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Foraminifera from the Colorado Shale of North-Central Montana

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David P. Wilson

FORAMINIFERA FROM THE COLORADO SHALE
OF NORTH-CENTRAL MONTANA

A Thesis

Submitted to

the Department of Geology

Montana School of Mines

Butte, Montana

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science in Geological Engineering

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INTRODUCTION

The use of foraminifera in the determination of geologic age, and in the correlation of strata, is one of the most important techniques in oil field stratigraphic studies. The petroleum industry in many regions relies on these microscopic life forms to determine the positions of oil-bearing horizons and to determine the tops of beds. In northern Montana the Colorado group of strata, a series of about 2,000 feet of dense, dark similar shales, is known to contain foraminifera; but detailed and systematic studies of these forms have not been made. This paper represents the beginning of such a study.

At the outset the authors of this paper were complete novices in the field of micropaleontology, but they sincerely hope that their contribution, however small, may be of some value to the field.

The authors wish to express their thanks to Dr. E. S. Perry, head of the Department of Geology, and to Mr. Alvin M. Hanson, Assistant Professor of Geology, both of the Montana School of Mines, for their assistance and guidance during the work on the problem. Thanks are also due Mr. C. E. Erdmann of the United States Geological Survey, Great Falls, Montana, through whose cooperation the samples were obtained, and Mr. B. R. Alto and Mr. K. H. Holmes, also of the United States Geological Survey, Great Falls, Montana, who collected the samples in the field. Dr. E. G. Koch, head of the Department of Chemistry at the Montana School of Mines, was consulted concerning the chemical breakdown of shales, and Mr. D. W. McGlashan, Associate Professor of Mineral Dressing, permitted the use of certain laboratory equipment.

THE COLORADO GROUP

General Stratigraphy

During the early part of Upper Cretaceous time most of central and eastern Montana was submerged by a vast sea which extended from the Arctic region to the Gulf of Mexico. It was in this sea that the sediments of the Colorado group were deposited. The shore-line, whose position at any one time is not exactly known, extended across Montana from north to south in the general region of the Rocky Mountains. Later in Upper Cretaceous time the seas are believed to have receded from the land and then repeatedly transgressed it from the east. (9:5)*

In Montana, in general, the Colorado group is divided into the following formations; (7:27)

Colorado group
- Niobrara shale
- Carlile shale
- Frontier formation
- Mowry shale
- Thermopolis shale

This division is more readily made in southern Montana and Wyoming where lithologic differences between the various

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* Numbers in brackets refer to the bibliography; the publication and the page number.

members exist, but in northern Montana the lithologic characteristics of the members of the group are so similar that in common practice by oil field geologists a division is not made. As described by Knappen and Moulton (7:27) in southern Montana the divisions of the Colorado have the following characteristics.

Thermopolis Shale

The Thermopolis shale is sometimes divided into three members consisting of lower and upper shales and a middle sandstone.

The lower shale member is made up primarily of black fissile marine shales and is approximately 270 feet thick. Sandy horizons are not uncommon in the lower shale member, and thin layers of bentonite are also found.

The sandstone member of the Thermopolis ranges in thickness from a few inches to 30 feet and is thought to be of fluvial origin. The sandstone is quite coarse grained and contains plant fragments, fish teeth, and other bits of organic refuse. Knappen and Moulton (7:28) are of the opinion "that the sand was deposited on a barely submerged mud flat over which streams of considerable size meandered."

The upper shale member of the Thermopolis is approximately 410 feet thick and is made up dominantly of black shale with interbedded sandstone. A zone containing iron concretions is present as are numerous beds of bentonite.

Mowry Shale

The Mowry shale consists mainly of drab, sandy shale interbedded with black shale. The upper portion of the formation contains soft, gummy, dark-colored clays which resemble bentonite, and a zone of repeatedly alternating layers of sandstone and black shale. The Mowry is characterized by the presence of many fossil fish scales which constitute an excellent marker horizon. The thickness of the Mowry shale is 265 feet.

Frontier Formation

The Frontier formation is made up primarily of sandy, buff-colored shale with interbedded sandstone and shale, and a buff to rusty-colored sandstone which is coarse and poorly cemented. Clay and bentonite beds are present, mainly in the lower one-half of the formation. The thickness of the Frontier is approximately 420 feet.

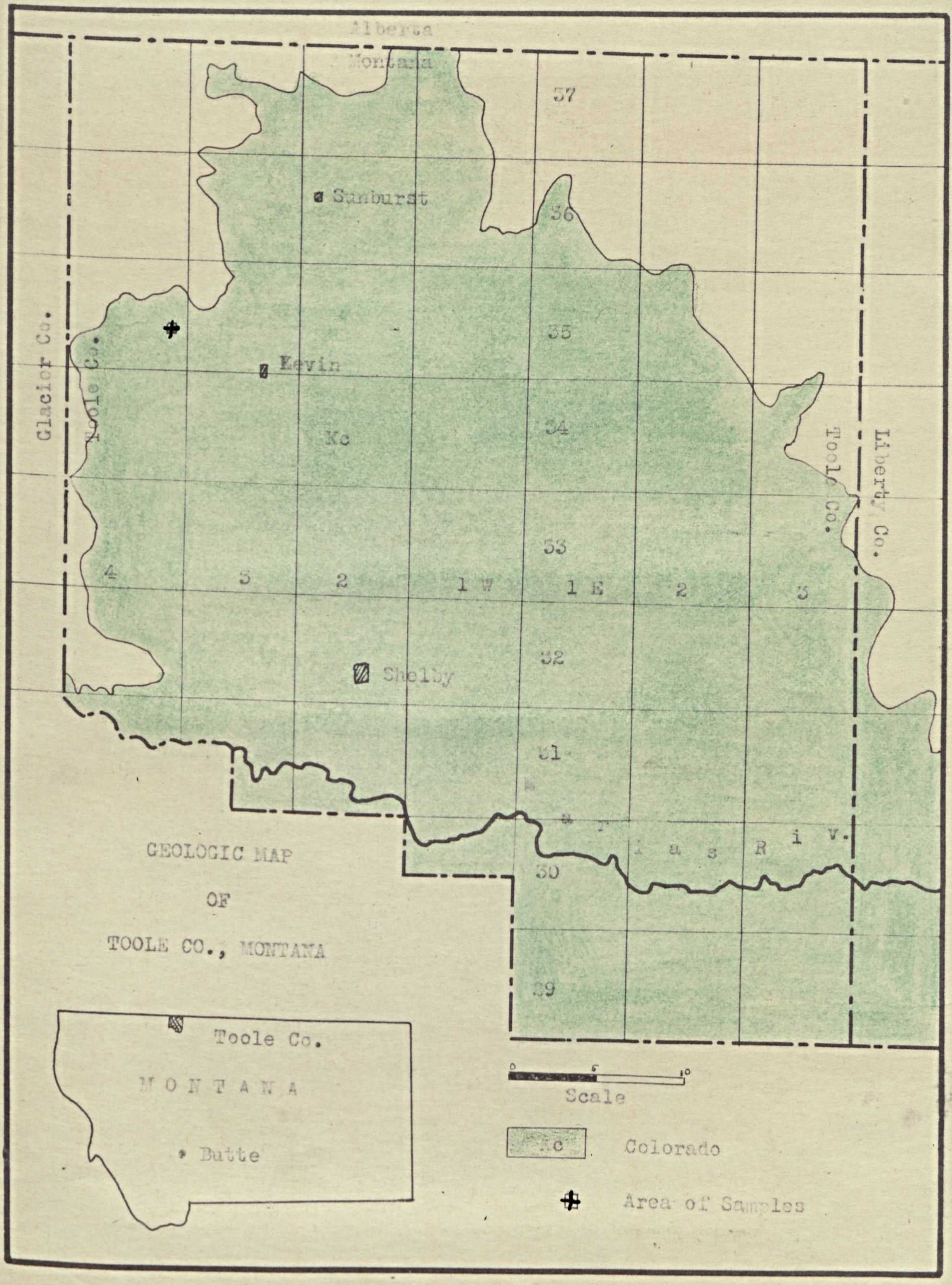
Carlile and Niobrara Shales

Because of the extreme similarity of these two formations it is difficult, if not impossible, to distinguish between them over most of the state of Montana. The lower portion of the Carlile and Niobrara shales consists of approximately 420 feet of dark shales. Near the middle of the formations are layers of bentonite and limestone which are overlain by more than 600 feet of soft, dark shale and minor sandstone horizons. The total thickness of the Niobrara and Carlile formations is 1,140 feet.

DESCRIPTION OF SAMPLES

As was previously stated, the samples used for this study were collected by members of the United States Geological Survey. The material came from the E. $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 24, T. 35 N., R. 4 W., Toole County, Montana. Sampling of the Colorado shale began immediately below the bentonite member which separates it from the overlying Telegraph Creek formation, and two-pound samples were taken at five foot intervals. The twenty-nine samples which were studied represented the upper 140 feet of the Colorado shale.

Generally speaking, the material might well be described as unfossiliferous; the only samples in which foraminifera were numerous were numbers 23 and 24 which occurred 110 and 115 feet, respectively, below the top of the Colorado shale. All types of foraminifera described in this paper, except *Globigerina cretacea*, were found in one or the other of these two samples, and fragments believed to have been from this



After Andrews, Lambert, & Stose

type were found in number 24. Specimens found in samples taken higher in the section were scarce, very small, and generally quite poorly preserved. Few foraminifera were found in sample numbers 25 through 29; however, those found were of average size, and were quite well preserved.

LABORATORY PROCEDURE

Drying

In order that shale samples may be broken down into grain size they must be relatively free from absorbed water. As the shale was received from the field it appeared to be quite moist, so the following procedure was employed to dry it. The samples were placed in ordinary pie pans, numbered to correspond to the sample numbers, and dried at a temperature of approximately 125 degrees Fahrenheit for a period of from 48 to 72 hours. After the above treatment several samples were soaked and digested with sodium carbonate according to the procedure recommended by Cushman (2:28) and Glaesner (5:56) in order to determine the effectiveness of the drying process.

It was found, after soaking and digesting, that the shale did not break down in the desired manner, so a different drying procedure was tried. This consisted of drying the samples in an electric oven at a temperature of approximately

Figure 1. Mortar and pestle used to grind samples.

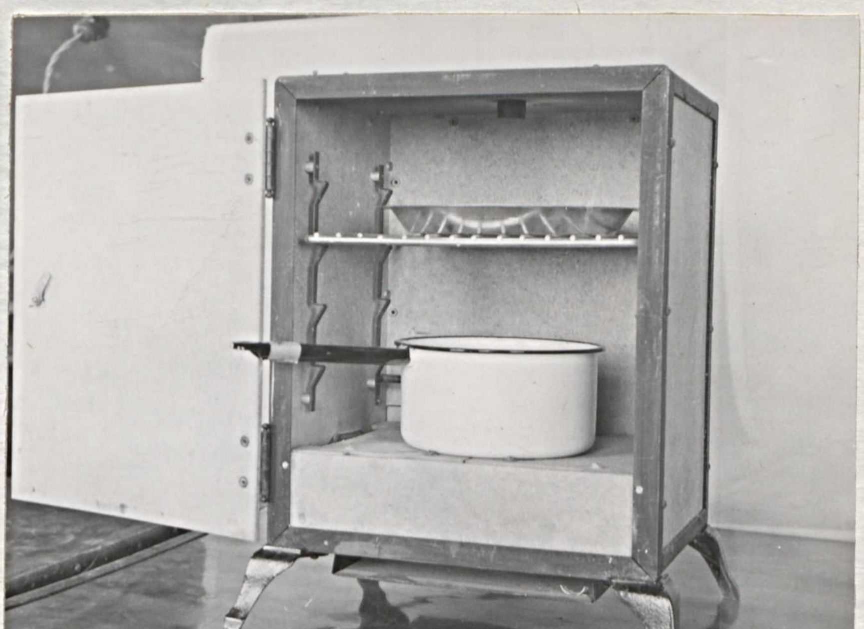


Figure 2. Photograph showing oven used to dry decanted samples.

225 degrees Fahrenheit for a period of 20 hours. After this treatment the shale was soaked, and digested with sodium carbonate, but no improvement was noted in the breaking down of the material. Because the capacity of the oven was limited to three samples, the original air-drying method was reverted to. After working with several samples and experiencing considerable difficulty in breaking down the material, it was suggested that reduction of the size of the particles might be of assistance. An attempt was made to use a laboratory roll crusher, but due to the platy nature of the shale, this treatment was not effective. Also, a considerable quantity of fine material was produced, and it was feared that the delicate foraminiferal tests might be crushed. The method of crushing finally adopted was the use of a cast iron mortar and pestle in which the shale was reduced to fragments about the size of shelled rice.

Soaking and Digestion

Following crushing, a sample of suitable size was placed in a pan and covered with one quart of water and allowed to soak for a period of 24 hours. Three tablespoons of sodium carbonate were then added to the "mud" and the mixture boiled for a length of time which it was hoped would be sufficient to break down the remaining fragments to grain size. Various

Figure 3. View showing screened samples and equipment used in mounting specimens.

Figure 4. Binocular microscope, light, and slides used in examination and mounting of specimens.

samples were boiled for as long as eight hours, but not in a single instance did the shale completely break down in the desired manner. Sodium hydroxide was experimented with on several samples in an attempt to break them down properly but was found to be no more effective than sodium carbonate. The sodium carbonate method was the one ultimately adopted.

Decanting

Following digestion the mixture was allowed to cool and the liquid decanted off. The finer clay particles, aided by the flocculating action of the sodium carbonate, remained in suspension, while the larger, heavier particles and the foraminifera sunk to the bottom of the vessel. The decanting was repeated until the liquid remained clear after a short settling time. Following decanting, the residue, containing the foraminiferal tests, was dried in air in preparation for screening.

Screening

Because the foraminifera in the smaller size ranges, that is, the material passing a 200-mesh screen, are of little value in a study of this nature, the dried samples were screened to remove the finer particles. This process not only served to reduce the amount of material to be examined in the search for suitable specimens, but also gave an idea as to the size of the foraminifera. Screens of 60-mesh, 100-mesh, and 200-

mesh size were used. The majority of the specimens were found in the plus 100-mesh and plus 200-mesh portions, with only a few occuring in the plus 60-mesh portion, and none in the minus 200-mesh. After screening, the material was placed in small glass bottles and labeled with the sample number and mesh size.

Mounting

Following sizing, the samples were examined with Spencer binocular microscopes, and suitable specimens were removed and mounted on slides having numbered squares, and having been prepared by coating their surface with gum tragacanth, a transparent water soluble adhesive. The desired specimens were then removed from the sample on the tip of a moistened camel's hair brush from which all but a few of the bristles had been removed. Sufficient moisture remains on the test to cause it to adhere to the slide.

Photography

All specimens were photographed with a Korelle-Reflex camera using size 120 Plus-X film. The camera lens was removed, and the lens mount was fitted with a 10-inch tube which projected downward over the eyepiece of the microscope. The microscope used was a Lietz petrographic model from which the objective lens had been removed, and in its place substituted a special lens containing an iris diaphragm, and having a focal length of 24 millimeters. The specimens were mounted on the conventional type of slide and were lighted directly by means of a carbon arc lamp.

The most vexing problem encountered in photographing the specimens was that of obtaining proper depth of focus. Attempts were made to use a Spencer binocular microscope, and a Nachet petrographic microscope, but a sharp image was not obtained with either of these instruments. The use of the diaphragm lens with the Lietz microscope at least partially solved this problem.

Because of the high magnification which was necessary, the irregularities in the surface of the gum tragacanth were very prominent, and light reflected from these irregularities caused the appearance of dark spots on the negatives. These imperfections in the negatives were eliminated from the prints by means of "painting out" on the negative all but the foraminiferal test. Slight enlargements were made for final illustration.

CHECK LIST OF FORAMINIFERA

Below is a list of foraminifera which were found in the samples of Colorado shale studied. The sample number in which the various species were found are listed, and from these numbers it is a simple matter to determine the distance below the top of the Colorado shale from which the specimens came. The terms used to describe the relative abundance of the species refer to their abundance in the sample or samples in which they were found.

Check List

Neobulimina canadaensis Cushman and Wickenden

Samples in which found: Nos. 1, 2, 16, 24, 25, 27, 28.

Relative abundance: common.

Textularia sp.

Samples in which found: No. 26.

Relative abundance: rare.

Gumbelina globulosa Ehrenberg

Samples in which found: Nos. 1, 24, 25, 26, 28.

Relative abundance: rather common.

Planulina kansasensis Morrow

Samples in which found: Nos. 23, 24, 25.

Relative abundance: common.

Pleurostomella watersi Cushman

Samples in which found: No. 24.

Relative abundance: rare.

Gaudryina sp.

Samples in which found: No. 23.

Relative abundance: rare.

Globigerina cretacea d'Orbigny

Samples in which found: Nos. 1, 20, 26, 28.

Relative abundance: rather common.

SUMMARY AND CONCLUSIONS

Perhaps the greatest difficulty encountered during the work on this problem, and an obstacle which proved to be very time consuming, was the reluctance of the shale to break down into grain sizes. Although great numbers of forms were not recovered, it seems probable that the material obtained is representative of the fauna, and if greater numbers of individuals had been obtained, the number of genera and species would not have been increased.

As compared with the Upper Cretaceous foraminiferal fauna of the Gulf Coast region of the United States, the fauna described herein is extremely impoverished, and is not distinctive. The paucity of the fauna can be explained, at least in part, by the condition of the seas during Upper Cretaceous time. During this time the seas were repeatedly transgressing the land and receding from it, and as a result brackish conditions undoubtedly existed at various times. Very few foraminifera live in brackish seas.

It is the opinion of the writers that the foraminiferal fauna of the Upper Colorado shale would be of little, if any, economic significance; the foraminifera do not occur in sufficient numbers, and the fauna is not distinctive, all of the described species having a relatively long stratigraphic range.

It is, of course, entirely possible that a continuation of this study, that is, a study of the micro fauna of lower horizons in the Colorado, may reveal foraminiferal zones which will be of use in stratigraphic studies.

CLASSIFICATION

PHYLUM PROTOZOA

CLASS SARCODINA

SUBCLASS RHIZOPODA

Order FORAMINIFERA

Family ELLIPSOIDINIDAE

Genus PLEUROSTOMELLA Ruess 1860

Pleurostomella watersi Cushman

Genotype Pleurostomella watersi Cushman

Plate 1, figures 3, 4

Pleurostomella watersi Cushman, Upper Cretaceous Foraminifera of the Gulf Coastal Region of the United States and Adjacent Regions, U. S. G. S. Prof. Paper 209, p. 132, pl. 54, figs. 22, 23, 1946.

Test elongate, slender, biserial, broadening slightly toward apertural end, broadly rounded in cross-section, axis twisted; sutures distinct and depressed; chambers globular, inflated; walls finely perforate; aperture in inner face of last chamber, aperture higher than broad, large, flat tooth-like projection in base (?).

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny 1826

Globigerina cretacea d'Orbigny

Plate 1, figures 1, 2

Globigerina cretacea Loetterle, Nebr. Geol. Surv. Bull. 12, 1937, pl. 7, fig. 1, 2.

Test is a low trochoid spire made up of from 4 to 6 chambers which are globular and inflated, increasing rapidly in size toward the last added; sutures distinct and depressed; walls calcareous and white; umbilicus broad and deep; aperture in form of opening in umbilicus.

Family BULIMINIDAE

Subfamily BULIMININAE

Genus NEOBULIMINA Cush and Wickenden 1928

Neobulimina canadaensis Cushman and Wickenden

Plate 2, figures 9, 10

Neobulimina canadaensis Cushman, *Upper Cretaceous Foraminifera of the Gulf Coastal Region of the United States and Adjacent Areas*, U. S. G. S. Prof. Paper 206, 1946, p. 125, pl. 52, figs. 11, 12, 13.

Test elongate, broadest near middle, tapering toward both ends, early portion triserial, adult stage biserial;

chamber inflated and globular; sutures distinct and depressed; walls white, calcareous, appear perforate; aperture on inner side of last chamber, at base of depression.

Family TEXTULARIDAE

Subfamily TEXTULARINAE

Genus TEXTULARIA De France 1824

Genotype *Textularia* *sagittula* De France

Textularia sp.

Plate 2, figure 12

Test triangular, compressed, biserial in earlier stages, tapering rapidly toward last formed chamber; chambers and sutures not distinct; walls arenaceous; aperture at base of inner margin of last formed chamber (?).

Family VERNEUILINIDAE

Genus GAUDRYINA d'Orbigny 1839

Genotype *Gaudryina* *rugosa* d'Orbigny

Guadryina sp.

Plate 2, figure 11

Test triserial in early portions, becoming biserial in adult stage; chambers oval, rounded; sutures distinct and depressed in biserial portion, not so distinct in earlier stage; walls finely arenaceous, surface slightly rough;

aperture at base of inner margin of last formed chamber in base of slight depression.

Family HETEROHELICIDAE

Genus GUMBELINA Egger 1899

Genotype Textularia globulosa Ehernberg

Gumbelina globulosa Ehernberg

Plate 2, figures 7, 8

Gumbelina globulosa Loetterle, Nebr. Geol. Surv. Bull. 12, 1937, p. 33, pl. 4, figs. 8a, b.

Test triangular, broadest at the apertural end, tapering rapidly to a blunt point; walls smooth, calcareous, finely perforate, white to translucent; chambers inflated, globular, rapidly increasing in size; sutures distinct and depressed; aperture semi-lunar in shape, at base of inner edge of last chamber.

Family ANOMALINIDAE

Genus PLANULINA d'Orbigny 1826

Planulina kansasensis Morrow

Plate 1, figures 5, 6

Planulina kansasensis Loetterle, Nebr. Geol. Surv. Bull. 12, 1937, p. 28, pl. 8, fig. 2a.

Test compressed, slightly trochoid, involute ventrally; eight to ten chambers in final convolution, slightly inflated, increasing in size toward last added, all chambers visible on dorsal side; sutures distinct, slightly depressed, curved gently backward; walls calcareous, perforate; aperture not prominent, at periphery, slightly produced ventrally.

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PLATE I

Figure

1. *Globigerina cretacea* d'Orbigny (dorsal view)

   X 97.5

2. *Globigerina cretacea* d'Orbigny (ventral view)

   X 97.5

3. *Pleurostomella watersi* Cushman

   X 97.5

4. *Pleurostomella watersi* Cushman (apertural view)

   X 97.5

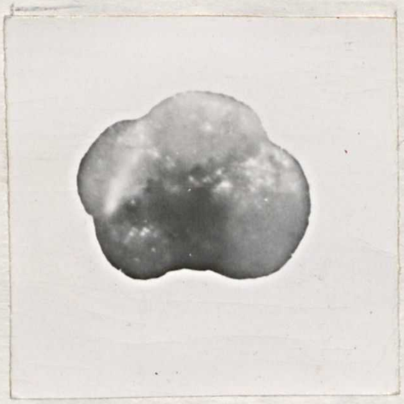
5. *Planulina kansasensis* Morrow (ventral view)

   X 97.5

6. *Planulina kansasensis* Morrow (dorsal view)

   X 65

PLATE I



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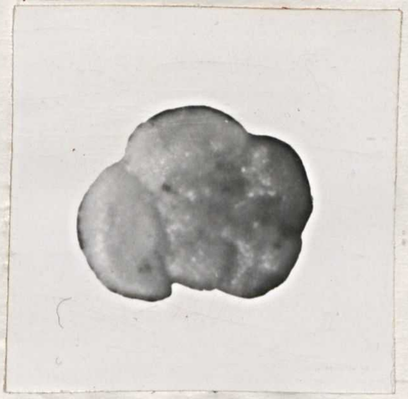

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PLATE II

Figure

7. <u>Gumbelina</u> <u>globulosa</u> Ehernberg

X 97.5

8. <u>Gumbelina</u> <u>globulosa</u> Ehernberg (apertural view)

X 97.5

9, 10. <u>Neobulimina</u> <u>canadaensis</u> Cushman and Wickenden

X 97.5

11. <u>Gaudryina</u> sp.

X 97.5

12. <u>Textularia</u> sp.

X 97.5

PLATE II

7

8

9

10

11

12

APPENDIX

APPENDIX

SECTION OF UPPER PART OF COLORADO SHALE

A section of the upper part of the Colorado shale and the transition zone was measured on October 28-29, 1943, by C. E. Erdmann. This section was subsequently augmented by a fossil collection by J. B. Reeside, Jr. and R. W. Imlay on September 3, 1944. The section, excluding the transition zone, as given by Erdmann is as follows:

	Feet	Inches
Clay, gray, weathered, exfoliated bentonite, (weathers rusty) with an occasional parting of thin gray shale. A persistent layer. Probably a marker for the top of the Colorado shale.		2-4
Shale, dark gray to black. Highly fissile. Papery. Non-continuous layer of large (diameter, 2 inches, thickness, 8 inches or more) septarian concretion of dense, dark gray limestone with septae of crystalline brown calcite. Fossils in thin gray micaceous sandstone on top of concretions. Fossil collection No. 1; *Baculites* sp?; *Ostrea* sp?.	4	6
Clay, gray (weathers rusty), bentonite exfoliated, weathered. Layers 1/8 to 1/2-inch thick, interbedded with gray shale. A persistent band. Contains some layers (1/4-inch thick) finely prismatic calcite.		2-3
Shale, dark gray, soft, non-calcareous, fissile; non-continuous layer of small oval concretions, sandy, gray limestone (4 inches by 10 inches) about 1 foot above base.	5	1

	Feet	Inches
An assemblage of thin, non-continuous wavy layers of fine-grained gray sandstone 1/2 to 2 inches thick. Finely laminated. Part easily into paperlike sheets, and are separated by thin, evenly bedded silty, gray shale (that predominates) in beds 3 to 4 inches thick. Makes a resistant ledge. Sandstone is locally finely cross-bedded, calcareous, and becomes more abundant toward top.	4	6
Light-gray, dense, shaly limestone, weathering buff, with cone-in-cone structure.		$1\frac{1}{2}$-3
Shale, dark gray with thin laminae of lighter gray siltstone and fine-grained sandstone. Upper 2 feet more sandy and resistant, and perhaps should be included with unit above.	6	4
An assemblage of thin (1/16 to 2 inch) hard, fine-grained, gray, thinly laminated sandstone with wavy bedding, interlayered with somewhat greater amounts of gray, silty shale that contains small oval concretions of light and dark gray (ribbon structure) laminated limestone. Concretions usually do not exceed 18 inches in diameter by 6 inches thick. Most abundant in middle part of bed. Very often rest upon the thicker layers (2 inches or more) of sandstone, and the top of the sandstone and the overlying shale are warped around them. The whole makes a relatively resistant ledge. Fossil collection No. 2 made about 2 feet below top of this unit: Baculites sp.?; Scaphites sp.?; Ammonites sp.?; Ostrea sp.?	6	3

	Feet	Inches
Shale, dark gray, fissile, as below.	1	2
Limestone, gray, dense, weathering buff. Some secondary fibrous calcite. Rude cone-in-cone structure at top. Fibrous calcite in thin 1/4 inch bands parallel to bedding and separated by thin partings soft, flaky buff shale, calcareous, with flakes muscovite and an occasional quartz grain. Looks like a weathered, altered, exfoliated bentonite.		3-6
Shale, dark gray to black, becoming more silty, and containing an occasional thin (1 inch) layer of fine-grained gray sandstone, with thin carbonaceous partings. Makes slope. Thin, non-persistent concretionary zone at base. Fossil collection No. 3. Inoceramus lundbreckensis; Inoceramus labiatus (Goldfuss); Ostrea sp.?	10	0
Sandstone, fine-grained, gray, salt and pepper, with minute fragments of black carbonized vegtal material. Finely and evenly laminated.	0	1
Shale, dark-gray, fissile.	0	5
Siltstone (very fine-grained sandstone), gray, fine wavy laminae, making layers 1/4-inch thick that are separated by thinner layers of dark gray shale.		3
Shale, dark-gray to black, as below, becoming more silty toward top.	8	
Shale, soft, weathered, buff, ochreous. Finely laminated. Bedding surfaces dusted with very fine clastic muscovite. Non-gritty. Some small clear crystals of gypsum (selenite). Probably bentonitic in part.		1/2

	Feet	Inches
Shale, dark-gray to black, fissile, soft. Finely laminated. Becomes brownish toward top. Surface covered with a litter of thin chips of fine-grained gray sandstone and occasional crystals of gypsum. Surfaces sandstone fragments smooth, uneven, conchoidal fracture parallel to bedding.	5	
Shale, gray, poorly exposed in slope.	37	
Sandstone, thin, fine-grained, gray chippy.		6
Shale, gray, fissile, with scattered crystals of selenite.	1	6
Limestone, sandy, gray, weathering buff. Thin-bedded. Some cone-in-cone concretionary material. Grades laterally into thin flat-topped concretions up to 8 feet in diameter that have a very pronounced concentric structure. Small residual fragments of the bed are very numerous and locally make a "pavement". Fragments containing coprolites were noted on this surface.		6
Shale, gray, fissile.		4
Limestone, concretionary, dense, dark-gray, weathering dove-gray, and showing a fine, sandy, laminated texture. Fossils: <u>Scaphites sp.</u>?; <u>Inoceramus sp.</u>?; <u>Ostrea sp.</u>?		4
Shale, gray, fissile, as below.	1	6
Sandstone, gray, fine-grained, thinly laminated. Parts easily into thin chips.		2
Shale, gray, fissile, as below.		6
Bentonite, rusty, weathered exfoliated.		2-3

	Feet	Inches
Shale, gray, sandy, papery, with a zone of closely spaced oval concretions of gray limestone about 1 foot thick and 4 to 6 feet in diameter, in the lower foot.	3	
Sandstone, brown, medium-grained, calcareous. Contains small irregular masses of dense gray limestone, and some white calcite. Heavy concentrations of <u>Baculites sp</u>.?; a small <u>Ostrea</u> common; <u>Scaphites</u> <u>ventricosis</u>; <u>Scaphites</u> <u>vermiformis</u>; <u>Anomia sp</u>.?; <u>Inoceramus sp</u>.?; and vertebrate bones present. Fossil collection No. 4, Reeside, Sept. 3, 1944.		2-5
Shale, dark-gray, poorly fissile. Small oval limestone concretions 2 feet above base.	10	
Limestone, concretionary. Oval masses of dense, gray limestone, weathering "dove-gray". Septarian; much shattered. Cementing material, white and brown crystalline calcite. Concretions are usually about 4 feet in diameter, 8 inches thick, and occur at intervals of about 30 feet. Fossiliferous. <u>Ostrea sp.?</u> A small, spiked gastropod. Collections.		8
Shale, dark gray, poorly fissile.	16	
Limestone, concretionary. Dark-gray, dense, weathering dove-gray. Septarian type. Thickness 12 inches, diameter 6 feet; non-continuous at intervals of 10 to 30 feet.	1	
Shale, dark-gray, as below.	2	6
Bentonite, rusty, weathered exfoliated		2
Shale, dark-gray, as below.	1	4

	Feet	Inches
Sandstone, gray, fine-grained, chippy.		4
Shale, dark-gray, soft, poorly fissile an occasional crystal of selenite. Makes slope.	20	
Base concealed in wash.		
Total measured thickness	154	2