MICROFAUNA OF THE VERENDRYE MEMBER OF THE PIERRE FORMATION

by

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INTRODUCTION

Purpose and Scope

This thesis is a portion of a study being carried on by the State University of South Dakota Department of Geology of the paleontology and paleoecology of the Upper Cretaceous Pierre Formation that outcrops over much of the western half of South Dakota. This research program carried on by the Department of Geology is planned to obtain greater understanding of the late Cretaceous history of South Dakota.

This thesis is a study of the microfossils of the Verendrye Member of the Pierre Formation in central South Dakota. This study will include environmental determinations, ecological interpretations, microfaunal correlation with other stratigraphic units and biostratigraphic correlation of the Pierre formation and the Verendrye member.

Methods of Investigation

The shale and clay samples containing the specimens studied were collected in the spring of 1960 from four localities adjacent to the Missouri River from southwest of Pickstown to north of the old Cheyenne Agency as shown on the map, Figure 1. Approximate liter-size channel samples were taken at five-foot intervals starting at the base and proceeding upward at selected stratigraphic sections.

1
Figure 1

Map Showing
Sample Localities
(Base map from Searight, 1937)
The samples were washed on a U.S. Standard Tyler #230 sieve (1/16 mm) leaving only particles of dimensions greater than 1/16 mm. The microfauna was then extracted from the washed residue with the aid of a microscope and a moistened 000 camel hair brush. The microfossils were placed on cardboard faunal sides which were coated with gum tragacanth adhesive.

Line drawings were made of selected specimens on onion skin paper and affixed to thicker white paper for photographing.

The microfossils were identified by comparing the fauna with published descriptions and plates and by comparing with type specimens of Hoff (1959) and Johnson (1960). The fauna contained nine forms which could be classed only to their genera; their specific epithet was undeterminable. These forms upon further study may prove to be new forms.

Previous Investigations

The first micropaleontological investigations of the Pierre formation were made by Applin in 1933. She listed foraminifera from the Pierre shale, Niobrara formation and Carlile shale. In 1937, Seiright listed a few diagnostic foraminifera subdividing the Pierre formation into lithological members along the Missouri River Valley in South Dakota. Later in an attempt to zone the member, he (1938) prepared a list of foraminifera of the Sully member, which at that time contained the Agency, Oacoma, and Verdigry zones. The Pierre formation was locally zoned on the basis of the most dominant species by Dietrich (1951) from a deep well near Scottsbluff, in western Nebraska. Wilson (1958) listed and described foraminifera from the Pierre formation along the
Theos by Hoff (1959) and Johnson (1960) have been prepared at the University of South Dakota in conjunction with the paleontological and paleoecological study being conducted by the Geology Department of the State University of South Dakota.

One thesis (Hoff, 1959) listed, identified and illustrated the microfauna of the Lacoma facies of the DeGrey member, and the other (Johnson, 1960) did the same for the foraminifera of the Gregory member.

Acknowledgments

The writer wishes to thank Dr. R. E. Stevenson, Professor and Chairman of the Department of Geology at the State University of South Dakota, for suggesting the problem, offering aid, encouragement and constructive criticism, and Dr. Allen F. Agnew, Professor of Geology, for his careful review of this manuscript. Thanks are extended to Curtis L. Johnson for the information he offered on collecting procedures and methods of extracting and mounting of the fossils.

The writer also wishes to express his gratitude to his wife Janice A. Lange for her aid in the preparation of charts and plates.
Regional Stratigraphy

The Pierre Formation was named Fort Pierre Group by Meek and Hayden in 1861 for exposures in the area of the old Fort Pierre fur-trading post. Since then, the name has been shortened to Pierre Formation. Meek and Hayden divided the formation into four units based on the kind and amount of fossils present; however, they did not assign any formal names.

In 1937, Searight divided the Pierre formation of the Missouri Valley into five members, from the base upward: Gregory (upper and lower), Sully (Agency, Oacoma and Verendrye zones), Virginia Creek, Hotbridge, and Elk Putte. A year later Searight assigned the name of Sharon Springs to the lower Gregory and changed the name of the upper Gregory to Gregory marl and reclassified it as the basal Sully unit. Ories and Rothrock (1941) assigned the name Crow Creek sand and marl to Searight's (1938) Gregory marl. They also reclassified the upper Sharon Springs as the Gregory member and divided it into a basal marl zone and an upper shale zone. Ories (1942) combined the Agency and Oacoma zones into the Agency-Oacoma zone. The Agency-Oacoma zone was named the Degaer member by Crandell (1950) who also raised the Crow Creek sand and marl and the Verendrye to member ranks. The reader is referred to Figure 2 for a summary of the changes just discussed.
Figure 2  Summary of changes in the Nomenclature of the units of the Pierre Formation in Central South Dakota

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At the present time the Pierre formation of central South Dakota is subdivided into the following members listed from the base upward: Sharon Springs, Gregory, Crow Creek, DeGray (Oacoma bentonitic facies and Agency siliceous shale facies), Verendrye, Virgin Creek, Mobridge, and Elk Butte members. The Mobridge and Elk Butte are locally called the "Upper Pierre" unit because in some areas the Mobridge and Elk Butte members are very difficult to separate. The reader is referred to Figure 3 for a generalized section of the Pierre formation in central South Dakota.

Pierre Stratigraphy in Central South Dakota

The Pierre Formation (Week and Hayden, 1861) is Upper Cretaceous (Campanian) in age as shown by Figure 3. The formation extends from Kansas and Colorado northward nearly to the Arctic Ocean (Rust, 1892) and from the Rocky Mountains in Colorado eastward to central Minnesota. The Pierre formation underlies most of South Dakota, where it ranges from zero to tens of feet in thickness in eastern South Dakota gradually becoming thicker westward where it reaches about 3,900 feet in central Wyoming (Tourielot, Schultz, and Gill, 1960). The Pierre shale consists of dark gray to black clays and shales, marls, concretions, some sand, and many interbeds of bentonite.

The Niobrara Formation (Week and Hayden, 1861) of Coniacian and Santonian age conformably underlies and interfingers the Pierre formation in South Dakota. Lithologically the Niobrara ranges from a marl through a chalky marl to chalk in central South Dakota (Bolin, 1952). Overlying the Pierre formation conformably is the Fox Hills Formation which is of Maestrichtian age.
Figure 3 Generalized Columnar Section of the Pierre Formation in Central South Dakota (Base figure from Hoff, 1959, Johnson, 1960)

Fox Hills Formation

785

Upper Pierre

700

Virgin Creek member

500

Verendrye member

300

DeGrey member

Oacoma facies

Agency facies

Crow Creek mem.

Gregory member

200

Sharon Springs member

150

-125

-100

-75

-50

-25

Niobrara Formation

Sand
Calcareous Sand
Shale
Calcareous Shale
Marl
Limestone
Mg Concretions
CaCO₃ Concretion
The Fox Hills consists of greenish to buff coarse- to fine-grained sand, silt, dark-gray to gray silty clay and clay.

**Review of Pierre Subdivisions**

**Sharon Springs Member** Elías, 1931

The basal member of the Pierre shale in Kansas was termed Sharon Springs by Elías in 1931. In eastern and central South Dakota the Sharon Springs member is the basal unit of the Pierre formation; however, in western South Dakota the Sharon member lies between the Sharon Springs equivalent (Mitten member) and the Niobrara formation (Robinson, Mapel and Cobban, 1959).

The member consists mainly of dark gray to black, fissile, slightly bituminous shale, which contains abundant fish scales and many bentonite layers ranging from less than one to 18 inches in thickness (Crandell, 1958).

The member ranges from seven feet in thickness at the old Cerant Plant near Yankton, which is 65 miles east and south of Pickstown, to 95 feet at outcrops near the Oaho Dam site located six miles north of Pierre. The member thickens to the west. Fossils are very rare in the Sharon Springs.

**Gregory Member** Searight, 1937

The Gregory member was described in 1937 by Searight at outcrops now covered by waters of Port Randall reservoir near the east end of the old Wheeler (Rosebud) bridge located about ten miles north and west of Pickstown in Gregory County, South Dakota.

Johnson (1960) described the lithology as follows:

"The Gregory member is composed mainly of medium to dark gray shales, interlayered calcareous and chalky shales, with the upper limits being dominantly light-
buff to gray marls throughout south-eastern and central South Dakota. Other significant characteristics are cream colored, bentonite beds: laterally varying inter-stratified layers of limy concretions; and abundant iron-brown, fossiliferous concretions scattered throughout the Gregory."

The Gregory member outcrops on the walls of the Missouri River from the vicinity of the old Cement Plant at Yankton and Lake Harroda, which is located 75 miles east of Pickstown, northward as far as the Bad River about two miles south of Pierre, South Dakota. The member ranges in thickness from 22 feet near the Wheeler Bridge to 125 feet at the White River located about six miles south and west of Chamberlain, South Dakota (Fetsch, 1946). The index fossil for the Gregory member is Baculites praemansae Cobban.

**Crow Creek member** Griese and Rothrock, 1941

In 1941, Griese and Rothrock assigned the name Crow Creek to the sand and marl zones of Searight's (1937) upper Gregory. The reader is referred to Figure 2 which is a review of later changes of the Pierre nomenclature. At present the Crow Creek member is the unit between the lower Gregory member and the overlying DeGray member.

The Crow Creek member consists mainly of marl, fine- to coarse-grained buff-colored calcareous sandstone and calcareous chert. The member extends from the vicinity of Yankton northward along the Missouri River Valley to DeGray where it passes below the River. The thickness of the member ranges from a few inches to about 10 feet.

Stevenson (1951) and Crandall (1958) reported finding micro-
fossils in the Crow Creek member.
DeGrey member Crandell, 1950

The DeGrey member as defined by Crandell (1950) includes all the beds between the top of the Crow Creek and the base of the Verendrye member. The member is divided into a lower siliceous (Agency) and an upper bentonitic facies (Oacoma). The Agency siliceous facies was recognized and named by Russell (1930) at outcrops in southeastern Dewey County near the old Cheyenne Indian Agency and is composed of light gray to black, hard siliceous shale. The Oacoma bentonitic was named by Searight (1937) at outcrops near Oacoma, South Dakota. This facies consists of light to dark gray bentonitic beds that weather to dark "pop corn" surfaces with an abundance of manganiferous iron nodules present.

The member is exposed in the Missouri River valley from the area of the old cement plant near Yankton to southeastern Walworth County. The bentonitic facies (Oacoma) is most prominent to the south. Thicknesses range from 160 feet near Pierre to 82 feet at the type section which is six miles east of the east edge of the Canning Quadrangle located about 13 miles east and south of Pierre, South Dakota. The index fossil for the DeGrey member is Baculites corrugatus Elias.

Verendrye member Searight, 1937

The name Verendrye was given by Searight (1937) to the upper part of the Bully member between the underlying Oacoma facies and the overlying Virgin Creek member. Crandell (1950) raised the Verendrye to a member rank because (1) a member is a subdivision of a formation, (2) a zone is a unit containing rock deposited
during the time of existence of a faunal or floral assemblage which may cross lithological boundaries, and (3) zones should not be given formal names.

The member consists of light- to olive-gray shale and claystone which weathers first to soft flakes and chips followed by light-olive to brownish gray gumbo.

The member extends in South Dakota from the Nebraska-South Dakota state line northward and passes below the younger Virgin Creek member a few miles south of Mobridge, South Dakota. The index fossil for the Verendrye member is *Raculites compressus* Say s.l.

The reader is referred to the section which deals with the detailed lithology and micropaleontology of the member.

**Virgin Creek member** Searight, 1937

The Virgin Creek member was named by Searight in 1937 from exposures in the valley of Virgin Creek and from exposures on the bare flats and hills above the Creek located 1½ miles south of Promise in northeastern Dewey County, South Dakota.

The Virgin Creek member is the unit between the Verendrye member and overlying Mobridge or the lower part of the Upper Pierre Unit. The bentonite layers (15 or more) occur throughout the member but are more numerous in the lower portion.

The Virgin Creek has been traced in South Dakota from southeastern Gregory County where the member outcrops near the Missouri River northward where the outcrops widen to 25 miles in the region of the Noreau River located about 25 miles north and west of the old Cheyenne Agency. The top of the member disappears below the Missouri River about six miles south of the South
Dakota—North Dakota boundary. The thickness varies from 55 feet in western Charles Mix County to approximately 170 feet in Stanley County to about 224 feet in northeastern Dewey County and 157 feet near Mobridge, South Dakota.

The member is fossiliferous, the index form being *Cuculites alleni* Cobban. Searight reported microfossils occurring in the member.

**Mobridge and Elk Butte members - “Upper Pierre Unit”**

The Mobridge and Elk Butte members (Upper Pierre Unit) consists of the beds between the Virgin Creek member and the overlying Fox Hills formation. In some areas, notably the south central and central portion of South Dakota, the Mobridge and Elk Butte members can be distinguished; however, in the area to the west and north the two members become nearly impossible to separate. This paper is concerned with the area along the Missouri River; therefore the members will be discussed separately.

The Mobridge member (Searight, 1937) was named from exposures west of Mobridge and consists of all the beds between the Virgin Creek and Elk Butte members. The member is composed of a succession of highly calcareous shale, marl, and chalk beds. The member extends from the northern to the southern boundary of South Dakota and westward as far as South Dakota Highway 53 located 65 miles west of the old Cheyenne Agency and possibly farther. Thickness ranges from 90 feet up to 230 feet near the Carlin Bridge over the Cheyenne River located 55 miles northwest of Pierre, South Dakota.

The name Elk Butte was assigned to the beds of shale which lie at the top of the Pierre between the Mobridge member and Fox
ills Formation. The member consists of very fine-textured medium gray siliceous shale. The Elk Butte member extends from southeastern Gregory County and southwestern Charles Mix County northward to northeastern Corson County. The member ranges from 60 feet in thickness near Huleah in eastern Gregory County, to 310 feet between Elk Butte and Wakpala in eastern Corson County.

The index fossils for the "Upper Pierre Unit" are Maculites, Basulites, Heck and Hayden, S. grandis Hall and Meek, and B. clinolobatus Mayes.
Introduction

Since the Verendrye is the stratigraphic unit that is the
most significant in the area investigated for the microfossils being investigated it was felt advis-
able to consider it in greater detail than the other units.

Searight (1937) defined the Verendrye as a zone of the Sully
member lying above the manganiferous and bentonitic strata of the
Ooosa zone and below the basal bentonitic strata of the Virgin
Creek member. In 1950, Crandell stated that the zone rank was
invalid due to the meaning of the word zone (p. 11) and raised
the Verendrye to a member rank. He also placed the Agency-Ooosum
facies as a unit into the DeGrey member. In 1952 and 1953 Cran-
dell again stated that the Agency-Ooosum boundary was not sub-
stantiated and used the terms, "lower siliceous facies" as equal
to the Agency and the upper "shale and bentonite facies" as equal
to the Ooosum. The distinctly different lithologic characters of
the two units is a good reason to keep the formal names, Agency
and Ooosum, but facies is the proper terminology rather than zone.

The Verendrye member consists of the strata between the
underlying siliceous and bentonitic DeGrey member and the over-
lying olive-gray shale of the Virgin Creek member.

Areal Extent

The Verendrye member is exposed in the Missouri River bluffs
from the Yankton area northwestward to near Mobridge in north-
The northernmost exposure of the member located as reported by Searight, 1937, in section 33 R. 17 N., 13 W., about ten miles southeast of Mobridge, South Dakota. Figure 4 shows the known areal extent of the Verendrye member in central South Dakota.

The member is confined to the lower part of the Missouri Valley and tributary valleys in the southern part of the State and extends to several miles in the central and northern areas of State. The westward extension of the Verendrye is not definitely known because the lithology merges with that of its equivalent, the unnamed "Dark Shale" member (Robinson, Mapel, and Cobban, 1959). The "Dark Shale" member which lies above the Sullivan Hill member (Oacoma equivalent) and under the Kara member (Virgin Creek equivalent) consists of about 200 feet of dark or black shales which contain gray and red-brown-weathering limestone concretions (Robinson, Mapel, and Cobban, 1959). The reader is referred to Figure 5 which shows the correlation of the Pierre formation of central and western South Dakota.

**Lithology**

The member consists of interstratified light- to medium-gray laminated illitic shale and light-olive to olive-gray to gray laminated illitic claystone. According to Tourlelot, Schultz, and Hill (1960) most samples of Pierre shale consist of 65 to 95 percent clay minerals such as illite and montmorillonite, 15 to 25 percent quartz, a few percent feldspar, and small amounts of carbonate, biotite, pyrite, gypsum, jarosite, clinopilolite, and...
Figure 4
Outcrop Map of the Verendrye Member in Central South Dakota
(Base map from Searight, 1937)
Figure 5  Correlation of the Pierre Formation of Central and Western South Dakota with accompanying zones (compiled from Cobban, 1962; Cobban and Reeside, 1952; Gill and Cobban, 1961; Robinson, Mapel and Cobban, 1959; Stevenson, R.E., oral communication; Zapp and Cobban, 1960)

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<td></td>
<td>&quot;Upper Pierre&quot;</td>
<td>&quot;Dark&quot;</td>
</tr>
<tr>
<td></td>
<td>Virgin Creek</td>
<td>Kara</td>
</tr>
<tr>
<td></td>
<td>Verendrye</td>
<td>&quot;Shale&quot;</td>
</tr>
<tr>
<td></td>
<td>De Grey</td>
<td>Oacoma bentonitic facies</td>
</tr>
<tr>
<td></td>
<td>Agency siliceous facies</td>
<td>Monument Hill</td>
</tr>
<tr>
<td></td>
<td>Crow Creek</td>
<td>&quot;Silty&quot;</td>
</tr>
<tr>
<td></td>
<td>Gregory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sharon</td>
<td>Mitten</td>
</tr>
<tr>
<td></td>
<td>Springs</td>
<td></td>
</tr>
<tr>
<td>Niobrara</td>
<td>Gammon</td>
<td></td>
</tr>
</tbody>
</table>

- Baculites clinolobatus
- B. grandis
- B. baculus
- B. eliasi
- B. reesidei
- B. cuneatus
- B. compressus
- B. corrugatus
- Exiteloceras jenneyi
- Didymoceras stevensoni
- Baculites pseudovatus
- B. scotti
- B. gregoryensis
- B. n. sp "F" ×
- B. n. sp "E" ×
- B. n. sp "D" ×
- B. asperiformis
- B. maclearni
- B. obtusus
- Scaphites hippocrepis

* Zapp and Cobban, 1960
Organic matter. They also state that montmorillonite is more abundant in the clay fraction of the upper Pierre in central South Dakota. The writer feels that the high percentage of montmorillonite in the upper Pierre is caused by the bentonitic character of the Oacoma facies and the basal Virgin Creek.

Crandell (1956) described two types of iron-manganese carbonate concretions present in the Verendrye member. The first type is large, round, oval or kidney shaped having dimensions of one to three feet in length and one to six inches in thickness; the second type is smaller measuring six to 16 inches in length and one to three inches in diameter. Concentrations of the first type were found in the south central part of the State.

The contact of the Oacoma facies with the Verendrye member can usually be picked easily within four or five feet because of the distinct lithological change between the gray bentonitic Oacoma and the grayish-olive shale of the Verendrye. A similar situation exists between the Verendrye and the Agency facies in the northern outcrop area. A gradational zone serves as the contact between the Verendrye and the Virgin Creek. Searight (1937) placed the base of the Virgin Creek and the top of the Verendrye at the base of a succession of a number (five or more) of bentonite layers. The writer placed the boundary at the base of a series of bentonite layers, following Searight's method, keeping in mind that minor lithological characters are at times the only evidence of a depositional break or change.
Thickness

The Verendrye member varies greatly in thickness. The member is thin in the southeastern areas of the State and thickens towards the north and west. The following is a table of the thicknesses of the Verendrye member.

<table>
<thead>
<tr>
<th>Locality</th>
<th>Thickness in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Wheeler Bridge</td>
<td>68</td>
</tr>
<tr>
<td>Randall Creek (60L1 and 60L2)</td>
<td>65</td>
</tr>
<tr>
<td>White River (60L3)</td>
<td>105</td>
</tr>
<tr>
<td>* Deccena</td>
<td>130</td>
</tr>
<tr>
<td>* Crow Creek</td>
<td>170</td>
</tr>
<tr>
<td>* Ft. Pierre</td>
<td>170-180</td>
</tr>
<tr>
<td>* Bijou-Iona Hills</td>
<td>177-196</td>
</tr>
<tr>
<td>* Ft. Bennett</td>
<td>122</td>
</tr>
<tr>
<td>* Chantier Creek</td>
<td>142</td>
</tr>
<tr>
<td>Cheyenne Agency (60L4)</td>
<td>100</td>
</tr>
<tr>
<td>* Petsch (1946)</td>
<td></td>
</tr>
</tbody>
</table>

Paleontology

Megallosa in the Verendrye member of the Pierre formation in central South Dakota are very rare. *Euculites compressus* Say s.l. was reported by Searight (1937) from a bed of gray shale which contains limestone concretions along the Bad River, one mile west of Wondte located 25 miles southwest of Pierre. Cobb and Hesside (1952) indicated the species was the index form for
The DeGrey Verendrye and Virgin Creek members, then Robinson, Hospel, and Cobban (1959) restricted it to the Verendrye and lower Virgin Creek. Cobban (1962) states that *Pseudosyrinx compressus* Say s. l. is found in the basal part of the dark-gray shale member (*"Dark Shale" member*) in the Black Hills area. The reader is referred to Figure 5 for the correlation of the Pierre formation of central and western South Dakota with accompanying zones.

The member also contains bones of marine reptiles, fish bones, and aragonitic *Inoceramus* prisms. To the west in the equivalent strata (*"Dark Shale" member*) megafossils are more common. The Verendrye has a well-developed microfauna which will be discussed in the following sections.

**Descriptions of Sample Locations**

The map shown in Figure 1 shows the collecting locations of the samples from which the reported fauna was obtained. The localities have been assigned the University of South Dakota locality numbers 60LL through 60L4. The letters a, b, c, ... are being used to locate the successive five foot channel samples at each locality beginning at the lower sample and continuing upward with respect to the lower and upper contacts of the Verendrye member.

**Section 1**

**Locality 60LL:** Sample location 60LL is located in the SW corner of NE1/4 NE1/4 sec. 19 T. 95 N., R. 65 W., starting on the bank of Randall Creek and proceeding southeast for approximately 100 yards up the slope.
<table>
<thead>
<tr>
<th>Thickness in Feet</th>
<th>Member</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Verendrye</td>
<td>Surface was weathered to buff color. Olive-green shale found 2 1/2 feet below the surface. Present was a three inch brown concretion.</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>Olive-green shale.</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>The basal contact was placed at the place where the dominant olive-green shale was present. A 1/4 inch bentonite layer was present near the base of the Verendrye.</td>
</tr>
<tr>
<td>5</td>
<td>Ocoma</td>
<td>Blackish-green fissile bentonitic shale.</td>
</tr>
</tbody>
</table>

**Locality 60L2:** Sample locality 60L2 is located near the center of the west line of NW 1/4 sec. 20 T. 95 N., R. 65 W., from 45 feet above the Ocoma-Verendrye contact upward. The locality 60L2 is approximately 300 yards southeast of 60L1.

<table>
<thead>
<tr>
<th>Thickness in Feet</th>
<th>Member</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>5+</td>
<td>Virgin Creek</td>
<td>Gray to olive-green shale with thin (1-1/2 inch) bentonite layers.</td>
</tr>
<tr>
<td>20</td>
<td>Verendrye</td>
<td>Olive-green shale.</td>
</tr>
</tbody>
</table>

**Section 2**

**Locality 60L3:** The locality 60L3 is located near the center of NW 1/4 sec. 26 T. 104 N., R. 73 W., about two miles north of the bridge where South Dakota Highway 47 crosses the White River.

<table>
<thead>
<tr>
<th>Thickness in Feet</th>
<th>Member</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>5+</td>
<td>Virgin Creek</td>
<td>Slaty olive-green shale with numerous bentonite beds occurring.</td>
</tr>
<tr>
<td>100</td>
<td>Verendrye</td>
<td>Olive-green shale.</td>
</tr>
</tbody>
</table>
Thickness in feet | Member | Lithology
---|---|---
5 | Verendrye-
Old Agency | Gray to black shale grading into olive-green partly blocky shale.

**Section 2**

**Locality 60L4:** The locality 60L4 is located at the center of sec. 34 T. 11S R. 79 W., about 1½ miles due north of the Old Cheyenne Indian Agency.

<table>
<thead>
<tr>
<th>Thickness in Feet</th>
<th>Member</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>5+</td>
<td>Virgin Creek</td>
<td>Slaty green shale containing numerous bentonites.</td>
</tr>
<tr>
<td>95</td>
<td>Verendrye</td>
<td>Uniform partly blocky in aggregates of about one inch along the side of olive-green shale. The weathered shale is blackish green.</td>
</tr>
</tbody>
</table>
| 5 | Verendrye-
Agency | The lower portion of the five feet contained a black shale of the Agency facies which graded into the olive-green shale of the Verendrye. |
| 5+ | Agency | Black siliceous shale. |
Introduction

A varied fauna of Upper Cretaceous foraminifera and an abundance of radiolaria are found in the Verendrye member. The Verendrye contains 73 species of foraminifera composing 45 genera and 25 families. The classification of the foraminifera follows Gunther (1946), Frizzell (1956), and Loeblich et al. (1961).

Also found and classified are four species of radiolaria with one individual occurring in extreme abundance.

Other microfossils identified are two genera of ostracods, an unidentifiable form "G" (Hoff, 1959) and sponge spicules.

Foraminifera

The Verendrye contains an abundance of diversified foraminifera. In that many different forms are found although none are of extreme abundance. The following are the nine most dominant foraminifera listed in decreasing abundance with their generic percent of frequency of the total population: *Ampudiascus craticola* - 6.7%, *Pulisma aspera* - 14%, *Trachasaccus depressus* - .85%, *Arenobacter taurinensis* - .9%, *Pterochelis globulus* - 34%. *Ampudiascus antiquus*, *A. elabrinus*, and "*Glo-

\[\text{The generic percent is found by dividing the total number of individuals of a genus into the total number of individuals found in the sample. Five of the most populated samples were used for this investigation.}\]
Two individuals, "Globigerina" cretacea and *Heterohelix globulosa*, of the nine dominant forms are planktonic and the remaining seven forms are free living benthonic forms. *Ammodiscus cretaceous* is the most common foraminifera being found in 56% of the samples investigated.

The southernmost section, Section 1 (locality 60L1 and 60L2), contains far fewer fossils with much less variety of species than do the northern sections, section 2 (locality 60L3) and section 3 (locality 60L4). Section 1 contains in abundance *Heterohelix globulosa* while section 2 contains *Ammodiscus cretaceous, A. caulinitus, Silicosioidolina* and "*Globigerina* cretacea.* Section 3 contains *Ammodiscus cretaceous, Bathymyphon taurinensis*, and *Trochammina depressa*, of which the latter two are absent in section 1 and 2. *Silicosioidolina*, an arenaceous form, is found abundantly in section 2 but is rare or absent in sections 1 and 3. The stratigraphic ranges of the dominant forms in sections 1, 2, and 3 can be determined by referring to Table 2 and Figure 6.

<table>
<thead>
<tr>
<th>Form</th>
<th>Section 1</th>
<th>Section 2</th>
<th>Section 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ammodiscus cretaceous</em></td>
<td>upper 1/2</td>
<td>upper 1/2</td>
<td>throughout</td>
</tr>
<tr>
<td><em>Bulimina aspera</em></td>
<td>---</td>
<td>upper 1/2</td>
<td>throughout</td>
</tr>
<tr>
<td><em>Trochammina depressa</em></td>
<td>---</td>
<td>upper 1/2</td>
<td>throughout</td>
</tr>
<tr>
<td><em>Bathymyphon taurinensis</em></td>
<td>center 1/2</td>
<td>upper 1/2</td>
<td>throughout</td>
</tr>
<tr>
<td><em>Heterohelix globulosa</em></td>
<td>lower 1/2</td>
<td>upper 1/2</td>
<td>---</td>
</tr>
<tr>
<td><em>Silicosioidolina</em></td>
<td>---</td>
<td>upper 1/2</td>
<td>upper 1/2</td>
</tr>
<tr>
<td><em>Ammodiscus caulinitus</em></td>
<td>lower 1/2</td>
<td>throughout</td>
<td>lower 1/2</td>
</tr>
<tr>
<td><em>A. globulatus</em></td>
<td>---</td>
<td>upper 1/2</td>
<td>throughout</td>
</tr>
<tr>
<td>&quot;<em>Globigerina</em> cretacea&quot;</td>
<td>---</td>
<td>throughout</td>
<td>---</td>
</tr>
<tr>
<td>Section 1</td>
<td>Section 2</td>
<td>Section 3</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>A.cret</td>
<td>Bul. as</td>
<td>A.cret</td>
<td></td>
</tr>
<tr>
<td>Bath. faur</td>
<td>T.d</td>
<td>Bath. faur</td>
<td>T.d</td>
</tr>
<tr>
<td>H.g</td>
<td>A. gau</td>
<td>A. gau</td>
<td></td>
</tr>
<tr>
<td>A. gau</td>
<td>G.c</td>
<td>Bul. a</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bath. faur</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A. gau</td>
<td>A. glab</td>
</tr>
</tbody>
</table>
The lesser or rare forms can be determined by referring to the population distribution chart, Table 3.

Four of the 14 species Johnson (1960) considered as being dominant forms in the Gregory member are found in the Verendrye member. Three of the common species, *Ammodiscus cristasceus*, *Bulimina aspera* and *B. orlika*, are bentonic forms and one, *Heterohelix striata* is a planktonic foraminifera which is found abundantly in the Oacoma facies of the DeGray member. This species is also found in the Verendrye but not as a dominant form. It appears that the type of foraminiferal faunal assemblages change from the bentonic fauna of the Gregory to the planktonic fauna of the Oacoma and then back to the bentonic fauna of the Verendrye member.

**Radiolaria**

Radiolaria of the Verendrye member were classified according to Campbell, 1954. The radiolarias present in the Verendrye member are *Dictyomitra* (*Dictyumitra*) *multicostata*, *D. (D.)* sp. *q*., *Sphagodelia* sp. *A*., and *Conosphaera*.

The most abundant radiolarian was *Dictyomitra* (*D.*) *multicostata* occurring in 80 percent of the samples investigated.

Radiolaria are also found in other units of the Pierre Formation. Johnson (1960) reports three general and four species in the upper one half of the Gregory member and Hoff (1959) reports 11 species of radiolaria from the bentonic Oacoma facies.

Johnson and Hoff stated that *D. (D.)* *multicostata* was the dominant radiolarian. It appears that the planktonic radiolaria
<table>
<thead>
<tr>
<th>Localities</th>
<th>60L1</th>
<th>60L2</th>
<th>60L3</th>
<th>60L4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locality</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td><em>AMMINTIDAE</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Anisodonta</em></td>
<td></td>
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</tr>
<tr>
<td><em>Hygophila alexandrae</em></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>Taurinensis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Taurinensis</em></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><em>A. complanata</em></td>
<td></td>
<td></td>
<td>XX</td>
<td>XX</td>
</tr>
<tr>
<td><em>MODISIDAE</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cinclus cretaceus</em></td>
<td></td>
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</tr>
<tr>
<td><em>Cinclus trivialis</em></td>
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<tr>
<td><em>Glabratus</em></td>
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<tr>
<td><em>Hesperospora cheiodes</em></td>
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<tr>
<td><em>Gordius</em></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><em>CHIENONELLIDAE</em></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><em>Pachyax sp. A.</em></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>CHIENONELLIDAE</em></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>Cheraeopsis</em></td>
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<tr>
<td><em>C. barkerensis</em></td>
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</tr>
<tr>
<td><em>Mocobaculites</em></td>
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<td></td>
</tr>
<tr>
<td><em>KULARIIDAE</em></td>
<td></td>
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</tr>
<tr>
<td><em>Proplectammina</em></td>
<td></td>
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</tr>
<tr>
<td><em>PROPELECTAMMINIDAE</em></td>
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</tr>
<tr>
<td><em>OCHAMMINTIDAE</em></td>
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</tr>
<tr>
<td><em>Chomonina depressa</em></td>
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</tr>
<tr>
<td><em>TAXOPHRAGMIDAE</em></td>
<td></td>
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</tr>
<tr>
<td><em>Trichonympha</em></td>
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<tr>
<td><em>V. buletta</em></td>
<td></td>
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<tr>
<td><em>V. texulariformis</em></td>
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<tr>
<td><em>Veulinoideus insignis</em></td>
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</tr>
<tr>
<td><em>V. trilaterus</em></td>
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<tr>
<td><em>LIOLIIDAE</em></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><em>Lingucolus</em></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><em>L. münsteri</em></td>
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</tr>
<tr>
<td><em>OSARIDAE</em></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>H. macrodiscus</em></td>
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</tr>
</tbody>
</table>

Legend:  
- = Flood  
- = Abundant  
- = Common  
- = Uncommon  
X = Rare
<table>
<thead>
<tr>
<th>Locality</th>
<th>60L1</th>
<th>60L2</th>
<th>60L3</th>
<th>60L4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>Bulbus pseudocultratus</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tauculina sp. A.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudonatica triangularis</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tauculina curvatura</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Mundo</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Jarvisi</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Tenuina aculeata</td>
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</tr>
<tr>
<td>Catenula</td>
<td></td>
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</tr>
<tr>
<td>At D. consobrina</td>
<td>X</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gracilis</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Torneiana</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Dosaria cf. N. paupercula</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Naumann</td>
<td></td>
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</tr>
<tr>
<td>Isopalmula primitiva</td>
<td></td>
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<td>X</td>
</tr>
<tr>
<td>Pseudolabellina rugosa</td>
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</tr>
<tr>
<td>Tegena cf. L. globosa</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hispida</td>
<td></td>
<td></td>
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Legend: ■ = Flood, □ = Abundant, □ = Common, □ = Uncommon, X = Rare
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<td>L. striata</td>
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<td>Rugoglobigerina rugosa</td>
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<td>H. nigula simplex</td>
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<td>P. dumplei</td>
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**Legend:**
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- = Abundant
- = Common
- = Uncommon
X = Rare
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<th>60L3</th>
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<td>a b c d e f g h i j k l m n o p q r s t</td>
<td>a b c d e f g h i j k l m n o p q r s t</td>
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<td><em>plitera</em> coenensis</td>
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<td>X</td>
<td>X</td>
<td>-</td>
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<td>CORYTHIDAE</td>
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<td><em>plitera</em> (D) multicostata</td>
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<td><em>plitera</em> sp. C.</td>
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<td>ODISCIDAE</td>
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<tr>
<td><em>plitera</em> sp. B</td>
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<td><em>plitera</em> sp. C</td>
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<td>Spicule</td>
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</table>

Legend:
- = Flood
- = Abundant
- = Common
- = Uncommon
X = Rare
first appeared in the upper Gregory, and continued stratigraphi-

cally throughout the Cacoma facies and the Verendrye member.

Post (1892) reported Dictyomitra from the Pierre shale of north-

western Manitoba, Canada.

Also present are some unidentifiable small siliceous nearly

spherical forms with from very little ornamentation to no orna-

mentation on the outer surface.
Introduction

One of the most important applications of a paleontological investigation is in the biostratigraphic zoning of the investigated unit and correlating the unit with other stratigraphic units. Microfossils can be used to zone a member depending on whether (1) certain fossils are restricted to a stratum or (2) certain fossils found commonly in the strata are absent from a stratigraphic zone. Correlation of a unit with another unit in a distinct geographic area is confirmed by the occurrence of identical species within the units.

Zonation

In attempting to zone the member it was found that no marked biostratigraphic strata are present. The only biostratigraphically restricted fossil was Silicosiampolina which is restricted to the upper 1/4 of sections 2 and 3. Table 2 and Figure 6 show the stratigraphic extent of the dominant foraminiferal forms.

The fauna when compared with the fauna of the Gregory member and Ocoma facies may be used to assist in the micropaleontological zoning of the Pierre formation. Johnson (1960) identified 123 species of foraminifera comprising a diversified benthonic fauna from the Gregory member. Hoff (1959) reported 23 species of foraminifera from the Ocoma with only a single foraminifera, the planktonic Heterohelix striata and a radiolarian Dictyocladia.
(2.) *multicoastata* occurring in abundance. The Verendrye member contains 73 species of foraminifera with nine dominant forms. Seven of the nine are benthonic forms. The change from a highly diversified benthonic Gregory fauna to a predominantly planktonic Gacoma fauna and then back to the predominantly benthonic fauna of the Verendrye may prove to be a method of biostratigraphically dividing the Pierre formation. These changes in faunas may be caused by the influx of volcanic ash, now shown as bentonite, which may have added undesirable elements, making bottom conditions unfavorable for the benthonic forms during Gacoma deposition. Further study in the Gregory, Gacoma, and Verendrye equivalents in the Pierre formation is recommended to determine if this same faunal sequence exists elsewhere. The change could be used to determine more accurately the boundaries of the Gregory, Gacoma, and Verendrye or their equivalents in the thicker more complex areas of the Pierre formation.

In 1951, Dietrich zoned the Pierre formation on the basis of abundant foraminifera which were obtained from a deep well near Scottsbluff, in western Nebraska. The zones were named after the most abundant foraminifera found in that stratigraphic unit, and his subzones were named after lesser abundant forms restricted to a smaller sequence of strata than the faunal zones. The zones are shown in the following table.
Table 4. Biostratigraphic Zoning of the Pierre in Western Nebraska (Dietrich, 1951).

<table>
<thead>
<tr>
<th>Thickness in feet</th>
<th>Zone</th>
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<tbody>
<tr>
<td>180</td>
<td>(Gyrodiscina) DEPRESSA zone</td>
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<tr>
<td>150</td>
<td>UPPER (fossil Heterohelix) STRIATA</td>
</tr>
<tr>
<td>210</td>
<td>(Fossil Gyrodina) GLOBOSA zone</td>
</tr>
<tr>
<td>360</td>
<td>UPPER BARREN zone (Gyrodiscina depressa)</td>
</tr>
<tr>
<td>150</td>
<td>LOWER (fossil Heterohelix) STRIATA zone</td>
</tr>
<tr>
<td>250</td>
<td>LOWER BARREN zone</td>
</tr>
<tr>
<td>470</td>
<td>BULIMINA ASPERA zone</td>
</tr>
<tr>
<td>60</td>
<td>(Fossil Anomalina) RUBIGNOSA zone</td>
</tr>
<tr>
<td>1633</td>
<td>(Fossil Bulimina) PROLIKA zone</td>
</tr>
</tbody>
</table>

**Correlation**

Comparison of the dominant forms of the Gregory, Ocoma, and Verendrye in central South Dakota with the zones of Dietrich (1951) shows some similarities. Johnson (1960) listed Bulimina aspera as a dominant form in the Gregory member of the Pierre in central South Dakota. The Gregory could possibly be correlated with the lower BULIMINA ASPERA zone of Dietrich. Hoff (1959) reported that Heterohelix striata is the most dominant foraminifera in the Ocoma facies of the DeGrey member. It appears that there is most likely a correlation between the Ocoma facies and the LOWER STRIATA zone of Dietrich (1951). Overlying this zone is the UPPER BARREN zone characterized by the form Gyrodina depressa. This form is found in the Verendrye by not as an abundant foraminifera which makes correlation with Dietrich's zone questionable, but possible.
The Verendrye member of east and central South Dakota is
correlative with the unnamed "Dark Shale" member in the area
north and west of the Black Hills by Tourlelot, Schults, and Gill
(1960) on the basis of lithology. Robinson, Mapel and Cobban
(1959) also correlate the Verendrye member with the "Dark Shale"
member in western South Dakota on the basis of ammonite zones.
The reader is referred to Figure 5 for the correlation of the
Pierre of central and western South Dakota with accompanying
zones.

Cobban and Reeside (1952) correlated the Navarro group with
the upper Pierre and lower Fox Hills on the presence of Baculites
compressus Say s.l. A microfaunal correlation between the Veren-
drye member and the Texas Gulf series does not agree with Cobban
and Reeside (1952). The following table shows a better correla-
tion between the Taylor and Verendrye than between the Navarro
and the Verendrye.

| Table 5. Correlation between Texas Gulf Series and Verendrye Member. |
|-------------------|------------------|-----------------|------------------|
| Unit              | Total Species    | Species in Common | Percent of Verendrye Found in Other Units |
| Verendrye         | 73               |                 |                  |
| Taylor            | 280              | 40               | 54.7             |
| Navarro           | 147              | 27               | 37.0             |
PALAEOCOLOGY

Introduction

Ecology is the science of environmental interrelations, the study of the structure and temporal processes of populations, communities and other groups and interrelations of the individuals composing these units. Palaeoecology is the ecology of fossil remains of past life. Parameters are factors that act as ecological controls which can be measured quantitatively such as percentages of light penetration to certain depths or the minimum and maximum temperatures of the sea at given depths. The most common controlling factors are depths ranging from zero to about 11,000 meters in modern oceans, temperatures which vary from near four degrees to 30 degrees Centigrade, turbidity which is the condition of a volume of water whereby an abundance of sediment is interspersed in the water, useful light than may penetrate up to 160 meters, substrate up to 160 meters, substrate characters such as mud or coral, currents which are water streams in continuous motion, and organisms which live in the sea with the foraminifera.

The parameters of an ocean impose restrictions on the organisms which live in that body of water. Organisms which live within a certain set of parameters must have tolerances within the limits of these parameters. By determining the ecological parameters of each organism in its present environment, the environmental limits of those organisms can be determined.
The paleoecology of a fauna is reconstructed by comparing paleoecological characteristics of the past with similar known situations of today. Paleoecological evidence characteristics, such as lithology and form and structure of a foraminiferal test, will indicate possible parameters of the environment in which the organisms lived.

Thus reconstruction of ancient marine environment is based on the comparison of the paleontological and lithological evidence with known processes and parameters of the modern ocean.

Ecological Factors of Paleoecological Importance

Depth. Depth is one of the most important controlling factors in marine ecology in that a change in depth may cause a change in temperature, light, substrate character, and currents.

Phleger (1960) reported that there seems to be general widespread foraminiferal faunal boundaries at depths of 20, 50, 100, 200-300, 400-500, 1000, and 2000 meters in the oceans. The most striking faunal boundary is at 100 meters, whereas the least striking faunal boundary is at 2000 meters of depth.

Grimsdale and Markhoven (1955), following the method proposed by Smith (1955), plotted the percentages of 455 bottom samples of the Gulf of Mexico and found a definite correlation between the ratio of planktonic to benthonic individuals and depth.

Phleger (1960) reports that it is not possible to generalize on the world-wide depth distribution of many actual species and that except for deep sea forms there are few benthonic species
which are world-wide in distribution. There are three types of species distribution (Phleger, 1960) that can be used to determine the depth at which a foraminiferal fauna may live, (1) discrete depth range, where species have a definite shallow and/or deep limit of occurrence, (2) overlap ranges of species in which two or more occur together in a specific depth range, and (3) frequency of species meaning a certain species can be found over a wide range of depths but occurs more frequently at a certain depth.

Depth can also be determined on the uniformity and size of the particles in which the fauna are found. Phleger (1960) shows that up to a depth of 250 meters the sediments are varied in size ranging from one to 50 microns while at depths greater than 250 meters the sediment size averages near one micron and is uniform.

Temperature. Temperature is a controlling factor in ecology because temperature somewhat regulates growth and reproduction of foraminifers by regulating body processes. Hutchins (1947) states that organisms survive well in a definite range of temperatures; however, reproduction and repopulation are completed at a narrower range of temperature than needed for survival. Gunter (1957) states that organisms have different temperature optima and limits for different body processes, particularly reproduction. Following Gunter's idea Phleger (1960) listed four critical levels of temperature with relation to reproduction and survival: (1) minimum temperature for survival, (2) minimum temperature for reproduction, (3) maximum temperature for reproduction, and (4) maximum temperature for survival.
Studies listed by Phleger (1960) have shown that a foraminiferal population can survive efficiently in a range of temperatures of from 10 to 35 degrees Centigrade and that the maximum and minimum temperature of reproduction are separated by four or five degrees Centigrade. Survival can exist above and below the extremes of temperature, but little growth takes place.

Temperature in the modern ocean decreases as the depth increases. The temperature decreases from 15 to 30 degrees Centigrade in surface water to 15-18 degrees at 100 meters of depth, to 10 degrees Centigrade at 200 meters, to near four degrees Centigrade with very little variation from near 900 meters to deep water (Phleger, 1960).

**Salinity.** Pearse and Gunter (1957) report that salinity of ocean water is the sum total of the dissolved salts in the ocean measured in parts per million (p.p.m.) and that the normal is near 35 p.p.m. They also report that in lagoons, near shore ponds and water bodies without outlets the salinity may increase to 104 p.p.m., and that excess salinities are uncommon in oceans while lower values of salinity occur where fresh water is entering the ocean.

Phleger (1960) states that although the degree of salinity may have some effect in near-shore habits, it is not known to have any effect in deeper water. Laboratory studies have shown that some species (Strublina beccarii) can grow and reproduce under extreme conditions (20 p.p.m. to 40 p.p.m. of salinity) (Bradshaw, 1959), while other species such as Notiaella heterocarya, Groll grew best at salinities of 26 p.p.m. to 30 p.p.m. (Bradshaw, 1955).
Salinity therefore may affect the biological processes in near-shore areas, but in open and deeper parts of the ocean the salinity has little effect and is near the normal of 35 p.p.t. at all times.

**Turbidity and Light.** Stainforth (1952) reported that turbidity, which is a condition where the water contains an abundance of sediment in suspension, was a controlling factor in distribution by limiting photosynthesis of food in plants by limiting light penetration. Light penetrates the ocean deepest at noon when the limits of sufficient light reach a depth of 160 meters to allow benthonic plants to grow (Clarke, 1954). Clarke also reported that at a depth of 250 meters the light intensity is 0.001 percent of the intensity at the surface. Light is an essential factor in the manufacturing of sugars by plants during the process of photosynthesis. A decrease in light penetration by the absorption of the particles of sediment in the water decreases photosynthesis which in turn breaks the food chain from phytoplankton to foraminifera resulting in an insufficient amount of food for an abundant varied foraminiferal population.

**Substrate.** There seems to be a slight relationship between the benthonic foraminifera and the substrate. Seaside foraminifera live attached to bare surfaces such as coral or rocky bottom. Unattached free living benthonic foraminifera occur more frequently where a muddy substrate exists because there is a greater amount of food associated with the smaller clay particles (Phleger, 1960). Fox (1957) reports that argillaceous and calcareous sands rather than concentrations of quartz sand contain the most varied fauna of benthonic foraminifera.
Currents. Odum (1961) states that the sea is in continuous circulation driven by steady winds and the rotation of the earth. The velocity of the movement and mixing of the ocean water has a definite effect on the organisms which live in that body of water. In near-shore waters the surface waters waves and tides cause the greatest amount of movement and mixing while in deeper areas the movement is generally slow. An important ecological effect of deep sea currents is the agitation of the muddy substrate on the continental shelf and slope which makes available to organisms as foraminifera a greater quantity of food. A second effect is the aeration of the water by carrying oxygen from the surface and from aquatic plants to the organisms (foraminifera) in the water body.

Turbidity movements (water containing large amounts of sediment) may decrease the light penetration by absorbing the light; causing a decrease in the amount of photosynthesis carried on. The decrease in photosynthesis again results in an insufficient amount of food available to supply an abundant varied foraminiferal population.

A second more direct way in which turbidity movements could act as a limiting factor is that where turbidity currents lose their velocity, the carried materials will settle out and may bury organisms on the sea floor.

Other Organisms. Organisms present in the ocean of today which are capable of photosynthesis and serve as food for foraminifera are phytoplankton. Phytoplankton include such organisms as diatoms and dinoflagellates.
Paleocology of the Verendrye Member

Depth. The depth of the Verendrye sea is placed at from 120 meters to 485 meters with an average near 340 meters. This corresponds to the outer continental shelf and continental slope.

Plotting the percentages of benthonic foraminifera in the total populations shows a depth range of 120 meters to 485 meters. The percentages of benthonic individuals, Table 6, were compared with the percent-depth ratios reported by Smith (1955), Figure 7, and the indicated depths were recorded in Table 6.

![Figure 7: Depths indicated by percent benthonic foraminifera after Smith, 1955](image)

| Table 6. Percentages of Benthonic Foraminifera and Indicated Depths. |
|--------------------------|-------------------------|
| Sample       | % Benthonic | Indicated Depths |
| 60L1i        | 44          | 495            |
| 60L3b        | 82          | 120            |
| 60L3h        | 57          | 400            |
| 60L3n        | 43          | 480            |
| 60L4i        | 70          | 200            |

An attempt to use the dominant forms with respect to definite ranges of genera showed the following.

![Table 7: Depth Ranges of Dominant Genera (Phleger, 1960).](image)

<table>
<thead>
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<th>Genera</th>
<th>Depth Ranges (meters)</th>
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<tr>
<td>Acrodiscus</td>
<td>0 100 200 300 400 500 600 700 800 900 1000 2000</td>
</tr>
<tr>
<td>Bulimina</td>
<td></td>
</tr>
<tr>
<td>Silicosigomolina</td>
<td></td>
</tr>
<tr>
<td>Nathysiphon</td>
<td>*deep water form</td>
</tr>
<tr>
<td>Trochammina</td>
<td></td>
</tr>
</tbody>
</table>

* Takayanagi (1960) reports *Nathysiphon* as a deep water form.
The wide range of depth occurrences of the dominant forms, Table 6, makes the use of (1) overlap ranges of species in which two or more occur in a specific range and (2) frequency of species meaning a certain depth range, impossible in determining the depth of the Verendrye sea.

The uniform fine grained argillaceous material indicates an area deeper than 250 meters (Phleger, 1960) which agrees with the depths indicated by percent benthonic individuals, Table 6.

Temperature. The temperature of the Verendrye sea ranged from 15 degrees Centigrade at the surface to about 13 degrees Centigrade at 120 meters of depth.

The surface temperature was determined from Dictyomitra (D.) multicosata, a planktonic radiolarian which Tappan (1950) stated was a cold water form. Since the ocean today ranges from 15 to 30 degrees Centigrade at the surface and D. (D.) multicosata is a cold water form, the temperature of the surface water of the Verendrye sea was near 15 degrees Centigrade.

The deeper waters especially near the continental slope are more stable than the surface waters, and range from 10 to 15 degrees Centigrade in the modern ocean where flourishing benthonic foraminiferal populations live. Since the Verendrye contains a flourishing benthonic foraminifera from a depth of 120 to 485 meters the temperature of the water near the bottom must have ranged from near 13 degrees Centigrade at 120 meters of depth to about eight degrees Centigrade near 500 meters of depth.

Salinity. Salinity has very little effect on deep water forms and it has been shown that the salinity of deeper sea water is near the average normal of 35 p.p.m. at all times. The Veren-
Dry sea has been shown to be deeper than 100 meters, therefore ocean conditions existed and salinity must have been near the normal of 35 p.p.m.

**Turbidity and Light.** The varied foraminifera population in the Verendrye indicates that sufficient light was present in the upper waters for the photosynthetic photoplankton which serve as food for the foraminifera. Both, the foregoing facts and the sediments show no sign that turbidity was present in the Verendrye sea.

**Substrate.** The substrate of the Verendrye sea was muddy as indicated by the argillaceous lithology of the member and the fact that in modern oceans free living benthonic foraminifera are found in greater number in and on a muddy substrate.

**Currents.** The fine intercalated structure of the sediment plus the fine size of the particles indicate quite slow moving waters. The abundant and varied benthonic fauna indicated that enough current was present to transport oxygen to the organisms near the bottom and to agitate the muddy substrate making sufficient food available for the foraminifera.

**Other Organisms.** Phytoplankton were present in the Verendrye sea and served as food for the foraminiferal population. *Baculites compressus* Say was present and now serves as the index form for the member. Palecypods were present as indicated by prisms of aragonite from the shell of the animals. Bones of fish and marine reptiles are also found in the member, indicating that both were present in the Verendrye sea.
Summary of Verendrye Ecology

The Verendrye sea was characterized by the following:
depth ranged from 120 to 405 meters and averaged near 340 meters;
temperature ranged from 15 degrees Centigrade at the surface to
10 degrees Centigrade at 200 meters of depth; salinity was near
the normal of 35 p.p.m.; turbidity and light were sufficient to
permit photosynthesis; the substrate was muddy with an abundance
of food present; currents of a mild magnitude were present;
other organisms were present of which the phytoplankton were
the most important.
APPENDIX
SYSTEMATIC DESCRIPTIONS

Phylum PROTOZOA
Class RHIZOPODIA
Subclass GRANULOSPIRICOLOSA
Order FORAMINIFERIDA
Family RHIZAMMIDAE

Genus Bathysiphon Sars, 1872

Bathysiphon alexandri Cushman, 1933

Plate 1, Figure 1

Description: Test tubular, circular, elongate; wall composed of fine amorphous and fine sand grains with such calcareous cement, wall thin, white, constricted at intervals; aperture formed by opening at end of tubular test.

Dimensions: Figured specimen 8 mm. long, diameter 3 mm.


Locality: COL3t; COL41,n,t.

Stratigraphic position: Upper Verendrye.

Bathysiphon laurinensis Sacco

Plate 1, Figure 2
Kalamatia cubica WHITE, 1933, Jour. Paleont., vol. 7, p. 185, pl. 27, fig. 3.

Description: Test unilocular, elongate, straight, subcylindrical; wall thick, white in color; wall consisting of cement plus amorphous material; test open at both ends.

Dimensions: Figured specimen, length 1.1 mm., diameter .2 mm.


Locality: 60L1-s; 60L3-k,v; 60L4-b,f,i,j,k,l,n,o,q,r,s,t.

Stratigraphic position: Throughout Verendrye.

Family SACCAMINIDAE

Genus Felosina Brady, 1879

Felosina complanata Franke

Plate 1 Figure 3

Felosina complanata FRANK, 1911, F. preuss. geol. Landesanstalt Jahrb., vol. 52, pt. 2, p. 107, pl. 3, figs. 1a,b.

Description: Test free, lenticular in shape, biconvex; single chamber; wall rough, arenoaceous, particles of calcareous material cemented by calcareous cement, aperture simple located at terminus of short slender neck.

Dimension: average size, diameter, 16 mm.  
Locality: C0L2-a,b; C0L3-a,d,k; C0L4-c.  
Stratigraphic position: Lower Verendrye.

Family ANODIDIDAE

Genus Anodiscus Reuss, 1861

Anodiscus cretaceus (Reuss)

Plate 1 Figure 4

Corynus cretacea (Reuss). Reuss, 1845, Verstein bokm, kreide, pl. 1, p. 59, pl. 13, figs. 64, 65.


Description: Test close, planispiral, coiled, slightly involute, biconcave; the single tube-like chamber increasing gradually and uniformly in size, with many whorls; wall very finely arenaceous, noncalcareous, smooth, usually white; aperture formed by open end of last coil, a slight restriction of tube was found adjacent to the aperture.

Dimensions: Figured specimen, diameter of test .7 mm.


Locality: COLX-h; COLX-a,b,i,j,k,l,m,n,p,q,r,s,t,u,v; COLX-a,b,c,d,f,g,h,i,k,l,n,o,p,q,r,s,t.

Stratigraphic position: Throughout Verendrye.


Ammodiscus multicornis Berthelin

Plate 1, Figure 5.
Description: Test planispirally coiled, irregularly circular, discoidal, early portion of coil not visible, test nearly completely involute; tube-like chamber increasing gradually in size; wall very finely arenaceous, color white, aperture at open end of tube.

Dimensions: Figured specimen, diameter .6 mm.

Figured specimen: U.S.3.g. #61-5.

Locality: 601.1-b,f; 601.2-a; 601.3-f,h,j,l,m,p,q,s,u,v; 601.4-b, d,s.

Stratigraphic position: Lower Verendrye.

Remarks: Not found in Ocoma or Gregory.

*Ammobaculites gibratus* Cushman and Jarvis

Plate 1, Figure 6


Description: Test circular, planispirally coiled, concave on both sides, tubular chamber gradually and uniformly increasing in size, succeeding coils slightly involute, walls thin, smooth, white, composed entirely of calcareous cement, aperture semi-circular, aperture at open end of tube.

Dimensions: Figured specimen, diameter .9 mm, length .2 mm.

Figured specimen: U.S.3.g. #61-6.

Locality: 601.3-a,i,j,n,r,s,t,u,v; 601.4-a,b,g,h,k,n,p,s.

Stratigraphic position: Throughout Verendrye.
Remarks: Not found in Georze and Gregory.

Genus Cloosaspira Rzeck, 1883

Cloosaspira chordoides (Jones and Parker)

Plate 1, Figure 7.


Cloosaspira chordoides (Jones and Parker) WHITE, 1928, Jour. Geol., vol. 2, p. 137, pl. 27, fig. 3. CUSHMAN, 1918, U.S. Geol. Survey Prof. Paper 806, p. 19, pl. 2, fig. 1;3.


Description: Test coiled with protoconch and long, tubular, undivided second tube-like chamber winding around its earlier coils in various places; wall very finely arenaceous; smooth, glossy surface; aperture formed by open end of tube.

Dimensions: Average size, diameter 3 mm. to 4 mm.


Locality: 6011-f; 6013-e.

Stratigraphic position: Lower Verendrye.

Remarks: Rare, only 2 specimens found in lower Verendrye.

Cloosaspira cordialis (Jones and Parker)

Plate 1, Figures a,b.


Cloosaspira cordialis (Jones and Parker) CUSHMAN, 1918, U.S.

AND JARVIS, 1928, Cushman, Lab. Form. Research Contr., vol. 4, p. 67, pl. 12, fig. 7-8.


CUSHMAN AND JARVIS, 1936, Jour. N.Y. Acad. Sci., vol. 35, p. 267, pl. 2, fig. 15, 16.

Description: Test composed of a subglobular proloculum and a long undivided tubular second chamber, coiled as thread on a spool, early turns planispiral, the later turns in irregular planes, the coils increasing in size slightly as added; wall finely aragonitic cemented with calcareous material, exterior smooth; aperture formed by open end of tube.

Dimensions: Average size, diameter .2 mm.

Figured specimen: U.S.N.M. 618.

Locality: 6015-a, d, f.

Stratigraphic position: Throughout Verendrye.

Remarks: Rare, only 3 specimens found at locality 6013.

Family ASCHEMOSERILIDAE

Genus Reophax Montfort, 1803

Reophax sp.

Plate 1, Figures 9-10


Description: Test elongate, unserial, sides nearly parallel, periphery irregular; chambers compressed 4-6 in number; wall
arenaceous, composed of calcareous grains cemented by calcareous material; sutures indistinct, suture areas slightly depressed; aperture simple, found terminal on a short neck.

**Dimensions:** Average size, length .3 cm.

**Figured specimen:** 3, U.S.D. #61-9.

**Locality:** 6013-j; 6014-f, h, i, j, k, l, o, q.

**Stratigraphic position:** Upper Varorhyne.

**Remarks:** All 2. sp. found were found crushed.

**Family LITUOLIDAE**

**Genus Barkerina Frizzell and Schwartz, 1960**

**Barkerina af. B. barberensis**

**Plate 1, Figures 11a, b, c.**


**Cribrostomoides frizzelli STEAD, 1961, Texas Jour. Sci., vol. 3(4), p. 508, pl. 1, fig. 5.**

**Description:** Test planispiral, involute, periphery slightly irregular, chambers numerous, 13-13 in last whorl, thin and wide, chambers subcircular in cross section; 2 deep umbilicus visible; wall calcareous, slightly roughened due to numerous distinct perforations; sutures distinct, slightly depressed; apertural face formed by flattened side of last chamber in the direction of coiling, high, broad.

**Dimensions:**

**Figured specimen:** 3, U.S.D. #61-10.
Locality: 601.4-c,d,h,k,m,o,p,q.

Stratigraphic position: Found in most northerly section at locality 601.4. Throughout Verendrye.

Remarks: Specimens closely resemble H. barkerensis of Frizzell. However, all specimens were crushed as if one side was pulled in one direction and the other side pulled in the opposite direction.

Genus *Amphocerolites* Cushman, 1910

*Amphocerolites* sp. A

Plate 1, Figure 12

Description: Test free, early portion of 3 chambers coiled planispirally, later 6 chambers uniserial, becoming slightly smaller as added; chambers of latter portion circular in cross section, rectangular in sagittal section, early chambers subspherical in form; wall finely arenaceous of light grained material with much transparent cement. Sutures distinct, depressed; aperture simple, terminal.

Dimensions: Average length .4 mm, diameter .1 mm.

Figured specimen: S. U. S. P. #61-11.

Locality: 601.4-j,n,p,s.

Stratigraphic position: Upper Verendrye.

Remarks: The specimens differ in that successive chambers becoming smaller in later chambers.

Family *TEXTULARIIDAE*

*Genus Spiropleustes* Cushman, 1927
Sciarapectinae sp. A

Plates 1 Figure 11

**Description:** Test free, 1/2 as broad as long, tapering, periphery smooth, acute; early portion of 4-5 chambers coiled planispirally, later 11-12 chambers biserial, chambers triangular in cross-section, increasing regularly and gradually in size as added; sutures distinct, broad; wall smooth finely arenaceous; aperture low broad at junction of last 2 formed chambers.

**Dimensions:** Average size, length .4 mm, width .2 mm.

**Figured specimen:** S.U.S.B. #61-15.

**Locality:** Gold-a.

**Stratigraphic position:** Lower Verendrye.

**Family TROCHAMMINIDAE**

**Genus Trochammina** Parker and Jones, 1899

**Trochammina Depressa** Loco

**Plates 1 Figure 14**


**Description:** Test trochospiral, compressed, periphery lobulate, early chambers not readily discernible, 5 to 6 chambers visible ventrally, chambers increasing rapidly in size as added; wall arenaceous, calcareous particles cemented with calcareous cement; sutures indistinct but constricted at the margin to give a lobulate periphery.

**Dimensions:** Average size, diameter .5 mm.
Family MASTOPOPHORIDAE

Genus Candyrina d'Orbigny

Candyrina bullettia

Plate 1. Figures 16a,b.

Candyrina bullettia CANNEY, 1936, Texas Univ. Bull. 2612, p. 28, pl. 4, fig. 4. BOBEN, 1958, Micropaleon., vol. 1, no. 4, p. 283, text-figs. 5, 6.


Description: Test generally cylindrical, greatest diameter determined by last two chambers, chambers slightly inflated, chambers on one side much larger than opposite chambers; test tapers slightly for 4/5 of the length toward the initial end,
the last 1/5 to the blunt end is greatly tapered; initial end
of shell is triserial, later portion biserial; sutures dis-
tinct, slightly depressed; wall finely arenaceous with a glossy
finish, aperture a low broad opening at margin of last formed
chamber.

Dimensions: Average size, length .7 mm. to .9 mm., diameter
.3 mm. to .5 mm.

Figure specimen: S.U.S.B. #61-15.

Locality: 60L1-a; 60L4-a.

Stratigraphic position: Lower Verendrye.

Remarks: Bowen (1955) states that Erothia was originally de-
scribed as differing from Gaudryine was the youthful trochoid
first whorl. On closer examination it was found that both
have the early trochoid whorls.

Gaudryina of 2. textulariformis Nakkady and Talaat

Plate 1  Figure 15

Gaudryina textulariformis NAKKADY AND TALAAT, 1956, Micropaleo.,
vol. 5, pt. 4, p. 457, pl. 6, figs. 3a-d, (not figs. 3c,3d).

Description: Test short biserial, tapering toward blunt end,
the greatest breadth formed by last two chambers; chambers uni-
serial; last four chambers inflated, last two chambers greatly
inflated; sutures distinct, depressed in specimen; wall thin,
composed of much calcareous cement; aperture arched opening at
base of last chamber.

Dimensions: Average size, length .15 mm., greatest diameter
.15 mm.

Figure specimen: S.U.S.B. #61-14.
Locality: SOLA-b.

Stratigraphic position: Rare, found only in one locality.

*Genus Clavulinoides* Cushman, 1936

*Clavulinoides insignis* (Plummer)

*Plate 7, Figures 17a, b*

*Tritaria trisarcinata* (Rouss) CUSH, 1896, Univ. Texas, Bull., 8612, p. 27, pl. 5, fig. 4 (not Textularia trisarcinata Rouss).

*Clavulin insignis* PLUMMER, 1931, Univ. Texas, Bull. 3101, p. 138, pl. 8, figs. 1-4.


Description: Test free, elongate, 3 nearly flat sides, triangular in cross section throughout, slightly twisted about long axis, periphery acute and irregular, periphery keel-like formed at acute extremities of each chamber; chambers distinct, numerous; 6 in later portion and are uniserial, 9-11 in early portion and triserial. Wall smooth, very finely arenaceous with much calcareous cement, finely perforate; sutures distinct, greatly depressed in uniserial portion, slightly depressed in triserial portion; aperture simple, located at terminus of neck which has 3 lobes in the directions of the keeled peripheries.

Dimensions: Average sizes, length .5 mm. to 1 mm., diameter .05 mm. to .2 mm.


**Clavulinaeidae trilaturns (Cushman)**

**Plate 1, Figure 13a,b.**


Clavulinaeidae trilaturns (Cushman), 1943, Cushman Lab. Forams. Research Contr. vol. 19, p. 32, pl. 9, fig. 7.

Clavulinaeidae trilaturns (Cushman), 1944, Cushman Lab. Forams. Research Contr. vol. 20, p. 2, pl. 1, fig. 7.


Clavulinaeidae trilaturns (Cushman), 1954, Bur. Econ. Geol., Univ. Texas, Sept. Invest. 82, p. 75, pl. 6, figs. 6a,b.

**Description:** Test free, elongate, tapering, triangular in cross section throughout, periphery irregular, small keel at angles of triangular chambers; chambers numerous, 10-12 in early portion and triserial, 4-8 in later portion which is uniserial; uniserial chambers inflated, last formed chamber much inflated; sutures indistinct in early portions becoming distinct and much depressed in later portion, in later portions the sutures becoming horizontal; wall finely arenaceous with calcareous cement, slightly rough; aperture simple, terminal.
**Dimensions:** Average size, length .7 mm. to 1 mm., diameter .1 mm.

**Figured specimen:** S.U.S.D. #61-17.

**Locality:** 6012-a, b, c, d; 6013-a, e, p, q, r.

**Stratigraphic position:** Upper Verendrye.

**Family MILIOCIDENTES**

**Genus Quincuncicoculina d'Orbigny, 1936**

*Quincuncicoculina* sp. A

**Plate 2 Figures 2a-b.**

**Description:** Test nearly 3 times as long as broad, elongate, oval; periphery broadly rounded; chambers distinct; sutures distinct; wall smooth, calcareous, areas between chambers depressed; aperture simple, at end of short stout neck.

**Dimensions:** Average size, length .3 mm., breadth .3 mm., width .16 mm.

**Figured specimen:** S.U.S.D. #61-16.

**Locality:** 6014-a.

**Stratigraphic position:** Upper Verendrye.

**Remarks:** Found most abundantly in locality 6014.

**Genus Silicosicoculina**

*Silicosicoculina* sp. A

**Plate 2 Figures 1a-b.**

**Description:** Test nearly as broad as long, elongate, oval, bi-convex; chamber indistinct, wall smooth, calcareous, imperforate; sutures indistinct; aperture simple, found at termination.
of short neck.

**Dimensions:** Average size, length .5 mm., breadth .3-.4 mm.

**Figured specimen:** S.U.S.E. #61-4E.

**Locality:** 6012-a.b.i,k,l.m.n.p,q,r,s,t, 6014-g.s,q.s,t.

**Stratigraphic position:** Throughout Verendrye.

**Family HEDGERITIDAE**

**Genus Robulus Bonfort, 1908**

**Robulus macrodiscom** (Reuss)

**Plate 2, Figures 3a,b.**


Lenticulina macrodiscom (Reuss). White, 1923, Jour. Paleont., vol. 5, p. 195, pl. 28, fig. 7.

Robulus macrodiscom (Reuss). Cushman and Jarvis, 1932, U.S. Nat. Mus. Proc., vol. 80, art. 14, p. 29, pl. 7, figs. 3a,3b.


Cushman, 1942, Cushman Lab. Foram. Research Contr., vol. 17, p. 60, pl. 15, figs. 9a, b.


Johnson, 1950, Univ. S. Dak., M.S. Thesis, p. 88, pl. 2, figs. 23a, b.

**Description:** Test planispiral, strongly involute, subcircular, large raised central area, periphery acute, high, thin keel; chambers numerous, 6-10 in last whorl, subtangential to curved chambers; sutures liasate toward central area becoming thin toward periphery; wall finely perforate, calcareous; apertural face triangular, aperture elongate slit found at periphery of apertural face.

**Dimensions:** Average specimen, diameter .4 mm., thickness .25 mm.
**Figurom specimen:** S.U.3.3.5. 762-19.

**Locality:** 60L2-a,d; 60L3-c,n,r.

**Stratigraphic position:** Lower Verendrye.

**Rohulina munsteri (Roemer)**

Plate 2. Figures 4a,b, 5a,b.

*Rohulina munsteri* ROEMER, 1863, Verstein. norddeutschen Geoliten-
gebirges, Nachtrag., p. 43, pl. 22, fig. 29. ROEMER, 1860-61, 
Verstein norddeutschen Kreidegebirges, p. 98, pl. 15, fig. 30.

*Cristellaris munsteri* (Roemer) HEBB, 1863, Akad. Wiss. Wien, 

*Rohulina munsteri* (Roemer) CUSHIAN, 1932, Jour. Paleol., vol. 6, 
p. 354, pl. 50, figs. 2a,2b. CUSHIAN, 1941, Cush. Lab. 

*Cushian and HEBBERG, 1941, Cush. Lab. Forum. Research Contr., 
vol. 17, p. 56, pl. 21, figs. 14a,14b. CUSHIAN AND DEARRICK, 
19, p. 351, pl. 50, fig. 28. CUSHIAN, 1944, Cush. Lab. Forum. 
Research Contr., vol. 30, p. 93, pl. 13, fig. 7. CUSHIAN, 
70, p. 21, pl. 1, fig. 5. FRIZELL, 1954, Bur. Econ. Geol., 
Univ. Texas, Dept. Invest. 26, p. 31, pl. 8, figs. 13,14.

**Description:** Test planispiral, involute, strongly biconvex, 
periphery subacute, nonlobulate, with narrow margin of clear 
calcareous material; chambers numerous, 3-10 in final whorl, 
chambers indistinct in early portion becoming distinct in 
later portion; sutures distinct, slightly curved; wall smooth, 
calcareous, aperture slit located at periphery of aperture 
face.

**Dimensions:** Average size, diameter 0.4 mm. to 0.5 mm., thick-
ness 0.1 to 0.3 mm.
**Figured specimen:** 3, U.S.D. #61-32.

**Locality:** COLL-a; COLL-a, e, f, h, o, q, r.

**Stratigraphic position:** Throughout Verendrye.

**Robulus pseudogultratus** Cole

*Plate 2, Figures 6a, b*


**Lenticulina rotulata** (Lamark) COUSMAN, 1946, U.S. Geol. Survey, Prof. Paper 208, p. 56, pl. 19, figs. 1-7, not fig. 19 (not of Lamark).

**Description:** Test planispiral, involute, periphery rounded with a conspicuous thin transparent keel; chambers numerous, 8-10 chambers in the last whorl, increasing gradually and uniformly in size; sutures becoming more distinct in later portions; central area not easily discernible; wall calcareous, smooth, finely perforate; radiate aperture found at periphery of small apertural face.

**Dimensions:** Average specimen, diameter .8 mm., thickness .3 mm.

**Figured specimen:** 3, U.S.D. #61-32.

**Locality:** COLL-f; COLL-3-h, r.

**Stratigraphic position:** Throughout Verendrye.

**Remarks:** Found only in samples COLL-f and COLL-3-h, r.

**Genus Lenticulina** Lamark, 1804

**Lenticulina** sp. A

*Plate 2, Figures 7a, b*

Description: Test free, planispiral, involute, somewhat broader than long, periphery acute; 9 chambers in final whorl; chambers slightly inflated; sutures distinct in later chamber and slightly curved, sutures indistinct in early portion and sutures not depressed; wall calcareous, smooth, sparsely perforate throughout test; aperture found at periphery of apertural face.

Dimensions: Average size, diameter 1.1 mm. to .4 mm.


Locality: GOLI-a.

Stratiigraphic position: Lower Verendrye.

Genus Garaenocaria Defrance, 1924

Garaenocaria triangularia (d'Orbigny) Plate 2, Figures 5a,b.

*Jarascenia triangularis* (d'Orbigny) *Cushman and Church*, 1929,
Calif. Acad. Sci. Proc., 4th ser., vol. 18, p. 506, pl. 37,
Research, Contr., vol. 17, p. 98, pl. 21, figs. 38a, b. *Cush-
mAnn, 1944, Cushman Lab. Forum. Contr., vol. 20, p. 5, pl. 2,
fig. 5. *Cushman*, 1945, U.S. Geol. Survey, Prof. Paper 506,
Geol. Mines and Water Resources Bull. 2, p. 223, pl. 22,
fig. 15. *Bandy*, 1951, Jour. Paleont., vol. 25, no. 4, p. 494,
pl. 72, figs. 11a, b. *Harnady*, 1962, Bull. Inst. Egypte,
vol. 33, p. 415, pl. 6, figs. 5. *Huxley*, 1954, Jour. Econ.
Geol., Univ. Texas, Dept. Invest. 22, p. 35, pl. 8, figs.
131, pl. 5, fig. 1.

**Description:** Test planispiral, early chambers completely in-
volute becoming uncoiled and uniserial in later portions;
chambers few, usually 5-7, triangular in cross-section; su-
tures distinct, curved; wall smooth, calcareous, very finely
perforate; aperture face depressed, aperture radial, very
small, aperture located at periphery of apertural face.

**Dimensions:** Average specimen, diameter .3 mm., thickness
.4 mm.

**Figural specimen:** G.U.S.E. #61-23.

**Locality:** 6013-f, n, m.

**Stratigraphic position:** Upper Verendrye.

*Genus Marginalina d'Orbigny, 1826*

**Marginalina curvature** *Cushman*

Plate 2. Figures 2a, b.

*Marginalina curvature* *Cushman*, 1939, Cushman Lab. Forum. Research
Contr., vol. 14, p. 34, pl. 5, figs. 13, 14. *Cushman and
10, fig. 3. *Cushman*, 1946, U.S. Geol. Survey, Prof. Paper

Description: Test elongate, early portion planispirally coiled, later portion becoming uncoiled and uniserial; chambers distinct, 6 chambers visible, chambers becoming more inflated toward apertural end, chambers of later portion nearly circular in cross section; sutures not depressed in early portion, becoming slightly depressed in later portion, wall smooth, calcareous; aperture radiate at the peripheral angle.

Dimensions: Average size, length .4 mm., diameter .1 mm.


Locality: COLD-b.

Stratigraphic position: Lower Venetian.

*Marginalina munda* Cushman

Plate 2, Figures 10a,b


Description: Test planispiral, elongate, compressed, periphery subacute, early portion close coiled, evolute in early portions, test slightly curved; chambers distinct, about 8 in number, increasing in size uniformly, later chambers triangular in side view; sutures distinct, subtangent; wall smooth, calcareous aperture radiate, at periphery of apertural face.
Dimensions: Average size, diameter .5 mm., width .3 mm.


Locality: 60L2-d.

Stratigraphic position: Lower Verendrye.

Marginalina Jarvisi Cushman

Plate 2. Figures 11a,b.


Lenticulina grata Reuss CUSHMAN AND JARVIS, 1939, Cushman Lab. Forma. Research Contr., vol. 4, p. 96, pl. 14, fig. 3 (not Reuss).

Marginalina grata (Reuss) CUSHMAN AND JARVIS, 1939, U.S. Nat. Mus. Proc., vol. 30, art. 14, p. 96, pl. 7, fig. 7, pl. 8, fig. 8 (not Reuss).

Marginalina schloenbachi (Reuss) CUSHMAN AND JARVIS, 1939, U.S. Nat. Mus. Proc., vol. 30, art. 14, p. 96, pl. 8, figs. 9 (not Reuss).


Description: Test planispiral, elongate, earliest portion coiled, involute, later portion uncoiled, periphery rounded; ventral margin slightly concave; chambers distinct, few, 4 to 6 visible, chambers inflated; sutures distinct, curved; wall smooth, calcareous; aperture radial, located at the periphery angle of apertural face.

Dimensions: Average size, diameter .5 mm., width .1 mm.


Locality: 60L1-r.

Stratigraphic position: Upper Verendrye.
Dentalina aculeata d'Orbigny, 1826

**Dentalina aculeata d'Orbigny**

*Plate 3, Figure 12.*

**Podoceras (Dentalina) aculeata** d'ORBIGNY, 1840, Soc. geol. France Mem., 1st ser., vol. 4, p. 13, pl. 1, figs. 2,3.


**Lagena globulifera** (Brady) PLUMMER, 1931, Univ. Texas, Bull. 3101, pp. 174-175, pl. 11, fig. 15a (not 15b; not of Brady).


**Description:** Single elongate, subcircular chamber, very thin projections occurring at ends of chambers representing connections to adjacent chambers; wall perforate, calcareous, wall covered with very small spines.

**Dimensions:** Figures specimen, length 1.1 mm.


**Locality:** COL3-p.r.t.

**Stratigraphic position:** Upper Verendrye.

**Remarks:** Cushman states that a complete specimen of D. aculeata has never been found.

**Dentalina catenula** REUSS

*Plate 3, Figure 15.*


**Cushman, 1940, Cushman, Lab. Forma. Research Contr., vol. 16,**
Dentalina soluta, (Reuss) FLUMMER, 1931, Univ. Texas, Bull. 5301, pp. 100-161, pl. 11, fig. 14 (not of Reuss).

Dodeaeas farrigina (Goldani) CARNEY, 1926, Univ. Texas, Bull. 5013, p. 34, pl. 4, fig. 11 (not Orthoceras farrigina Goldani).

**Description:** Test elongate, uniserial, slightly curved, initial end with elongate spines; chambers few, about 2 to 3 in number, chambers pyriform, somewhat overlapping; sutures distinct, somewhat depressed; wall clear, smooth, calcareous; aperture terminal, radiate.

**Dimensions:** Average length .3 mm., diameter .1 mm.

**Figured specimen:** U.S.S.D. #61-29.

**Locality:** 60L19-b.

**Stratigraphic position:** Lower Forelandy.

**Dentalina cf. D. consobrina d'Orbigny**

Plate 2, Figure 1

7 Dentalina consobrina d'Orbigny, 1846, Foram. Foss. Vienna, p. 42, pl. 2, fig. 1-5.

**Dentalina filiformis** (Reuss)?, CUSHMAN AND JARVIA, 1939, U.S. Nat. Mus. Proc., vol. 80, art. 14, p. 57, pl. 9, fig. 6,7.


**Description:** Test elongate, uniserial, chambers of nearly same diameter throughout, slight increase of chamber diameter
toward aperture end, chambers tapering distinctly at each suture and increasing in length as added, chambers slightly inflated, sutures distinct and depressed. Aperture not present.

**Dimensions:** Figured specimen, length .6 mm., diameter .1 mm.

**Figured specimen:** J.U.S.D. #61-29.

**Locality:** 6CL1-a,1.

**Stratigraphic position:** Lower Varangye.

**Remarks:** Cushman (1946) states most specimens of *D. cf. D. conchoptya* are incomplete and aperture end is almost never well preserved.

**Dentalina gracilis** (d'Orbigny)

*Plate 3, Figure 2.*

**Nodosaria (Dentalina) gracilis** D'ORBIGNY, 1840, Soc. Geol. de France, Ann., 1st ser., vol. 4, p. 14, pl. 1, fig. 5.


**Description:** Test elongate, uniserial, curved slightly; chambers numerous, about 9, chambers distinct, early chambers with strighten sizes, later chambers somewhat lobulate, chambers increasing gradually and regularly in size as added; sutures
distinct, in earlier portion not depressed to noticeable depressed in later portion; wall thick, wall composed of two layers, inner layer brown, outer layer white and smooth; aperture terminal, radiate.

Dimensions: Average length .3 mm., diameter .1 mm.


Locality: 6011-a, h, i; 6012-c, d, p.

Stratigraphic position: Throughout Verendrye.

**Dentalina lorrainea d’Orbigny**

Plate 3, Figure 3


**Hedasaria lorrainea (d’Orbigny)**. KENIG, 1846, Verstein, bohm.

**Kreidefaulstoff**, pt. 2, p. 57, pl. 5, fig. 5. FRANK, 1939, Kreifswaldean Univ., Geol. palent. Inst., Abh., vol. 6, p. 34, pl. 3, fig. 12.

Description: Test elongate, uniserial, slightly curved, initial and rounded; chambers increasing gradually in length as added, diameter of early chambers increasing rapidly, diameter of later chambers approximately constant, slightly inflated; sutures distinct, slightly depressed; wall calcareous, smooth,
aperture terminal on a raised neck-like projection of the plate-like apertural face.

Dimensions: Average size, length .3 mm., diameter less than .1 mm.


Locality: 6012-b; 6013-a,b.

Stratigraphic position: Middle Foram.drye.

Genus *Nodosaria* Lamarck, 1918

*Nodosaria* cf. II. *papuculata* Reuss

Plate 3, Figure 4

*Nodosaria papuculata* Reuss, 1845, Verstein bohm. Freideform.-


Description: Test elongate, uniserial, slightly tapering, chambers distinct, inflated near base; wall surface ornamented by 15-17 large costae which run from aperture neck to suture line and from suture to suture, between large costae very small costae occur which are much shorter in length than the larger costae, wall perforate, calcareous; aperture simple, at termi-
nus of short very stout neck.

Dimensions: Average size, length .3 mm., diameter .2 mm.

Locality: 6013-n.r.

Stratigraphic position: Middle Verendrye.

*Rodoceras nausanni* Reuss

**Plate 3 Figure 6.**


Description: Test free, straight, uniserial, periphery slightly lobulate; chambers few, usually 4-5, nearly spherical, initial 4 chambers increasing slightly as added, last formed chamber much enlarged; sutures distinct, being slightly depressed in early portion of test and becoming greatly depressed in later portion; wall thin, smooth, calcareous, finely perforate; aperture simple in center of flattened area on terminus of last formed chamber, flattened area has a raised irregular lip at periphery.

Dimensions: Average size, length .5 mm., diameter .2 mm.

Figured specimen: 6013-n.r. No. 53.

Locality: 6013-n.r.

Stratigraphic position: Middle Verendrye.

*Genus Falsocospilus* Bartenstein, 1946

*Falsocospilus primitiva* (Cushman)

**Plate 3 Figure 6.**
Falsamula simplex CUSHMAN, 1939, Cusl. Lab. Foram. Research Contr., vol. 14, p. 36, pl. 6, fig. 1 (not Flabellina simplex Reuss).


Falsamula simplex (Cushman), BARTENSTEIN, 1946, Senckenbergiana, vol. 25, p. 126, pl. 1, figs. 8-9.


Description: Test elongate, initial portion planispiral and later uniserial, compressed, greatest thickness in area of planispiral region, test thinning to periphery; adult chambers chevron shaped with sides nearly parallel; chambers distinct; sutures more distinct in later portions; wall very delicate; aperture terminal, slit-like with a slender neck.

Dimensions: Average size, length .6 mm., thickness .3 mm.

Figured specimen: U.S. N. #61-34.

Locality: 6011-1; 6012-5.

Stratigraphic position: Throughout Verendrye.

Genus NeoFlabellina Bartenstein, 1949

NeoFlabellina ruscana (d'Orbigny)

Plate 3, Figure 2

Jahrb., vol. 20, p. 176. KARRER, 1873, Naturw. Ver. Neu-
Vorpommern u. Hagen Bütt., Jahresber. 18, p. 160. GÖSS, 1883,
5, fig. 4. BESSER, 1901, Freunds. geol. Landesanstalt Abb.,
new ser., vol. 3, p. 47, pl. 9, figs. 30-34; pl. 18, figs.
Abh., Abh. II. 2, vol. 21, p. 108, pl. 10, figs. 5, 6; pl.
30, pl. 1, fig. 3. CUSHMAN, 1927, Cushman Lab. Forum. Research
6, p. 279, pl. 42, fig. 20. PROESCH, 1934, Zeitschr. Deutschen
Paläontologie-Vereins, Jahrg., p. 45. CUSHMAN, 1935, Cushman Lab.

Flobellina interruptata von der Marsch, 1858, Ver. preuss. Rhein-
land Verh., vol. 15, p. 63, pl. 1, fig. 5. REISS, 1866, Akad.
216, pl. 9, fig. 1. KIERON, ALLEN AND HAMMELAND, 1910, Royal
Micr. Soc. Jour., p. 452, pl. 9, fig. 2. FRANK, 1912, Natur-
Bull. 72, p. 54, pl. 10, fig. 51. FRANK, 1928, Grafswalda
Univ. Geol.-palent. Inst., Abh., vol. 4, p. 64, pl. 5, fig.
13. FRANK, 1932, Freunds. geol. Landesanstalt Abb., new ser.,
vol. 111, p. 92, pl. 8, fig. 17. CUSHMAN, 1933, Cush. Lab.
Forum. Research Contr., vol. 6, p. 50, pl. 4, figs. 16-17.
CUSHMAN, 1930, Jour. Paleol., vol. 5, p. 207, pl. 58, fig. 9.
CUSHMAN, 1931, Texas Univ. Bull. 3191, p. 165, pl. 12, figs.
1-5. CUSHMAN, 1932, Jour. Paleol., vol. 6, p. 336. SANDILES,
13-14. SANDILES, 1932, Jour. Paleol., vol. 6, p. 279, pl. 42,
fig. 21.

41, pl. 6, fig. 3.

Erectedicularia baudouiniana (d'Orbigny) CUSHMAN, 1926, Cush. Lab.
Forum. Research Contr., vol. 9, pt. 1, p. 52, pl. 3, fig. 5
146, pl. 84, fig. 13.

Ellobellina projecta (Casey) FLETCHER, 1931, Texas Univ. Bull.
3191, p. 165, pl. 12, figs. 5-9.

Falcula russica (d'Orbigny), (in part) CUSHMAN, 1940, Forum.,
vol. 3, fig. 70, pl. 35, fig. 3. CUSHMAN, 1944, Cush. Lab. Forum.
Research Contr., vol. 83, p. 8, pl. 9, fig. 6. CUSHMAN AND
BRADBURY, 1944, Jour. Paleol., vol. 18, p. 335, pl. 52, fig.
7. CUSHMAN, 1946, U.S. Geol. Survey, Prof. Paper 206, p. 83,
pl. 51, figs. 9-17.

Description: Test free, much compressed, broadly rounded in initial region, early chambers planispirally coiled, later chambers uniserial and chevron shaped, about 12 in number, chevron chambers narrow and of uniform width, extending back on both sides; sutures raised and sharp; wall thick, calcareous; aperture simple, located terminally on short stout neck.

Dimensions: Average specimen, length .75 mm., thickness .4 mm.

Figured specimen: U.S.G.S. #61-35.

Locality: 6015-c.

Stratigraphic position: Base of Verendrye.

Genus Lagena Walker and Jacob, 1798

Lagena cf. L. globosea (Montagu)

Plate 3, Figure 8


Description: Test free, flask shaped, nearly spherical, without only portions of basal spine common to genus; wall can be white, opaque, calcareous or transparent, amorphous and ashen in color; aperture simple terminal on a short fine neck.

Dimensions: Average size, diameter .2 mm. to .2 mm.
Figured specimen: 3.5.3.3. #61-37.

Locality: 6012-c, 6013-1, 6014-4.

Stratigraphic position: Middle Verendrya.

Lacuna hispida Haus

Plate 3. Figure 2.

Lacuna hispida MEISS, 1963, Akad. der Wiss., Math.-natur.,
vol. 46, p. 215, pl. 8, figs. 77-79. CARLEY, 1936, Univ.
Texas, Bull. 2618, p. 30, pl. 3, fig. 4. CUSHMAN AND THORO,
1943, Cushman, Lab. Form. Research, Contr., vol. 19, p. 61,
pl. 15, fig. 26. CUSHMAN, 1946, U.S. Geol. Survey, Prof.

Description: Test free, single chamber, elongately spherical,
with short thin spine, long slender neck; wall calcareous,
white, perforate, thick with numerous short stout spines; apert-
ture simple, terminal on long slender neck.

Dimensions: Average size, diameter .3 mm., length .7 mm.

Figured specimen: 3.5.3.3. #61-37.

Locality: 6012-c, 6013-1.

Stratigraphic position: Lower Verendrya.

Lacuna sp. A

Plate 3. Figures 10a-b.

Description: Test free, single chamber, funnel shaped with a
flattened end, wall calcareous, thin, smooth, finely perforate;
aperture simple, large in center of flattened end; numerous
small fine teeth-like protuberances extending from inner lip
of aperture.

Dimensions: Average size, diameter .35 mm., length .4 mm.

Figured specimen: 3.5.3.3. #61-33.
Locality: 60L3-3n.

Stratigraphic position: Middle Verendrye.

Remarks: Found only at single locality and in single sample.

Family POLYMORPHINIDAE

Genus *Ramilina* R. Jones, 1975

*Ramilina* sp. A

Plate 3, Figure 11

*Ramilina* sp. MCGUAN, 1957, Jour. Paleos., vol. 31, pl. 35, Fig. 86.

Description: Test free, consisting of a single globular chamber, a constricted short neck region and a broader region terminating in a convex face; wall thick, calcareous, finely perforate; larger portion of test covered with spines; aperture small, circular, at center of concave apertural face.

Dimensions: Average size, length 0.2 mm.


Locality: 60L3-1n.

Stratigraphic position: Upper Verendrye.

Family ROUVICERINIDAE

Genus *Rouvicera* Cushman, 1928

*Rouvicera* cf. *R. americana*

Plate 3, Figure 12

Research, Spec. Pub. 5, pl. 26, figs. 3a-c. PROCTER, 1936.
Sverig. geol. Unders., ser. C, p. 132, pl. 9, figs. 4a-c.
COUSINS, 1946, U.S. Geol. Survey, Prof. Paper 206, p. 115,
pl. 49, figs. 4a-c, 5a-b. PREISS, 1954, Bur. Econ. Geol.,
Univ. Texas, Rept. Invest. 22, p. 113, pl. 16, figs. 15a-b.
GALLIHUGH, 1957, U.S. Nat. Mus., Bull. 215, p. 149, pl. 34,
Geophysics, Commonwealth Aust., Bull. 57, p. 68, pl. 16,
figs. 3-6. JOHNSON, 1960, Univ. Texas, M.A. Thesis, p. 90,
pl. 3, fig. 15a, b.

Description: Test elongate, tapering, greatest width formed
by last 2 chambers, earlier chambers small, tabular, obscure
but appear biserial, the later formed chambers larger, broadly
lenticular, becoming triserial and more isolated from one an-
other; sutures distinct, becoming depressed markedly in later
portion of test; wall thin and rough; chambers inflated; apert-
ure rounded, at the end of a short cylindrical neck, with a
phialine lip.

Dimensions: Average size, length .6 mm., width .5 mm.


Locality: 60L1-a.

Stratigraphic position: Lower Verendrye.

Remarks: Differs from F. americana in that specimens' ap-
erture neck is small and slender.

Family BULIMINIDAE

Genus Prebulimina Hofker, 1953

Prebulimina ovula (Reuss) 1844

Plate 5, Figure 45

315. REUSS, 1845, Verstein. bohm. Kreide, vol. 1, p. 37,
pl. 6, fig. 75 (not invalidated by F. ovula d'Orbigny;


Bulimina metaphysialis d'Orbigny CUSHMAN, 1931, Jour. Paleol., vol. 5, p. 357, pl. 9b, figs. 14a-b (not of d'Orbigny).


Bulimina ventricosa BROTHEN, 1936, Sveriges geol. undersökning, ser. C, no. 396, p. 104, pl. 8, figs. 10a-c, text figs. 42, 43.

Pachybulimina ovata (Reuss) BERTHEI, 1951, Publ. naturhist. Dan. Sc., Limburg, 4, p. 6, figs. 7 a-f.


Description: Test small, triserial, subcircular in transverse section, greatest breadth above the middle area, tapering strongly and evenly to a rounded initial end; chambers numerous, about 14 in number, chambers obscure, enlarging very rapidly in size as they are added; sutures very slightly or not at all depressed; wall smooth, calcareous, very finely perforate; aperture small elongate slit with raised adjacent areas, located on last chamber, subterminally.

Dimensions: Figured specimen, length .3 mm., breadth .2 mm.


Locality: 60L3-b.

Stratigraphic position: Lower Verendrye.

Genus Bulimina d'Orbigny, 1826

Bulimina aspera Cushman and Parker

Plate 3, Figures 14a-b


CUSHMAN AND PARKER, 1936, Cushman Lab. Foram. Research Cent., vol. 11, p. 100, pl. 15, figs. 12,15,16 (not figs. 13,14).


Bulimina subornata SANDRIDGE, 1932, Jour. Paleon., vol. 6, p. 290, pl. 43, fig. 2 (not H. B. Brady).
Bulimina elongata D'Orbigny, CAMBRIDGE, 1932, Jour. Paleol., vol. 5, p. 281, pl. 43, fig. 3 (not d'Orbigny).


Description: Test medium, consisting of 4 or 5 whorls, two times as long as broad, tapering or earliest 1/2 of specimen, initial and bluntly pointed; chambers numerous, about 10 in number, slightly inflated; sutures distinct, slightly depressed; wall thin, calcareous, wall of initial and more roughened than wall of later portion of test; aperture elongate parallel with test on last chamber.

Dimensions: Figured specimen, length 0.3 mm., diameter 0.25 mm.

Figured specimen: U.S. Geol. No. 61-42.

Locality: 60L5-c, n, r, u; 60L6-e, b, d, e, f, h, i, j, k, l, m, q, r, s, t.

Stratigraphic position: Throughout Verendrye.

Bulimina kickapooensis Cole var. pingue Cushman and Parker

Plate 3, Figures 15a, b.
Description: Test triserial, about 2 1/2 to 3 times as long as broad, tapering toward initial end, consisting of five or six whorls; chambers numerous, about 10-12, distinct, last few chambers greatly inflated, sutures deeply depressed and very distinct; wall smooth, calcareous, perforate; aperture loop-shaped at apex of last formed chamber.

Dimensions: Figured specimen, length .7 mm., diameter .3 mm.

Figured specimen: CUS.5.5.9. #61-43.

Locality: 60L1-1; 60L2-a,b,c,d; 60L3-c,d,e,i,n,o,p.q; 60L4-k.

Stratigraphic position: Throughout Verendrye.

**Fulminina prolina** Cushen and Parker

**Plate 3. Figure 16**


**Fulminina speciosa** FRIKIZELL, 1956, Sveriges geol. undersöknings ser. C, no. 396, p. 126, pl. 8, fig. 5.

Description: Test triserial, long and narrow, about 2 1/2 times as long as broad, tapering very slightly along entire
length, triangular in transverse section, somewhat twisted on
its axis toward the initial end, consisting of 7 or 8 whorls;
chambers distinct, numerous, those of successive whorls placed
directly over each other with adjacent series meeting in a
zigzag line; sutures distinct; wall smooth, coarsely perfor-
ated, calcareous; aperture elongate, placed above junction of
second and third chambers.

**Dimensions:** Figured specimen, length .4 mm., diameter .1 mm.

**Figured specimen:** J.U.S.D. #61-46.

**Locality:** 60L2-a,b,c,d; 60L3-a,c,f,n,o; 60L4-a,f,h.

**Stratigraphic position:** Throughout Verendrye but more abundant
in lower part.

Genus *Neoabulimina* Cushman and Wickenden, 1920

*Neoabulimina canadensis* Cushman and Wickenden

Plate 4. Figure 1

*Neoabulimina canadensis* CUSHMAN AND WICKENDON, 1920, Cushman. Lab.

Research Contr., vol. 4, p. 113, pl. 1, figs. 1,2.

Pub. 4, pl. 22, figs. 24a,24b. CUSHMAN, 1933, Cushman. Lab.

Research Spec. Pub. 5, pl. 27, figs. 15a-15c. CUSH-

vol. 12, p. 9, pl. 2, figs. 9,10. JENNINGS, 1936, Bull. Am.

Paleo., vol. 23, no. 78, p. 31, pl. 3, fig. 22. FRIZZELL,

1943, Journ. Paleo., vol. 17, p. 350, pl. 57, fig. 3.

CUSH-

vol. 20, p. 25, pl. 14, figs. 12,13. CUSHMAN AND BRADFORD,

1944, Journ. Paleo., vol. 18, p. 337, pl. 53, figs. 9,10.

CUSHMAN, 1946, U.S. Geol. Survey Prof. Paper 206, p. 128,
pl. 52, figs. 11,12. FRIZZELL, 1954, Univ. Texas Bur. Econ.

Geol. Rept. Invest. 22, p. 116, pl. 17, figs. 11a,11b. ROFF,

1959, Univ. S. Dak., M.A. Thesis, p. 53, pl. 2, fig. 5.

JONSON, 1960, Univ. S. Dak., M.A. Thesis, p. 119, pl. 4,

fig. 16a,b.
Description: Test small, elongate; fusiform, triserial for 12 to 15 chambers, then biserial for 4 to 6 chambers, greatest width near middle, tapering slightly toward each end; chambers distinct, subglobular, inflated; sutures very distinct, depressed; wall smooth, calcareous, finely perforate, translucent; aperture narrow, slit, running from the top of last chamber to junction of last two chambers.

Dimensions: Average size, length .2 mm., width .1 mm.


Locality: 60L3-a, b; 60L3-t.

Stratigraphic position: Lower Verendrye.

Genus Bolivina d’Orbigny, 1839

Bolivina expilicata Cushman and Hedberg

Plate 4, Figure 2


Description: Test biserial, stout, greatest diameter near aperture, tapering gradually to small initial end; in end view nearly circular; chambers distinct in larger portion, indistinct in early portion; sutures fairly distinct in later portion, indistinct in earlier portion; basal portions of chambers extended into fingerlike projections, with deep moderately long depressions between, the projections; wall coarsely perforate; aperture at base of apertural face.
Dimensions: Figured specimen, height .3 mm., diameter .9 mm.


Locality: 6011-e.

Stratigraphic position: Lower Verendrye.

Remarks: Rare, 2 specimens found in sample 6011-e.

Genus Loxostoma Shrenberg, 1854

Loxostoma clavatum (Cushman)

Plate 4, Figure 3

Bolivina clavata CUSHMAN, 1927, Cushman, Lab. Foram. Research Contr., vol. 2, pt. 4, p. 57, pl. 12, figs. 5a, 5b.


Description: Test elongate, biseriak, rapidly tapering, club shaped, early portions showing slight twist; chambers distinct, about 10 in number, later chambers slightly inflated, last chamber subcircular in cross section; chamber bases projected towards initial end in form of finger-like projections, deep depressions between projections, chambers increasing uniformly in size as added, somewhat overlapping; sutures more distinct in later portions, early sutures at right angles to central axis, later sutures becoming oblique; wall smooth, finely
perforate; aperture elongate, ovate, on periphery of last chamber.

Dimensions: Average size, length .7 mm., breadth .2 mm.


Locality: Co Col-a.i.

Stratigraphic position: Lower Verendrye.

**Loxostoma cushmani** Wickenden

Plate 4, Figure 4


**Loxostoma cushmani** (Cushman). CUSHMAN (not Cushman, 1927), 1932, Jour. Paleol., vol. 6, p. 340, pl. 51, figs. 8a, 8b.


Description: Test elongate, early portion biserial, later portion becoming uniserial, tapering, periphery rounded, chambers of early portion indistinct, later ones distinct and inflated, slightly overlapping, chambers number about 12, chambers have their bases protruding as finger-like projections with a width about equal to width of depression; sutures in early portions not visible, in later portions distinct; wall
smooth, calcareous, finely perforate; aperture elongate, ovate slit, located midway on last chamber between chambers junctions and terminus of specimen.

Dimensions: Average specimen, length .8 mm., diameter .3 mm.

Figured specimen: U.S.D. #61-49.

Locality: 60L1-a.

Stratigraphic position: Lower Verendrye.

**Loxostomum sp.** (Cushman)

**Plate 4, Figure 5.**

*Hoffman (Cushman), 1937, Cushman Lab. Foram. Research Contr., vol. 3, pt. 4, p. 67, pl. 12, figs. 3a,b.*


Description: Test elongate, biseriel, compressed, periphery rounded, twisted slightly in early portion; chambers distinct and numerous, 17-18 in number, increasing in size and breadth as added; sutures distinct, straight, slightly depressed, area at sutures wholly without perforations; wall thick, calcareous, very finely perforate, aperture elongate, somewhat curved in adult located terminally.

Dimensions: Average size, length .8 mm., breadth .3 mm.

Figured specimen: U.S.D. #61-49.

Locality: 60L1-a; 60L3-c.

Stratigraphic position: Middle Verendrye.
Family ELLIPSOIDACEAE

Genus Ellipsonodosaria Silvestri, 1900

Ellipsonodosaria alexanderi Cushman

Plate 4, Figure 6


Description: Test uniserial, elongate, slightly curved or straight, tapering slightly towards initial end; greatest diameter formed by last two chambers; chambers distinct, numerous 14-16, inflated, increasing in length as added; sutures distinct, deeply depressed in later portion; wall ornamented with many short spines, pointing towards initial end; aperture circular at end of broad distinct neck.

Dimensions: Figured specimen, length .6 mm., greatest diameter .1 mm.


Locality: 601.3-e.f.

Stratigraphic position: Lower Verendrye.

Ellipsonodosaria aff. E. oxilla

Plate 4, Figure 7


Description: Test free, very elongate, uniserial, slender, slightly curved, initial portion of test missing; test has tube-like appearance; diameter increasing slightly as length is added; all chambers indistinct, sutures not discernible; wall smooth, with irregular numerous conspicuous spiny projections, calcareous, tan in color; aperture not present.

Dimensions: Average size, length 1 mm., greatest diameter .2 mm.


Locality: 6013 a, p.

Stratigraphic position: Upper Verendrye.

Remarks: Due to elongate structure only portions are found. The specimens have spiny projections not found on holotype.

Family ROTALIIDAE

Genus Gyrodina d'Orbigny, 1850

Gyrodina depressa (Alth)

Plate 4, Figures 2a,b,c


Rotalia cratagan COWNEY, 1906, Texas Univ. Bull. 2612, pl. 48, fig. 1.


**Description:** Test trochoid, compressed, dorsal side slightly convex, showing 3-5 whorls, ventral deeply convex, periphery rounded, last 3-4 chambers slightly inflated; last whorl contains 15-14 chambers; sutures distinct, slightly curved on dorsal side, sutures radial on ventral side, sutures becoming slightly depressed toward apertural end; wall smooth, calcareous, very finely perforate; aperture a small slit at base of apertural face.

**Dimensions:** Average size, diameter .4 mm.

**Figured specimen:** 5.0.3.0.461-62.

**Locality:** 6011-o, 1; 602-o; 603-q, r, u; 604-o, d, 1.

**Stratigraphic position:** Throughout Verendrye.

**Family HETEROBELICIDAE**

**Genus Heterohelix Ehrenberg, 1841**

*Heterohelix globulosa* (Ehrenberg)

**Plate 4 Figures 9a-b**

Textularia globiformis KUNZE (in part), 1860, Kaiserlichen Akad. Wiss., mathematisch-naturwissenschaftliche Kl. (Anzeiger; Sitzungsberichte; Mitteilungen), (Vien), ser. 49, p. 228, pl. 18, figs. 7, 8.

Guambelina globiformis (Reuss) SCHEER, 1931, Koniglichen Bayerischen Akademie der Wissenschaften, mathematisch-physikalischen Klasse (Abhandlungen; Mitteilungen) (Munchen), Class 3, no. 21, pt. 1, p. 25, pl. 14, figs. 35, 56, 53, 94, 85.


Description: Test biserial, rapidly tapering, greatest diameter near aperture end, initial and acute, planispirally coiled, 1 1/2 - 2 times as long as broad; chambers becoming regularly and uniformly larger as added; about 14 in number, chambers inflated throughout, chambers nearly spherical; suture distinct, depressed markedly throughout; wall smooth, calcareous, finely perforate; aperture broad, low, with a lip.

Dimensions: Average size, length .5 mm., width .3 mm., thickness .1 mm.


Locality: 6012-a; 6012-c; 6013-f, n, o, p, q, u.

Stratigraphic position: Throughout Verendrye.

Remarks: Abundant throughout Verendrye, found in lower Gregory, throughout Ocean (?), and in other members of Pierre formation.

Heterohelix pulchra Broten

Plate 4, Figure 10

Cymbelina tessara (Ehrenberg) CUSHMAN, 1932, Jour. Paleol., vol. 6, p. 336, pl. 51, figs. 4, 8 (not 6, tessara Ehrenberg).


Cymbelina pulchra BROTTEN, 1935, Öreges geol. unders., ser. 6, no. 396, Arkbl 30(no. 3), pp. 1-806, pl. 1-14, 69 text figs.


Heterohelix pseudogemmata (Cushman) HOFF, 1959, Univ. S. Dak., M.A. Thesis, pp. 48-49, pl. 1, figs. 14a, b (not of Ehrenberg).

Description: Test free, compressed, test planispiral in early few chambers, becoming biserial in later portions, 1 1/2 times as long as broad, tapering rapidly, about 1/3 of initial portion with smooth periphery, last 2/3 of test has a distinct indented periphery; chambers somewhat inflated, last few chambers slightly overlapping opposite chambers; wall smooth, calcareous, very finely perforate; aperture elongate arched opening with a lip and distinct flange, lips not extending far onto the opposite overlapped chamber.

Dimensions: Average size, length .3 mm., width .1 mm.

Figured specimen: S.U.S.I. #61-34.

Locality: 60LL-1.

Stratigraphic position: Middle Verendrye.

Heterohelix striata (Ehrenberg)
Plate 4, Figures 11a, b.

Textularia striata EHRENBERG, 1839, Königliche Preussiche Akademie der Wissenschaften, p. 138, pl. 4, figs. 1-3.


RANDY, 1951, Jour. Paleont., vol. 25, no. 4, p.

Description: Test free, initial portion of test planispirally coiled, later chambers becoming biserial, test 2 times as long as broad, greatest breadth formed by last two chambers, breadth increasing slightly as chambers are added; chambers alternating throughout, number about 18, inflated becoming nearly spherical in shape in the later portion of test; sutures distinct, more depressed in latter portion of test; wall calcareous, finely perforate, last chamber showing little perforation; aperture large low arched opening, located at junction of last 3 formed chambers.

Dimensions: Average size, length .4 mm., width .1 mm.

Figured specimen: S.U.S.B. #61-35.

Locality: 60L.3-u.

Stratigraphic position: Upper Verendrye.

Remarks: Found very abundantly inGenusa member.

Genus Ventilabrella Cushman, 1928

Ventilabrella australiana Cushman

Plate 4, Figure 12


Description: Test biserial which in the late portion develop in 2 rows; chambers numerous, about 16, early chambers nearly
spherical, later chambers (3) becoming inflated, uniformly increasing in size as added; sutures distinct, depressed; wall smooth, calcareous, punctate.

**Dimensions:** Average size, length .3 mm., breadth .15 mm.

**Figured specimen:** S.U.3.B. #61-56.

**Locality:** 60L4-b.

**Stratigraphic position:** Lower Verendrye.

**Family** GLOBOTHURACINIDAE

**Genus** Globothyrocena. Cushman, 1927

**Globothyrocena** sp. A

**Plate 4. Figures 12a-b.**

**Globothyrocena ranseori** Bolli. Said and Kenawy, 1956, Micro-

**palaeon., vol. 2, no. 2, p. 150, pl. 5, fig. 15 (not Bolli).**

**Description:** Test trochoid, dorsal side convex, ventral side

inflated; last whorl consists of 5 chambers, the last chamber

conspicuously larger; ventral portion of test covered with

many small dorsal spines, dorsal spines fewer and shorter than

ventral spines; wall perforate, calcareous; dorsal sutures

less distinct than ventral sutures, dorsal suture lines mark-

ed by many small beads; aperture simple, opening circular.

**Dimensions:** Average size, diameter .6 mm., thickness .2 mm.

**Figured specimen:** S.U.3.B. #61-57.

**Locality:** 60L2-a, d; 60L3-u.

**Stratigraphic position:** Throughout Verendrye.

**Remarks:** The specimen resembles **G. ranseori** of Said and Kenawy

but does not resemble the originally described **G. ranseori** of

Bolli.
Genus Globorotalites Brozeen, 1945

*Globorotalites conicus* (Carsey)

Plate 4, Fig. 14a-b,c.

*Isoventralina rotuliana* (Montford) var. *conica* Carsey, 1926, Univ. Texas Bull. 312, p. 46, pl. 4, fig. 13.

*Globorotalia micheliniensis* (D'Orbigny). Cushman, 1931, Cushman Lab. Foram. Research Contr., vol. 7, p. 94, pl. 8, figs. 8a-8c.


*Eponides micheliniensis* (D'Orbigny) Pilsbry, 1931, Univ. Texas Bull. 310, p. 192, pl. 14, fig. 11 (not of D'Orbigny).

*Gyroidina abalanesensis* sandrianae, 1938, Jour. Paleont. vol. 6, p. 283, pl. 43, figs. 13-15.

*Gyroidina micheliniensis* (D'Orbigny). Cushman, 1938, Jour. Paleont. vol. 6, p. 348, pl. 51, figs. 12a-12c (not of D'Orbigny).

*Globorotalites micheliniensis* (D'Orbigny) Cushman, 1948, Foram. Rept. Invest. 70, p. 59, pl. 14, fig. 7a-7c. (not of D'Orbigny).


Description: Test planoconvex, trochoid, dorsal side flattened or even slightly convex, ventral side concave, uniliicate; periphery angle acute and slightly lobulate with a small keel;
chambers indistinct, 6 or 7 in final whorl, increasing gradually and uniformly in size; wall smooth, calcareous; aperture indistinct, elongate at the margin of the final chamber on the dorsal side.

**Dimensions:** Average size, diameter .6 mm., thickness .4 mm.

**Figured specimen:** U.S. D. #61-56.

**Locality:** 601.8.

**Stratigraphic position:** Lower Verendrye.

**Family GLOBICELINIDAE**

**Genus Globicarinoides** d'Orbigny, 1845

"Globicarinoides" d'Orbigny, 1846

Plate 5. Figures la,b.


**Description:** Test free, trochospiral, umbilical area indistinct owing to filling of foreign matter, peripheral edge lobulate, chambers inflated, increasing rapidly in size as added, arranged in two whorls, five chambers in final whorl, suture somewhat distinct; wall calcareous, covered with many
fine spire-like projections.

**Dimensions:** Average size, diameter .6 mm., thickness .2 mm.

**Figured specimen:** S.U.S.B., #61-59.

**Locality:** 601, 1-a; 6012-d; 6013-c, f, g, h, i, n, o, p, q, r.

**Stratigraphic position:** Found abundantly in the Lower Verran-
drys.

**Remarks:** Loeblich states that *Globigerina* is not found in the
Upper Cretaceous. Loeblich also states that there is an ab-
sence of any distinct morphologic features which prevent the
separation of the so-called Lower Cretaceous and Paleocene
from the closely associated Upper Cretaceous forms.

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**Globigerina planispira Tappan**

**Plate 3. Figures 8a, b, c.**

122, pl. 10, figs. 2a-c. TAPPAN, 1943, Jour. Paleol., vol.
17, p. 613, pl. 63, fig. 3. LCSO, 1944, Am. Midland Natur.
Econ. Geol., Univ. Texas, Rep. Invest. 22, p. 127, pl. 20,
figs. 2a-c. RGPF, 1932, Univ. S. Dak., M.A. Thesis, p. 67,
pl. 3, figs. 1a, b, c.

**Description:** Test free, trochoid, nearly planispiral, peri-
phery bulbous; 6 to 7 chambers in a whorl, increasing rapidly
in size, chamber nearly spherical; sutures distinct, constrict-
ed; wall calcareous, last two chambers covered with numerous
very small spines, preceding chambers covered with numerous
stout spines; wall perforate; deep umbilicus, aperture at base
of final chamber, aperture semicircular extending into umbili-
cus.

**Dimensions:** Average size, diameter .8 mm., thickness .1 mm.
Figured specimen: S.I.3.3. 6L-60.

Locality: 6OL1-a; 6OL2-a,b,c; 6OL3-a,b,c,q; 6OL4-1.

Stratigraphic position: Throughout Verendrye.

Remarks: See "Globigerina" cratonea.

Genus Planomalina Loeblich and Tappan, 1946

Planomalina aspida

Plate 5, Figures 3a,b,c, 4a,b.

Genus aspida MINSTER, 1854, Microgeologie, Leipzig, Taf. 27, figs. 57,58; Taf. 29, figs. 42,43a. BESERR, 1881, Die Foraminiferen der Aachen Kreide, Pruss. geol. Landesanstalt. Abh., p. 73, pl. 14, figs. 1-6.

Planomalina aspida (Ehrenberg) MINSTER, 1854, Microgeologie, Leipzig, Taf. 30, figs. 26a,b.


Planoconina aspersa, Johnson, 1960, Univ. S. Dak., M.A. Thesis, p. 143, pl. 7, figs. 5a-b.

Description: Test small, planispiral, subcircular in outline, periphery broadly rounded, strongly lobulate throughout; chambers distinct, 6 to 8 chambers found in last whorl, chamber size increasing rapidly and uniformly in size, last chamber greatly inflated and conspicuous; sutures distinct, depressed; wall thin, calcareous, finely spinose, especially on early chambers; aperture a high arched opening at base of final chamber, appearing to engulf earlier chambers.

Dimensions: Average size, diameter .8 mm., thickness .1 mm.


Locality: 601-8, 601-9; 6013-a, b, p, p; 601-1.

Stratigraphic position: Throughout Verendrye.

Remarks: Due to studies on Foraminifera by Loeblich and collaborators (1957) the genus Globigerinella has been placed in Planoconina, because it was found both Globigerinella and Planoconina have coiled early portions.

Genus Globigerinella Laličer, 1948

Globigerinella multispina Laličer

Plate 5, Figures 5a-b.
Description: Test trochoid, becoming planispiral in later portions, chambers globular, 6 chambers visible, last formed chamber is divided into two smaller chambers, one found on each side of the axis of coiling; wall calcareous, thin, last divided chamber with small blunt spines, earlier chamber with longer blunt spines; sutures distinct and depressed; aperture crescent shaped found on the base of each of the divide pair of the last formed chamber in the direction of coiling.

Dimensions: Average size, diameter .5 mm., thickness .4 mm.

Figured specimen: S.U.S.B. #61-63.

Locality: 60.2-b; 60.3-a; 60.4-1.

Stratigraphic position: Middle Verendrye.

Genus Euchelicerina

Euchelicerina rugosa (Pilsumer)

Plate 5, Figures 6a, b.

Euchelicerina croatiae d'Orbigny CANBY, 1926, Univ. Texas, Bull. 2612, p. 45, pl. 5, figs. 5a,b (not of d'Orbigny).


Euchelicerina rugosa (Pilsumer) KEMIS, 1955, Micropaleon., Vol. 1, No. 4, P. 207, pl. 1, fig. 10.

Description: Test free, trochosiral, umbilical region distinct, peripheral lobulate, chambers inflated; last short
contains 4-5 chambers, chambers in last row approximately equal size, last chamber much more inflated than others; wall thick with outer portion of each chamber covered with moderate elongate spine-like projections; aperture found on last chamber, aperture large, oblong shaped with a slightly raised lip area.

**Dimensions:** Average size, diameter from .6 mm., thickness from .1 mm.

**Figured specimens:** S.U.S.D. #61-64.

**Locality:** 6011-a; 6012-a,b,c,d; 6013-b,e,f,i.

**Stratigraphic position:** Throughout Verendrye.

**Remarks:** Differs from *G. crenatus* in that the aperture is large and extends nearly across the umbilical side of the last chamber.

**Genus Hasticerinella Cushman, 1927**

**Hasticerinella simplex Morrow**

**Plate 5, Figures 7a,b.**

**Hasticerinella simplex Morrow, 1943, Jour. Paleoe., vol. 9, p. 199, pl. 30, figs. 6a,b.**

**LUSTRIUM, 1937, Nebr. Geol. Survey Bull., 2nd ser., Bull. 12, p. 48, pl. 7, figs. 5a,b.**

**CUSHMAN, 1946, U.S. Geol. Survey, Prof. Paper 206, p. 143, pl. 61, fig. 10.**

**FRIZZELL, 1954, Bur. Econ. Geol., Univ. Texas, Sept. Invest. 28, p. 187, pl. 80, figs. 13a,13b.**

**Description:** Test free, trochoid; chambers in early portion globular, 4 chambers in final whorl, chambers of last whorl proceeding from globular shape to a very elongate final chamber with a rounded end; wall finely spinose, calcareous; sutures distinct, slightly depressed; aperture indistinct.

**Dimensions:** Average size, greatest diameter .25 mm., thickness .05 mm.

Locality: Coll-a.

Stratigraphic position: Lower Valeneyre.

Remarks: The single specimen was small but well preserved.

Family ANOMALINIDAE

Genus Anomalina d'Orbigny, 1835

Anomalina hanbesti Plummer

Plate 5, Figures 3b, c.


Description: Test small, planispiral, evolute, much compressed, periiphery subacute; chamber small, miliar, 15-30 in number, chambers triangular in cross section, increasing slowly in size as added; sutures distinct, slightly limbate; wall smooth, calcareous, perforate; aperture an elongate slit located at base of apertural face with a slight lip.

Dimensions: Average size, diameter .2 mm., to .1 mm.

Locality: 6013-e.o.

Stratigraphic position: Upper Verendrye.

_Anomaline rubricinaea_ Cushman

_Plate 6, Figures 1a-b.


_Anomaline rubricinaea_ WHITE, 1931, Jour. Paleol., vol. 2, p. 303, pl. 41, figs. 65-68.

Description: Test trochoid, closely coiled, dorsal side slightly convex, ventral side somewhat concave, 9 or 10 chambers in last formed whorl, chambers somewhat indistinct, last formed sutures distinct; dorsal side of specimen somewhat punctate; aperture distinct, slit like, opening along ventral side of last chamber.

Dimensions: Average size, diameter .25 mm., thickness .1 mm.


Locality: 6013-e; 6013-k.

Stratigraphic position: Lower Verendrye.

_Anomaline sp. A_

_Plate 6, Figures 1a-b.

Description: Test free, trochoid, slightly involute, periphery broadly rounded with small knob; chambers numerous, 10-11 in final whorl, slightly inflated, last chamber large, extending
to both sides of previous whorl; wall smooth calcareous, thin, finely perforate; sutures slight depressed, indistinct, curved; aperture slit shaped between last formed chamber and previous whorl, extending nearly full length of final chamber.

**Dimensions:** Average size, diameter .3 mm., thickness .1 mm.

**Figured specimen:** S.U.S.D. #61-69.

**Locality:** 6013-r.

**Stratigraphic position:** Upper Verendrye.

**Genus Flanulina d’Orbigny, 1856**

**Flanulina correcta** (Casey) Cushman

**Plates & Figures In.b.c.**

**Flanulina correcta** CARNEY, 1929, Texas Univ. Bull. 2612, p. 65, pl. 5, fig. 5. FLAMMAR, 1931, Texas Univ. Bull. 3101, p. 183, pl. 14, figs. 1a-d.


**Description:** Test trochoid, compressed, one side more flattened than other; lobulate, chambers distinct, 10-12 chambers in last whorl and 10-11 chambers in early whorls, early chambers low and broad, later chamber becoming thin and high, wall thin, calcareous, distinctly perforate; aperture along one slit along ventral base of last chamber.

**Dimensions:** Average size, diameter .5 mm., thickness .1 mm.

**Figured specimen:** S.U.S.D. #61-69.

**Locality:** 6011-a,1.
Stratigraphic position: Throughout Verendrye.

\textit{Flamulina duhlikai} (Applin)

\textbf{Plates 4, Figures 4a, b, c.}

\textit{Anomalina taylorensis} \textbf{DURLIS AND APPLIN, 1934, Pan-Am. Geol.-


\textit{Texas, Bull. 812, p. 47, pl. 6, figs. 1a, b.}

\textit{Truncatulina duhlikai} \textbf{APPLIN, 1935, in APPLIN, ELIJUSH AND

\textit{ERNES, Am. Assoc. Petrol. Geologist, Bull. 9, p. 99, pl. 3,

\textit{fig. 6.}


\textit{Geol. Bull. 44, p. 65, pl. 12, figs. 3a-c. CUSHMAN, 1931,

\textit{Jour. Paleont., vol. 5, p. 342, pl. 36, figs. 6a-c. CUSHMAN,


\textit{4a-c. CUSHMAN, 1940, Cushman Lab. Formos. Research Contr.,

\textit{vol. 16, p. 38, pl. 6, figs. 10a-c. CUSHMAN AND BREDERICK,

\textit{1942, Cushman Lab. Formos. Research Contr., vol. 16, p. 66,

\textit{pl. 13, figs. 29-31. CUSHMAN, 1944, Cushman Lab. Formos. Re-

\textit{search Contr., vol. 20, p. 18, pl. 3, fig. 17. CUSHMAN AND

\textit{BREDERICK, 1944, Jour. Paleont., vol. 18, p. 341, pl. 35, fig.


\textit{158, pl. 64, figs. 14, 15.}


\textit{Univ. Texas, Sept. Invest. 26, p. 158, pl. 21, figs. 12a,

\textit{b,c.}

\textbf{Description:} Test trochoid, nearly planospiral, much compress-

\textit{ed, periphery acute and slightly keeled; chambers numerous,

\textit{8-10 in final whorl, chambers in early portion indistinct be-

\textit{coming very distinct in later portion, chambers increasing in

\textit{size gradually and uniformly as added, stout dome-like umbili-

\textit{cal plug; wall smooth calcareous, finely perforate; aperture

\textit{elongate slit, found at base of last chamber.

\textbf{Dimensions:} Average size, diameter .6 mm., thickness .15 mm.

\textbf{Figured specimen:} 3.7.3.6, 161-70.

\textbf{Locality:} 601-c.
Conus Pullenia Parker and Jones, 1868

Pullenia cratacea Cushman

Plate 6. Figures 5a,b.


Pullenia corveuli (White). LOEBEL, 1937, Nebr. Geol. Survey Bull., 2nd Ser., vol. 12, p. 62, pl. 11, figs. 3a,b (not of White).


Description: Test planispiral, subglobular, involute, very slightly umbilicate, periphery broadly rounded; chamber 5-7 in last whorl, chambers distinct, increasing gradually in size as added; sutures distinct, slightly curved near periphery, depressed slightly; wall smooth, calcareous, distinctly perforate; aperture elongate narrow slit at the base of aperture face, extending from one umbilicus to the other.

Dimensions: Average sizes, diameter .4 mm., thickness .3 mm.


Locality: 6011-a; 6013-c,b,g,r.

Stratigraphic position: Throughout Verendrye.
Family *CIBOLITIDAE*

Genus *Pseudonnella* Cushman and ten Don, 1948

*Pseudonnella* cf. *P. navarroana* (Cushman)

Plate 6, Figures 6a,b,6c


*Pseudonnella navarroana* (Cushman) 1954 FRIEZELL, 1954, Bur. Econ. Geol., Univ. Texas, Rept. Invest. 23, p. 126, pl. 13, figs. 9a,9b,9c.

**Description:** Test free, biconvex, trochoid, periphery acute with a marked heel; chambers distinct, numerous, 9 in final ventral whorl, 51 chambers present, chambers increasing gradually in size, slightly inflated; wall thin, calcareous, finely perforate; suture distinct, curved, slightly depressed, ending in a clear central area; aperture formed by flattening of final whorl in direction of coiling; aperture long thin slit located near center of aperture face.

**Dimensions:** Average size, diameter .6 mm., thickness .3 mm.

**Figured specimen:** 3.U.S.G. #61-78.

**Locality:** 6013-c.

**Stratigraphic position:** Upper Varndrye.

**Remarks:** The described specimen differs from *P. navarroana* in having a smaller heel and the location and position of aperture.
Family CIBICIDINAE

Genus Cibicides Donfort, 1808

Cibicides cocoensia (N. Berry)

Plate 6, Figures 7a, b, c.


Ancyroline pseudo-cocoensis CUSHMAN, 1931, Tem. Div. Geol. Bull. 41, p. 61, pl. 15, figs. 43a-c (not Carsey).


Description: Test coiled, involute, trochoid, nearly equally biconvex, somewhat compressed, peripheral margin subcarinate; chambers numerous about 12 chambers in last formed whorl, very slightly curving; sutures liiastic, slightly raised, comma shaped; wall calcareous, punctate; aperture an arched slit at base of last formed chamber, extending toward umbilicus.

Dimensions: Average size, diameter 6 mm., thickness .2 mm.

Figured specimen: S.U.S.O. #61-73.

Locality: 60L2-d; 60L3-1,p.

Stratigraphic position: Throughout Verendrye.
Class ACTINOPODA
Subclass ANICLARIA
Order OECODORIDA
Superfamily TRIACANTHINAE
Family STICHOCENTRINIDAE

Genus CONOPHOREA Haedel, 1868

Conosphera sp.

Plate 2, Figure 1


Form L. HOFF, 1959, Univ. G. Dak., M.A. Thesis, p. 36, fig. 5.

Description: Test subcircular flattened dorso-ventrally; numerous short stout blunt conical elevations irregularly arranged on test; no indication of pores or internal cavity or chamber.

Dimensions: Figured specimen, diameter .3 mm.

Figured specimen: 5015-a. #81-74.

Locality: 6015-a.

Stratigraphic position: Lower Verendrye.

Remarks: Rare, 2 found in sample 6015-a.

Genus DICTYOMITRA ZITTEL

DICTYOMITRA MULTICOSTATA ZITTEL, 1876

Plate 2, Figures 2-3.

DICTYOMITRA MULTICOSTATA ZITTEL, 1876, Zeit. deutsch. geol. Gesell., vol. 28, p. 91, pl. 2, figs. 2-4. HAEDEL, 1878.


Description: Shell slenderly conical with 6-10 strutures; area between successive strutures bludging; terminal joint either wide open or partially closed forming a elongated raised slit; wall moderately thick; surface of bulging portions shaped into about 30 pleats converging toward the epi-

cal end, in specimens the pleats continued to or acrossed the strutures forming small somewhat raised spine-like projec-
tions.

Dimensions: Figured specimens, lengths .3 mm., diameter .1 mm. Figured specimens: S. U. S. D. #61-70; S. U. S. D. #61-76.

Locality: 60L1-c, c, e, f, g, h; 60L2-b, c, d; 60L3-b, c, d, f, h, i, j, k, l, m, p, r, s, t, u, v; 60L4-a, b, c, d, e, f, g, h, i, j, k, l, q, r, s, t.

Stratigraphic position: Found very abundant throughout the Verendrya, abundantly in Oceans, Gregory and other members of the Pierre.

Remarks: The shells break up and in many samples the result-
ing appearance is doughnut shaped with pleats around the out-
side.

Dictyosmitre sp. f

Plate 7, Figure 4.

Dictyonitra sp. D. HOFF, Univ. S. Dak., M.A. Thesis, pp. 74-75, pl. 4, fig. 8.

Description: Test conical, with outline modified by three or four rounded protuberances; small ovate thorax enclosed in a thick wall. The first row of protuberances immediately following the thorax is very pronounced, subsequent ones less pronounced; some specimens show very good pore development while in other specimens the pores are closed; the apical end may be varied as to amount of protuberance and bluntness.

Dimensions: Figured specimens, length .5 mm., diameter .1 mm.

Figured specimen: S.U.S.D. 661-77.

Locality: 601.1-c,d,e,f,g,h; 601.4-a,b,c,d,f,i.

Stratigraphic position: Local abundant in upper portion of Verendrye, also found elsewhere in Pierre.

Form 0

Plate 7 Figures 3, 6

Form 7 HOFF, 1959, Univ. S. Dak., M.A. Thesis, p. 81, pl. 5, fig. 10.

Description: Test doughnut shaped with or without a center area; inner area depressed; diameter of inner area approximately equal to width of either outer inflated areas; no pores or chamber discernible.

Dimensions: Figured specimen, diameter .3 mm.

Figured specimen: S.U.S.D. 661-78.

Locality: 601.1-c,d,e,g; 601.2-a; 601.3-j,k,s,t,v; 601.4-i,j.

Stratigraphic position: Abundant throughout Verendrye.
Family Spongidecim (Koch, 1898)

Genus Rhopalodictyum Ehrenberg, 1860

Rhopalodictyum sp. A

Plate 7, Figure 7

Rhopalodictyum sp. A. Johnson, 1960, Univ. S. Dak., M.A. Thesis, P. 185, Pl. 9, Fig. 4.

Description: Shell consists of 4 broadly rounded lobes of approximately equal length and width, lobes appear to meet at 90°, flattened dorso-ventrally; area at junction of 4 lobes slightly inflated; surface covered with very fine pores.

Dimensions: Average size, diameter .3 mm.


Locality: 6011-c, d, e; 6012-a; 6013-h, l.

Stratigraphic position: Lower Verendrye.

Phylum PORIFERA

Class HYALOSPORIFERA

Plate 7, Figure 8

Description: Hexactis (triactins), rays straight, meet at right angles, smooth, white.


Locality: 6013-j, m, p, r, u.

Stratigraphic position: Throughout Verendrye.
1. Barron and Blow (1960) re-examined d'Orbigny's material of *Globigerina oretacea* from the Lower Campanian White Chalk of St. Germian, near Paris, and found that the lectotypes possessed two broadly spaced but weakly developed keels. The presence of keels convinced Barr (1962) that *Globigerina oretacea* d'Orbigny should be placed in the genus *Globotruncanella* Cushman.

An examination of the "Globigerina" oretacea of this paper does not reveal the presences of keels; therefore the "Globigerina" oretacea discussed here is not correctly identified as to species and perhaps even genus since Loeblich et al. (1957) state that *Globigerina* is not present in the Upper Cretaceous. A new name has not been introduced here because the collection is too restricted geographically and stratigraphically.
1. Bathysiphon alexanderi CUSHMAN. (p. 44) side view.
2. Bathysiphon taurinensis SACCO. (p. 44) side view, x 40.
3. Pelagicina complanata FRANKE. (p. 45) side view, x 45.
4. Ammodiscus cretaceus (Reuss). (p. 46) side view, x 15.
5. Ammodiscus scutatus PERTHEIN. (p. 47) side view, x 40.
6. Ammodiscus celestias CUSHMAN AND JARVIS. (p. 48) side view, x 50.
7. Glomospira charoides (Jones and Parker). (p. 49) top view, x 72.
8. Glomospira gordialis (Jones and Parker). (p. 49) a. top view, b. bottom view, x 72.
9,10. Beophax sp. CUSHMAN AND JARVIS. (p. 50) side view, x 60.
14. Trochammina depressa LOZO. (p. 53) dorsal view, x 50.
16. Gadavrina bullata (Carsey). (p. 54) a. side view, b. apertural view, x 60.
17. Clavulinoides insignis (Plummer). (p. 56) a. side view, b. apertural view, x 50.
18. Clavulinoides trilaterus (Cushman). (p. 57) a. side view, b. apertural view, x 45.
MILIOLIDS, NODOSARIIDS
PLATE TWO

1. *Ulicostamolina* sp. A. (p. 58) a. side view, b. apertural view, x 50.
2. *Quinquiloculina* sp. A. (p. 58) a. side view, b. apertural view, x 50.
4. *Robulus münsteri* (Roemer) (p. 60) a. side view, b. apertural view, x 45.
5. *Robulus pseudoculturatus* CROLE (p. 61) a. apertural view, b. side view, x 15.
8. *Marginalina curvature* CUSHMAN (p. 63) a. apertural view, b. side view, x 50.
9. *Marginalina munda* CUSHMAN (p. 64) a. side view, b. apertural view, x 60.
10. *Marginalina jarvisi* CUSHMAN (p. 65) a. side view, b. apertural view, x 60.
11. *Pentalina aculeata* D'ORBIGNY (p. 66) side view, x 120.
12. *Pentalina oatenula* REUSSS (p. 66) side view, x 50.
PLATE THREE

Figure


2. Denticula gracillia (d'Orbigny). (p. 68) side view, x 20.

3. Denticula lorneliana (d'Orbigny). (p. 69) side view, x 50.


5. Nodosaria paucercula Reuss. (p. 71) side view, x 50.

6. Falsocolpocyclina primitive (Cushman). (p. 71) side view, x 72.

7. Neofisonella rucoea (d'Orbigny). (p. 72) side view, x 50.


9. Lagena bicida Reuss. (p. 75) side view, x 45.

10. Lagena sp. A. (p. 75) a. side view, b. top view, x 45.

11. Ramulina sp. A. (p. 76) side view, x 85.


13. Prorotalinita ovalis Reuss. (p. 77) front view, x 72.

14. Buliminopsis aspera Cushman and Parker. (p. 79) a. front view, b. top view, x 72.

15. Buliminopsis kickxiiensis Cole var. ninae Cushman and Parker. (p. 80) a. front view, b. top view, x 50.

16. Buliminopsis prolina Cushman and Parker. (p. 61) front view, x 80.

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NODOSARIIDS, BULIMINIDS
1. Neobulimina canadensis CUSHMAN AND WICKENDON. (p. 82) front view, x 120.
2. Bolivina explicata CUSHMAN AND HEDBERG. (p. 83) side view, x 72.
3. Loxostomum clavatum (Cushman). (p. 84) front view, x 50.
4. Loxostomum cushmani WICKENDON. (p. 85) side view, x 60.
5. Loxostomum remna (Cushman). (p. 86) side view, x 50.
6. Ellipsomodosaria alexanderi CUSHMAN. (p. 87) side view, x 50.
7. Ellipsomodosaria aff. E. exilis (p. 87) side view, x 20.
9. Heterohelix globulosa (Ehrenberg). (p. 89) a. side view, b. front view, x 45.
10. Heterohelix pulchra BROTZEN. (p. 91) side view, x 45.
11. Heterohelix striata (Ehrenberg). (p. 92) a. side view, b. front view, x 50.
12. Ventilabrella austiniensis CUSHMAN. (p. 93) side view, x 65.
13. Globotruncanina sp. A. (p. 94) a. ventral view, b. dorsal view, x 50.
14. Globorotalia conica (Carsey). (p. 95) a. dorsal view, b. apertural view, c. ventral view, x 50.
BULIMINIDS, ROTALIIDS, GLOBIGERINIDS
PLATE FIVE

Figure
1. "Globigerina" cretacea D'ORDIGNY. (p. 96) a. dorsal view, b. ventral view, x 45.

2. Globigerina planispira TAPPAN. (p. 97) a. right view, b. apertural view, c. left view, x 72.

3. Planomalina aspera (Ehrenberg). (p. 98) a. right view, b. apertural view, c. left view, x 65.

4. Planomalina aspera. (p. 98) a. right view, b. apertural view, x 70.

5. Biglobigerinella multispina LALICKER (p. 99) a. front view, b. left side, x 60.

6. Rugoglobigerina rugosa (plummer). (p. 100) a. dorsal view, b. ventral view, x 50.

7. Hasticarinella simplex MARROW. (p. 101) a. ventral view, b. dorsal view, x 70.

8. Anomalina henbesti PLUMMER. (p. 102) a. right view, b. front view, c. left and apertural view, x 50.
PLATE SIX

Figure

1. *Anomalina rubiginosa* CUSHMAN. (p. 103) a. ventral view, b. front and apertural view, c. dorsal view, x 50.

2. *Anomalina sp. A.* (p. 103) a. ventral view, b. front and apertural view, c. dorsal view, x 60.


5. *Pullenia cretacea* CUSHMAN. (p. 106) a. side view, b. apertural view, x 50.


ORBITOIDS, CASSIDULINIDS
PLATE SEVEN

Figure

1. Conosphaera sp. (p. 109) x 45.

2, 3. Dictyomitriella multicostata ZITTEL. (p. 109) Fig. 2, side view, x 80, fig. 3, side view, x 80.

4. Dictyomitria sp. C (p. 110) side view, x 100.

5, 6. Form G. (p. 111) top view, x 50.

7. Rhophalodictyum sp. A. (p. 112) top view, x 45.

8. Sponge Spicule, (p. 112) x 45.
PLATE 7

RADIOLARIANS, PORIFERA
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