. 41, p. 28, pl. 3, fig. 3.

Dentalina reussi Plummer (not Neugeboren) 1931, Texas Univ. Bull. 3101, p. 151, pl. 11, fig. 5; Sandidge 1932, Jour. Paleont., v. 6, p. 274, pl. 42, fig. 10.

Dentalina basiplanata Cushman 1938, Cushman Lab. Foram. Research Contr., v. 14, pt. 2, p. 38, pl. 6, figs. 6-8; 1940, Cushman Lab. Foram. Research Contr., v. 16, pt. 4, p. 82, pl. 14, figs. 1-6; Cushman and Hedberg 1941, Cushman Lab. Foram. Research Contr., v. 17, p. 88, pl. 21, fig. 23; Cushman and Todd 1943, Cushman Lab. Foram. Research Contr., v. 19, p. 56, pl. 10, fig. 7; Cushman and Deaderick, 1944, Jour. Paleont., v. 18, p. 333, pl. 51, figs. 17-18; Schijfsma 1946, Meded. Geol. Stichting, ser. C-V-no. 7, v. 42, pt. 2, fig. 12; Cushman and Renz 1946, Cushman Lab. Foram. Research, spec. publ. no. 18, p. 28, pl. 4, figs. 12-13; Cushman 1946, U.S. Geol. Survey, Prof. Paper 206, p. 68, pl. 24, figs. 1-6; 1949, Maryland Dept. Geol., Mines and Water Resources Bull. 2, p. 251, pl. 22, fig. 12; 1949, U.S. Geol. Survey, Prof. Paper 221-A, p. 5, pl. 2, fig. 17; Bandy 1951, Jour. Paleont., v. 25, p. 499, pl. 73, fig. 6; Civrieux 1952, Bol. de Geol. (Venezuela), v. 2, no. 5, p. 264, pl. 4, figs. 9-11; Peterson 1952, Utah Geol. and Min. Bull. 47, pt. IIIA, pp. 35-36, pl. I, figs. 22-23; Frizzell 1954, Univ. Texas Bur. Econ. Geol., rpt. invest. 22,

p. 86, pl. 9, figs. 32-33; Said and Kenawy 1956, Micropaleont., v. 2, p. 132, pl. 2, fig. 29; Pozaryska 1957, Paleont. Polonica, no. 8, p. 75, pl. 7, fig. 6; Belford 1960, Australia Bur. Min. Res., Geol. and Geophys. Bull. 57, p. 25, pl. 7, figs. 1-5; Olsson 1960, Jour. Paleont., v. 34, p. 13, pl. 2, figs. 21-22; Tappan 1962, U.S. Geol. Survey, Prof. Paper 236-C, p. 174, pl. 45, fig. 17; Graham and Church 1963, Stanford Univ. Pub. Geol. Sci., v. 8, no. 1, p. 27, pl. 2, fig. 11; Martin 1964, Geol. Bundesanstalt Wien, Jahrb., sonderbd. 9, p. 69, pl. 4, fig. 13; Sliter 1968, Univ. Kansas Paleont. Contr., ser. 49, art. 7, p. 57, pl. 5, figs. 8-11; Eicher and Worstell 1970, Micropaleont., v. 16, no. 3, p. 284, pl. 2, fig. 22.

Description.—Test very elongate, slightly tapering, usually slightly curved; early portion showing oblique costae that indicate coiling, especially in the microspheric form, often slightly compressed; chambers distinct, earlier chambers not inflated, later chambers become increasingly inflated as added; earlier chambers much more strongly overlapping; sutures distinct, somewhat limbate, earlier sutures flush with the surface, oblique, later sutures progressively more depressed and more nearly at right angles to the elongate axis; wall smooth, or the earliest portion sometimes slightly roughened; aperture terminal, radiate. Dimensions of average-sized specimens: length, about 0.75 mm; breadth, about 0.17 mm.

Remarks.—Representatives of the species occur rather abundantly in all measured sections and sporadically throughout all sections. The species is most consistently present in samples from the Tununk Shale, and ranges through beds of Taylor and Navarro age in the Gulf Coastal region of the United States. It has also been reported from Upper Cretaceous rocks in Europe, Egypt, Venezuela, and Australia. It was originally described from the Ripley Formation of Tennessee (Cushman, 1931).

Type specimens.—Figured specimens BYU 2449, 2451; reference specimens BYU 2450, 2452.

DENTALINA LEGUMEN (Reuss, 1851)

Pl. 6, figs. 8, 9

Nodosaria (Dentalina) legumen Reuss 1845, Verst. Bohm. Kreideform., abt. 1, p. 28, pl. 13, figs. 23-24.

Dentalina legumen Reuss 1851, Haidinger's Naturwiss. abh., v. 4, p. 10, pl. 1, fig. 14; 1860, Akad. Wiss. Wien, Math-naturwiss. Kl., Sitzungsber., v. 40, p. 187, pl. 3, fig. 5; Franke 1928, Preuss. Geol. Landesanstalt Abh., new ser., v. 111, p. 27, pl. 2, fig. 23; Cushman and Jarvis 1932, U.S. Nat. Mus. Proc., v. 80, art. 14, p. 30, pl. 9, fig. 9; Brotzen 1936, Sveriges Geol. Undersokning, ser. C., no. 396, p. 75, pl. 5, fig. 9; Cushman 1940, Cushman Lab Foram. Research Contr., v. 16, pt. 4, p. 77, pl. 13, figs. 7-8; Cushman and Todd 1943, Cushman Lab. Foram. Research, Contr., v. 19, p. 57, pl. 10, fig. 5; Cushman 1944, Cushman Lab. Foram. Res. Contr., v. 20, p. 86, pl. 13, fig. 14; 1946, U.S. Geol. Survey, Prof. Paper 206, p. 65, pl. 23, figs. 1-2; Cushman and Renz 1946, Cushman Lab. Foram. Research, special publ. no. 18, p. 27, pl. 4, fig. 10; Civrieux 1952, Bol. de Geol. (Venezuela), v. 2, no. 5, p. 263, pl. 4, fig. 7; Frizzell 1954, Bur. Econ. Geol., Univ. of Texas, rpt. invest. no. 22, p. 88, pl. 9, figs. 56-57; Pozaryska 1957, Pal. Polon., no. 8, p. 81, text-fig.

16; Graham and Church 1963, Stanford Univ. Pub. Geol. Sci., v. 8, no. 1, p. 29, pl. 2, figs. 14-16; Sliter 1968, Univ. of Kansas Paleont. Contr., no. 49, art. 7, p. 58, pl. 5, figs. 17-18, 24.

Dentalina nana Cushman (not Reuss) 1931, Tenn. Div. Geol., bull. 41, p. 29, pl. 3, fig. 21; Cushman 1931, Tenn. Div. Geol., bull. 41, p. 27, pl. 3, fig. 21.

Description.—Test free, elongate, gently arcuate; chambers initially strongly overlapping, later becoming elongated; sutures oblique, initially flush, later depressed; wall calcareous, finely perforate, surface smoothly finished: aperture terminal, eccentric, radiate. Dimensions of average-sized specimens: length, about 0.42 mm; breadth, about 0.11 mm.

Remarks.—Specimens occur very sporadically and in small numbers throughout all measured sections. Specimens show some variability in the obliquity of the sutures and in the amount of inflation of the chambers. However, the specimens found fit well within the variability described for the species. *Dentalina legumen* is recognized by distinctly oblique sutures and overlapping chambers (Cushman, 1946). The present forms have considerable variation in test outline and dimensions and closely resemble specimens illustrated by Graham and Church (1963) and Sliter (1968). This species has previously been reported from Navarro, Taylor, and Austin-age beds of the Gulf Coastal region of the United States and from Upper Cretaceous beds in California, Venezuela, and Europe. It was originally described from the Cretaceous of Lemberg (Reuss, 1851).

Type specimens.—Figured specimens BYU 2562, 2563; reference specimens BYU 2478, 2479, 2582, 2606.

DENTALINA UTAHENSIS Peterson, 1953
Pl. 6, figs. 12, 13, 14

Dentalina utahensis Peterson 1953, Utah Geol. and Min. Survey, bull. 47, p. 38, pl. II, figs. 3-4.

Dentalina summitensis Peterson 1953, Utah Geol. and Min. Survey, bull. 47, p. 39, pl. II, figs. 5-6.

Description.—Test elongate, slightly tapering, gently curved; initial end often with distinct spine; early chambers indistinct, strongly overlapping; later chambers distinct, slightly overlapping, about as long as broad; sutures on initial portion indistinct, flush with surface, sutures on later portion distinct, depressed; surface smooth to ornamented by numerous longitudinal costae, continuous from chamber to chamber, usually sixteen to eighteen in number; costae somewhat oblique when present; aperture terminal, radiate, at inner angle of terminal face of the last-formed chamber. Dimensions of average-sized specimens: length, about 2.50 mm; breadth, about 0.35 mm.

Remarks.—This species, as here limited, includes *D. utahensis* and *D. summitensis* as described by Peterson (1953), for there is a complete gradation from smooth forms to strongly ornamented forms in most of the samples examined from the study area of this paper. There does not appear to be any tendency for either form to become dominant higher or lower in the stratigraphic section. Because of the continuous gradation between the two forms it appears that ornamentation should be considered as a variation within the species and not significant for speciation. It is therefore recommended that the species *summitensis* be suppressed. Specimens occur in fair abundance in single samples from the lower portion of the Blue Gate Shale in the Woodside, Ferron-Castledale, and Emery sections. Specimens occur in considerable abundance throughout the upper Tununk Shale of all sections where the Tununk Shale was sampled. This species was originally described from the Frontier Formation of northern Utah (Peterson, 1953).

Type specimens.—Figured specimens BYU 2463, 2464, 2465; reference specimen BYU 2466.

Genus FRONDICULARIA DeFrance in d' Orbigny, 1826

FRONDICULARIA GOLDFUSSI Reuss, 1860

Pl. 7, figs. 1, 2

Frondicularia goldfussi Reuss 1860, Akad. Wiss. Wien, Math-naturwiss. Kl., Sitzungsber, v. 40, p. 192, pl. 4, fig. 7; Egger 1899, K. bayer, Akad. Wiss., Math-naturh., Abt., Abh., kl. 2, v. 21, p. 89, pl. 13, figs. 12, 13, 16, 17; Cushman 1930, Cushman Lab. Foram. Research Contr., v. 6, p. 33, pl. 5, fig. 3; 1936, Cushman Lab. Foram. Research Contr., v. 12, p. 15, pl. 3, figs. 21-22; Cushman and Hedberg 1941, Cushman Lab. Foram. Research Contr., v. 17, p. 91, pl. 22, figs. 7-10; Cushman 1944, Cushman Lab. Foram. Research Contr., v. 20, p. 8; 1944, Am. Jour. Sci., v. 242, p. 611, pl. 1, figs. 12-14; pl. 2, figs. 1-2; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 335, pl. 52, figs. 11-12; Cushman 1946, U.S. Geol. Survey, Prof. Paper 206, pp. 87-88, pl. 34, figs. 18-20; pl. 35, figs. 1-2; 1949, Maryland Dept. Geol., Mines and Water Resources Bull. 2, p. 255, pl. 23, fig. 7; Bandy 1951, Jour. Paleont., v. 25, no. 4, p. 497, pl. 72, fig. 61-b; Frizzell 1954, Bur. Econ. Geol., rpt. invest. 22, p. 98, pl. 12, figs. 28-29; Said, Rushdi and Kenawy 1956, Abbas, Micropaleont., v. 2, p. 136, pl. 2, fig. 36; Pozaryska 1954, Krystyna, Palaeont. Polonica, no. 8, p. 143, pl. 22, fig. 4, pl. 25, fig. 3; Sliter 1968, Univ. Kansas Paleont. Contr., no. 49, art. 7, p. 61, pl. 6, fig. 4.

EXPLANATION OF PLATE 7

FIG. 1.—*Frondicularia goldfussi* Reuss. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2492)

FIG. 2.—*Frondicularia goldfussi* Reuss. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X35. (BYU 2491)

FIG. 3.—*Frondicularia inversa* Reuss. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2489)

FIG. 4.—*Lagena sulcata* (Walker & Jacob) Parker & Jones. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X275 (BYU 2493)

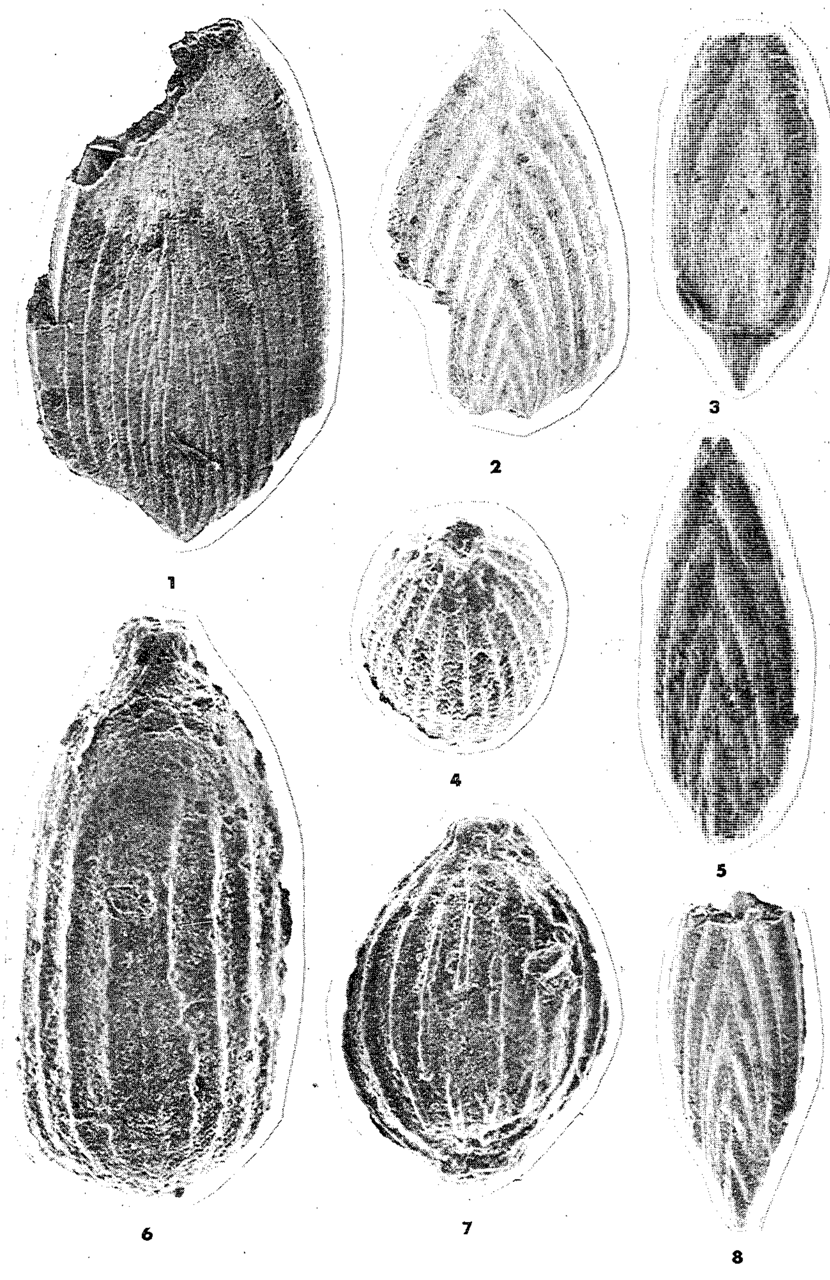
FIG. 5.—*Frondicularia inversa* Reuss. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2508)

FIG. 6.—*Lagena sulcata* (Walker & Jacob) Parker & Jones. Middle part of Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X275. (BYU 2499)

FIG. 7.—*Lagena sulcata* (Walker & Jacob) Parker & Jones. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X275. (BYU 2498)

FIG. 8.—*Frondicularia inversa* Reuss. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2490)

PLATE 7



Description.—The species has a basal spine and a rounded or slightly elongate proloculum, the following chambers increasing very slightly in width as added, the sutures becoming progressively more curved, slightly limbate, but not rising above the flattened, broad face of the test; wall may be smooth to a few fine vertical costae on each chamber, and not crossing the sutures; periphery distinctly truncate, even slightly concave; apertural end usually projects slightly into a very short, apertural neck; at the base the chambers reach well back, forming a broadly wedge-shaped base with the central portion projecting. Dimensions of average-sized specimens: length, about 1.45 mm; breadth, about 0.85 mm.

Remarks.—Specimens occur only as rare to relatively rare forms in the Tununk Shale at the Ferron-Castledale section. These specimens fit the descriptions of this species rather well except most specimens have the basal spine broken off. This species has previously been reported from Taylor-age and Austin-age beds of the Gulf Coastal region of the United States, and from Upper Cretaceous rocks of southern California, Egypt, and northern Europe. The species was originally described from Upper Cretaceous beds of Westphalia, Germany (Reuss, 1860).

Type specimens.—Figured specimens BYU 2491, 2492.

FRONDICULARIA INVERSA Reuss, 1844
Pl. 7, figs. 3, 5, 8

Frondicularia inversa Reuss 1844, Geognostische Skizzen Bohmen, v. 2, pt. 1, p. 211; 1945, Verstein Bohm. Kreideformation, pt. 1, p. 31, pl. 8, figs. 15-19; pl. 13, fig. 42; 1875, Paleontolographica, v. 20, pt. 2, p. 94, pl. 2, figs. 5-7; Perner 1892, Foram. Ceskeho Cenomanu (resumé), p. 59, pl. 7, fig. 9; Franke 1925, Greifswald Univ., Geol.-palaeont. Inst., abh. Contr., v. 12, p. 16, pl. 3, figs. 23-24; Brotzen 1936, Fritz, Sveriges Geol. Undersokning Arsb. 30, no. 3, ser. C, no. 396, 206, p. 96, pl. v. 6, p. 48, pl. 4, fig. 1; Cushman 1936, Cushman Lab. Foram. Research, 6, fig. 12; Cushman 1946, U.S. Geol. Survey, Prof. Paper 206, p. 86, pl. 33, figs. 11-18; Peterson 1953, Utah Geol. and Min. Survey, bull. 47, p. 39, pl. II, figs. 7-9; Frizzell 1954, Bur. Econ. Geol., Univ. of Texas, rpt. invest. 22, p. 98, pl. 12, figs. 31-32; Pozaryska 1957, Krystyna, Palaeont. Polonica, no. 8, p. 145, pl. 23, fig. 8, text-pl. 3, fig. 1; Takayanagi 1960, Yokichi, Tohoku Univ. Sci. Repts., ser. 2 (geol.), v. 32, p. 112, pl. 6, fig. 22; Sliter 1968, Univ. Kansas Paleont. Contr., no. 49, art. 7, p. 62, pl. 6, fig. 6.

Description.—Test elongate, elliptical, very strongly compressed; periphery rounded, base with a short, stout spine; chambers distinct, the proloculum narrow, elongate; later chambers gradually failing to reach the base, giving a narrow tapering shape to that part of the test; sutures distinct, flush with the surface to slightly indented, gently curved, usually crossed by fine discontinuous vertical costae, especially near the apertural end; aperture terminal radiate. Dimensions of average-sized specimens: length, about 0.95 mm; breadth, about 0.40 mm.

Remarks.—Specimens occur in all measured sections with the exception of the Factory Butte section. The species was found only in the Tununk Shale in all other sections except in the Emery section, where examples were found in the middle Blue Gate Shale. This species has been recorded by various authors whose combined records give a range from the Lower Cretaceous to the top of the Upper Cretaceous. In the American material the species is characteristic of beds of Austin age (Cushman, 1946).

Type specimens.—Figured specimens BYU 2489, 2490, 2508; reference specimens BYU 2488, 2509.

Genus LAGENA Walker and Jacob in Kanmacher, 1798

LAGENA SULCATA (Walker and Jacob) Parker and Jones, 1929
Pl. 7, figs. 4, 6, 7

Serpula (*Lagena*) *sulcata* Walker and Jacob 1798, F. Kanmacher, London, Dillon and Keating, 712 p.

Lagena sulcata (Walker and Jacob) Carsey 1926, Univ. Texas Bull., no. 2612, p. 31, pl. 7, fig. 4; Cushman 1931, Tennessee Div. Geol., bull. 41, p. 37, pl. 5, figs. 9-11; Jennings 1936, Bull. Am. Paleont., v. 23, no. 78, p. 23, pl. 2, fig. 23; Cushman 1946, U.S. Geol. Survey, Prof. Paper 206, p. 94, pl. 39, figs. 18-21; Lessard 1973, Utah Geol. and Min. Survey, special studies 45, p. 21, pl. 1, fig. 8.

Lagena sulcata (Walker and Jacob) Parker and Jones var. *semiinterrupta* W. Berry 1929, in Berry and Kelley, U.S. Nat. Mus. Proc., v. 76, art. 19, p. 5, pl. 3, fig. 19.

Description.—Test spherical to elliptical with hyaline, calcareous walls; unilocular; well-formed vertical costae widely varying in number, terminating at neck; aperture is a centrally located, simple opening at the end of a short neck. Dimensions of average-sized specimens: length, about 0.25 mm; breadth, about 0.14 mm.

Remarks.—Specimens referred to this species occur in each section where the Tununk Shale was sampled. Some specimens have fewer and slightly coarser costae and may be of a different species. In the Mancos Shale *L. sulcata* appears to be a useful stratigraphic index species. This species has been reported previously from the Navesink Marl and Mt. Laurel Sand of New Jersey, the Navarro-age Ripley Formation and Selma Chalk of Tennessee, the Tununk Shale of Utah, and the Upper Cretaceous of central Texas.

Type specimens.—Figured specimens BYU 2493, 2498, 2499; reference specimens BYU 2494, 2495, 2496, 2497, 2510, 2511.

Genus LENTICULINA Lamarck, 1804

LENTICULINA MUENSTERI (Roemer, 1839)
Pl. 8, figs. 1, 2

Robulina muensteri Roemer 1839, Verstein. norddeutschen Oolithengebirges, Nachtrag., p. 48, pl. 22, fig. 29; 1841, Verstein. norddeutschen Kreidegebirges, p. 98, pl. 15, fig. 30.

Robulus muensteri (Roemer) Cushman 1932, Jour. Paleont., v. 6, p. 334, pl. 50, figs. 2a-b; 1941, Cushman Lab. Foram. Research Contr., v. 17, pt. 3, p. 58, pl. 15, fig. 6; Cushman and Hedberg 1941, Cushman Lab. Foram. Research Contr., v. 17, p. 86, pt. 4, pl. 21, figs. 14a-b; Cushman and

Deaderick 1942, Cushman Lab. Foram. Research, Contr., v. 18, pt. 3, p. 56, pl. 10, figs. 10-13; 1944, Jour. Paleont., v. 18, p. 331, pl. 50, fig. 28; Cushman 1944, Cushman Lab. Foram. Research, Contr., v. 20, p. 85, pl. 13, fig. 7; 1946, U.S. Geol. Survey, Prof. Paper 206, p. 53, pl. 17, figs. 3-9; Gauger 1953, Utah Geol. and Min. Survey, bull. 47, pt. IIIB, p. 66, pl. 7, figs. 1-2; Frizzell 1954, Univ. of Texas, Bur. Econ. Geol., rpt. invest. 22, p. 81, pl. 8, figs. 1a-b, 2-4; Mello 1969, U.S. Geol. Survey, Prof. Paper 611, p. 53, pl. 5, figs. 6a-b.

Cristellaria muensteri Reuss 1862, Akad. Wiss. Wien, Math-naturwiss. Kl., Sitzungsber, vol. 46, pt. 1, p. 77, pl. 9, figs. 3-4.

Lenticulina exarata (von Hagenow) Reuss, Graham and Church 1963, Stanford Univ. Publ. Geol. Sci., v. 8, no. 1, p. 34, pl. 3, fig. 9.

Lenticulina muensteri (Roemer) Sliter 1968, Univ. of Kansas Paleont. Contr., ser. 49, art. 7, p. 66, pl. 7, figs. 9, 13.

Description.—Test planispiral, completely involute, not much compressed with large umbos; periphery sharply angled, slightly keeled; chambers distinct, of uniform shape and increasing gradually in size as added; not inflated, eight to twelve in the final whorl; sutures distinct, slightly to moderately limbate and raised, tangential, slightly curved; wall smooth, glassy, without visible perforations; aperture at the outer peripheral angle, radiate, with a more elongate slit extending a short distance into the apertural face. Dimensions of average-sized specimens: diameter, about 0.62 mm; thickness, about 0.28 mm.

Remarks.—Specimens were found in all measured sections and sporadically throughout each section. The greatest abundances occur in the lower Blue Gate Shale and the upper Tununk Shale. Considerable variation is shown in this species (if the specimens included really belong in one species). Specimens from the Mancos Shale correspond well with the description given by Cushman (1946). This species has been reported from deposits of Austin, Taylor, and Navarro ages in Tennessee, Mississippi, Texas, and Arkansas. The species has been reported from the Arkadelphia Marl of Arkansas, Lawson Limestone of Florida, Niobrara Formation of South Dakota, Hilliard Shale of

EXPLANATION OF PLATE 8

FIG. 1.—*Lenticulina muensteri* (Roemer). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X109. (BYU 2459)

FIG. 2.—*Lenticulina muensteri* (Roemer). Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Oblique view, X70. (BYU 2453)

FIG. 3.—*Lenticulina taylorensis* (Plummer). Upper part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X109. (BYU 2446)

FIG. 4.—(?) *Lenticulina* sp. Lower part of the Upper Mancos Shale, Woodside section, Emery County, Utah. Apertural view, X140. (BYU 2559)

FIG. 5.—*Lenticulina taylorensis* (Plummer). Upper part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X109. (BYU 2445)

FIG. 6.—*Saracenaria triangularis* (d'Orbigny). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X109. (BYU 2448)

FIG. 7.—*Saracenaria triangularis* (d'Orbigny). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X109. (BYU 2448)

FIG. 8.—(?) *Lenticulina* sp. Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X70. (BYU 2461)

PLATE 8

Wyoming, and the Niobrara Formation of Wyoming. Other Upper Cretaceous reports of this species are from Colombia, Spanish Sahara, Venezuela, Germany, Poland, Egypt, California, and Maryland. It was originally described from the Upper Cretaceous of Germany (Roemer, 1839).

Type specimens.—Figured specimens BYU 2453, 2459; reference specimens BYU 2454, 2458, 2560.

LENTICULINA TAYLORENSIS (Plummer, 1931)
Pl. 8, figs. 3, 5

Cristellaria gibba Carsey (not d'Orbigny) 1926, Texas Univ. Bull. 2612, p. 37, pl. 5, fig. 4.
Astoculus taylorensis Plummer 1931, Texas Univ. Bull. 3101, p. 143, pl. 11, fig. 16, pl. 15, figs. 8-11.
Robulus taylorensis (Plummer) Cushman 1941, Cushman Lab. Foram. Research, Contr., v. 17, pt. 3, p. 57, pl. 15, figs. 5a-b; Cushman and Deaderick 1942, Cushman Lab. Foram. Research, Contr., v. 18, p. 56, pl. 10, figs. 14-15; 1944, Jour. Paleont., v. 18, p. 331, pl. 50, fig. 25; Cushman 1946, U.S. Geol. Survey, Prof. Paper 206, p. 53, pl. 18, fig. 20.
Lenticulina taylorensis (Plummer) Sliter 1968, Kansas Univ., Paleont. Contr. no. 47, art. 7, p. 68, pl. 7, figs. 14-15; Mello 1969, U.S. Geol. Survey, Prof. Paper 611, p. 54, pl. 5, figs. 7a-b.

Description.—Test planispiral, incompletely involute, uncoiling in the final part of largest specimens; only a small part of previous whorls visible in umbilical areas, moderately compressed; umbilical areas flush with the surface of the test or slightly depressed; axial periphery smooth or with a small keel, equatorial periphery smooth or with slight indentations at the sutures; chambers distinct, of uniform shape, increasing gradually in size as added, very slightly if at all inflated, eight to twelve chambers per whorl, usually nine to eleven; sutures distinct, in some specimens slightly limbate, gently curved toward the periphery, flush in most specimens, slightly depressed in some; wall smooth, thick, glassy, without visible perforations; aperture radial, at the apex of the apertural face, with an elongate, widened slit extending down into the slightly convex apertural face. Dimensions of average-sized specimens: diameter, about 0.42 mm; thickness, about 0.20 mm.

Remarks.—Specimens occur in the Emery, Ferron-Castledale, and Woodside sections and occur sporadically throughout each section. They closely resemble specimens of *Robulus taylorensis* in Cushman (1946), but differ in having a slightly less convex umbilicus and slightly less tangential sutures. This species has been reported from Alabama, Mississippi, Texas, and Arkansas from beds of Austin and Taylor age, and also from the upper Pierre Shale of north-central South Dakota. The species was originally described from the upper Taylor Marl of Texas (Plummer, 1931).

Type specimens.—Figured specimens BYU 2445, 2446; reference specimens BYU 2444, 2447.

(?) LENTICULINA sp.
Pl. 8, figs. 4, 8

Description.—Test free, planispiral, sides compressed, periphery rounded, chambers increasing gradually in size, breadth greater than height; sutures radial, curved convex toward apertural face, flush to raised, aperture at peripheral angle. Dimensions of average-sized specimens: diameter, about 0.64 mm; thickness, about 0.10 mm.

Remarks.—The species occurs in all measured sections with the exception of the Factory Butte section, but occurs only in the Blue Gate Shale. There were no complete specimens recovered; all have the final chambers missing. Placement of this species is therefore questionable, as it may be more closely related to *Astoculus.*

Type specimens.—Figured specimens BYU 2462, 2559; reference specimen BYU 2461.

Genus SARACENARIA DeFrance in de Blainville, 1824

SARACENARIA TRIANGULARIS (d'Orbigny, 1840)
Pl. 8, figs. 6, 7

Cristellaria triangularis d'Orbigny 1840, Sec. Geol. France Mem., 1st ser., v. 4, p. 27, pl. 2, figs. 21-22; Reuss 1845, Verstein. bohm. Kreideformation, pt. 1, p. 34, pl. 8, fig. 48; 1846 (in Geintz), Grundriss der Verstein., p. 663, pl. 24, fig. 29; d'Orbigny 1850, Prodrome de paleontologie stratigraphique universelle des animaux mollusques et rayonnes, v. 2, p. 281, no. 1375; Reuss 1854, Akad. Wiss. Wien, Math-naturwiss. Kl., Denkschr., v. 7, p. 68; 1862, Akad. Wiss. Wien, Math-naturwiss. Kl., Sitzungsber., v. 46, pt. 1, p. 70, 93 (1863); Berthelin 1880, Soc. Geol. France Mem. 3d ser., v. 1, p. 55; Beissel 1891, Preuss. Geol. Landesanstalt abh., new ser. v. 3, p. 53, pl. 10, figs. 1-9; Matouschek 1895, Lotos, v. 43, p. 146; Egger 1899, K. bayer. Akad. Wiss., Math-naturh. abt., abh., kl. 2, v. 21, p. 117, pl. 12, figs. 5-6; Heron-Allen and Earland 1910, Royal Micro. Soc. Jour., p. 421; Franke 1912, Natur. Ver. Preuss. Rheinlande u. Westfalens Verh., 69 jahrg., v. 59, p. 279 (1913); Chapman 1917, W. Australia Geol. Survey Bull. 72, p. 30, pl. 9, fig. 80.

Saracenaria triangularis (d'Orbigny) Cushman and Church 1929, Calif. Acad. Sci. Proc., 4th ser., v. 18, p. 505, pl. 37, figs. 13-14; Cushman and Hedberg 1941, Cushman Lab. Foram. Research, Contr., v. 17, p. 88, pl. 21, figs. 35a-b; Cushman 1944, Cushman Lab. Foram. Research, Contr., v. 20, p. 8, pl. 2, fig. 5; 1946, U.S. Geol. Survey, Prof. Paper 206, p. 58, pl. 28, figs. 1-3; 1949, Maryland Dept. Geol., Mines and Water Res., bull. 2, p. 253, pl. 22, fig. 16; Bandy 1951, Jour. Paleont., v. 25, no. 4, p. 494, pl. 72, fig. 11; Hagn 1953, Palaeontographica, v. 104, abt. A, p. 52, pl. 6, fig. 4; Frizzell 1954, Texas Univ., Bur. Econ. Geol., rpt. invest. no. 22, p. 83, pl. 8, fig. 28; Said and Kenawy 1956, Micropaleont., v. 2, p. 131, pl. 3, fig. 1; Trujillo 1960, Jour. Paleont., v. 34, no. 2, p. 316, pl. 45, fig. 12; Sliter 1968, Univ. Kansas, Paleont. Contr., art. 7, p. 74, pl. 9, fig. 3-4.

Astacolus jarvisi Brotzen 1936, Sveriges geol. Undersokning, ser. C, no. 396, p. 56, pl. 3, figs. 5a-b.

Saracenaria sp. cf. *S. triangularis* (d'Orbigny) Takayanagi 1960, Tohoku Univ. Sci. Repts., ser. 2 (geol.), v. 32, p. 106, pl. 6, fig. 8.

Saracenaria jarvisi (Brotzen), Graham and Church 1963, Stanford Univ. Pub. Geol. Sci., v. 8, no. 1, p. 46, pl. 5, fig. 13.

Description.—Test free, large, initially planispirally coiled, later tending to uncoil; triangular in transverse section, periphery acute, chambers elongate, curved, increasing rapidly in size, sutures distinct, flush to slightly depressed, curved; wall calcareous, finely perforate, surface smooth; aperture terminal, radiate. Dimensions of average-sized specimens: diameter, about 0.35 mm; thickness, about 0.24 mm.

Remarks.—This species occurred in one sample only, in the lower Blue Gate Shale in the Ferron-Castledale section, with four specimens present in the sample. The specimens present are much smaller than those described elsewhere but appear to be within the range of variation as described by Cushman (1946). This species has been widely recorded from the Upper Cretaceous of Europe as well as from the Upper Cretaceous of the Gulf Coastal region of the United States.

Type specimens.—Figured specimen BYU 2448.

Genus VAGINULINOPSIS Silvestri, 1904

VAGINULINOPSIS AUSTINANA (Cushman, 1937)
Pl. 9, figs. 1, 2, 3

Marginulina austinana Cushman 1937, Cushman Lab. Foram. Research, Contr., v. 13, no. 4, p. 92, pl. 13, figs. 1-4; Cushman Lab. Foram. Research, Contr., v. 14, p. 92, pl. 13, figs. 1-4; Peterson 1953, Utah Geol. and Min. Survey, bull. 47, p. 32, pl. 1, figs. 7-8.

Marginulina austinana Cushman var. *directa* Cushman 1937, Cushman Lab. Foram. Research, Contr., v. 13, p. 93, pl. 13, fig. 5-8; 1946, U.S. Geol. Survey, Prof. Paper 206, p. 59, pl. 20, fig. 11-16; Peterson 1953, Utah Geol. and Min. Survey, Bull. 47, p. 32, pl. 1, figs. 9-15.

Marginulina austinana Cushman var. *austinana* Cushman 1946, U.S. Geol. Sur-

EXPLANATION OF PLATE 9

FIG. 1.—*Vaginulinopsis austinana* (Cushman). Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2483)

FIG. 2.—*Vaginulinopsis austinana* (Cushman). Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2484)

FIG. 3.—*Vaginulinopsis austinana* (Cushman). Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X70. (BYU 2485)

FIG. 4.—(?) *Ramulina* sp. Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X112. (BYU 2516)

FIG. 5.—(?)*Vaginulinopsis* sp. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2482)

FIG. 6.—(?)*Vaginulinopsis* sp. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X54. (BYU 2481)

FIG. 7.—*Neobulimina canadensis* (Cushman & Wickenden). Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X275. (BYU 2440)

FIG. 8.—*Ramulina arkadelphina* (Cushman). Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X109. (BYU 2513)

FIG. 9.—*Neobulimina canadensis* (Cushman & Wickenden). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X275. (BYU 2437)

PLATE 9

vey, Prof. Paper 206, p. 59, pl. 20, figs. 5-10; Frizzell 1954, Bur. Econ. Geol., Univ. Texas, Rpt. Invest., no. 22, p. 84, pl. 8, fig. 32-33.

Marginulina directa Cushman, Bandy 1951, Jour. Paleont., v. 25, p. 498, pl. 73, fig. 1.

Marginulinopsis n. sp. 1 Young 1951, Jour. Paleont., v. 25, p. 57, pl. 15, fig. 5, figs. 6, 19; n. sp. 2 Young 1951, Jour. Paleont., v. 25, p. 57, figs. 6, 17-18; n. sp. 3 Young 1951, Jour. Paleont., v. 25, p. 58, pl. 11, fig. 16; pl. 12, fig. 7; figs. 1-6; sp. Young 1951, Jour. Paleont., v. 25, p. 58, figs. 5, 24, 26, 29.

Marginulinopsis frontierensis Young 1951, Jour. Paleont., v. 25, p. 52, pl. 11, figs. 9-12; figs. 5, 2-8.

Marginulinopsis ammonitiformis Young 1951, Jour. Paleont., v. 25, p. 52, pl. 11.

Marginulinopsis amplaspira Young 1951, Jour. Paleont., v. 25. p. 54, pl. 11, figs. 15, 17-21; figs. 6, 2-16; Fox 1954, U.S. Geol. Survey, Prof. Paper 254-E, p. 115, pl. 25, figs. 13-14; Lamb 1968, Geol. Soc. Am. Bull., v. 79, p. 842.

Vaginulinopsis sp. cf. *V. austiniana austiniana* (Cushman) Graham and Church 1963, Stanford Univ. Publ., Geol. Sci., v. 8, no. 1, p. 47, pl. 5, fig. 14.

Vaginulinopsis directa (Cushman) Sliter 1968, Univ. of Kansas, Paleont. Contr., no. 49, art. 7, p. 75, pl. 9, fig. 9.

Marginulinopsis austinana (Cushman) Lessard 1973, Utah Geol. and Min. Survey, Special Studies 45, p. 22, pl. 1, fig. 10.

Description.—Test elongate, compressed, early portion closely coiled and umbonate, later portion uncoiled, dorsal side gently curved, ventral side slightly lobulate; chambers of the early coiled portion indistinct, later uncoiled chambers more distinct, not inflated to slightly inflated; sutures indistinct in unserial portion, where they are slightly curved, somewhat limbate, with a bosslike thickening toward the dorsal side; wall smooth except for the sutural enlargements; aperture radiate, at outer peripheral angle. Sutures in the coiled portion vary from smooth flush to raised. Periphery rounded to slightly keeled. Dimensions of average-sized specimens: length, from 0.74 to 1.42 mm; diameter of coil, from 0.27 to 0.41 mm; breadth, from 0.27 to 0.37 mm.

Remarks.—This species is one of the most abundant of the Nodosariidae, and occurs in all sections where the Tununk Shale was sampled. Because of its distinctiveness and abundance, it appears to be an excellent marker. Specimens vary considerably in appearance. Some of the variation seems to result from the ability of the species to resorb calcium carbonate and use it to construct the later chambers. Young (1951) attempted to divide this group into a number of species. However, with such large abundances (100 to 499 specimens per sample) to work with and such a short stratigraphic range (300 feet) it appears that each variation grades into another and that the variations are variations within the species and not significant for speciation. This species has been reported from the Austin Group of the Gulf Coastal region, Frontier Formation of southern Montana, Greenhorn Formation of South Dakota, Allen Valley Shale and Frontier Formation of Utah, and the Graneros and lower Carlile shales of northwestern New Mexico.

Type specimens.—Figured specimens BYU 2483, 2484, 2485; reference specimens BYU 2486, 2487.

(?) VAGINULINOPSIS sp.
Pl. 9, figs. 5, 6

Description.—Test close-coiled in early stage, later uncoiling, slightly compressed, aperture at dorsal angle, radiate. Dimensions of average-sized specimen: length, about 0.89 mm; breadth, about 0.30 mm.

Remarks.—Specimens occur in the upper Blue Gate Shale and in the Masuk Shale at the Woodside, Ferron-Castledale, and Emery sections. Only a few fragments were recovered and preservation is poor, making identification uncertain.

Type specimens.—Figured specimens BYU 2481, 2482; reference specimens BYU 2480.

Family POLYMORPHINIDAE d'Orbigny, 1839
Subfamily RAMULININAE Brady, 1884
Genus RAMULINA Jones in Wright, 1875
RAMULINA ARKADELPHIANA Cushman, 1938
Pl. 9, fig. 8

Ramulina arkadelphiana Cushman 1938, Cushman Lab. Foram. Research Contr., v. 14, pt. 2, p. 43, pl. 7, figs. 12-14; 1946, U.S. Geol. Survey Prof. Paper 206, p. 99, pl. 43, figs. 3-8; Peterson 1953, Utah Geol. and Min. Survey Bull. 47, p. 41, pl. II, figs. 10-11; Lessard 1973, Utah Geol. and Min. Survey, Special Studies 45, p. 23, pl. 2, fig. 1.

Description.—Test calcareous, wall thin, finely hispid with irregularly elongate or fusiform portions from which somewhat tapering tubular projections extend in various directions, tapering towards the ends, which have rounded openings. Dimensions of average-sized specimens: length, about 0.60 mm; breadth, about 0.20 mm.

Remarks.—The species occurs in all measured sections with the exception of the Factory Butte section, and is distributed rather sporadically throughout each section. This species has been reported from the Frontier Formation of northern Utah and the Tununk Shale of eastern Utah, as well as from the Navarro Group of the Gulf Coastal region of the United States. It was originally described from the Arkadelphia Marl of Arkansas (Cushman, 1946).

Type specimens.—Figured specimen BYU 2513; reference specimens BYU 2512, 2514.

(?) RAMULINA sp.
Pl. 9, fig. 4

Description.—Test consisting of a globular, elongate, or fusiform chamber with tubular processes tapering from each end; wall calcareous, smoothly finished, finely perforate. Dimensions of average-sized specimens: length, about 0.40 mm; breadth, about 0.25 mm.

Remarks.—Specimens occur in all measured sections with the exception of the Factory Butte section, and are distributed rather sporadically throughout each

section with slightly greater abundances present in the Tununk Shale. Only single chambers were recovered; therefore, classification is very questionable.
Type specimens.—Figured specimen BYU 2516; reference specimens BYU 2515, 2517.

Superfamily BULIMINACEA, Jones, 1875

Family TURRILINIDAE, Cushman, 1927
Subfamily TURRILININAE, Cushman, 1927
Genus NEOBULIMINA Cushman and Wickenden, 1928
NEOBULIMINA CANADENSIS Cushman and Wickenden, 1928
Pl. 9, figs. 7, 9

Neobulimina canadensis Cushman and Wickenden 1928, Cushman Lab. Foram. Research Contr., v. 4, p. 13, pl. 1, figs. 1-2; Cushman 1931, Tenn. Div. Geol. Bull. 41, p. 48, pl. 8, figs. 1a-c; 1933, Cushman Lab. Foram. Research, Special Pub. 4, pl. 22, figs. 24a-b; 1933, Cushman Lab. Foram. Research, Special Pub. 5, pl. 27, figs. 15a-c; Cushman and Parker 1936, Cushman Lab. Foram. Research Contr., v. 12, p. 9, pl. 2, figs. 9-10; Jennings 1936, Bull. Am. Paleont., v. 23, no. 78, p. 31, pl. 3, fig. 22; Frizzell 1943, Jour. Paleont., v. 17, p. 350, pl. 57, fig. 3; Cushman and Todd 1943, Cushman Lab. Foram. Research Contr., v. 19, p. 66; Cushman 1944, Cushman Lab. Foram. Research Contr., v. 20, p. 93, pl. 14, figs. 12-13; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 337, pl. 53, figs. 9-10; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 125, pl. 52, figs 11-12; Cushman and Parker 1947, U.S. Geol. Survey Prof. Paper 210-D, p. 132, pl. 29, figs. 32-33; Nauss 1947, Jour. Paleont., v. 21, no. 4, p. 340, pl. 48, figs. 5a-b; Tappan 1951, Cushman Found. Foram. Research Contr., v. 2, pt. 1, p. 5, pl. 1, figs. 21a-b; 1951, in Payne and others, U.S. Geol. Survey Oil and Gas Inv. Map OM-126, sheet 3, fig. 21 (6); Bolin 1952, South Dakota Geol. Survey Rpt. Invest. 70, p. 44, pl. 3, fig 6; Frizzell 1954, Univ. of Texas Bur. Econ. Geol., Rpt. Invest. 22, p. 116, pl. 17, fig. 11; Tappan 1962, U.S. Geol. Survey Prof. Paper 236-C, p. 185, pl. 48, figs. 18-27; Sliter 1968, Univ. of Kansas Paleont. Contr., ser. 49, art. 7, p. 82, pl. 11, figs. 10, 14; Mello 1969, U.S. Geol. Survey Prof. Paper 611, p. 78, pl. 9, figs. 5a-c.

Description.—Test elongate, fusiform, greatest width near the middle, tapering slightly toward either end, about 2½ times as long as wide in adult specimens; early triserial stage of twelve to eighteen chambers, the biserial adult stage of four to six chambers, each part making about one-half the mass of the test; chambers distinct, subglobular, inflated; sutures very distinct, depressed; wall calcareous, coarsely perforate; aperture in the early triserial portion oblique and comma shaped, in the adult biserial stage broader, the portion at the basal edge of the chamber broad and the elongate axis nearly at right angles to the margin of the chamber; the whole aperture in the adult at the base of a distinct depression. The microspheric form is often somewhat irregular and twisted. Dimensions of average-sized specimens; length, about 0.29 mm; breadth, about 0.15 mm.

Remarks.—The species occurs at all measured sections and is distributed rather sporadically throughout the upper Blue Gate Shale but much more abundantly in samples of the lower Blue Gate and Tununk Shales. Agreement with the type figure and description is good in all respects. This species has been reported from the Eagle Ford Shale and from beds of Austin, Taylor, and Navarro ages in Gulf Coast deposits, as well as from the Niobrara Formation of South Dakota and Wyoming, the Sage Breaks Member of the Carlile Shale and the Greenhorn Formation of South Dakota and Wyoming, the Upper Cretaceous of northern Alaska, and the Navesink Formation of New Jersey. The species has also been reported from the Upper Cretaceous of the Spanish Sahara. This species was originally described from the Upper Cretaceous Bearpaw Shale of Alberta, Canada (Cushman and Wickenden, 1928).

Type specimens.—Figured specimens BYU 2437, 2440; reference specimens BYU 2438, 2439, 2441, 2442, 2443, 2474, 2475, 2476, 2477.

Genus PRAEBULIMINA Hofker, 1953

PRAEBULIMINA CUSHMANI (Sandidge, 1932)

Pl. 10, figs. 1, 2, 3

Buliminella cushmani Sandidge 1932, Jour. Paleont., v. 6, p. 280, pl. 42, figs. 18-19; Cushman and Parker 1936, Cushman Lab. Foram. Research, Contr., v. 12, p. 8; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 337, pl. 53, fig. 5; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 119, pl. 50, fig. 15; Cushman and Parker 1947, U.S. Geol. Survey Prof. Paper 210-D, p. 58, pl. 15, figs. 10-11; Frizzell 1954, Bur. Econ. Geol., Rpt. Invest. 22, p. 114, pl. 16, fig. 40.

Praebulimina cushmani (Sandidge) Tappan 1962, U.S. Geol. Survey Prof. Paper 236-C, p. 187, pl. 49, figs. 1-5.

Description.—Test free, relatively short and robust, flaring; chambers inflated, about three to a whorl in the early stage, but with four per whorl in the adult, enlarging rapidly; sutures distinct, depressed; wall calcareous, finely perforate, surface smooth; aperture a loop-shaped opening, extending up the flattened face of the final chamber. Dimensions of average-sized specimens: length, about 0.21 mm; breadth, about 0.114 mm.

Remarks.—Specimens occur in all measured sections and are very abundant in most samples. Agreement with the type figure and description is good, except specimens found in the Mancos Shale are much smaller than those of the type area. This species has been reported previously from the Navarro-age Kemp Clay and Corsicana Marl of Texas, the Prairie Bluff Chalk of Alabama, and the Saratoga Chalk of Arkansas; and the Taylor-age Marlbrook Marl of Arkansas and the Austin Chalk of Texas. The species was first described from the Ripley Formation of Alabama (Sandidge, 1932).

Type specimens.—Figured specimens BYU 2428, 2467, 2471; reference specimens BYU 2425, 2426, 2427, 2472, 2473.

PRAEBULIMINA PROLIXA (Cushman and Parker, 1935)

Pl. 10, figs. 4, 5, 6

Bulimina puschi Cushman (not Reuss) 1931, Tennessee Div. Geology Bull. 41, pl. 7, figs. 19a-b.

Bulimina prolixa Cushman and Parker 1935, Cushman Lab. Foram. Research, Contr., v. 11, p. 98, pl. 15, figs. 5a-b; Cushman and Todd 1943, Cushman Lab. Foram. Research Contr., v. 19, p. 66, pl. 11, fig. 23; Cushman and Goudkoff 1944, Cushman Lab. Foram. Research Contr., v. 20, p. 58, pl. 10, fig. 1; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 337, pl. 53, fig. 8; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 122, pl. 51, figs. 19-22; Cushman and Parker 1947, U.S. Geol. Survey Prof. Paper 210-D, p. 82, pl. 19, fig. 25; Cushman 1949, U.S. Geol. Survey Prof. Paper 221-A, p. 8, pl. 4, fig. 4; Mello 1969, U.S. Geol. Survey Prof. Paper 611, p. 77, pl. 9, figs. 2a-c; Lessard 1973, Utah Geol. and Min. Survey, Special Studies 45, p. 23, pl. 2, fig. 2.

Bulimina wyomingensis Fox 1954, U.S. Geol. Survey Prof. Paper 254-E, p. 118, pl. 26, figs. 8-11.

Reussella prolixa (Cushman and Parker) Hofker 1957, Geol. Jahrb. Beihefte, no. 27, p. 209, fig. 255-56.

Praebulimina wyomingensis (Fox) Eicher 1965, Jour. Paleont., v. 39, no. 5, p. 903, pl. 106, fig. 4; 1967, Jour. Paleont., v. 41, no. 1, p. 185, pl. 19, fig. 7.

Praebulimina prolixa (Cushman and Parker) Kent 1967, Jour. Paleont., v. 41, no. 6, p. 1443, pl. 183, figs. 5-7.

Pyramidina prolixa (Cushman and Parker) Sliter 1968, Univ. of Kansas Paleont. Contr., ser. 49, art. 7, p. 86, pl. 12, figs. 7-8.

Description.—Test long and narrow, about 2½ times as long as broad, tapering very slightly through the whole length, triangular in section, with angles broadly rounded, often somewhat twisted on its axis toward the initial end; chambers numerous, six to seven whorls in adults, those of successive whorls placed directly over others particularly in the initial part, becoming less so in the later portions, adjacent series meeting in a zigzag line; sutures very slightly depressed; aperture elongate, well removed from the juncture of the third preceding chamber. Dimensions of average-sized specimens: length, about 0.25 mm; breadth, about 0.11 to 0.17 mm.

Remarks.—Specimens occur in all measured sections and were recovered throughout each section, with abundances of 1000 or more specimens per

EXPLANATION OF PLATE 10

FIG. 1.—*Praebulimina cushmani* (Sandidge). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X255. (BYU 2467)

FIG. 2.—*Praebulimina cushmani* (Sandidge). Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X255. (BYU 2428)

FIG. 3.—*Praebulimina cushmani* (Sandidge). Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X260. (BYU 2471)

FIG. 4.—*Praebulimina prolixa* (Cushman & Parker). Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X255. (BYU 2410)

FIG. 5.—*Praebulimina prolixa* (Cushman & Parker). Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X255. (BYU 2409)

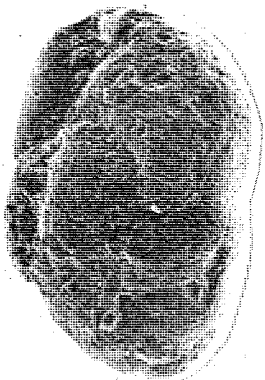
FIG. 6.—*Praebulimina prolixa* (Cushman & Parker). Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X275. (BYU 2431)

FIG. 7.—*Praebulimina venusae* (Nauss). Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X270. (BYU 2389)

FIG. 8.—*Praebulimina venusae* (Nauss). Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X270. (BYU 2386)

FIG. 9.—*Bolivina cretosa* Cushman. Lower part of the Tununk Shale, West Henry Mtns. section, Garfield County, Utah. Side view, X275. (BYU 2605)

PLATE 10



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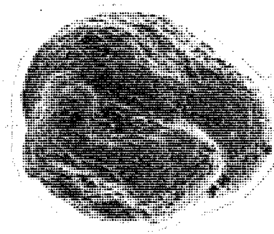

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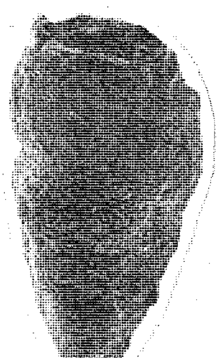

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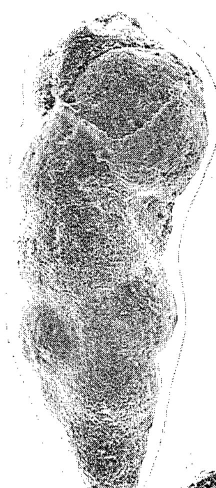
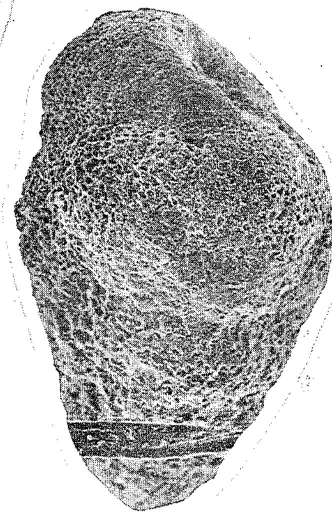
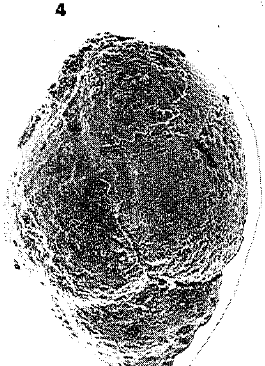


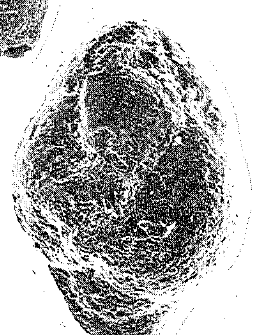
5



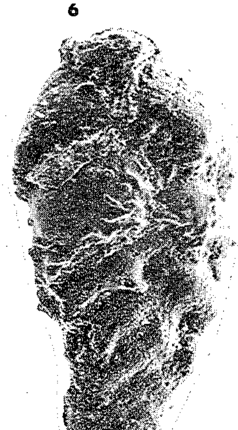
6



7



8



9

100-gram sample in many of the samples. Agreement with the type figure and description is good, except in a few samples where some specimens flare more rapidly and are more coarsely perforate. These specimens may be a different species. This species has been previously reported from beds of Taylor and Navarro ages in Gulf Coast deposits, from the Cody Shale of Wyoming, and from the Upper Cretaceous of Maryland and California. It has also been reported from Late Campanian in Israel, the Maestrichtian of Egypt, and from the Upper Cretaceous of Italy and France.

Type specimens.—Figured specimens BYU 2409, 2410, 2431; reference specimens BYU 2405, 2406, 2407, 2408, 2411, 2430, 2432, 2433.

PRAEBULIMINA VENUSAE (Nauss, 1947)
Pl. 10, figs. 7, 8

Bulimina venusae Nauss 1947, Jour. Paleont., v. 21, no. 4, p. 334, pl. 48, fig. 10; Tappan 1951, Cushman Found. Foram., Research Contr., v. 2, pt. 1, p. 6, pl. 1, figs. 23, 25, 26 (not fig. 24); 1951, Payne and others, U.S. Geol. Survey Oil and Gas Invest. Map OM-126, sheet 3, fig. 21 (7).

Praebulimina venusae (Nauss) Tappan 1962, U.S. Geol. Survey Prof. Paper 236-C, p. 188, pl. 49, figs. 19-21; Wall 1967, Alberta Res. Council Bull., no. 20, p. 94, pl. 15, figs. 19-22; Sliter 1968, Univ. Kansas Paleont. Contr., ser. 49, art. 7, p. 86, pl. 12, fig. 5; Morris 1971, Micropaleont., v. 17, no. 3, p. 278, pl. 6, fig. 7.

Description.—Test free, small, short, triserial throughout, rapidly flaring from a tiny early portion to an inflated later portion of greatest breadth, rounded in section; chambers triserially arranged in about four whorls, increasing quickly in size and becoming inflated; sutures distinct, depressed; wall calcareous, finely perforate, with smooth finish; aperture a loop-shaped opening extending up the face of the final chamber. Dimensions of average-sized specimens; length, about 0.19 mm; breadth, about 0.13 mm.

Remarks.—The species occurs in all measured sections with the exception of the Factory Butte section and is distributed sporadically throughout the sections. It occurs in greatest abundance in the Tununk Shale and in the lower Blue Gate Shale. This species is more elongate than *P. cushmani* and has three inflated chambers in the final whorl. Specimens found in the Mancos Shale are slightly smaller than those described elsewhere. The species has been reported previously from the Upper Cretaceous of northern Alaska, the Upper Cretaceous of California, and the Lewis Formation of northwestern Colorado, and was originally described from the Senonian of the Vermilion area, Alberta, Canada (Nauss, 1947).

Type specimens.—Figured specimens BYU 2386, 2389; reference specimens BYU 2387, 2388, 2390.

Family BOLIVINITIDAE Cushman, 1927
Genus BOLIVINA d'Orbigny, 1839
BOLIVINA CRETOSA Cushman, 1936
Pl. 10, fig. 9

Bolivina cretosa Cushman 1936, Cushman Lab. Foram. Research Specialist Pub. 6, p. 49, pl. 7, fig. 10; 1937, idem., Special Pub. 9, p. 43, pl. 6, figs. 2-5; 1944, idem., Contr., v. 20, p. 12, pl. 2, fig. 27.

Bolivina sp. Cushman 1931, Tennessee Div. Geol. Bull. 41, p. 50, pl. 8, fig. 7.

Description.—Test fusiform, small, about twice as long as broad, much compressed, periphery acute; chambers distinct, low and broad, increasing in breadth as added; sutures distinct, very slightly depressed, very strongly oblique, slightly curved; wall smooth or with occasional punctae; aperture narrow, elongate. Dimensions of average-sized specimens: length, about 0.22 mm; breadth, about 0.12 mm.

Remarks.—Specimens of the species are very rare, found in only two samples in the lower Blue Gate Shale in the Emery section. Agreement with the type figure and description is good, except the aperture of most specimens is slightly more necked than the type specimens.

Type specimens.—Figured specimen BYU 2605; reference specimen BYU 2611.

Superfamily DISCORBACEA Ehrenberg, 1838

Family DISCORBIDAE Ehrenberg, 1838
Subfamily BAGGININAE Cushman, 1927
Genus VALVULINERIA Cushman, 1926
VALVULINERIA INFREQUENS Morrow, 1934
Pl. 11, figs. 1, 2

Valvulineria infrequens Morrow 1934, Jour. Paleont., v. 8, p. 197, pl. 30, figs. 3a-c; Cushman and Deaderick 1942, Cushman Lab. Foram. Research Contr., v. 18, p. 64, pl. 15, figs. 17-19; Cushman 1944, Cushman Lab. Foram. Research Contr., v. 20, p. 95, pl. 14, fig. 22.

Description.—Test trochoid, dorsal side moderately convex, ventral side concave, periphery rounded; chambers distinct, somewhat inflated, of uniform shape but increasing rapidly in size as added, with the last-formed chamber much larger and more inflated on the ventral side, normally with a weak lobe over the umbilical region; sutures distinct, strongly depressed; aperture a low and elongate opening on the ventral side. Dimensions of average-sized specimens: diameter, about 0.18 mm; thickness, about 0.08 mm.

Remarks.—Specimens occur in the Woodside, Ferron-Castledale, and West Henry Mountains sections. The species is rather rare and was found only in samples in the lower Blue Gate Shale in the Woodside and Ferron-Castledale sections and in one sample in the Tununk Shale in the West Henry Mountain section. Specimens are much smaller than described elsewhere and are replaced by hematite. Therefore, identification of this species is somewhat questionable.

Type specimens.—Figured specimens BYU 2567, 2568; reference specimens BYU 2569.

Superfamily GLOBIGERINACEA Carpenter, Parker and Jones, 1862

Family HETEROHELICIDAE Cushman, 1927
Subfamily GUEMBELITRIINAE Montanaro Gallitelli, 1957
Genus GUEMBELITRIA Cushman, 1933
GUEMBELITRIA CRETACEA Cushman, 1933
Pl. 11, figs. 3, 4, 5

Guembelitria cretacea Cushman 1933, Cushman Lab. Foram. Research Contr., v. 9, pl. 2, p. 37, pl. 4, figs. 12a-b; 1933, Cushman Lab. Foram. Research, Special Publ. 4, pl. 21, figs. 3a-b; 1933, idem., Special Publ. 5, pl. 26, figs. 9a-b; Jennings 1936, Bull. Am. Paleont., v. 23, no. 78, p. 28, pl. 3, fig. 12; Cushman 1936, Geol. Soc. Am. Bull., v. 47, p. 418, pl. 1, figs. 12a-b; 1938, Cushman Lab. Foram. Research Contr., v. 14, pt. 1, p. 19, figs. 14a-b; Cushman and Hedberg 1941, Cushman Lab. Foram. Research Contr., v. 17, p. 91, pl. 22, fig. 17; Cushman and Todd 1943, Cushman Lab. Foram. Research Contr., v. 19, p. 65, pl. 11, fig. 16; Gallitelli 1957, U.S. Nat. Mus., Bull. 215, p. 136, pl. 31, figs. 1a-c; Olsson 1960, Jour. Paleont., v. 34, no. 1, p. 27, 28, pl. 4, fig. 8; Loeblich and Tappan 1964, Treatise on Invert. Paleont., pt. C, Protista 2, v. 2., p. C652, fig. 523; 1a-b; Said and Sabry 1964, Micropaleont., v. 10, no. 3, p. 390, pl. 3, fig. 32; Pessagno 1967, Palaeontographica, Am., v. 5, no. 37, p. 258, pl. 87, figs. 1-3.

Description.—Test triserial, small; chambers globular, nearly spherical; sutures much depressed; wall smooth, finely perforate; aperture large, semicircular or semielliptical at the inner margin of the last-formed chamber. Dimensions of average-sized specimens: length, about 0.15 mm; breadth, about 0.12 mm.

Remarks.—Specimens were found in the Woodside, Ferron-Castledale, and West Henry Mountains sections. The species occurs very abundantly in samples from the lower Tununk Shale and appears to be a useful marker. Agreement with the type figure and description is very good. This species has been reported from the Upper Cretaceous of New Jersey, the Corsicana Marl of Texas, the Santander del Norte of Colombia, S. A., and the Esna Shale of Egypt. The species was originally described from the Navarro of Texas.

Type specimens.—Figured specimens BYU 2550, 2552, 2553; reference specimens BYU 2551, 2554, 2555.

Subfamily HETEROHELICINAE Cushman, 1927

Genus HETEROHELIX Ehrenberg, 1843

HETEROHELIX GLOBULOSA (Ehrenberg), 1840

Pl. 11, figs. 6, 9

Textularia globulosa Ehrenberg 1840 (1838), K. Preuss. Akad. Wiss. Berlin, Abh., p. 135, pl. 4, figs. 2 beta, 4 beta, 5 beta, 7 beta, 8 beta; 1854, Mikrogeologie, pl. 21, fig. 87; Eley 1859, Geology in the Garden, p. 194, 202, pl. 2, fig. 9; pl. 9, fig. 9; Cushman 1927, Jour. Paleont., v. 1, p. 215, pl. 34, fig. 8; Franke 1928, Preuss. Geol. Landesanstalt. Abh., new ser., v. 111, p. 134, pl. 12, fig. 11.

Textilaria globifera Reuss 1860, Akad. Wiss. Wien, Math-naturwiss. Sitzungsber., v. 40, p. 232, pl. 13, figs. 7-8; Egger 1907, Naturw. Ver. Passau Ber., p. 18, pl. 5, fig. 4; 1909, K. bayer. Akad. Wiss., Math-phys. Kl., Jahrg. 11, Abh., Sitzungsber., p. 22, pl. 2, fig. 16; 1910, Naturw. Ver Regensburg Ber., p. 12, pl. 5, fig. 11; Franke 1925, Greifswald Univ., Geol.-palaeont. Inst. Abh., v. 6, p. 11, pl. 1, fig. 13.

Guembelina globifera (Reuss) Egger 1899, K. bayer. Akad. Wiss., Math.-naturh. Abt., Abh., Kl. 2, v. 2, v. 21, pt. 1, p. 33, pl. 14, figs. 35-36, 53-55; Chapman 1917, Western Australia Geol. Survey Bull. 72, p. 14, pl. 2, fig. 18; 1926, New Zealand Geol. Survey Paleont. Bull. 11, p. 33, pl. 8, fig. 4; White 1929, Jour. Paleont., v. 3, p. 35, pl. 4, fig. 9.

Guembelina globulosa (Ehrenberg), Egger 1899, K. Bayer. Akad. Wiss. Math.-naturh., Abt., Abh., Kl. 2, v. 21, pt. 1, p. 32, fig. 43; Chapman 1917, Western Australia Geol. Survey Bull. 72, p. 14, pl. 2, fig. 17; 1926, New Zealand Geol. Survey Paleont. Bull. 11, p. 33, pl. 8, fig. 5; Cushman 1927, Cushman Lab. Foram. Research Contr., v. 3, p. 190; Carman 1929, Jour. Paleont., v. 3, p. 312, pl. 34, figs. 10-20; White 1929, Jour. Paleont., v. 3, p. 36, pl. 4, figs. 10a-b; Cushman 1931, Tennessee Div. Geol., Bull. 41, p. 43, pl. 7, figs. 3-5; 1931, Cushman Lab. Foram. Research Contr., v. 7, p. 39, pl. 5, figs. 7a-b; 1932, Jour. Paleont., v. 6, p. 338; Morrow 1934, Jour. Paleont., v. 8, no. 2, p. 194, p. 29, figs. 18a-b; Cushman 1936, Geol. Soc. Am. Bull., v. 47, p. 418, pl. 1, figs. 8a-b; Glaessner 1936, Problems of Paleont., v. 1, p. 108, pl. 2, fig. 2; Jennings 1936, Bull. Am. Paleont., v. 23, no. 78, p. 27, pl. 3, fig. 9; Voorwijk 1937, Royal Acad. Amsterdam Proc., v. 40, p. 5; Loetterle 1937, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 34, pl. 5, fig. 3; Cushman 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 6, pl. 1, figs. 28-33; Cole 1938, Florida Geol. Survey Bull. 16, p. 34, pl. 3, fig. 10; Cushman and Hedberg 1941, Cushman Lab. Foram. Research Contr., v. 17, p. 92, pl. 22, figs. 15a-b; Macfadyen 1942, Geol. Mag., v. 79, p. 139, (list); Cushman and Todd 1943, Cushman Lab. Foram. Research Contr., v. 19, p. 64, pl. 11, fig. 12; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 336, pl. 53, figs. 2-3; Cushman 1946, U.S. Geol. Survey Prof. Paper no. 206, p. 105-6, pl. 45, figs. 9-15; Loeblich 1951, Cushman Lab. Foram. Research, Contr., v. 2, pt. 3, p. 108, pl. 12, figs. 4-5; Young 1951, Jour. Paleont., no. 1, p. 63, pl. 14, figs. 12, 23-26; Gauger 1953, Utah Geol. and Min. Survey, Bull. 47, p. 77, pl. 9, figs. 3-14.

Guembelina pupa White 1929, Jour. Paleont., v. 3, p. 38, pl. 4, fig. 11.

Guembelina spinifera Cushman 1931, Tennessee Div. Geol., Bull. 41, p. 43, pl. 7, figs. 8a-b; Cushman 1946, Cushman, U.S. Geol. Survey Prof. Paper 206, p. 108, pl. 46, figs. 15a-b.

Heterohelix globulosa (Ehrenberg) Gallitelli 1957, U.S. Nat. Mus., Bull. 215, p. 137, pl. 31, fig. 12-15; Eternod Olvera 1959, Assoc. Mexicana Geol. Petroleras, Bol., v. 11, p. 69, pl. 1, figs. 17-18; Belford 1960, Australia Bur. Min. Res., Geol. and Geophys. Bull. 57, p. 59, pl. 15, fig. 10-11; Tappan 1962, U.S. Geol. Survey Prof. Paper 236-C, p. 196, pl. 55, fig. 1-2; Graham and Church 1963, Stanford Univ. Pub. Geol. Sci., v. 8, no. 1, p. 61, pl. 7, fig. 11; Martin 1964, Geol. Bundesanstalt Wien, Jahrb., Sonderbad. 9, p. 84, pl. 10, fig. 10; Takayanagi 1965, Tohoku Univ. Sci. Repts., ser. 2, (Geol.), v. 32, p. 195, pl. 20, fig. 1; Eicher 1965, Jour. Paleont., v. 39, no. 5, p. 904, pl. 106, fig. 3; Pessagno 1967, Palaeontographica Am., v. 5, no. 37, p. 260, pl. 87, figs. 5-9, 11-13; Wall 1967, Alberta, Research Council of Alberta, Bull. 20, p. 102, pl. 3, fig. 26-37; Lamb 1968, Geol. Soc. Am. Bull., v. 79, p. 842; Sliter 1968, Univ. Kansas Paleont. Contr., no. 49, art. 7, p. 94-95, pl. 14, figs. 1-3; Morris 1971, Micropaleont., v. 17, no. 3, p. 280, pl. 7, fig. 3; Lessard 1973, Utah Geol. and Min. Survey, Special Studies 45, p. 24, pl. 2, fig. 5.

Description.—Test rapidly tapering, greatest breadth toward the apertural end, initial end subacute, 1½ to 2 times as long as broad, in side view, with the chambers regularly enlarging to the greatest width at the last-formed chamber, periphery distinctly indented throughout; chambers inflated throughout, increasing in size rather more rapidly toward the apertural end, nearly spherical; sutures distinct, depressed throughout; wall smooth, finely perforate; aperture broad, low, with a slightly thickened rim. Dimensions of average-sized specimens: length, about 0.22 mm; breadth, about 0.12 mm.

Remarks.—The species occurs in all measured sections. Abundances are rather rare in the Masuk Shale and distribution is rather sporadic. Specimens are abundant to very abundant and distribution is uniform throughout the Blue Gate and Tununk shales. This species shows considerable variability of position of the final chamber, presence of the initial planispiral coil, and presence or absence of surface ornamentation, but remains within the limits of figured and described types from other areas. This species has a very wide distribution, having been reported from the lower Taylor Marl to the Navarro-age Kemp Clay in deposits of the Gulf Coastal region; from the Frontier Formation of northern Utah; the Graneros and Mowry Shales of Wyoming and Colorado; the Greenhorn Formation of New Mexico, Colorado and Kansas; the Vimy Member of the Blackstone Formation in the Rocky Mountain foothills of Canada, as well as from the Plains region of northwestern Alberta and from the Upper Cretaceous of California. This species also occurs in Europe, the Far East, Australia, Africa, mid-Pacific, and South America.

Type specimens.—Figured specimens BYU 2532, 2536; reference specimens BYU 2533, 2534, 2535.

Genus BIFARINA Parker and Jones, 1872

BIFARINA HISPIDULA (Cushman, 1938)
Pl. 11, figs. 7, 8

Rectoguembelina hispidula Cushman 1938, Cushman Lab. Foram. Research Contr., v. 14, pt. 1, p. 21, pl. 3, figs. 20-22; 1946, U.S. Geol. Survey Prof. Paper 206, p. 109, pl. 46, figs. 19-21; Frizzell 1954, Texas Univ., Bur. Econ. Geol. Rpt. Invest. 22, p. 110, pl. 16, fig. 1.

EXPLANATION OF PLATE 11

FIG. 1.—*Valvulineria infrequens* Morrow. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X265. (BYU 2568)
FIG. 2.—*Valvulineria infrequens* Morrow. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X270. (BYU 2567)
FIG. 3.—*Guembelitria cretacea* Cushman. Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X275. (BYU 2552)
FIG. 4.—*Guembelitria cretacea* Cushman. Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X280. (BYU 2553)
FIG. 5.—*Guembelitria cretacea* Cushman. Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X280. (BYU 2550)
FIG. 6.—*Heterobelix globulosa* (Ehrenberg). Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X275. (BYU 2536)
FIG. 7.—*Bifarina hispidula* (Cushman). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X244. (BYU 2435)
FIG. 8.—*Bifarina hispidula* (Cushman). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X244.
FIG. 9.—*Heterohelix globulosa* (Ehrenberg). Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X244. (BYU 2532)

PLATE 11

Bifarina hispidula (Cushman) Kent 1967, Jour. Paleont., v. 41, no. 6, p. 1447, pl. 183, fig. 11.

Description.—Test elongate, slightly tapering, biserial for most of the length, latest portion uniserial; chambers inflated, earliest chambers biserial, gradually becoming more loosely so; last-formed chambers rectilinear and nearly globular or slightly pyriform; sutures depressed; wall finely hispid throughout; aperture rounded, at the end of a short neck that is eccentrically placed in most specimens. Dimensions of average-sized specimens: length, about 0.20 mm; breadth, about 0.10 mm.

Remarks.—Representatives of the species occur only in the Ferron-Castledale section and only in samples from the lower Blue Gate Member. Specimens were found only sporadically and not in great abundance. These specimens agree very well with the type figure and description, except they are slightly smaller. This species has been reported from the lower Mancos Shale of western Colorado and was originally described from the lower and middle part of the Austin Chalk of Texas.

Type specimens.—Figured specimens BYU 2434, 2435; reference specimen BYU 2436.

Family PLANOMALINIDAE Bolli, Loeblich and Tappan, 1957

Genus GLOBIGERINELLOIDES Cushman and Ten Dam, 1948

GLOBIGERINELLOIDES ASPERA (Ehrenberg, 1854)

Pl. 12, figs. 1, 2, 4

Rotalia aspera Ehrenberg 1854, Mikrogeologie. Leipzig: L. Voss, p. 24, pl. 24, figs. 57-58; pl. 28, fig. 42; pl. 31, fig. 44; Beissel 1891, Preuss. Geol. Landesanstalt., Abh., p. 73, pl. 14, figs. 1-6.

Phanerostomum asperum Ehrenberg 1864, Mikrogeologie. Leipzig: L. Voss, p. 23, pl. 30, figs. 26a-b.

Globigerina aequilateralis Brady, Chapman 1892, Geol. Soc. London, Quart. Jour., v. 48, p. 517, pl. 15, fig. 14; 1896, Roy. Micr. Soc. Jour., p. 589, pl. 13, fig. 7; Egger 1902, K. bayr. Akad. Wiss. Abh., v. 21, p. 169, pl. 21, figs. 9-11; Heron-Allen and Earland, J. 1910, Roy. Micr. Soc. Jour., p. 424, pl. 8, figs. 11-12; Chapman 1917, West Australian Geol. Soc. Bull. 72, p. 44, pl. 12, fig. 125.

Globigerina aspera (Ehrenberg) Egger 1899, K. bayr. Akad. Wiss. Abh., 2 Cl. Bd. 21, Munchen, p. 170, pl. 21, figs. 18-20; 1907, 20 Berict d. nath. Ver. Passau, p. 49, pl. 7; Franke 1914, Deutsche geol. Gesell. Zeitschr., Bd. 66, p. 442, pl. 27; 1928, Preuss. Geol. Landesanstalt Jahrb., Bd. 48, p. 632; 1928, Preuss. Geol. Landesanst., Abh., N.F., Heft. 111 p. 192, pl. 18, figs. 10a-c.

Globigerinella aspera (Ehrenberg) Carmen 1929, Jour. Paleont., v. 3, no. 3, p. 315, pl. 34, fig. 6; Cushman 1931, Tennessee Div. Geol. Bull. 41, p. 59, pl. 11, figs. 5a-b; 1931, Cushman Lab. Foram. Research Contr., v. 7, no. 2, p. 45, pl. 6, figs. 5a-b; Loetterle 1937, Neb. Geol. Survey Bull. 12, 2nd ser., p. 45, pl. 7, figs. 4a-b; Cole 1938, Florida Geol. Survey Bull. 16, list, pl. 4, fig. 5; Marie 1941, Mém. Mus. Nat. Hist. Paris, n.s., tome 12, fasc. 1, p. 235, pl. 36, figs. 336a-b; Hagn 1953, Palaeontographica, Bd. 104, Abt. A, p. 92, pl. 8, fig. 7; Herm 1962, Bayerische Akad. Wiss. Abh., Math.-naturw. Kl. N.F., H. 104, p. 49, pl. 3, fig. 6.

Globigerinella voluta Sandidge 1932, Jour. Paleont., v. 6, p. 284, pl. 44, figs. 1-2.

Globigerinelloides aspera (Ehrenberg) Brotzen 1936, Sveriges Geol. Undersökning, Abh., v. 30, no. 3, ser. C, no. 396, p. 170, pl. 13, fig. 2; Schijfsma 1946, Mededeel. Geol. Sticht. (C), sect. 5, no. 7, p. 94-96, pl. 6, fig. 8; Bandy 1951, Jour. Paleont., v. 25, p. 508, pl. 75, fig. 3; Belford 1960, Australia Min. Resources, Geol. and Geoph., Bull. 57, p. 91, pl. 25, figs. 4-6; Graham and Church 1963, Stanford Univ. Publ. Geol. Sci., v. 8, no. 1, p. 64-65, pl. 7, figs. 17a-c; Takayanagi 1965, Sendai, Japan, Tohokie Univ. Sci. Rept., ser. 2, v. 36, no. 2, p. 201-2, pl. 20, figs. 9a-c; Barr 1966, Paleont., v. 9, pt. 3, p. 503-4, pl. 78, figs. 4a-b; Pessagno 1967, Palaeontographica Americana, v. 5, no. 37, p. 274-75, pl. 60, figs. 4-5; Barr 1968, Jour. Paleont., v. 42, no. 2, p. 313-14, pl. 37, figs. 3, 6; 1968, Geology and Archaeology of Northern Cyrenaica, Libya, Tripoli, Petrol. Expl. Soc. Libya, p. 139, pl. 2, figs. 2a-b; 1972, Micropaleont., v. 18, no. 1, p. 11, pl. 1, figs. 3a-b.

Planomalina alvarezi Eternod Olvera 1959, Asoc. Mexicana Geólogos Petroleros, Bol., v. 11, p. 91, pl. 4, figs. 5-7; Martin 1964, Jahrb. Geol. Bundesanstalt, v. 9, p. 84, pl. 10, figs. 8-9.

Planomalina yaucoensis Pessagno 1960, Micropaleont., v. 6, p. 98, pl. 2, fig. 14-15.

Planomalina aspera (Ehrenberg) Barr 1962, Paleont., v. 4, pt. 4, p. 561, 563, pl. 69, figs. 4a-b.

Planomalina (*Globigerinelloides*) *aspera aspera* (Ehrenberg), Van Hinte 1963, Wien, Jahrb. Geol. Bundesanstalt, Sonderbad. 8, p. 97, pl. 12, figs. 2a-3; 1965, Kgl. Ned. Akad. Wetensch. Amsterdam Proc., ser. B, v. 68, no. 2, p. 85, pl. 1, figs. 2a-b.

Description.—Test free, small planispiral, biumbilicate, periphery moderately lobate, six to seven chambers in the final whorl, inflated, globular, slightly overlapping; sutures distinct, depressed, radial, wall calcareous, finely perforate, surface smooth to finely hispid; aperture a moderately high arch at the base of the final chamber, with small lip. Dimensions of average-sized specimens: diameter, about 0.12 mm; thickness, about 0.06 mm.

Remarks.—Specimens occur in all measured sections, with the exception of the Woodside section, and occur rather sporadically throughout the sections. These specimens agree very well with the type specimens figured and described by Barr (1966, 1968) and by Pessagno (1967) and are therefore considered conspecific. The species has a reported stratigraphic range from the Upper Coniacian to Maestrichtian and a wide areal distribution.

Type specimens.—Figured specimens BYU 2519, 2520, 2521; reference specimen BYU 2518.

Family ROTALIPORIDAE Sigal, 1958

Subfamily HEDBERGELLINAE Loeblich and Tappan, 1961

Genus HEDBERGELLA Brönnimann and Brown, 1958

HEDBERGELLA DELRIOENSIS (Carsey, 1954)

Pl. 12, figs. 3, 5, 6, 7, 8

Globigerina cretacea d'Orbigny var. delrioensis Carsey 1926, Texas Univ., Bull., no. 2612, p. 43.

Globigerina cretacea d'Orbigny, Morrow 1934, Jour. Paleont., v. 8, no. 2, p. 198, pl. 10, figs. 7-8; Tappan 1940, Jour. Paleont., v. 14, no. 2, p. 121, pl. 19, fig. 11; 1943, Jour. Paleont., v. 17, no. 5, p. 512, pl. 82, figs. 16-17; Young 1951, Jour. Paleont., v. 25, no. 1, p. 65, pl. 14, figs. 1-3; Peterson 1953, Utah Geol. and Min. Survey, Bull. 47, p. 45, pl. 2, figs. 15a-b.

Globigerina infracretacea Glaessner 1937, Lab. Moscow Univ., Paleont. Publ., Studies Micropaleont., v. 1, no. 1, p. 28, 47, pl. 1.

Globigerina gautierensis Brönnimann 1952, Bull. Amer. Paleont., v. 34, no. 140, p. 11, pl. 1, figs. 1-3.

Globigerina delrioensis Carsey, Frizzell 1954, Texas Univ. Bur. Econ. Geol., Rept. Invest. 22, p. 127, pl. 20, fig. 1.

Praeglobotruncana gautierensis (Brönnimann) Bolli 1959, Bull. Amer. Paleont., v. 39, no. 179, p. 265, pl. 21, figs. 3-6; Jones 1960, Cushman Lab. Foram. Research Contr., v. 11, pt. 3, p. 102, pl. 15, figs. 1a-c, 2a-c, 5, 7a-c, 8, 9a-c.

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

Hedbergella delrioensis (Carsey) Loeblich and Tappan 1961, Micropaleont., v. 7, no. 3, p. 275, pl. 2, fig. 11-13; Renz, Luterbacher, and Schneider 1963, Eclogae Geol. Helv., v. 56, no. 2, p. 1083, pl. 9, figs. 5a-c; Eicher 1965, Jour. Paleont., v. 39, no. 5, p. 904, pl. 106, figs. 2, 6; Wall 1967, Research Council of Alberta, Bull. 20, p. 105, pl. 3, figs. 1-12; pl. 13, figs. 13-21; Pessagno, Jr., 1967, Paleontographica Amer., v. 5, no. 37, p. 282-83, pl. 48, figs. 1-5; Barr 1968, Geology and Archaeology of Northern Cyrenaica, Libya, Tripoli, Petrol., Expl. Soc. Libya, p. 144, pl. 2, figs. 5a-c; Lamb 1968, Geol. Soc. Am. Bull., v. 79, p. 842; Barr 1972, Micro-

EXPLANATION OF PLATE 12

FIG. 1.—*Globigerinelloides aspera* (Ehrenberg). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X290. (BYU 2521)

FIG. 2.—*Globigerinelloides aspera* (Ehrenberg). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X290. (BYU 2520)

FIG. 3.—*Hedbergella delrioensis* (Carsey). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X109. (BYU 2544)

FIG. 4.—*Globigerinelloides aspera* (Ehrenberg). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X275. (BYU 2519)

FIG. 5.—*Hedbergella delrioensis* (Carsey). Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X109. (BYU 2522)

FIG. 6.—*Hedbergella delrioensis* (Carsey). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X109. (BYU 2526)

FIG. 7.—*Hedbergella delrioensis* (Carsey) Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X140. (BYU 2529)

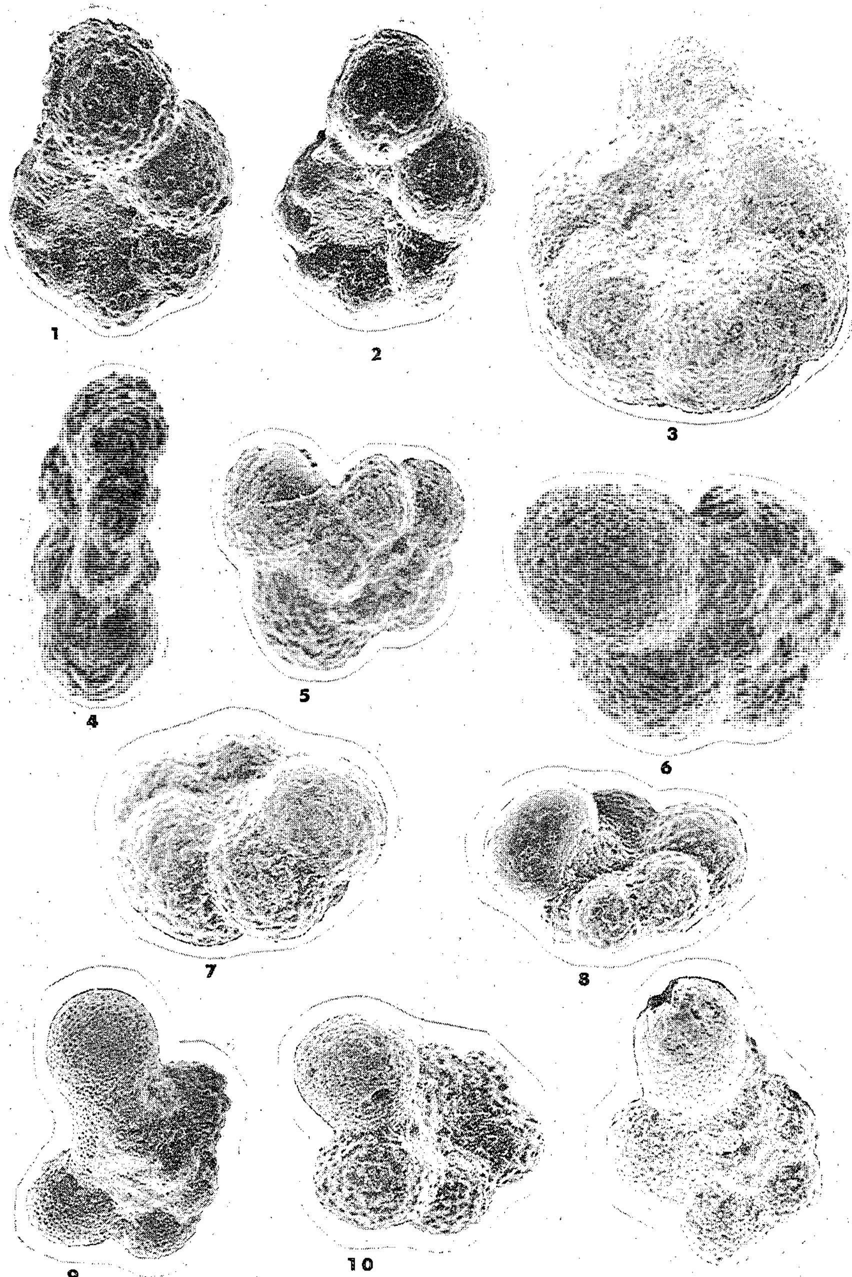
FIG. 8.—*Hedbergella delrioensis* (Carsey). Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X140. (BYU 2523)

FIG. 9.—*Clavihedbergella simplex* (Morrow). Upper part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Dorcal view, X140. (BYU 2594)

FIG. 10.—*Clavihedbergella simplex* (Morrow). Upper part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X140. (BYU 2590)

FIG. 11.—*Clavihedbergella simplex* (Morrow). Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X140. (BYU 2531)

PLATE 12



paleont., p. 13, pl. 2, figs. 1a-c; Lessard 1973, Utah Geol. and Min. Survey, Special Studies 45, p. 24-25, pl. 2, fig. 6.

? *Hedbergella delrioensis* (Carsey) Todd and Low 1964, Deep-Sea Research, v. 11, p. 402, pl. 1, figs. 2a-c.

Description.—Test free, in a low trochospiral coil of about two volutions, early whorl flush to slightly depressed below the final whorl on the spiral side, opposite side deeply umbilicate, peripheral outline strongly lobulate; chambers much inflated, nearly spherical, increasing rapidly in size as added, with four to six chambers in the final whorl, most commonly five; sutures distinct, straight to slightly curved, deeply constricted; wall calcareous, distinctly perforate, earlier chambers with a papillate surface, final chamber less ornamented, no indication of a keel or poreless margin; aperture an arch on the umbilical side, interiomarginal and extraumbilical-umbilical. Dimensions of average-sized specimens: diameters from 0.30 to 0.45 mm; thicknesses from 0.20 to 0.30 mm.

Remarks.—Specimens recovered from the Masuk and upper Blue Gate members tend to be smaller and with a more pronounced trochoid coiling. Those specimens recovered from the lower Blue Gate and Tununk Members tend to be more robust and slightly flatter. This species occurs in all measured sections and is distributed sporadically throughout the Masuk Shale, with rather few specimens per sample. In the Blue Gate and Tununk shales the species is more evenly distributed and occurs in much greater numbers. This species has been previously recorded from the Graneros, Greenhorn, and Carlile formations of Kansas, the Frontier Formation of southern Montana and northern Utah, the Vimy Member of the Blackstone Formation of Alberta, Canada, the Greenhorn and Carlile shales of northwestern New Mexico, the Grayson and Del Rio formations of Texas, and from the Cretaceous rocks of Trinidad.

Type specimens.—Figured specimens BYU 2522, 2523, 2526, 2529, 2544; reference specimens BYU 2524, 2527, 2528, 2543, 2545.

Genus CLAVIHEDBERGELLA Banner and Blow, 1959

CLAVIHEDBERGELLA SIMPLEX (Morrow, 1934)

Pl. 12, figs. 9, 10, 11

Hastigerinella moremani Cushman 1931, Cushman Lab. Foram. Research Contr., v. 7, p. 86, pl. 11, figs. 2-3.

Hastigerinella simplex Morrow 1934, Jour. Paleont., v. 8, no. 2, p. 198, pl. 30, figs. 6a-b; Loetterle 1937, Neb. Geol. Survey, 2nd ser., Bull. 12, p. 46, pl. 7, fig. 5; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 148, pl. 16, fig. 10.

Hastigerinella simplicissima Magné and Sigal 1954, in Cheylan, Magné, Sigal, and Grekoff, Soc. Géol. France, Bull., ser. 6, v. 3 (1953), p. 487, pl. 14, figs. 11a-c.

Schackoina sp. cf. *S. Gandolfii* Reichel., Küpper 1956, Cushman Found. Foram. Research Contr., v. 7, pt. 2, p. 44, pl. 8, figs. 4a-c.

Clavihedbergella simplex (Morrow) Loeblich and Tappan 1961, Micropaleont., v. 7, no. 3, p. 279-80, pl. 3, figs. 11-14; Ayala 1962, Soc. Geol. Mex., Bol., v. 25, p. 25-26, pl. 4, figs. 1a-c; Pessagno 1967, Palaeontographica Am., v. 5, no. 37, p. 285-86, pl. 52, figs. 1-2; Barr 1968, In: Barr, F.T., Ed., Geol. and Archaeology of Northern Cyrenaica, Libya, Tripoli, Petrol.

Expl. Soc. Libya, p. 144, pl. 2, figs. 8a-c; 1972, Micropaleont., v. 18, no. 1, p. 14-15, pl. 2, figs. 2a-b.

Description.—Test free, of medium size, trochospirally coiled, subglobular to elongate chambers forming about two to two and one-half whorls, the early whorl with about five globular chambers, the final whorl with four to six chambers, the last two or three radially elongate to subclavate; sutures distinct, depressed; wall calcareous, finely perforate, surface finely spinose; aperture an interiomarginal arch extending from the periphery to the umbilicus, with a narrow bordering lip. Dimensions of average-sized specimens: diameter, about 0.24 mm; thickness, about 0.11 mm.

Remarks.—Specimens occur in all measured sections, occurring sporadically throughout each section. Specimens from the Mancos Shale are generally somewhat smaller than those described by Morrow (1934). The immature portion of the specimens is very close in form to *Hedbergella* and would certainly be placed under that genus. This species has been reported previously from the Niobrara Chalk of Nebraska and South Dakota, the Austin Chalk of Texas, the Cretaceous of Antiqua, B.W.I., the Upper Cretaceous deposits of Cuba, and the Late Cretaceous of northeastern Libya. The species was originally described from the Hartland Shale Member of the Greenhorn Formation in Kansas (Morrow, 1932).

Type specimens.—Figured specimens BYU 2531, 2590, 2594; reference specimens BYU 2525, 2530, 2591, 2592, 2593.

Family GLOBOTRUNCANIDAE Brotzen, 1942

Genus GLOBOTRUNCANA Cushman, 1927

GLOBOTRUNCANA MARGINATA (Reuss, 1845)
Pl. 13, figs. 1, 2

Rosalina marginata Reuss 1845, Stuttgart, I. Schweizerbart, abh. 1, pt. 2, p. 36, pl. 8, figs. 54, 74; pl. 13, fig. 68.

Globotruncana marginata (Reuss) Thalman 1934, Eclogae Geol. Helv., Lausanne, v. 27, p. 414; Cushman 1944, Cushman Lab. Foram. Research Contr., v. 20, p. 15, pl. 3, fig. 9; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 340, pl. 53, fig. 29; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 150, pl. 62, figs. 1-2; Gauger 1953, Utah Geol. and Min. Survey, Bull. 47, p. 82, pl. 9, figs. 27-29; Lamb 1968, Geol. Soc. Am. Bull., v. 79, p. 842; Barr 1972, Micropaleont., v. 18, no. 1, p. 22, pl. 4, figs. 8a-c; Lessard 1973, Utah Geol. and Min. Survey, Special Studies 45, p. 25, pl. 2, fig. 7.

Globotruncana linneiana marginata (Reuss) Jirová 1956, Acta Univ. Carolinae, Prague, Geol., v. 2(14), no. 3, p. 239-55, pl. 1, figs. 1a-c; pl. 2, figs. 1-3; pl. 3, figs. 1a-c (neotype).

Description.—Test rotaloid with calcareous wall; dorsal side evolute, slightly convex, with chambers that overlap; sutures on dorsal side slightly beaded; ventral side involute with slightly compressed chambers; four to five chambers in last formed whorl; umbilical vestibule with remnants of tegilla; double keeled aperture opens into umbilical vestibule. Dimensions of average-sized specimens: diameter, about 0.45 mm; thickness, about 0.18 mm.

Remarks.—Specimens referred to this species occur in all measured sections, with the exception of the Emery section, and occur sporadically throughout the lower Blue Gate and Tununk members. Specimens agree rather well with the type figure and description given by Cushman (1946), although the beading along the dorsal suture is somewhat less conspicuous than those described by Cushman (1946). This species has been reported from the Tocito Sandstone of northwestern New Mexico, the Tununk Shale of eastern Utah, the Hilliard Formation of northeastern Utah, and from the Austin-, Taylor-, and Navarro-age deposits of the Gulf Coastal region. The species was originally described from the Turonian of Bohemia (Reuss, 1945).

Type specimens.—Figured specimens BYU 2537, 2540; reference specimens BYU 2538, 2539, 2541, 2542.

Superfamily ORBITOIDACEA Schwager, 1876

Family CIBICIDAE Cushman, 1927
Subfamily PLANULININAE Bermudez, 1952
Genus PLANULINA d'Orbigny, 1826
PLANULINA AUSTINANA Cushman, 1938
Pl. 13, figs. 3, 4, 5

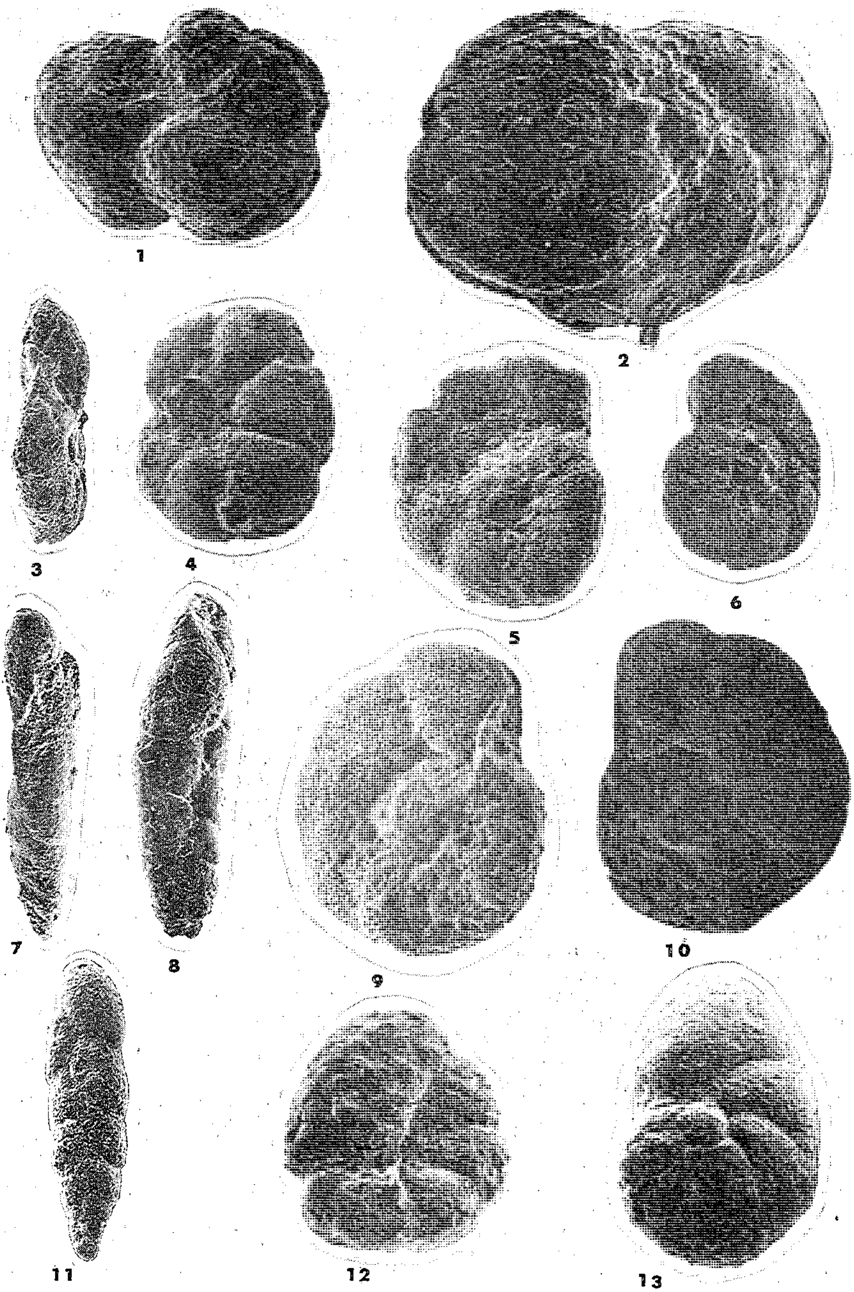
Planulina austinana Cushman 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 68, pl. 12, figs. 2a-c; 1940, Cushman Lab. Foram. Research Contr., v. 16, p. 33, pl. 6, figs. 6a-c; 1946, U.S. Geol. Survey Prof. Paper 206, p. 156, pl. 64, fig. 10.

Description.—Test very much compressed, partially evolute on both sides, particularly the dorsal side, which is very slightly umbonate; ventral side slightly

EXPLANATION OF PLATE 13

FIG. 1.—*Globotruncana marginata* (Reuss). Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X109. (BYU 2540)
FIG. 2.—*Globotruncana marginata* (Reuss). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X109. (BYU 2537)
FIG. 3.—*Planulina austinana* Cushman. Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X109. (BYU 2423)
FIG. 4.—*Planulina austinana* Cushman. Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X109. (BYU 2424)
FIG. 5.—*Planulina austinana* Cushman. Lower part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X109. (BYU 2422)
FIG. 6.—*Planulina kansasensis* Morrow. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X109. (BYU 2413)
FIG. 7.—(?) *Cassidella* sp. Middle part of the Tununk Shale, West Henry Mtns. section, Garfield County, Utah. Side view, X109. (BYU 2598)
FIG. 8.—(?) *Cassidella* sp. Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Side view, X130. (BYU 2595)
FIG. 9.—*Planulina kansasensis* Morrow. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X109. (BYU 2416)
FIG. 10.—*Planulina kansasensis* Morrow. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X109. (BYU 2414)
FIG. 11.—(?) *Cassidella* sp. Middle part of the Tununk Shale, West Henry Mtns. section, Garfield County, Utah. Side view, X109. (BYU 2597)
FIG. 12.—(?) *Nonionella* sp. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X275. (BYU 2561)
FIG. 13.—(?) *Nonionella* sp. Upper part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X275. (BYU 2601)

PLATE 13



umbilicate; periphery subacute, lobate; chambers distinct, somewhat inflated, of uniform shape, increasing very gradually in size as added, six to eight in the adult whorl; sutures distinct, only slightly depressed; wall smooth, finely perforate; aperture a low opening at the base of the last-formed chamber at the periphery and extending over along the dorsal side. Dimensions of average-sized specimens: diameter, about 0.30 mm; thickness, about 0.08 mm.

Remarks.—Specimens of the species were found in the Woodside, Ferron-Castledale, and West Henry Mountains sections. This species was recovered only from the Tununk Member and appears to be a useful marker for the Tununk interval. Specimens from the Mancos Shale differ from those of the type figure and description in that they have fewer chambers in the adult whorl and are somewhat smaller. *P. austinana* differs from *P. kansasensis* in that the periphery of *P. austinana* is more acute and there is less calcareous deposit in the central area, particularly on the ventral side. This species has been reported from the Austin Chalk of Texas (Cushman, 1938).

Type specimens.—Figured specimens BYU 2422, 2423, 2424; reference specimen BYU 2421.

PLANULINA KANSASENSIS Morrow, 1934
Pl. 13, figs. 9, 10

Planulina kansasensis Morrow 1934, Jour. Paleont., vol. 8, p. 201, pl. 30, figs. 2a-b, 12a-c, 15a-c; Loetterle 1937, Neb. Geol. Survey Bull., 2d ser., Bull. 12, p. 49, pl. 8, figs. 2a-c; Cushman 1940, Cushman Lab. Foram. Research Contr., v. 16, p. 34, pl. 6, figs. 8a-c; 1946, U. S. Geol. Survey Prof. Paper 206, p. 157, pl. 64, fig. 12; Bolin 1952, So. Dakota Geol. Survey, Rpt. Invest. 70, p. 62, pl. 4, figs. 10a-c; Gauger 1953, Utah Geol. and Min. Survey, Bull. 47, p. 85, pl. 10, figs. 12-24; Frizzell 1954, Texas Univ., Bur. Econ. Geol., Rpt. Invest. 22, p. 132, pl. 21, fig. 16; Bolin 1956, Jour. Paleont., v. 30, no. 2, p. 294, pl. 39, figs. 14, 16; Mello 1969, U.S. Geol. Survey Prof. Paper 611, p. 98, pl. 11, figs. 4a-c.
Planulina dakotensis Fox 1954, U.S. Geol. Survey Prof. Paper 254-E, p. 119-20, pl. 26, figs. 19-21.

Description.—Test much compressed, dorsal and ventral sides nearly flat, dorsal side evolute, ventral side partially involute; periphery rounded, chambers numerous, eight to ten in final whorl; sutures distinct between the later chambers, slightly depressed, curved outward and backward; central area on both sides covered by a calcareous deposit varying in thickness from a film to a thick rounded plug, which may be transparent showing the covered chambers; wall smooth perforate; aperture obscure, extending along the base of the last chamber onto the ventral side. Dimensions of average-sized specimens: diameter, about 0.38 mm; thickness, about 0.10 mm.

Remarks.—Specimens occur in the Woodside, Ferron-Castledale, and West Henry Mountains sections, and only in the lower Blue Gate Shale and in the uppermost part of the Tununk Member. This species appears to be a useful marker in the Mancos Shale. Specimens agree with the type figures and description except that they are much smaller. This species differs from *P. austinana* in having a more rounded periphery, a greater amount of calcareous deposits in the central portion, and a more distinct aperture with a slight flap extending into the ventral area. This species has been reported from the

Smokey Hill Member of the Niobrara Formation of Kansas, Nebraska, and South Dakota, the Austin-age deposits of the Gulf Coastal region, the Hilliard Formation of Utah, the Niobrara Formation of North Dakota and Wyoming, the Cody and Carlile Shales of South Dakota and Wyoming, the Upper Cretaceous of Minnesota, and from the Boyne Member of the Vermilion River Formation in Saskatchewan and Manitoba, Canada. The species was originally described from the Fort Hays Member of the Niobrara Formation of Kansas (Morrow, 1934).

Type specimens.—Figured specimens BYU 2413, 2414, 2416; reference specimens BYU 2415, 2417.

Superfamily CASSIDULINACEA d'Orbigny, 1839

Family CAUCASINIDAE N. K. Bykova, 1959
Subfamily FURSENKOININAE Loeblich and Tappan, 1961
Genus CASSIDELLA Hofker, 1951
(?) CASSIDELLA sp.
Pl. 13, figs. 7, 8, 11

Description.—Test free, narrow, elongate, triserial in early stage, later biserial, very slightly twisted, chambers broad, low; sutures distinct, depressed; wall calcareous, finely perforate, surface smooth; aperture a long narrow slit extending up face from base of final chamber. Dimensions of average-sized specimens: length, about 0.44 mm; breadth, about 0.12 mm.

Remarks.—Specimens occur in all measured sections, with the exception of the Factory Butte section, and occur sporadically throughout each section. The greatest abundances were recovered from the Tununk Shale. The specimens recovered were nearly always pyritized or altered to hematite. Occasionally enough of the outer wall is preserved to exhibit the calcareous perforate wall structure. Tooth plate and details of aperture are not sufficiently preserved to allow further designation.

Type specimens.—Figured specimens BYU 2595, 2597, 2598; reference specimens BYU 2596, 2599.

Family LOXOSTOMIDAE Loeblich and Tappan, 1962

Genus LOXOSTOMUM Ehrenberg, 1854
LOXOSTOMUM sp.
Pl. 14, figs. 1, 2

Description.—Test somewhat rhomboid, two or three times as long as broad, greatest width formed by the last two chambers, the periphery flattened as are the other two broader faces, angles very slightly keeled; sutures somewhat indistinct, limbate; surface finely perforate; aperture an elongate slit at the top of the last-formed chamber, may have a slight neck. Dimensions of average-sized specimens: length, about 0.22 mm; breadth, about 0.11 mm.

Remarks.—Specimens referred to this species were recovered only from a small interval in the lower Blue Gate Shale in the Ferron-Castledale section. Preservation is generally poor. A few specimens (Pl. 14, fig. 1) appear to be similar to *Bolivinita eleyi* as figured and described by Cushman (1946). Other specimens have a slightly more rounded periphery and the chambers are less distinctly angular (Pl. 14, fig. 2). Because of poor preservation and a paucity of specimens, more definite identification is not attempted.

Type specimens.—Figured specimens BYU 2564, 2600; reference specimens 2565, 2566.

Family NONIONIDAE Schultze, 1854

Subfamily NONIONIDAE Schultze, 1854
Genus NONIONELLA Cushman, 1926
(?) NONIONELLA sp.
Pl. 13, figs. 12, 13

Description.—Test free, trochospiral, slightly compressed, periphery rounded, spiral side partially evolute, opposite side involute with final chamber overhanging umbilical region; chambers relatively numerous, broad, low. Dimensions of average-sized specimens: length, about 0.14 mm; breadth, about 0.11 mm.

Remarks.—This species is rather rare and is always pyritized or altered to hematite. Therefore, most of the diagnostic features are obscured, and specific identification is not possible. This species occurs rather sporadically throughout all measured sections, with the exception of the Factory Butte section.

Type specimens.—Figured specimens BYU 2561, 2601; reference specimen BYU 2560.

Family ALABAMINIDAE Hofker, 1951

Genus GYROIDINA d'Orbigny, 1826
GYROIDINA GLOBOSA (Hagenow, 1944) var. ORBICELLA Bandy, 1951
Pl. 14, figs. 3, 4, 5, 6, 7, 8

Gyroidina globosa (Hagenow) Cushman and Goudkoff 1944, Cushman Lab. Foram. Research Contr., v. 20, p. 61, pl. 10, fig. 6; Goudkoff 1945, Am. Assoc. Petroleum Geol. Bull., v. 29, no. 7, p. 968 (table).

EXPLANATION OF PLATE 14

FIG. 1.—*Loxostomum* sp. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X268. (BYU 2564)

FIG. 2.—*Loxostomum* sp. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X268. (BYU 2600)

FIG. 3.—*Gyroidina globosa* (Hagenow) var. *orbicella* Bandy. Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X268. (BYU 2404)

FIG. 4.—*Gyroidina globosa* (Hagenow) var. *orbicella* Bandy. Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X268. (BYU 2402)

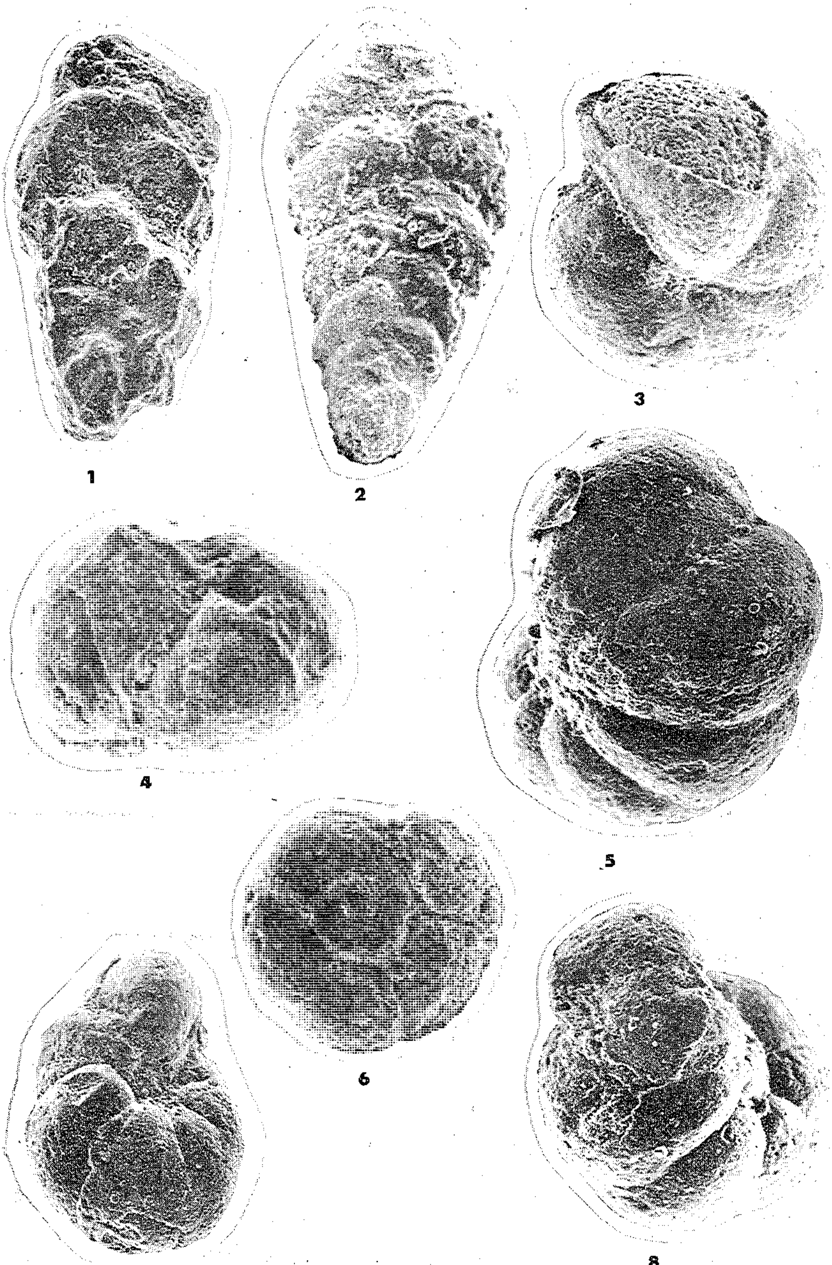
FIG. 5.—*Gyroidina globosa* (Hagenow) var. *orbicella* Bandy. Middle part of the Tununk Shale, West Henry Mtns. section, Garfield County, Utah. Ventral view, X268. (BYU 2608)

FIG. 6.—*Gyroidina globosa* (Hagenow) var. *orbicella* Bandy. Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X260. (BYU 2403)

FIG. 7.—*Gyroidina globosa* (Hagenow) var. *orbicella* Bandy. Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X140. (BYU 2401)

FIG. 8.—*Gyroidina globosa* (Hagenow) var. *orbicella* Bandy. Middle part of the Tununk Shale, West Henry Mtns. section, Garfield County, Utah. Ventral view, X268. (BYU 2607)

PLATE 14



Gyroidina globosa (Hagenow) var. *orbicella* Bandy 1951, Jour. Paleont., v. 25, no. 4, p. 505, pl. 74, figs. 2a-c; Morris 1971, Micropaleont., v. 17, no. 3, p. 279, pl. 7, figs. 7-8.

Gyroidina sp. cf. *Gyroidina orbicella* Bandy, Graham, and Church 1963, Stanford Univ. Pub. Geol. Sci., v. 8, no. 1, p. 58, pl. 7, figs. 1a-c.

Description.—Test free, small, compact, dorsal side slightly convex, ventral side very convex with a small shallow umbilicus; periphery smooth or very slightly lobate; edge broadly rounded; chambers closely appressed, about six to eight, increasing very gradually in size as added; sutures radial, straight to slightly curved; wall smooth, calcareous, finely perforate; aperture a low slit at base of septal face, extending from the edge of the test to the umbilicus. Dimensions of average-sized specimens: diameter, about 0.16 mm; thickness, about 0.13 mm.

Remarks.—Specimens referred to this species occur in all measured sections and are distributed sporadically throughout each section. The species varies considerably in size, ranging from 0.13 to 0.23 mm in diameter and from 0.10 to 0.16 mm in thickness. It has been reported from the Upper Cretaceous of California and from the Lewis Formation of northwestern Colorado, and was first described from the Upper Cretaceous of San Diego County, California (Bandy, 1951).

Type specimens.—Figured specimens BYU 2401, 2402, 2403, 2404, 2607, 2608; reference specimens BYU 2384, 2385, 2609, 2610.

Family OSANGULARIIDAE Loeblich and Tappan, 1964

Genus GLOBOROTALITES Brotzen, 1942

GLOBOROTALITES SUBCONICUS (Morrow, 1934)

Pl. 15, figs. 1, 2

Globorotalia subconica Morrow 1934, Jour. Paleont., v. 8, p. 200, pl. 30, figs. 11, 18; Loetterle 1937, Neb. Geol. Survey, Bull. 12, p. 43-44, pl. 6, fig. 10; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 153, pl. 63, fig. 4.

Globorotalites subconica (Morrow) Frizzell 1954, Texas Univ., Bur. Econ. Geol., Rpt. Invest. 22, p. 130, pl. 20, fig. 32; Kent 1964, Jour. Paleont., v. 41, no. 6, p. 1451, pl. 184, figs. 5-6.

Description.—Test planoconvex, subconical, dorsal side slightly convex or flat; the cone flares near the periphery giving them a gently concave profile, umbilical cavity at the apex small but distinct, periphery keeled or very sharply rounded; chambers indistinct, about six in last whorl; sutures on ventral side may be slightly depressed but not depressed on dorsal side, curved; wall smooth, finely perforate; aperture elongate, extending along the inner edge of the last chamber. Dimensions of average-sized specimens: diameter, about 0.14 mm; thickness, about 0.13 mm.

Remarks.—The species occurs in the Woodside and Ferron-Castledale sections and is restricted to a rather small interval in the lower Blue Gate Shale. Although this species occurs rather sporadically and is rather small, it is very distinct and appears to be a marker in the lower Blue Gate Shale portion of the Mancos Shale. This species has been reported previously from the Taylor Marl of Texas, from Austin-age Gober Tongue, the Austin Chalk, and the Brownstown Marl of Texas. It has also been reported from the Lower Niobrara Formation of western Colorado and from the Fort Hays Member of the Niobrara Formation of Kansas, Nebraska, and South Dakota. The species was originally described from the Upper Cretaceous Niobrara of Kansas (Morrow, 1934).

Type specimens.—Figured specimens BYU 2547, 2549; reference specimens BYU 2546, 2548.

Family ANOMALINIDAE Cushman, 1927

Subfamily ANOMALININAE Cushman, 1927

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA TENNESSEENSIS W. Berry, 1929

Pl. 15, figs. 3, 4, 5, 6

Anomalina tennesseensis W. Berry (in Berry and Kelley) 1929, U.S. Nat. Mus. Proc., v. 76, art. 19, p. 13, pl. 2, figs. 13-15; Cushman 1940, Cushman Lab. Foram. Research Contr., v. 16, p. 30, pl. 5, figs. 11a-c; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 340, pl. 53, figs. 33-34; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 155, pl. 64, fig. 3.

Description.—Test small, planispiral, slightly compressed laterally, composed of eight to nine chambers in the last whorl, slightly evolute on the dorsal side, only the last whorl visible on the ventral side, immature forms completely involute; sutures slightly depressed, more or less distinct; aperture a narrow curved slit at the base of the final chamber. Dimensions of average-sized specimens: diameter, about 0.28 mm; thickness, about 0.15 mm.

Remarks.—Specimens occur in all measured sections. Their distribution is very sporadic and they are rather rare in the Masuk Shale but are common to very abundant in most samples in the Blue Gate and Tununk shales. Specimens recovered from the Mancos Shale compare closely to the type figure and description, except they are slightly more involute on the dorsal side. The species has been reported previously from the Marlbrook Marl of Arkansas and from the Selma Chalk of Mississippi. This species was originally described from the Coon Creek Tongue of the Ripley Formation of Tennessee (Berry and Kelley, 1929).

Type specimens.—Figured specimens BYU 2379, 2382, 2393, 2395; reference specimens BYU 2380, 2381, 2392, 2394.

Genus GAVELINELLA Brotzen, 1942

GAVELINELLA NACATOCHENSIS (Cushman, 1938)

Pl. 15, figs. 7, 8, 9, 10

Planulina nacatochensis Cushman 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 50, pl. 8, fig. 9; 1940, Cushman Lab. Foram. Research Contr., v. 16, p. 36, pl. 6, figs. 12a-c; Cushman and Goudkoff 1944, Cushman Lab. Foram. Research Contr., v. 20, p. 63, pl. 10, figs. 13a-b; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 158, pl. 65, fig. 2.

Planulina mascula Bandy 1951, Jour. Paleont., v. 25, p. 506, pl. 74, fig. 8; Graham and Church 1963, Stanford Univ. Pub. Geol. Sci., v. 8, no. 1, p. 66, pl. 8, fig. 3; Martin 1964, Geol. Bundesanstalt Wien, Jahrb., Sonderbad. 9, p. 107, pl. 16, fig. 7.

Gavelinella nacatochensis (Cushman) Sliter 1968, Univ. of Kansas Paleont. Contr., ser. 49, art. 7, p. 124, pl. 23, figs. 4-5.

Description.—Test much compressed, nearly planispiral in the adult, periphery rounded, spiral side partially evolute with earlier whorls visible, umbilical side nearly involute; chambers distinct, averaging nine in the adult whorl, increasing very gradually in size as added, somewhat more overlapping on the dorsal side, very little inflated; sutures distinct, slightly limbate, evenly curved on the ventral side, straight to somewhat sigmoid on the dorsal side; wall smooth, finely perforate; aperture extending from the periphery over onto the dorsal side, with a slight, overhanging lip. Dimensions of average-sized specimens: diameter, about 0.29 mm; thickness, about 0.12 mm.

Remarks.—This species is one of the most abundant of the Anomalinidae and is found in all measured sections and in nearly all samples, with abundances of 1000 or more specimens per 100-gram sample in many of the samples. This species can be distinguished from *G. nelsoni* in that it is more nearly planispiral, lacks the deep umbilicus, and has rather conspicuous apertural flaps on the ventral side. The species has been reported previously from the Upper Cretaceous of Fresno and San Diego counties, California. It was first described from the Nacatoch Sand of Arkansas (Cushman, 1938).

Type specimens.—Figured specimens BYU 2377, 2500, 2502, 2503; reference specimens BYU 2374, 2375, 2376, 2501, 2504.

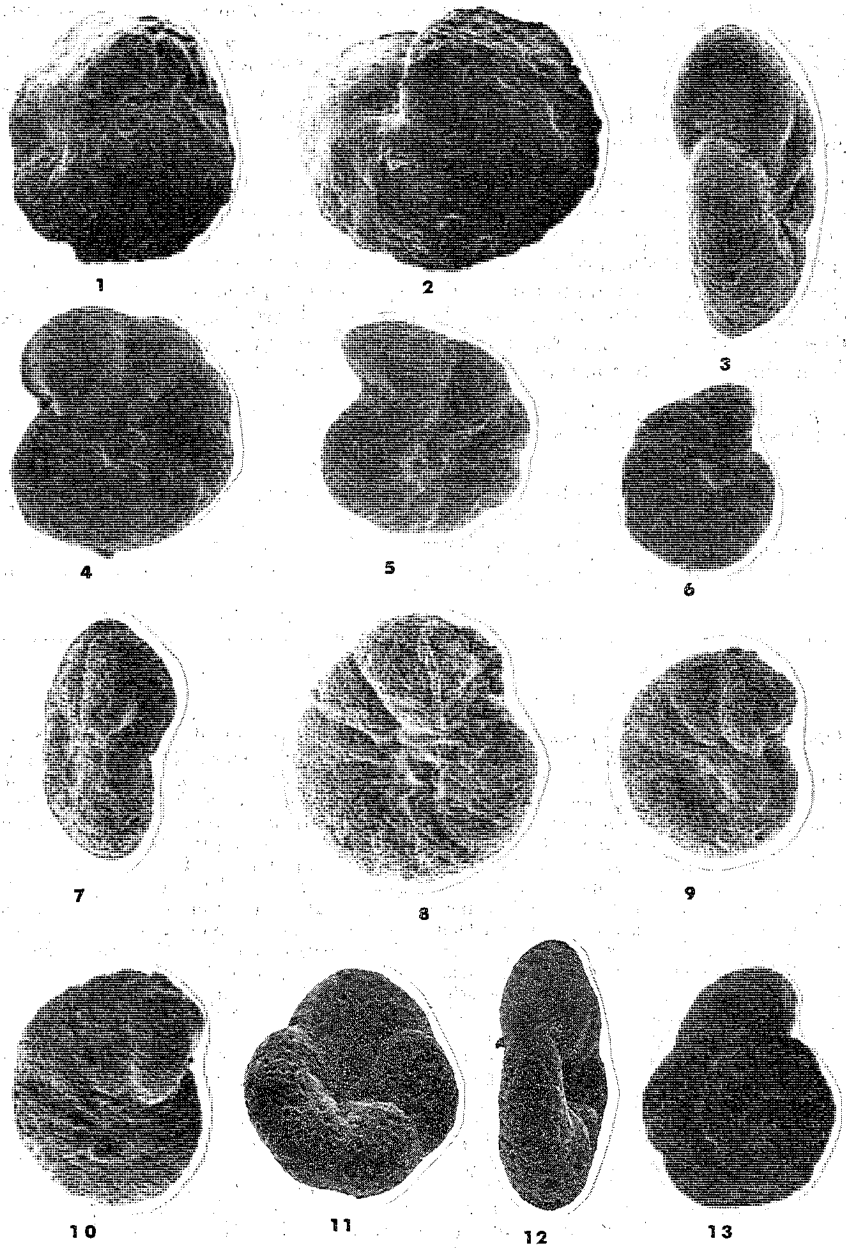
GAVELINELLA NELSONI (W. Berry, 1929)
Pl. 15, figs. 11, 12, 13

Anomalina nelsoni W. Berry, in Berry and Kelley 1929, U.S. Nat. Mus. Proc., v. 76, art. 19, p. 14, pl. 2, figs. 19-21; Cushman 1940, Cushman Lab.

EXPLANATION OF PLATE 15

FIG. 1.—*Globorotalites subconicus* (Morrow). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X264. (BYU 2549)
FIG. 2.—*Globorotalites subconicus* (Morrow). Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X240. (BYU 2547)
FIG. 3.—*Anomalina tennesseensis* W. Berry. Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X105. (BYU 2382)
FIG. 4.—*Anomalina tennesseensis* W. Berry. Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X108. (BYU 2379)
FIG. 5.—*Anomalina tennesseensis* W. Berry. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X105. (BYU 2393)
FIG. 6.—*Anomalina tennesseensis* W. Berry. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Side view, X108. (BYU 2395)
FIG. 7.—*Gavelinella nacatochensis* (Cushman). Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X105. (BYU 2504)
FIG. 8.—*Gavelinella nacatochensis* (Cushman). Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X108. (BYU 2503)
FIG. 9.—*Gavelinella nacatochensis* (Cushman). Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X105. (BYU 2500)
FIG. 10.—*Gavelinella nelsoni* (W. Berry). Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X108. (BYU 2397)
FIG. 11.—*Gavelinella nelsoni* (W. Berry). Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X105. (BYU 2399)
FIG. 12.—*Gavelinella nelsoni* (W. Berry). Middle part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X128. (BYU 2398)
FIG. 13.—*Gavelinella nelsoni* (W. Berry). Middle part of the Tununk Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X105. (BYU 2420)

PLATE 15



Foram. Research Contr., v. 16, p. 27, pl. 5, figs. 1-2; Cushman and Todd 1943, Cushman Lab. Foram. Research Contr., v. 19, p. 71, pl. 12, fig. 13; Cushman and Deaderick 1944, Jour. Paleont., v. 18, p. 340, pl. 53, fig. 32; Cushman 1946, U.S. Geol. Survey Prof. Paper 206, p. 154, pl. 63, figs. 8-9.

Cibicides nelsoni Plummer 1936, Univ. Texas Bull. 3501, p. 288, pl. 5, figs. 1-6.

Valvulineria nelsoni Jennings 1936, Bull. Am. Paleont., v. 23, no. 78, p. 32, pl. 4, figs. 1a-b.

Anomalina cf. *A. nelsoni* W. Berry, Cushman and Hedberg 1941, Cushman Lab. Foram. Research Contr., v. 17, p. 99, pl. 23, figs. 20a-c.

Description.—Test inflated, dorsal side slightly convex, ventral side deeply umbilicate; periphery broadly rounded, lobate; chambers numerous, seven to eight in the last-formed coil, inflated, gradually increasing in size; sutures distinct, depressed; wall punctate; umbilical cavity usually filled with shell material; aperture an arched slit with a slight lip above it at the base of the last chamber. Dimensions of average-sized specimens: diameter, about 0.26 mm; thickness, about 0.11 mm.

Remarks.—This species occurs in all measured sections and appears to be restricted to the Blue Gate and Tununk shales. Many of the samples had 1000 or more specimens per 100-gram sample. This species is more convex on the dorsal side than most of the specimens figured and described from other localities, except for the specimens figured and described by Cushman and Hedberg (1941) from the Mito Juan Formation of Colombia. The species has been reported as ranging from the highest beds of Navarro age down through the upper beds of Taylor age in deposits of the Gulf Coastal region. It has also been reported from the Upper Cretaceous of New Jersey and from the Mito Juan Formation of Colombia. The species was originally described from the Coon Creek Tongue of the Ripley Formation in Tennessee.

Type specimens.—Figured specimens BYU 2398, 2399, 2420; reference specimens BYU 2397, 2400, 2418, 2419.

GAVELINELLA (?) PARVULA
Pl. 16, figs. 1, 2

Trochammina parvula Crespin 1944, Roy. Soc. New South Wales, Jour. Proc., v. 78, pts. 1-2 (1945), p. 20, pl. 1, figs. 6a-c.

EXPLANATION OF PLATE 16

FIG. 1.—*Gavelinella* (?) *parvula*. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X275. (BYU 2412)

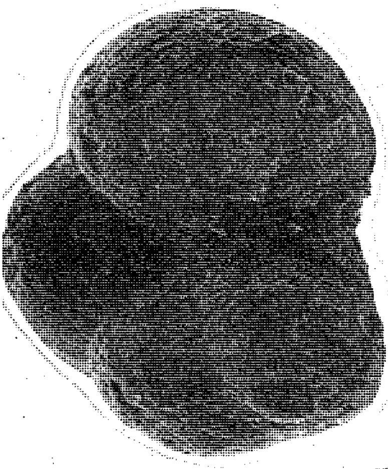
FIG. 2.—*Gavelinella* (?) *parvula*. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Apertural view, X275. (BYU 2396)

FIG. 3.—*Gavelinella* (?) *parvula*. Lower part of the Masuk Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X275. (BYU 2505)

FIG. 4.—(?)*Hoeglundina* sp. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Ventral view, X109. (BYU 2602)

FIG. 5.—(?) *Hoeglundina* sp. Lower part of the Blue Gate Shale, Ferron-Castledale section, Emery County, Utah. Dorsal view, X109. (BYU 2603)

PLATE 16



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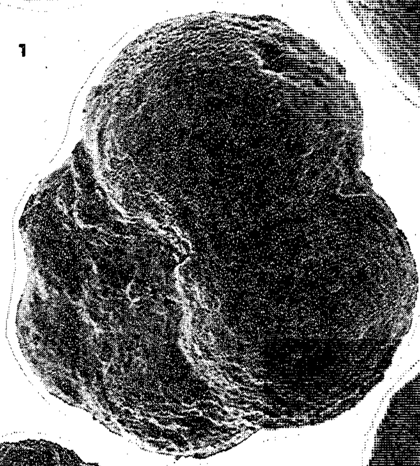

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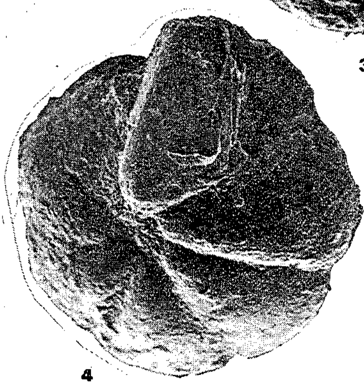

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Planulina cretacea Crespin 1944, Roy. Soc. New South Wales, Jour. Proc., v. 78, pts. 1-2 (1945), p. 22, pl. 1, figs. 11-12.

Valvulineria infracreatacea Crespin 1953, Cushman Lab. Foram. Research Contr., v. 4, pt. 1, p. 34-35, pl. 6, figs. 12-13.

Anomalina (*Gavelinella*) *moniliformis* (Reuss) Vasilenko 1961, Vnigri, Trudy, no. 171, p. 108-10, pl. 19, figs. 1-3, 5.

Gavelinella parvula (Crespin) Ludbrook 1966, South Australia, Geol. Survey Bull., no. 40, p. 141-42, pl. 12, figs. 23-24; Scheibnerova 1972, Micropaleont., v. 18, no. 2, p. 213-14, pl. 1, figs. 4a-b; pl. 2, figs. 3a-b; text-figs. 2a-c, 3a-c, 8 (figs. 1-4).

Gavelinella australiana Ludbrook 1966, South Australia, Geol. Survey Bull., no. 40, p. 140, pl. 12, figs. 19-22.

Gavelinella moniliformis (Reuss), Podobina 1966, Moscow; Izdat. Nauka, p. 81-82, pl. 18, figs. 1-2.

Description.—Test calcareous, perforate, trochospiral, biconvex; periphery rounded, rounded oval in shape; umbilicus broad, deep, partially closed by flaps; aperture a low interiomarginal slit extending from near periphery to umbilicus; chambers in last whorl usually five to six; septal sutures on umbilical side deep, radial, slightly curved. Dimensions of average-sized specimens: diameter, about 0.25 mm; thickness, about 0.13 mm.

Remarks.—Specimens occur in the Woodside, Ferron-Castledale, and West Henry Mountain sections, distributed sporadically throughout the Masuk and Blue Gate shales. Specimens from the Mancos Shale agree rather closely with those figured and described by Ludbrook (1966). Specimens recovered from the Mancos Shale are rather poorly preserved, and few were recovered. Specific identification, therefore, is somewhat questionable. This species has been reported previously from the Lower Cretaceous of northern New South Wales, Australia (Crespin, 1944).

Type specimens.—Figured specimens BYU 2396, 2412, 2505; reference specimens BYU 2378, 2506.

Superfamily ROBERTINACEA Reuss, 1850

Family CERATOBULIMINIDAE Cushman, 1927
Subfamily EPISTOMININAE Wedekind, 1937
Genus HOEGLUNDINA Brotzen, 1948
(?) HOEGLUNDINA sp.
Pl. 15, figs. 4, 5

Description.—Test free, trochospiral, close-coiled, biconvex; oblique supplementary sutures visible on the umbilical side of the test. Dimensions of average-sized specimens: diameter, about 0.48 mm; thickness, about 0.18 mm.

Remarks.—This species occurs in all measured sections, with the exception of the Factory Butte section, and are distributed rather sporadically throughout the sections. All specimens are badly altered to hematite, and most of the diagnostic features are obscured; therefore, identification of this form is very questionable.

Type specimens.—Figured specimens BYU 2602, 2603; reference specimen BYU 2604.

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