STATE OF SOUTH DAKOTA
Sigurd Anderson, Governor

STATE GEOLOGICAL SURVEY
E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

No. 70

MICROFOSSILS OF THE NIOBRARA FORMATION OF SOUTHEASTERN SOUTH DAKOTA

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by

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INTRODUCTION

The Niobrara formation was deposited over the entire State of South Dakota with the possible exception of the top of the Black Hills dome, marking the greatest extent of the Cretaceous sea in the state. Although it is somewhat limited in its areas of outcrop, the Niobrara is present in the subsurface over most of the state and has been reported from most oil and artesian water wells.

This investigation was undertaken to determine whether it is possible to zone the Niobrara formation of South Dakota on the basis of lithology, microfossils, or both. Eight outcropping localities were logged, sampled and examined for microfossils during this study, and two drill cores of the formation, made available by the U. S. Corps of Army Engineers, were sampled and studied. The index map on Figure 1 shows the localities from which samples were examined.

ACKNOWLEDGMENTS

The author received considerable aid in collecting the samples of the Niobrara used for this study and wishes to express his thanks to those who made much of the material available. Mr. Edwin Swift and Mr. John Trantina, of the U. S. Corps of Army Engineers, gave the South Dakota State Geological Survey the drill cores from the Gavins Point and Fort Randall Dam areas respectively. Mr. R. E. Curtiss collected samples of the Niobrara from the Yankton and Chamberlain

areas during the course of an investigation of cement raw materials which he conducted under the auspices of the South Dakota State Geological Survey, and these samples were made available for this investigation. Dr. R. E. Stevenson aided Mr. Curtiss in the collecting of the samples in the Chamberlain area, and with the author collected the samples from Sec. 8 of Clay County. Dr. Stevenson also aided in the logging of the drill cores and gave many valuable suggestions for the lithologic section of this report, for which the author is deeply indebted.

It was the encouragement of Dr. E. P. Rothrock, the State Geologist, which made this report possible, and the author is especially indebted to him for the opportunity to undertake this investigation.

PROCEDURE

The samples collected in the field for this investigation were obtained by channeling down the face of the outcrop when possible. Where a poor exposure was encountered or when the exposure was not readily accessible, grab samples were taken. Channel samples were taken of the drill cores in the laboratory. All samples were placed in cloth bags and correctly labeled with the locality, date and horizon.

The material was first pounded in a mortar, taking care not to break it down so fine that the microfossils were destroyed. The pulverized samples were then boiled in a saturated solution of sodium carbonate in order to break down the lime which forms the matrix of the rock. Boiling for about a half hour proved adequate for the soft, weathered samples, while the fresh material required boiling for approximately two hours.

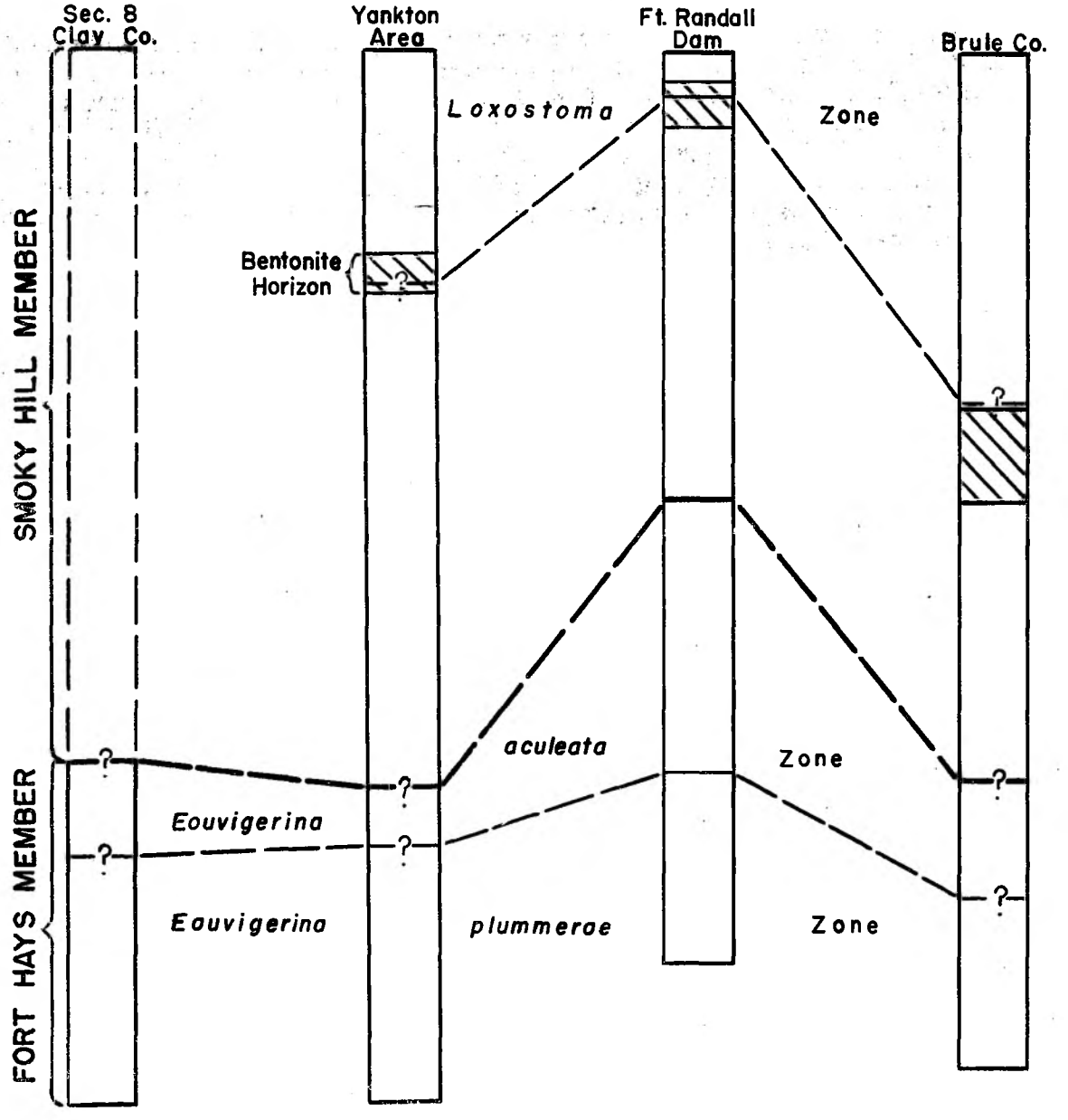
A binocular microscope was used in picking and identifying the specimens. They were placed in faunal slides according to locality, horizon and species. The best specimens were chosen for illustration and they were placed in individual slides.

In preparing the illustration, the outlines of the specimens were drawn with the aid of a camera lucida. As much of the ornamentation as possible was filled in while using the

camera lucida, and the remainder was carefully drawn free-hand while referring to the specimens under high power of the binocular microscope. The illustrations of the Foraminifera were prepared by the author and the Ostracoda were drawn by Mr. Paul Flanagan of the University of South Dakota. All specimens, including those illustrated, have been deposited in the microfossil collection of the South Dakota State Geological Survey.

GENERALIZED SECTIONS

Vertical Scale 1"=30'



1. Spirit Mound
2. Sec. 8, Clay Co.
3. Old Cement Plant
4. Sec. 21, Yankton Co.
5. Sec. 7, Cedar Co., Neb.
6. Fort Randall Dam
7. Sec. 29, Brule Co.
8. Sec. 15, Brule Co.
9. Sec. 36, Brule Co.
10. Sec. 17, Lyman Co.
11. Biskaborn Well

INDEX MAP

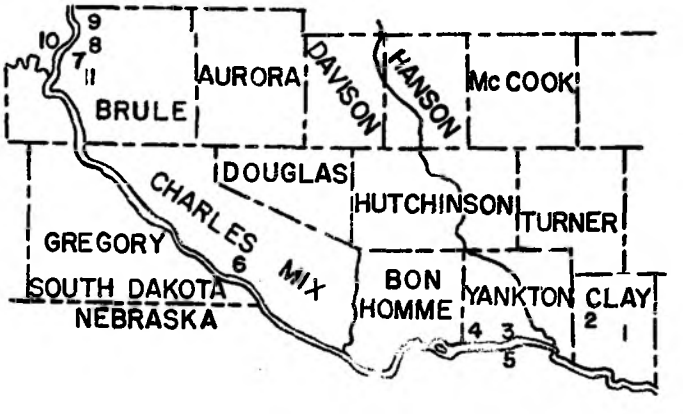


Figure 1

STRATIGRAPHY

The Niobrara is the upper formation in the Colorado group of the upper Cretaceous. It is sharply set off from the Sharon Springs member of the Pierre shale above, and the Carlile shale below. It was named by Meek and Hayden (1861, pp. 419, 422) from exposures along the Missouri River near the mouth of the Niobrara River in northeastern Nebraska. Cragin (1896, p. 51) named the upper, main body of the Niobrara the Smoky Hill chalk from exposures along the Smoky Hill River in Kansas. Mudge (1876, pp. 218-221) used the name Fort Hays division to include the upper part of the Benton and the lower part of the Niobrara. Williston (1893, pp. 108-109) restricted the term to the heavy stratified chalk of the basal Niobrara, but included it in the Benton. Cragin (1896), and also Williston (1897, p. 237) placed the Fort Hays in the Niobrara as its basal member, underlying the Smoky Hill member.

Lithologically the Niobrara formation varies from marl through chalky marl to chalk[1] in the area under discussion. It varies in thickness from a maximum of 182 feet at the quarry of the "Old Cement Plant" in Yankton County, to a minimum of 157 feet at Fort Randall Dam. The rock is dark grey to black when fresh but bleaches rapidly upon exposure to an orange, buff or white color. In the southern part of this area the formation consists of chalk and chalky marl. There is an increase in the amount of argillaceous material to the north, with an attendant decrease in $CaCO_3$ content, and it grades into a marl and chalky marl in the Chamberlain area. Chemical analyses show that the lighter colored, weathered rock is higher in $CaCO_3$ than the darker, fresh rock. (Curtiss, 1951a, p. 13; 1951b, p. 41) Under ordinary weathering conditions the $CaCO_3$ would be the first thing dissolved out, but apparently there has been a reversal of the ordinary weathering processes in this case with a resulting concentration of the carbonate near the surface.

The results of this investigation indicate that it would be extremely difficult to recognize a lithologic subdivision of the Niobrara formation in this area. The lower part of the formation is somewhat harder, more dense, and has a slightly more bentonitic[2] clay fraction than the upper part. These

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1. Throughout this report chalk is restricted to a rock consisting of 80 to 100% $CaCO_3$, chalky marl to a rock consisting of 65 to 80% $CaCO_3$, and marl to a rock consisting of 35 to 65% $CaCO_3$.
2. Determined by the benzidine test.

changes are very minor and would be a poor basis for subdividing the Niobrara into members. However, as they occur at the same horizon as the major microfaunal change, the Fort Hays-Smoky Hill contact is placed at this horizon. Since the main basis for subdivision is micropaleontologic rather than lithologic, it remains very difficult if not impossible to distinguish between the two members in the field without additional laboratory study.

In every section in which the upper part of the Niobrara was present there was a horizon marked by the presence of numerous thin seams of bentonite (Figure 1). Although this horizon varies in its position in relation to the top of the formation, it appears to be a time marker and this theory is supported by the paleontologic evidence. Where samples of short vertical range were taken Loxostoma cushmani did not occur below the bentonite horizon, and where larger samples were taken, this species was not found in any sample which began below these bentonites. More detailed sampling would be necessary to establish their exact relationship, but the evidence accumulated thus far suggests that Loxostoma cushmani made its debut in the Niobrara sea while these bentonites were being laid down.

GENERAL DISCUSSION OF THE FAUNA

During this investigation 59 species of Foraminifera and six species of Ostracoda were described from the Niobrara formation. Their distribution and relative abundance is recorded in Table 1. A study of these microfossils shows that it is possible, at least in the areas covered in this report, to divide the Niobrara into four faunal zones. These zones are graphically illustrated in the generalized sections on Figure 1. The largest faunal break is at the Smoky Hill-Fort Hays contact, and each of these members in turn can be divided into two zones. All of the ostracodes and 39 species of forams were restricted to the lower or Fort Hays member while only three species of forams were observed only in the Smoky Hill. The remaining sixteen species of Foraminifera occurred in both members although four of them were exceedingly rare in the Smoky Hill.

Foraminifera were very abundant in the Smoky Hill member but the number of species represented was relatively small. The bulk of the fauna of this member consists of three species; Gumbelina globulosa, Globigerina cretacea, and Globigerinella aspera. Loxostoma cushmani is common in and restricted to the upper part of the Smoky Hill, and defines the upper or Loxostoma zone. A few specimens near the top of this zone at some localities tend toward L. clavatum. The lower zone of the Smoky Hill member is marked by the absence of any Loxostoma.

Foraminifera are much more varied in the Fort Hays member, and in addition ostracodes were fairly common in most samples of this member. It is possible to zone this lower member on two small but very distinctive species of Eouvigerina which are quite restricted in their vertical range. E. aculeata is quite abundant in the upper part of the member and is found only very rarely in the lower part. E. plummerae is abundant in the lower part and was never observed to range upward into the horizon where E. aculeata is abundant. These two species are the only ones of any abundance that are restricted to either of these zones, so this zonation depends entirely on their occurrence.

The following microfaunal lists show the distribution of the species in relation to the Smoky Hill and Fort Hays members.

Species Found Throughout The Niobrara Formation

Foraminifera

*Dorothia pupoides (d'Orbigny)
*Robulus sp.
*Lenticulina sublaevis Morrow
Gumbelina globulosa (Ehrenberg)
Gumbelina moremani Cushman
Gumbelina plummerae Loetterle
Gumbelina pseudotessera Cushman
*Bulimina reussi Morrow
Virgulina sp. #1
*Valvulineria plummerae Loetterle
Globigerina cretacea d'Orbigny
Globigerinella aspera (Ehrenberg)
Schackoina trituberculata Morrow
Globotruncana canaliculata (Reuss)
Globotruncana marginata (Reuss)
Globorotalites umbilicata (Loetterle)
Planulina kansasensis Morrow

*Exceedingly rare in Smoky Hill Member.

Species Restricted to the Smoky Hill Member

Foraminifera

Neobulimina irregularis Cushman and Parker
Loxostoma clavatum (Cushman)
Loxostoma cushmani Wickenden

Species Restricted to the Fort Hays Member

Foraminifera

Spiroplectammina semicomplanata (Carsey)
Gaudryina (Siphogaudryina) austinana Cushman
Gaudryina (Pseudogaudryina) nebrascensis Loetterle
Dorothia cf. D. filiformis (Berthelin)
Robulus munsteri (Roemer)
Robulus navarroensis (Plummer)
Planularia umbonata Loetterle
Frondicularia extensa Morrow
Frondicularia undulosa Cushman
Kyphopyxa christneri (Carsey)
Globulina lacrima Reuss var. subsphaerica (Berthelin)
Ramulina cf. R. aculeata (d'Orbigny)
Bullopora sollasi (Chapman)
Ventilabrella austinana Cushman
Bolivinitella eleyi (Cushman)
Eouvigerina aculeata Cushman

(continued)

Planularia sp. #1
Marginulina bullata Reuss
Marginuulina sp. #1
Dentalina aculeata d'Orbigny
Dentalina granti (Plummer)
Dentalina lorneiana d'Orbigny
Dentalina niobrarensis Loetterle
Dentalina reflexa Morrow
Nodosaria zippei Reuss
Nodosaria sp. #1
Saracenaria triangularis (d'Orbigny)
Vaginulina texana Cushman
Palmula suturalis Cushman
Eouvigerina plummerae Cushman
Neobulimina canadensis Cushman and Wickenden
Virgulina tegulata Reuss
Pleurostomella austinana Cushman
Nodosarella gracillima Cushman
Gyroidina depressa (Alth)
Gyroidina nitida (Reuss)
Hastigerinella simplex Morrow
Globorotalites micheliniana (d'Orbigny)
Anomalina henbesti Plummer

Ostracoda

Cytherella bullata Alexander
Brachycythere sphenoides (Reuss)
Cythereis coryelli Loetterle
Cythereis foersteriana (Bosquet)
Cythereis niobrarensis Morrow
Cythereis subgracillis Morrow

DETAILED DISCUSSION OF LOCALITIES STUDIED

The following is a detailed discussion of the lithologic and faunal characteristics of the Niobrara formation at the various localities studied during this investigation.

CLAY COUNTY

Although the Niobrara formation undoubtedly underlies much of Clay County, it is generally covered by a thick mantle of glacial drift and is only exposed at a few places. Samples of the formation were collected by the author at Spirit Mound in the S½, NW¼, Sec. 14, T. 93 N., R. 52 W., and the author and Dr. Stevenson collected some grab samples from the chalk exposures in the E½, NE¼, Sec. 8, T. 93 N., R. 52 W. It was not possible to establish the exact stratigraphic position of these exposures as neither the top nor the bottom of the formation is exposed at either locality. However, it was possible to determine their position in the Niobrara with a fair degree of accuracy from a study of the microfossils.

The chalk exposed at Spirit Mound has been very highly weathered and is exceedingly soft. It is bentonitic and orange to buff in color. It abounds in microfossils with foraminifera being exceedingly abundant and represented by 43 species. In addition, five species of Ostracoda were also found in this material. Eouvigerina plummerae is abundant at this locality indicating the chalk is from the lower zone of the Fort Hays member.

The base of the chalk is covered in Sec. 8 but this exposure represents the lower 50 to 60 feet of the Niobrara. The samples collected at this locality all contained a good Fort Hays microfauna. Both the Eouvigerina plummerae and E. aculeata zones were well represented, so nearly the entire section of the Fort Hays member is probably represented in this exposure. The upper 18± feet is placed in the E. aculeata zone and the lower 42± in the E. plummerae zone. The following log was made in Sec. 8.

Glacial Drift
Niobrara Formation - 50 to 60 feet

2' - Hard, white, ledge forming chalk, bentonitic.

16' - Soft, shaly, highly bentonitic chalk, weathers buff.

7' - Creamy white, highly bentonitic chalk, weathers buff at base.

20' - Covered

5' - Slightly bentonitic, white chalk.

10' - Covered

Shale soil (?) - Carlile shale (?)

YANKTON AREA

The Niobrara formation is exposed in nearly vertical cliffs up to 135 feet high along the bluffs of the Missouri River in the vicinity of Yankton. Drill cores show that the formation has a total thickness of a little more than 180 feet in this area. The chalk is conformably overlain by the Sharon Springs member of the Pierre shale in most of this area. In places the Pierre shale and some of the Niobrara has been removed by pre-glacial erosion and the chalk is covered by a mantle of glacial drift. Samples of the Niobrara were collected by Mr. R. E. Curtiss from the quarry of the "Old Portland Cement Plant" in the SE¼, Sec. 17, T. 93 N., R. 56 W., and from the NW¼, Sec. 22, T. 93 N., R. 57 W. for analyses in connection with his investigation of cement raw materials. These samples were examined by the author for microfossils but they were of such magnitude, 15 and 20 foot channel samples were taken, that it was impossible to zone the chalk in these exposures. Portions of the Niobrara formation from a drill core in the SE¼, Sec. 7, T. 33 N., R. 1 W., Cedar Co., Nebraska, were also sampled and studied. The State Cement Plant's Chemical Laboratory made analyses of these samples which show that the outcropping material has a higher $CaCO_3$ content than the subsurface samples taken from the drill core. (Curtiss, 1951b, pp. 50-54) The Niobrara is a true chalk in its weathered outcrops while the material

from the core is a chalky marl. The higher $CaCO_3$ content of the outcropping material is apparently due to a concentration of $CaCO_3$ upon weathering, although this is a reversal of the ordinary weathering procedure.

At the quarry of the "Old Portland Cement Plant" the top 82 feet of the Niobrara is exposed in a nearly vertical cliff. U. S. Corps of Army Engineer records of a drill core near the site of this quarry show the Niobrara has a total thickness of 182.2 feet. Mr. Curtiss (1951b, pp. 48, 49) made the following brief log of the exposure at this quarry.

Pierre Shale
Niobrara formation - 82 feet

41' - Weathered, buff Niobrara chalk. Black when fresh but bleaches rapidly upon exposure. Contains Ostrea congesta.

34' - White chalk with some gray lenses or patches. Contains Ostrea congesta.

7' - Black slabby chalk to base of quarry.

Foraminifera were abundant in the samples collected at this quarry but the variety of species was limited showing that the entire outcrop is of the Smoky Hill member. Loxostoma cushmani was present in the top two twenty-foot channel samples, but the magnitude of these samples made it impossible to accurately establish the base of this zone.

About 135 feet of chalk is exposed in a steep bluff in the NW$\frac{1}{4}$ of Sec. 22. The lower 5 or 10 feet of this exposure is probably Fort Hays but this cannot be verified either by the lithology or microfossils at this time. The samples collected were of such magnitude that the Fort Hays fauna, if present in the lower 5 or 10 feet, could easily have been missed. The outcropping chalk is highly weathered, and a more detailed examination would be necessary to establish any lithologic change. Loxostoma cushmani was present in grab samples taken at 10.8 and 21.6 feet from the top, but the base of the Loxostoma zone cannot be determined as the first channel sample began at 37.9 feet from the top.

The upper part of the Niobrara has been removed from the area in Cedar Co., Nebraska, from which the drill core

was obtained, and the lower 85 feet is overlain by glacial drift. Only portions of the Niobrara from this core were obtained, and these were logged by Dr. Stevenson and the author as follows:

Depth

0	- 39'	- Glacial drift
39.0	- 1240'	- Niobrara formation
39.0	- 40.0'	- Very soft, pink to buff, very slightly bentonitic chalky marl, weathered.
44.6	- 45.6'	- As above, with occasional selenite veinlets.
46.2	- 46.6'	- As above, contains a 3½" hard selenite veinlet.
47.2	- 48.3'	- As above
48.3	- 49.3'	- As above
50.3	- 51.2'	- As above
51.9	- 52.9'	- As above
53.5	- 54.5'	- Partly as above and partly light grey and somewhat harder.
60.2	- 61.2'	- Soft, buff, very slightly bentonitic chalky marl.
66.2	- 66.7'	- As above
- - - -	- - - -	- Smoky Hill-Fort Hays Contact
71.7	- 72.7'	- Light grey, massive, bentonitic chalky marl, harder than above.
77.7	- 78.2'	- As above
78.2	- 83.4'	- As above
83.4	- 84.4'	- As above
94.4	- 95.4'	- As above
99.4	- 100.4'	- As above
105.9	- 106.9'	- As above with some grey streaks.
111.9	- 112.9'	- Mottled light and dark grey bentonitic chalk.
118.0	- 119.0'	- As above

The grey chalky marl is somewhat harder and is more bentonitic than the pinkish and buff material above. As there is also a faunal change at this horizon, it is chosen as the Smoky Hill-Fort Hays contact. Foraminifera are abundant throughout this material, but they are much more varied in the grey chalky marl. In addition, four species of ostracodes were observed rarely in the grey material. No Loxostoma were observed in these samples, the upper part of the Niobrara

including the entire Loxostoma zone having been removed prior to glaciation. Eouvigerina aculeata was present in the first two samples of the grey marl, but as there are five foot intervals between the next samples above and below, the thickness of this zone could not be accurately established. Eouvigerina plummerae was abundant in the samples from 40.6 feet above the base of the Niobrara on down.

FORT RANDALL DAM

A drill core from the Fort Randall Dam site was given to the South Dakota State Geological Survey by Mr. John Trantina while he was chief geologist at this project. This core, which started in the Pierre shale, included the entire section of the Niobrara, and extended about 20 feet into the Carlile shale, was logged, sampled and examined for microfossils during this investigation. The Niobrara formation is 157.1 feet thick in this core. On the basis of lithology and microfossils, the upper 76.8 feet is placed in the Smoky Hill member and the lower 80.3 feet in the Fort Hays. Dr. Stevenson and the author made the following detailed log of the Niobrara from this core.

Depth

46.0- 76.7 - Pierre shale
76.7-233.8 - Niobrara Formation

76.7- 78.1 - Brownish grey, soft, non-bentonitic, porous, chalky marl with white specks. Hard, noncalcareous, dark grey shale parting about 1" thick at 77.8'. A ¼" bentonite at 76.8'.

78.1- 83.2 - Light grey, harder, non-bentonitic, porous chalk with abundant white specks. 1½" and 3/4" bentonites at 81.7 and 82.2' respectively.

83.2- 86.4 - Brownish-grey, softer, non-bentonitic, porous chalky marl with white specks. ¼" bentonites at 83.3 and 84.1'.

86.4- 96.5 - Light grey, harder, non-bentonitic, porous chalk with white specks. ½" to 1" bentonites at 87.3, 87.6 and 89.7'.

96.5-103.0 - Grey, soft, non-bentonitic, porous chalk with abundant white specks.

103.0-146.0 - Light grey, non-bentonitic, harder, porous chalk with a few white specks.

146.0-153.7 - Light brownish-grey, non-bentonitic, porous chalky marl with white specks and local indistinct laminations.

- - - - - - - - Smoky Hill-Fort Hays Contact

153.7-159.0 - Very light grey, slightly bentonitic, porous chalky marl. Thin Ostrea zone at 157.5'.

159.0-161.0 - Light grey, bentonitic, chalky marl with white specks and shaly fracture.

161.0-183.5 - Very light grey, bentonitic, porous chalky marl with white specks, scattered dark grey spots and streaks, and occasional horizons with shaly fracture.

183.5-186.0 - Light grey, bentonitic, porous chalky marl with white specks and shaly fracture.

186.0-194.5 - Very light grey, bentonitic, porous chalky marl with white specks. Light streak with much biotite and some pyrite at 193.5'.

194.5-201.0 - Highly fossiliferous (Ostrea), bentonitic porous chalky marl. Very light grey in upper part and light grey with shaly fracture in lower part.

201.0-209.0 - Light grey, bentonitic, porous chalky marl with white specks and lenselike spots. Occasional Ostrea shells.

209.0-219.8 - Very light grey, bentonitic, porous chalky marl with a few medium grey horizons.

219.8-228.8 - Mottled very light and light grey, slightly bentonitic, porous chalky marl with some medium grey streaks with white specks. Fish scales at scattered horizons and occasional Ostrea shells near base. 60° fault at 228'.

228.8-231.0 - Mottled light and medium grey, slightly bentonitic, porous chalky marl with white specks and shaly fracture.

231.0-232.1 - Grey calcareous, fine sandstone with white chalk fragments.

232.1-233.8 - Grey calcareous, argillaceous, fine sandstone.

233.8-253.6 - Carlile shale. Bottom of hole at 253.6'.

Outwardly the Smoky Hill and Fort Hays members appear much alike lithologically but a detailed examination shows that they differ in several respects. The Fort Hays is generally lighter in color and somewhat harder than the Smoky Hill. It has bentonite disseminated throughout, it always turns bluish to purple when treated with benzedine, whereas the Smoky Hill is non-bentonitic but contains numerous thin seams of bentonite. Fossiliferous streaks containing abundant Ostrea shells, and perhaps some Inoceramus fragments,

are common in the Fort Hays but were not observed in the Smoky Hill. Insoluble residue tests of a few random samples indicate that the Fort Hays is a rather uniform chalky marl while the Smoky Hill varies from chalk to chalky marl of low calcareous content.

Foraminifera are abundant throughout the Niobrara but insofar as variety of species is concerned the fauna is largely restricted to the Fort Hays member. The bulk of the fauna of the Smoky Hill is made up of three species: Globigerina cretacea, Globigerinella aspera and Gumbelina globulosa; and only eight species were represented in all. The Loxostoma zone has a thickness of only 7.5 feet in this core. Foraminifera are much more varied in the Fort Hays, being represented by 37 species, and Ostracoda, although not found in abundance, are restricted to this member. As in all other sections studied, the Fort Hays can be divided into two zones. Eouvigerina aculeata is abundant in the upper 47.5 feet of this member and occurs only very rarely below this, while E. plummerae is an excellent guide to the lower 36.8 feet. No other species which occurs in any abundance was found to be restricted to either of these zones so it appears that their recognition depends entirely on the occurrence of these two, very small but distinctive species.

CHAMBERLAIN AREA

Only the upper part of the Niobrara formation is exposed in the bluffs of the Missouri River and its tributaries in the vicinity of Chamberlain, but the formation was determined to have a total thickness of approximately 175 feet in the Biskeborn well in the NW¼, Sec. 14, T. 103 N., R. 71 W., Brule Co. The top of the formation was established on a lithologic basis and the bottom from microfossils. As accurately as could be determined by a study of the microfossils from the cuttings of this well, the Smoky Hill member is about 125 feet thick and the Fort Hays about 50 feet thick. Of the Fort Hays, approximately 20 feet is placed in the Eouvigerina aculeata zone and about 30 feet in the E. plummerae zone.

Mr. R. E. Curtiss and Dr. R. E. Stevenson collected samples of the Niobrara from four localities in this vicinity. The outcrops sampled are in Sec. 36, T. 105 N., R. 71 W., Brule Co.; Sec. 17, T. 104 N., R. 71 W., Lyman Co.; and Secs.

15 and 19, T. 104 N., R. 71 W., Brule Co. The upper 91 feet of the Niobrara is exposed in Sec. 36, the upper 68 feet in Secs. 17 and 15, and the upper 30 feet in Sec. 29. Although only the Smoky Hill member is exposed, and this in varying amounts, Mr. Curtiss (1951a, p. 16) found that he could recognize three distinct color zones at each outcrop. It changes from buff near the top, to light grey, to medium to dark grey near the base. It is possible that this color transition is at least in part due to the bleaching effect of weathering. The medium to dark grey zone is somewhat more massive than the material above, and therefore the length of time required for weathering to change the color probably is increased. This dark zone contains from 6 to 9 thin buff bentonite seams at all four localities. Chemical analyses were made of the samples collected in this area by the State Cement Plant's Chemical laboratory in Rapid City for Mr. Curtiss' (1951a, pp. 20-23) investigation. These analyses show that the Niobrara is made up of marl and chalky marl in this area. Foraminifera are well represented in this material but are not as abundant as in the Niobrara from the other localities studied. The Fort Hays fauna was not encountered in any of the samples from the outcropping localities and although the Loxostoma zone is present, the base of it could not be determined because of the vertical range included in the samples.

Mr. Curtiss (1951a, p. 18) made the following log of the outcrop in Sec. 36.

Pierre Shale
Niobrara Formation - 91 feet

18' - Weathered, buff marl and chalky marl, thin bedded, little gypsum, 1 foot white layer at base.
53' - Light grey chalky marl and marl, some 1/8 to 1/4 inch gypsum veinlets, few iron gypsum concretions ½ to 2 inches in diameter, thin layers of buff chalky marl in upper part.
20' - Medium to dark grey zone massive chalky marl, contains 7 buff bentonites ½ to 2½ inches thick with a little iron and gypsum above and below.

SYSTEMATIC DESCRIPTIONS

Phylum PROTOZOA
Class SARCODINA
Subclass RHIZOPODA
Order FORAMINIFERA
Family TEXTULARIDAE
Subfamily SPIROPLECTAMMININEA
Genus SPIROPLECTAMMINA Cushman 1937

Spiroplectammina cf. S. semicomplanata (Carsey)
Plate 1, Figure 1

Textularia semicomplanata - Carsey, Texas Univ. Bull. 2612, pl. 3, fig. 4, 1926.

Spiroplectammina semicomplanata - Plummer, Texas Univ. Bull. 3101, p. 129, pl. 8, fig. 7 (not fig. 8), 1931.
Cushman, Cushman Lab. Foram. Research Contr., vol. 8, pp. 94, 96, pl. 11, figs. 8, 9, 1932.
Cushman and Hedberg, idem., vol. 17, p. 83, pl. 21, figs. 5, 6, 1941.
Cushman and Todd, idem., vol. 19, p. 51, pl. 9, fig. 3, 1943.
Cushman, U.S.G.S. Prof. Paper 206, p. 28, pl. 6, figs. 5-14, 1946.

Spiroplectammina anceps - Cushman, Tennessee Div. Geol. Bull. 41, p. 18, pl. 1, figs. 5a, b, 1931.

Test tapering from greatest breadth at apertural end to sharply rounded initial extremity, thickest in the middle, periphery acutely angular, faintly lobulate, chambers distinct, not inflated, increasing rapidly in breadth as added, later chambers much broader than high, earliest portion coiled, rapidly becoming biserial; sutures distinct, slightly depressed, slightly oblique, gently curved backwards towards periphery; aperture a low arched opening at base of final chamber; test arenaceous but smoothly finished. Length of figured specimen .27 mm., greatest breadth .16 mm.

This species has been previously recorded only from the Taylor and Navarro of the Gulf Coast area. In this study it occurred very rarely in the Fort Hays member at Spirit Mounds.

Family VERNEULINIDAE

Genus GAUDRYINA d'Orbigny, 1839

Subgenus SIPHOGAUDRYINA Cushman, 1935

Gaudryina (Siphogaudryina) austinana Cushman
Plate 1, Figure 2

Gaudryina (Siphogaudryina) austinana - Cushman, Cushman Lab. Foram. Research Sp. Pub. 7, p. 74, pl. 11, figs. 1-3, 1937.
Cushman and Deaderick, Cushman Lab. Foram. Research Contr., vol. 18, p. 53, pl. 9, figs. 15, 16, 1942.
Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 84, pl. 13, fig. 2, 1944. U. S. G. S. Prof. Paper 206, p. 35, pl. 8, figs. 5-7,1946.

"Test somewhat longer than broad, the early portion triserial and triangular, in the later portions biserial and somewhat compressed, the keel of one side dividing so that a generally quadrangular test results, angles sharp or somewhat rounded; chambers fairly distinct especially in the later portion, where they are somewhat inflated, sutures fairly distinct, oblique, the later sutures slightly depressed, wall arenaceous, with much cement, either smooth or slightly roughened on the exterior; aperture a small low opening in a rather deep, semicircular reentrant of the margin of the last formed chamber." Length of figured specimen .28 mm., breadth .15 mm.

The above description is taken from Cushman who reported it from the Austin chalk of the Gulf Coastal region. In this material it occurred rarely in the Fort Hays from the drill cores at Fort Randall Dam and in Cedar Co., Nebraska.

Subgenus PSEUDOGAUDRYINA Cushman, 1936

Guardryina (Pseudogaudryina) nebrascensis (Loetterle)
Plate 1, Figures 3a, b

Gaudryina nebrascensis Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 20, pl. 1, figs. 3a,b, 1937.
Cushman, Cushman Lab. Foram. Research Sp. Pub. 7a, p. 9, pl. 1, figs. 14a, b, 1946.

Test large, elongate, compressed, early portion triserial, sharply triangular, later and larger portion biserial, early stage of biserial portion triangular, the angle between the two longer sides becoming rounded in later stages, triserial portion tapering quite rapidly to bluntly pointed initial extremity, biserial portion tapering very gradually to greatest breadth at apertural end; chambers rather indistinct in triserial portion, very distinct in biserial portion, much overlapping, with a prominent shoulder near anterior end of each, surface concave below the shoulder, convex above, one series of biserial chambers with a sharply truncate periphery, with a posterior extension at each angle, other series with the peripheral margin angled, becoming rounded in last few chambers; sutures rather indistinct in triserial portion, flush with surface, distinct and depressed in biserial portion, appearing as nearly horizontal lines on narrower face and as sharp zigzag lines on two broader faces; aperture a low opening in a deep reentrant in the inner margin of the final chamber, wall arenaceous, rather smoothly finished. Length of illustrated specimen .79 mm., breadth .25 mm.

This is a very distinctive species which is probably restricted to the Fort Hays member. The types are from this member northeast of St. James, Nebraska. In this investigation it was found to be rare at Spirit Mound.

Family VALVULINIDAE

Subfamily EGGERELLINAE

Genus DOROTHIA Plummer, 1931

Dorothia cf. D. filiformis (Berthelin)
Plate 1, Figures 4a, b

Dorothia cf. D. filiformis - Cushman and Hedberg, Cushman Lab. Foram. Research Contr., vol. 11, p. 85, pl. 21, fig. 11, 1941.

A few specimens from the Fort Hays in Cedar Co., Nebraska, and Fort Randall Dam closely resemble Cushman's figures of this species.

Test very elongate, early portion tapering to pointed initial extremity, sides of later and much larger portion

parallel or very slightly tapering, earliest stage with four or more chambers in a whorl, number of chambers rapidly reduced to two with greatest part of test biserial, chambers indistinct in early portion, chambers of biserial portion distinct, slightly inflated, somewhat compressed, increasing gradually in height as added, very little if any increase in breadth; sutures distinct in biserial portion, depressed; wall smooth, finely arenaceous but with a large amount of calcareous cement, becoming almost entirely calcareous in last chambers, aperture a low-arched opening at base of last chamber. Length of figured specimen .90 mm., breadth .31 mm.

Dorothia pupoides (d'Orbigny)
Plate 1, Figures 5a,b

Gaudryina pupoides - d'Orbigny, Mem. Soc. Geol. France, ser.1, vol. 4, p. 44, pl. 4, figs. 22-24, 1840.
Sandidge, Jour. Paleo., vol. 6, p. 268, pl. 41, fig. 1, 1932.
Loetterle, Nebr. Geol. Survey Bull., 2nd ser., Bull.12, p. 19, pl. 1, figs. 1a, b, 1937.

Dorothia pupoides - Cushman, Cushman Lab. Foram. Research Sp. Pub. 7, p. 100, 1937.

Test gently tapering to bluntly pointed initial extremity, widest at apertural end; somewhat compressed, earliest stages with more than three chambers in a whorl, rapidly becoming triserial and then biserial; chambers of early stages indistinct, becoming distinct and slightly inflated in biserial stage, increasing regularly in size as added; sutures indistinct in early stages, distinct and slightly depressed in biserial stage, very slightly oblique; wall smooth, finely arenaceous with much calcareous cement, final chambers almost entirely calcareous; aperture an arched opening at the inner margin of the final chamber. Length of figured specimen .34 mm., breadth .28 mm.

This species was found in the Fort Hays member at every locality examined and occurred very rarely in the Smoky Hill from the Cedar Co., Nebraska, core.

Family LAGENIDAE

Subfamily NODOSARIINAE

Genus ROBULUS Montfort, 1808

Robulus munsteri (Roemer)
Plate 1, Figures 6a, b

Robulus munsteri - Roemer, Verstein, norddeutsche Oolithergebirges, Nachtrag., p. 48, pl. 22, fig. 29, 1839.
Cushman, Jour. Paleo., vol. 6, p. 334, pl. 50, figs. 2a, b, 1932; Cushman Lab. Foram. Research Contr., vol. 17, p. 58, pl. 15, fig. 6, 1941.
Cushman and Deaderick, Cushman Lab. Foram. Research Contr., vol. 18, p. 56, pl. 10, figs. 10-13, 1942; Jour. Paleo., vol. 18, p. 331, pl. 50, fig. 28, 1944.
Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 85, pl. 13, fig. 7, 1944; U. S. G. S. Prof. Pap. 206, p. 53, pl. 17, figs. 3-9, 1946.

Test closely coiled except for final portion which may become slightly evolute, somewhat compressed, with a smooth, rounded boss of clear shell material at each side, periphery with a narrow keel; chambers distinct, numerous, increasing gradually in size as added; sutures distinct, limbate, tangential, slightly curved, flush with surface of test; aperture at the peripheral angle, radiate with an enlarged ventral slit; wall smooth, finely perforate. Diameter of figured specimen .52 mm., thickness .27 mm.

Specimens showing a great deal of variation have been referred to this species from beds ranging in age from upper Austin to lower Navarro by Cushman. A few specimens from the Fort Hays member at Spirit Mound and the drill core at Fort Randall Dam agree well with some of Cushman's figures of this species.

Robulus navarroensis (Plummer)
Plate 1, Figures 7a, b

Cristellaria navarroensis - Plummer, Texas Univ. Bull. 2644, p. 39, figs. 4a, b, (in text), 1929.

Lenticulina navarroensis - Plummer, idem., Bull. 3101, p. 141, 1931.

Robulus navarroensis - Jennings, Bull. Am. Paleontology, vol. 23, no. 78, p. 15, pl. 1, figs. 14a, b, 1936.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 20, pl. 1, figs. 4a, b, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 17, p. 55, pl. 15, fig. 1, 1941.
Cushman and Todd, idem., vol. 19, p. 54, pl. 9, fig. 17, 1943.
Cushman, U. S. G. S. Prof. Pap. 206, p. 51, pl. 16, figs. 6-8, 1946.

Test closely coiled throughout, compressed, umbonate, periphery with a broad thin keel; chambers numerous, 10 to 12 in final whorl, distinct, of uniform shape and increasing gradually in size as added; sutures distinct, slightly limbate, gently curved, fusing with a boss of clear shell material at the center; aperture at the peripheral angle, radiate, with an elongate ventral slit; wall generally smooth, sutures sometimes slightly raised near center. Diameter of figured specimen .54 mm., thickness .31 mm.

This species is widely distributed in the upper Cretaceous of the south-central states. Loetterle reported it to be rare in the Fort Hays of Kansas, Nebraska and South Dakota and in the material it was also restricted to the Fort Hays.

Robulus sp.

The genera Robulus and Lenticulina are very difficult to work with as the generic distinction is based on an apertural feature, and the apertures of most specimens from this material are at least in part broken away. There is also a great deal of variation within species and they have not, for the most part, been studied sufficiently to determine just what allowances for variation should be made. Numerous specimens belonging to the genus Robulus, and probably some Lenticulinas, have been grouped together as Robulus sp. because of the difficulty of determining a specific designation. These specimens occur most frequently in the Fort Hays member but a few are from the Smoky Hill.

Genus LENTICULINA Lamarck, 1804

Lenticulina cf. L. sublaevis Morrow
Plate 1, Figures 8a, b

Lenticulina sublaevis - Morrow, Jour. Paleo., vol. 8, p. 189, pl. 30, figs. 14, 20a, b, 1934.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 22, pl. 1, figs. 7a, b, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 17, p. 66, pl. 16, figs. 10a, b, 1941; U. S. G. S. Prof. Pap. 206, p. 56, pl. 18, fig. 18, 1946.

Numerous specimens from the Fort Hays at every locality and one questionable specimen from the Smoky Hill in the core from Cedar Co., Nebraska, are referred to this species although the apertural characteristics indicate they should probably be placed in the genus Robulus. They agree well in other characteristics with published descriptions and figures of this species, and there is some doubt in the author's mind that Morrow and Loetterle correctly described and figured the aperture.

Test quite large, involute throughout, sides strongly convex, thickness about one-half the diameter, with a broad, smooth boss at each side, periphery slightly keeled to sharply rounded; chambers numerous, 10 to 12 in final whorl, early ones usually rather indistinct; sutures limbate, slightly curved, flush with surface or slightly raised, final ones somewhat depressed in large specimens; aperture at the outer peripheral angle, radiate, with a slight enlargement of the ventral slit on the apertural face. Diameter of illustrated specimen .45 mm., thickness .24 mm.

Genus PLANULARIA Defrance, 1824

Planularia umbonata Loetterle
Plate 1, Figures 9a, b

Planularia umbonata - Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 23, pl. 2, figs. 2a, b, 1937.

Test much compressed, sides nearly parallel in edge view except for slight thickening of umbonal region; early stage coiled, tending to become uncoiled in adult; periphery of coiled stage with a narrow keel, rounded or somewhat truncate in adult, thickened and smooth; chambers numerous, distinct, much broader than high, increasing very little in height as added, becoming strongly oblique in adult; sutures distinct, slightly limbate and raised, strongly oblique in later portion, curved and thickened into knob-like masses near peripheral margin; aperture at peripheral angle, radiate; wall finely perforate. Length of figured specimen .57 mm., breadth .22 mm., thickness .09 mm.

A single specimen which probably represents the megalospheric form of this species was found in the material collected at Spirit Mound. It is smaller, has a large bulbuous proloculum, an apertural neck, and a strongly truncated peripheral margin with a thin ridge on each side.

Loetterle reported this species from two localities in Nebraska. In this investigation it was found to occur rarely in the Fort Hays at Spirit Mound and in the cores from Fort Randall Dam and Cedar Co., Nebraska.

Planularia sp. #1
Plate 1, Figures 10a, b

Test much compressed, coiled, periphery acute, with a delicate keel in early portion of some specimens; chambers distinct, slightly inflated, increasing gradually in size as added, about seven in the final whorl; sutures distinct slightly depressed, gently curved; aperture at the peripheral angle, protruding and radiate; wall smooth except for depressed sutures. Diameter of figured specimen .33 mm., thickness .14 mm.

A few specimens from the Fort Hays member in Sec. 8, Clay Co., are referred to this species. It may represent an undescribed species but until more material can be collected and more literature can be studied, it is deemed advisable not to assign a new name to it.

Genus MARGINULINA d'Orbigny, 1826

Marginulina bullata Reuss
Plate 1, Figures 11a, b

Marginulina bullata - Reuss, Verstein bohm Kreideformation, pt. 1, p. 29, pl. 13, figs. 34-38, 1845.
Cushman, Cushman Lab. Foram. Research Contr., vol. 13, p. 96, pl. 14, figs. 9-15, 1937; idem., vol. 20, p. 6, pl. 1, fig. 21, 1944; U. S. G. S. Prof. Pap. 206, p. 62, pl. 21, figs. 32-37, 1946; Foraminifera, Ed. 4, key pl. 21, figs. 7a, b, 1948.

Test stout, earliest stage coiled, later uncoiled portion making up most of test, nearly circular in cross section; chambers distinct, few in number, early ones increasing rapidly in size, later ones much inflated; sutures distinct, early ones not depressed, later ones distinctly depressed, aperture radiate, at the dorsal peripheral margin, with a long, cylindrical neck; wall very smooth, finely perforate.

This species occurs in beds of Taylor and Lower Navarro age in the Gulf Coast region. In this material it was found only in the Fort Hays member at Spirit Mound where it was rare.

This species is quite variable in number of chambers and size of the test but the long, tubular apertural neck and strongly inflated chambers make it quite distinct from any other species of this genus.

Marginulina sp. #1
Plate 1, Figures 12a, b

Test elongate, slightly compressed, peripheral margin rounded, earliest portion coiled, rapidly becoming uncoiled; ventral margin straight or slightly convex, dorsal margin concave; chambers distinct, broader than high in uncoiled portion, increasing gradually in size as added; sutures quite distinct, flush with the surface, strongly oblique in the later portion; aperture at the dorsal peripheral angle, radiate; wall smooth. Length of figured specimen .55 mm., breadth .15 mm.

A few specimens from the Fort Hays at Spirit Mound do not seem to belong to any species described in the literature available so they are placed here and left unnamed for the present.

Genus DENTALINA d'Orbigny, 1826

Dentalina aculeata d'Orbigny
Plate 1, Figure 13

Dentalina aculeata - d'Orbigny, Soc. Geol. France Mem., 1st. ser., vol. 4, p. 13, pl. 1, figs. 2, 3, 1840. Cushman, Jour. Paleontology, vol. 6, p. 335, pl. 50, fig. 7, 1932; Cushman Lab. Foram. Research Contr., vol. 20, p. 6, pl. 2, fig. 11, 1944; U. S. G. S. Prof. Pap. 206, p. 67, pl. 26, figs. 17, 18, 1946.

A few incomplete specimens from this material probably belong to this species. They show one spiny chamber and parts of the connecting necks. The classification of these specimens is very questionable and Cushman (1946b, p. 67) states that "d'Orbigny's species may possibly represent the free end chambers of a Ramulina". Length of figured specimen .30 mm.

In this material this species was found to be rare in the Fort Hays Limestone at Spirit Mound; Sec. 8, Clay Co., and in the drill core from Cedar Co., Nebraska.

Dentalina cf. D. granti (Plummer)
Plate 1, Figure 14

Nodosaria filiformis - Carsey (not d'Orbigny), Univ. Texas Bull. 2612, p. 33, pl. 7, fig. 8, 1926.

Nodosaria granti - Plummer, Univ. Texas Bull. 2644, p. 83, pl. 5, fig. 9, 1926.

Dentalina granti - Plummer, Univ. Texas Bull. 3101, p. 149, pl. 11, figs. 8, 9, 1931.

Fragments of specimens which probably belong to this species were observed in the Fort Hays from Spirit Mound. The test is very long and fragile and it is improbable that any complete specimens will be found. Mrs. Plummer describes the species as follows:

"Test very long, slender, arcuate, smooth, with long apical spine, chambers numerous, elongate, varying from cylindrical to distinctly inflated; sutures flush with outline of test between early chambers on some tests or slightly constricted throughout growth on other tests; wall thick; aperture radiate and not protruding beyond end of final chamber.

"Observed length up to 5 mm.; maximum length probably much greater." Length of broken specimen figured .81 mm., diameter .14 mm.

Dentalina lorneiana d'Orbigny
Plate 2, Figure 1

Dentalina lorneiana - d'Orbigny, Soc. Geol. France Mem., 1st. ser., vol. 4, p. 14, pl. 1, figs. 8, 9, 1840.
Cushman, Tennessee Div. Geol. Bull. 41, p. 28, pl. 3, figs. 4-7, 1931.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 25, pl. 2, fig. 5, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 16, p. 77, pl. 13, figs. 12-14, 1940; U.S.G.S. Prof. Pap. 206, p. 66, pl. 23, figs. 7-11, 1946.

Test quite large, elongate, only slightly curved, gently tapering to broadly rounded initial end; chambers distinct, somewhat inflated, increasing quite rapidly in length as added, last few much longer than broad; sutures distinct, slightly depressed, oblique; aperture terminal, radiate, somewhat protruding; wall smooth except for depressed sutures, finely perforate. Length of figured specimen .78 mm., diameter .18 mm.

This species has a wide range in the Gulf Coast region and was reported by Loetterle from the Fort Hays limestone in Nebraska. In this study it was found to be very rare in the Fort Hays at Spirit Mound.

Dentalina niobrarensis Loetterle
Plate 2, Figure 2

Dentalina niobrarensis - Loetterle, Nebr. Geol. Survey Bull., 2nd ser., Bull. 12, p. 24, pl. 2, fig. 3, 1937.

Test elongate, slightly curved, gently tapering; chambers distinct, 4 to 6 in most specimens, slightly inflated, gradually increasing in size as added, initial chamber bulbuous and somewhat larger in diameter than the following one or two chambers; sutures distinct, depressed, later ones slightly oblique; wall smooth except for depressed sutures; aperture terminal, radiate. Length of figured specimen .59 mm., diameter .12 mm.

Loetterle reported this species from the Fort Hays member at two localities in Nebraska. In this material it was rare in the Fort Hays at Spirit Mound and in Sec. 8, Clay Co.

Dentalina reflexa Morrow
Plate 2, Figure 3

Dentalina reflexa - Morrow, Jour. Paleontology, vol. 8, p. 189, pl. 29, figs. 5, 20, 1934.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 24, pl. 2, fig. 4, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 16, p. 79, pl. 13, figs. 16, 17, 1940; U.S.G.S. Prof. Pap. 206, p. 66, pl. 23, figs. 13, 14, 1946.

Test elongate, gently curved, initial end slightly recurved, with a blunt spine; chambers few in number, megalospheric form usually with only two, microspheric form with four or five, increasing very little in height and breadth as added, only slightly inflated; sutures distinct, depressed, slightly oblique; aperture radiate, terminal, at the inner margin; wall smooth except for depressed sutures, finely perforate. Length of figured specimen .75 mm., diameter .13 mm.

Morrow described this species from the basal Niobrara of Kansas and Loetterle reported it from the Fort Hays of Kansas and Nebraska. In this investigation it was rare in the Fort Hays at Spirit Mound and Fort Randall.

Genus NODOSARIA Lamarck, 1812

Nodosaria zippei Reuss
Plate 2, Figures 4, 5

Nodosaria zippei - Reuss, Die Versteinerungen der bohemischen Kreid formation, pt. 1, p. 25, pl. 8, figs. 1-3, 1845.
Sandidge, Jour. Paleontology. vol. 6, p. 275, pl. 42, figs. 13, 14, 1932.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 26, pl. 3, fig. 2, 1937.

Nodosaria affinis - Cushman (not Reuss), Tennessee Div. Geol. Bull. 41, p. 30, pl. 3, figs. 16-20, 1931; U.S. G.S. Prof. Pap. 206, p. 70, pl. 25, figs. 8-23, 1946.

This species shows great variability in size, number of chambers, inflation of chambers, and number of costae, and is seldom found complete because of the fragility of the test. Sandidge's description of the species is as follows: "Test elongate, apiculate, tapering at the apertural end to the protruding apertural neck, and at the initial end to a short spine; chambers few, usually inflated, in megalospheric form decreasing in size as added, increasing in size in microspheric form; sutures constricted in later stages, septae visible as dark bands between early chambers; wall ornamented with 10 strong, sharp costae extending from apical spine to the aperture, giving the shell a fluted appearance, indented at the later sutures; aperture central, radiate, protruding." While this description fits the species quite well it might be added that the chambers are sometimes very numerous, at least in the microspheric form, and that the number of costae ranges from about 8 to 14.

There has been a great deal of confusion in the literature in distinguishing between this species and Nodosaria affinis Reuss. However as Sandidge concluded, it appears that Nodosaria zippei should be used for those forms with many costae (7 to 14) and N. affinis should be restricted to those forms with few costae (4 to 6).

Loetterle found this species throughout the Niobrara formation in Kansas, Nebraska and South Dakota, while in the material examined in this study it was found only in the Fort Hays from Spirit Mound.

Nodosaria sp. #1
Plate 2, Figure 6

Test small, elongate, gently tapering; chambers few, distinct, slightly inflated, higher than broad, increasing gradually in size as added; sutures distinct, depressed, horizontal; wall ornamented by five longitudinal costae which run uninterruptedly across the sutures; aperture terminal, radiate. Length of figured specimen .39 mm., diameter .06 mm.

A few specimens from the Fort Hays member at Fort Randall and Spirit Mound are placed here. They most closely resemble Nodosaria navarroana Cushman (1946, p. 73) but have much more elongate chambers. Cushman states also that his species has only four longitudinal costae although his figures show a specimen with five.

Genus SARACENARIA Defrance, 1824

Saracenaria triangularis (d'Orbigny)
Plate 2, Figure 7a, b

Cristellaria triangularis - d'Orbigny, Soc. Geol. France Mem., 1st ser., vol. 4, p. 27, pl. 2, figs.21, 22, 1840.

Saracenaria triangularis - Cushman and Church, California Acad. Sci. Proc., 4th ser., vol. 18, p. 505, pl. 37, figs. 13, 14, 1929.
Cushman and Hedberg, Cushman Lab. Foram. Research Contr., vol. 17, p. 88, pl. 21, figs. 35a, b, 1941.
Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 8, pl. 2, fig. 5, 1944; U.S.G.S. Prof. Pap. 206, p. 58, pl. 28, figs. 1-3, 1946.

Test closely coiled in early stage, becoming uncoiled in later portion, triangular in transverse section in adult, widest near base of apertural face, periphery sharp, slightly keeled in early portion, apertural face triangular in shape, with somewhat thickened and raised sides; chambers few in number, increasing gradually in size as added, widest at peripheral margin; sutures slightly limbate, curved, more strongly so in early portion, flush with surface, sometimes very slightly depressed in later portion; aperture radiate, at the peripheral angle, slightly protruding; wall smooth, finely perforate. Length of figured specimen .51 mm., breadth .34mm.

This species occurs in beds of Austin, Taylor and Navarro age in the Gulf Coast region, being particularly common in the upper Austin and Taylor beds. In this investigation it was found to be rare in the Fort Hays member at Spirit Mound.

Genus VAGINULINA d'Orbigny, 1826

Vaginulina texana Cushman
Plate 2, Figure 8

Vaginulina texana - Cushman, Cushman Lab. Foram. Research Contr., vol. 6, p. 30, pl. 4, figs. 2, 3, 1930.
Morrow, Jour. Paleontology, vol. 8, p. 192, pl. 29, fig. 10, 1934.
Cushman and Deaderick, Cushman Lab. Foram. Research Contr., vol. 18, p. 59, pl. 12, figs. 1-6, 1942.
Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 88, 1944.

Vaginulina sp. - Cushman, Cushman Lab. Foram. Research Contr. vol. 6, p. 30, pl. 4, figs. 12, 13, 1930.

Vaginulina regina - Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 27, pl. 3, fig. 4, 1937.

Test very variable in size and shape, sides straight to slightly concave dorsally and slightly convex ventrally, parallel or slightly tapering, test much compressed, periphery rounded, initial end with a short, blunt spine, sometimes slightly bulbuous; chambers very variable in number, somewhat obscured by surface ornamentation, strongly oblique, increasing gradually in height as added, not inflated; sutures limbate, strongly oblique, straight or somewhat curved, somewhat obscured by ornamentation; aperture radiate, at dorsal peripheral angle, slightly produced in most specimens; surface ornamented by strong, longitudinal costae, number increasing rapidly with increase in size of test, bifurcating towards apertural end as test broadens. Length of small specimen figured is .63 mm., breadth .15 mm.

This species has been reported only from beds of Austin age. Morrow found a single specimen which he referred to this species in the basal Niobrara of Kansas and Loetterle reported it from a single exposure of Fort Hays limestone in Nebraska. In this investigation it was found to be rare in the Fort Hays member at Spirit Mound.

Genus PALMULA Lea, 1833

Palmula suturalis (Cushman)
Plate 2, Figure 9

Flabellina suturalis - Cushman, Cushman Lab. Foram. Research Contr., vol. 11, p. 86, pl. 13, figs. 9-18, 1935.

Palmula suturalis - Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 28, pl. 3, fig. 5, 1937.
Cushman and Deaderick, Cushman Lab. Foram. Research Contr., vol. 18, p. 60, pl. 13, fig. 1, 1942; Jour. Paleontology, vol. 18, p. 334, pl. 52, fig. 5, 1944.
Cushman, U.S.G.S. Prof. Pap. 206, p. 82, pl. 32, figs. 3-14, 1946.

Test rhomboidal or cordate in shape, much compressed, periphery truncate, sometimes grooved; chambers distinct, very early ones coiled, then becoming chevron shaped, broadest at apices, increasing gradually in width as added; sutures distinct, platelike and much raised in early portion, becoming less high in later portion, increasing in height at the apices in some specimens, apical portion convex but seldom developing loops; aperture radial, terminal, sometimes with a slight neck; wall between sutures smooth, finely perforate. Length of figured specimen 1.29 mm., breadth .90 mm.

This species is widely distributed in beds of Upper Cretaceous age, being found in beds of Austin, Taylor, and lower Navarro age. Loetterle reported it from the Fort Hays limestone at several localities in Kansas, Nebraska and South Dakota. In this study it was found in the Fort Hays at Spirit Mound and Fort Randall.

Genus FRONDICULARIA Defrance, 1824

Frondicularia cf. F. extensa Morrow
Plate 2, Figure 10

Frondicularia extensa - Morrow, Jour. Paleo., vol. 8, p. 193, pl. 29, fig. 31, 1934.
Cushman, U.S.G.S. Prof. Pap. 206, p. 86, pl. 34, figs. 3, 4, 1946.

Test somewhat diamond shaped in outline, broadest at or slightly above the middle, thinnest along medium line, thence thickening to peripheral margins, periphery sharply rounded, slightly lobulate below widest portion; chambers distinct, chevron shaped, each chamber failing to extend over preceeding one at periphery, increasing quite rapidly in breadth but only slightly in height as added, proloculum bulbuous; sutures distinct, becoming limbate and somewhat sigmoidal in later portion, curved backwards and slightly raised at periphery; aperture terminal radiate, slightly projecting, wall smooth except for sutures, glassy in appearance. Length of figured specimen .61 mm., breadth .40 mm.

Only one specimen from the Fort Hays at Spirit Mound is referred to this species. Morrow described it from the basal Niobrara in Ellis Co., Kansas, the only locality at which he found it.

Frondicularia undulosa Cushman
Plate 2, Figure 11

Frondicularia undulosa - Cushman, Cushman Lab. Foram. Research Contr., vol. 12, p. 13, pl. 3, figs. 7-11, 1936.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 29, pl. 3, figs. 8, 9, 1937.
Cushman and Deaderick, Cushman Lab. Foram. Research Contr., vol. 18, p. 60, pl. 13, figs. 2, 3, 1942.
Cushman, idem., vol. 20, p. 89, 1944; U.S.G.S. Prof. Pap. 206, p. 87, pl. 34, figs. 9-13, 1946.

Test typically elongate, gently tapering, periphery sharply rounded or truncate, slightly lobulate in most specimens, initial end with a stout spine; chambers distinct, elongate, increasing gradually in size as added, proloculum bulbuous and with a central costae; sutures distinct, strongly oblique, curving backwards at the periphery; aperture terminal and protruding, radiate. Length of figured specimen .65 mm., breadth .22 mm.

This species occurred rarely in the Fort Hays at Spirit Mound and Fort Randall. Loetterle reported it from the Fort Hays at a few localities in Kansas, Nebraska and South Dakota.

Genus KYPHOPYXA Cushman, 1929

Kyphopyxa christneri (Carsey)
Plate 2, Figure 12

Frondicularia christneri - Carsey, Texas Univ. Bull. 2612, p. 41, pl. 6, fig. 7, 1926.

Kyphopyxa christneri - Cushman, Cushman Lab. Foram. Research Contr., vol. 5, p. 1, pl. 1, figs. 1-7, 1929; idem., vol. 6, p. 33, pl. 4, fig. 20, 1930; p. 85, pl. 12, fig. 2, 1930; Jour. Paleontology, vol. 6, p. 336, pl. 50, figs. 11, 12, 1932.
Loetterle, Nebraska, Geol. Survey Bull., 2nd ser., Bull. 12, p. 29, pl. 4, fig. 1, 1937.
Cushman and Deaderick, Cushman Lab. Foram. Research Contr., vol. 18, p. 62, pl. 14, figs. 1-7, 1942.
Cushman, idem, vol. 20, p. 89, pl. 13, figs. 23, 24, 1944, U.S.G.S. Prof. Pap. 206, p. 92, pl. 38, figs. 12-17, pl. 39, figs. 1-12, 1946; Foraminifera, Ed. 4, pl. 21, figs. 1, 2, 1948.

Test compressed but sides generally very slightly convex, apertural end very narrow, flaring to a broad initial extremity, widest near base, periphery truncate; chambers distinct, early ones coiled, then biserial, and finally uniserial, long and narrow, increasing little if at all in breadth, adult chambers strongly recurved at the base and enveloping earlier ones, sutures distinct, early ones strongly raised, platelike, later sutures greatly reduced, even slightly depressed in some specimens, with a raised ridge at the apices in some; aperture projecting, terminal, radiate; wall smooth except for sutures, perforate. Length of figured specimen .87 mm., breadth .54 mm.

This species ranges from the Austin through the Taylor marl. Loetterle reported it from the Fort Hays at Spirit Mound and in the cores from Fort Randall and Cedar County, Nebraska.

Family POLYMORPHINIDAE

Subfamily POLYMORPHININAE

Genus GLOBULINA d'Orbigny, 1839

Globulina lacrima Reuss var. subsphaerica (Berthelin)
Plate 2, Figure 13

Polymorphina subsphaerica - Berthelin, Soc. Geol. France Mem., ser. 3, vol. 1, p. 58, pl. 4, figs. 18a, b, 1880.

Globulina lacrima Reuss var. subsphaerica (Berthelin)-
Cushman & Ozawa, U. S. Nat. Mus. Proc., vol. 77, art. 6, p. 78, pl. 19, figs. 5-7, 1930.
Cushman, Tennessee Div. Geology Bull. 41, p. 41, pl. 6, figs. 10a-c, 1931.
Loetterle, Nebraska Geol. Survey Bull. 2nd ser., Bull. 12, p. 31, pl. 4, figs. 5a, b, 1936.
Cushman & Goudkoff, Cushman Lab. Foram. Research Contr., vol. 20, p. 57, pl. 9, fig. 14, 1944; U. S. G. S. Prof. Pap. 206, p. 96, pl. 40, fig. 13, 1946.

Numerous specimens from the Fort Hays limestone are referred to this variety. They agree very well in general shape with published figures and descriptions of this variety but the chambers and sutures are very indistinct.

This variety is widely distributed in the Upper Cretaceous of America. Loetterle reported it from the Fort Hays of Nebraska and gave the following description:

"Test compressed, subglobular, elongate-oval in end view, apertural extremity produced; chambers few, extending almost to base of test; sutures flush or faintly incised, indistinct in most specimens, aperture round, radiate, terminal." Length of figured specimen .30 mm., breadth .22 mm.

Subfamily RAMULININAE

Genus RAMULINA Rupert Jones, 1875

Ramulina aff. R. aculeata (d'Orbigny)
Plate 2, Figure 14

Ramulina aculeata - Cushman, U.S.G.S. Prof. Pap. 206, p. 100, pl. 43, figs. 11-16, 1946.

Several irregular sharply spined specimens from the Fort Hays member at Spirit Mound and from Sec. 8, Clay Co., are referred to this species. These specimens are all broken and incomplete but they seem to be identical with specimens from Mexico and Texas which Cushman placed in this species.

Genus BULLOPORA Quenstedt, 1856

Bullopora sollasi (Chapman)
Plate 2, Figure 15

Vitriwebbina sollasi - Chapman, Geol. Mag., N.S., Decade 3, vol. 9, p. 53, pl. 2, figs. 1-3, 1892.
Bogg, U.S.G.S. Bull. 88, p. 35, pl. 2, figs. 5a, b, 1898.

Bullopora sollasi - Loetterle, Nebr. Geol. Survey Bull., 2nd ser., Bull. 12, p. 32, pl. 4, fig. 7, 1937.

"Test attached, elongate, peripheral margin with a narrow, delicate flange; chambers few, inflated, elongate to hemispherical, connected by short, narrow, tubular necks, in some specimens with tubular lateral extensions; aperture terminal, rounded; wall calcareous, finely perforate."

Loetterle reported this species from a few exposures of the Fort Hays member and gave the above description. It was observed in the Fort Hays at Fort Randall and Spirit Mound during this investigation.

This species can be distinguished from Bullopora laevis (Sollas) by its possession of a narrow, delicate, marginal flange.

Family HETEROHELICIDAE

Subfamily GUMBELININAE

Genus GUMBELINA Egger, 1899

Gumbelina globulosa (Ehrenberg)
Plate 2, Figure 16

Textularia globulosa - Ehrenberg, Abhandl. K. preuss, Akad. Wiss. Berlin, p. 135, pl. IV, fig. B., 1838.

Gumbelina globulosa - Egger, Abhandl. kon. bay. Akad. Wiss. Munchen, kl. 11, vol. 21, pt. 1, p. 32, pl. 14, fig. 43, 1899.
Cushman, Cushman Lab. Foram. Research Contr., vol. 3, p. 190, 1927; Tennessee Div. Geology Bull. 41, p. 43, pl. 7, figs. 3-5, 1931.
Morrow, Jour. Paleontology, vol. 8, p. 194, pl. 29, figs. 18a, b, 1934.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 33, pl. 4, figs. 8a, b, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 14, p. 6, pl. 1, figs. 28-33, 1938.
Cole, Florida Dept. Cons., Geol. Bull. 16, p. 34, pl. 3, fig. 10, 1938.
Cushman and Hedberg, Cushman Lab. Foram. Research Contr., vol. 17, p. 92, pl. 22, figs. 15a, b, 1941.
Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 19, p. 64, pl. 11, fig. 12, 1943.
Cushman and Deaderick, Jour. Paleontology, vol. 18, p. 336, pl. 53, figs. 2, 3, 1944.
Cushman, U.S.G.S. Prof. Pap. 206, p. 105, pl. 45, figs. 9-15, 1946; Foraminifera, Ed. 4, key pl. 26, figs. 6a, b, 1948.

Test elongate, V-shaped, uniformly tapering to bluntly pointed initial end, periphery lobulate throughout, much more strongly so in final portion, earliest stage coiled, later biserial; chambers distinct, inflated, very strongly so in later portion, globular; sutures distinct, depressed, slightly oblique, aperture a broad, arched opening at base of final chamber, with a distinct lip; wall smooth, perforate. Length of figured specimen .35 mm., breadth .24 mm.

This species is widely distributed in the Upper Cretaceous of America and Europe. Morrow found it to occur throughout the Colorado group in Kansas and Loetterle found it throughout the Niobrara and the Lower Pierre in Kansas, Nebraska and South Dakota. In the study it was found throughout the Niobrara at every locality examined.

It is difficult to distinguish this species from Gumbelina reussi Cushman which occurs lower in the section. The two apparently grade into each other and many of Cushman's figures of G. reussi appear to be more closely related to G. globulosa. G. reussi is described as having the periphery of the early portion complete and in having the later chambers clearly set off from one another with a triangular indented area between.

Gumbelina moremani Cushman
Plate 2, Figures 17a, b

Gumbelina globifera - Morrow (not Reuss), Jour. Paleontology, vol. 8, p. 194, pl. 29, figs. 15, 17, 1934. Loetterle (not Reuss), Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 34, pl. 5, fig.3, 1937.

Gumbelina moremani - Cushman, Cushman Lab. Foram. Research Contr., vol. 14, p. 10, pl. 2, figs. 1-3, 1938; idem., vol. 20, p. 90, pl. 14, figs. 1a, b, 1944.

Test very elongate, gradually tapering to bluntly pointed initial end, periphery lobulate, earliest portion coiled, later biserial, sometimes tending toward Ventilabrella with a chamber developed at the side in the adult; chambers numerous, distinct, subglobular; sutures distinct, depressed throughout, aperture a high arched opening at base of final chamber, with a distinct lip and a flange on each side which may project onto the preceding chamber; wall smooth, finely perforate. Length of figured specimen .44 mm., breadth .22 mm.

Morrow records this species as occurring throughout the Colorado group in Kansas. It has been reported from beds of Austin age in the Gulf Coast region. In this investigation it was found throughout the Niobrara at some localities but never in any abundance.

This species differs from Gumbelina globulosa (Ehrenberg) in the larger number of chambers and in the more elongate and less tapering test.

Gumbelina plummerae Loetterle
Plate 2, Figure 18

Gumbelina plummerae - Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 33, pl. 5, figs. 1, 2, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 14, p. 15, pl. 3, figs. 3-5, 1938.
Cole, Florida Dept. Cons., Geol. Bull. 16, p. 34, pl. 3, fig. 9, 1938.
Cushman and Deaderick, Cushman Lab. Foram. Research Contr., vol. 18, p. 62, pl. 15, figs. 2-4, 1942.
Cushman, idem., vol. 20, p. 10, pl. 2, fig. 18, 1944; idem., vol. 20, p. 90, pl. 14, figs. 3a, b, 1944; U.S.G.S. Prof. Pap. 206, p. 104, pl. 45, figs. 1-3, 1946.

Test broad and thick, V-shaped, early portion tapering rapidly to bluntly pointed initial end, adult portion tapering more gradually, periphery of early portion complete, later strongly lobulate; chambers mostly biserially arranged, strongly inflated and appressed in adult, last few generally thicker than broad; sutures distinct, depressed; aperture a broad, low, arched opening at base of last chamber, with a distinct lip; wall distinctly costate, especially in early portion. Length of figured specimen .33 mm., breadth .22 mm.

This species occurs in beds ranging from Austin to lower Navarro age. Loetterle found it to be quite common throughout the Niobrara in Kansas, Nebraska and South Dakota. In this investigation it was found to occur throughout the Niobrara but was more common in the Smoky Hill.

This species can be distinguished from Gumbelina striata (Ehrenberg) by the thicker and more appressed final chambers, and by the more distinct costae.

Gumbelina pseudotessera Cushman
Plate 2, Figure 19

Gumbelina tessera - Cushman (not G. tessera Cushman, 1936, nor Grammostomum tessera Ehrenberg), Jour. Paleo., vol. 6, p. 338, pl. 51, figs. 4, 5, 1932.
Loetterle, Nebraska Geol. Survey Bull., 2nd Ser., Bull. 12, p. 34, pl. 5, fig. 4, 1937.

Gumbelina pseudotessera - Cushman, Cushman Lab. Foram. Research Contr., vol. 14, p. 14, pl. 2, figs. 19-21, 1938, idem., vol. 20, p. 10, 1944; idem., vol. 20, p. 91, pl. 14, fig. 5, 1944; U.S.G.S. Prof. Pap. 206, p. 106, pl. 45, figs. 16-20, 1946.

Test compressed, tapering rather rapidly to bluntly pointed initial end, greatest breadth at final chambers, periphery lobulate throughout, more strongly so in later portion; chambers distinct, slightly inflated, final ones becoming much broader than high and somewhat curved; sutures distinct, depressed, slightly curved in later portion; aperture a high arched opening at base of final chamber, with a narrow lip and a distinct flange on each side. Length of figured specimen .24 mm., breadth .16 mm.

This species differs from Gumbelina globulosa in the compressed test, shape of the later chambers, and curved sutures of the later portion.

This species ranges throughout beds of Austin and Taylor age. It was found throughout the Niobrara but was generally quite rare.

Genus VENTILABRELLA Cushman, 1928

Ventilabrella austinana Cushman
Plate 3, Figure 1

Ventilabrella austinana - Cushman, Cushman Lab. Foram. Research Contr., vol. 14, p. 26, pl. 4, fig. 19, 1938; idem., vol. 20, p. 92, pl. 14, fig. 7, 1944.

Ventilabrella eggeri - Loetterle (not Cushman), Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 35, pl. 5, fig. 5, 1937.

Test biserial in early portion as in Gumbelina, later becoming fan shaped with numerous chambers in a single plane, chambers numerous, somewhat compressed in biserial portion, globular in later portion, increasing gradually in size throughout biserial stage but variable in size in later portion, sutures distinct, depressed, aperture as in Gumbelina in early stage, later with numerous apertures; wall smooth, perforate. Length of figured specimen .34 mm., breadth .39 mm.

This species is found in beds ranging from middle Austin to lower Taylor age. Loetterle reports it as being rare throughout the Niobrara formation. In this investigation it was found in the Fort Hays member at Spirit Mound.

Subfamily BOLIVINITINAE

Genus BOLIVINITELLA Morie, 1941

Bolivinitella elevi (Cushman)
Plate 3, Figures 2a, b

Bolivinita elevi - Cushman, Cushman Lab. Foram. Research Contr., vol. 2, p. 91, pl. 12, figs. 11a, b, 1927; idem., vol. 7, p. 39, pl. 5, figs. 8a, b, 1931; Jour. Paleontology, vol. 6, p. 339, pl. 51, figs. 7a, b, 1932; U.S.G.S. Prof. Pap. 206, p. 114, pl. 48, figs. 18-20, 1946.

Bolivinitella elevi - Cushman, Foraminifera, Ed. 4, p. 258, pl. 21, figs. 10a, b, key pl. 26, fig. 21, 1948.

Test very small, much compressed, biconcave, broader faces more strongly concave, two or three times as long as broad, greatest breadth formed by final two chambers, tapering gradually to sharply rounded initial end, periphery sharp, keeled, chambers quite distinct in most specimens, biserially arranged throughout; sutures distinct in most specimens, strongly limbate, not raised; aperture elongate, terminal, sometimes extending into apertural face where it tapers out, with a raised border, wall calcareous, very finely perforate. Length of figured specimen .20 mm., breadth .10 mm.

This species has been recorded from beds of upper Austin and Taylor age in the Gulf Coast area. In this investigation it was found to be fairly common in the Fort Hays member at Spirit Mound.

It is very distinctive but because of its very small size is easily overlooked.

Subfamily EOUVIGERININAE

Genus EOUVIGERINA Cushman, 1926

Eouvigerina aculeata Cushman
Plate 3, Figures 3a, b

Eouvigerina aculeata - Cushman, Cushman Lab. Foram. Research Contr., vol. 9, p. 62, pl. 7, figs. 8a, b, 1933.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 36, pl. 5, fig. 9, 1937.
Cushman, U.S.G.S. Prof. Pap. 206, p. 116, pl. 49, fig. 13, 1946.

Test small, elongate, gently tapering to rounded initial extremity, greatest breadth near aperturral end, periphery of early part entire, sharply indented in later portion, chambers of early part indistinct, later ones distinct, with a sharp ridge somewhat below the middle, chamber convex above ridge and slightly concave below, sutures of early portion indistinct, later distinct and depressed; aperture rounded or oval, with a short, thick neck and phialine lip; wall finely perforate. Length of figured specimen .27 mm., breadth .13 mm.

This species is characteristic of beds of Austin and lower Taylor age. Loetterle found it sparingly throughout the Niobrara formation. In South Dakota it is very common in the upper part of the Fort Hays member, with few rare occurrences in the lower part of the member. Eouvigerina americana Cushman is much more clear cut and has a rhomboidal aperture.

Eouvigerina plummerae Cushman
Plate 3, Figures 4a, b

Eouvigerina plummerae - Cushman, Cushman Lab. Foram. Research Contr., vol. 9, p. 62, pl. 7, figs. 6, 7, 1933.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 36, pl. 5, fig. 8, 1937.
Cushman, U.S.G.S. Prof. Pap. 206, p. 116, pl. 49, figs. 10, 11, 1946.

Test small, elongate, very gently tapering, broader faces concave, narrow sides slightly convex, somewhat lobulate, angles sharp, keeled; chambers mostly biserial, distinct in most specimens, rapidly increasing in size as added; sutures distinct in most specimens, limbate, slightly depressed; aperture terminal, rounded or elliptical, with a short, distinct neck and phialine lip; wall thin, finely perforate, nearly translucent. Length of figured specimen .24 mm., breadth .09 mm.

The type of this species is from the Austin chalk of Texas. It has been reported only from beds of Austin age. It was quite abundant in all samples of lower Fort Hays examined and appears to be a good marker for this horizon.

This species is very distinct and easily recognized. The concave broader sides and sharp, keeled angles readily distinguish it from any other species of this genus.

Family BULIMINIDAE

Subfamily BULIMININAE

Genus BULIMINA d'Orbigny, 1826

Bulimina reussi Morrow
Plate 3, Figure 5

Bulimina reussi - Morrow, Jour. Paleontology, vol. 8, p. 195, pl. 29, fig. 12, 1934.
Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 11, p. 99, pl. 15, figs. 8, 10, 1935.

Cushman and Hedberg, idem., vol. 17, p. 95, pl. 22, figs. 30a-c,1941.
Frizzell, Jour. Paleontology, vol. 17, p. 350, pl. 57, fig. 2, 1934.
Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 12, pl. 2, fig. 25, 1944.
Cushman and Deaderick, Jour. Paleontology, vol. 18, p. 337, pl. 53, fig. 6, 1944.
Cushman, U.S.G.S. Prof. Pap. 206, p. 120, pl. 51, figs. 1-5, 1946.
Cushman and Parker, U.S.G.S. Prof. Pap. 210-D, p. 84, pl. 19, fig. 31, pl. 20, figs. 1-5, 1947.

Test small, somewhat ovate, widest slightly above middle initial end bluntly pointed, triserial throughout; chambers numerous, slightly inflated, increasing rapidly in size as added, earlier ones broader than high, those of final whorl much higher than broad, final convolution making up more than half of test; sutures distinct, depressed, especially in later part of test; aperture elongate, oblique, subterminal; wall smooth, finely perforate. Length of figured specimen .23 mm., breadth .14 mm.

This species is widely distributed in beds of Austin, Taylor and Navarro age in the Gulf Coast region. Morrow reported it from the basal Niobrara of Kansas. In this study it was found in most sections of the Fort Hays member examined.

This is a quite distinctive small species most closely related to Bulimina trihedra Cushman. However, it lacks the definitely trihedral character of that species, is shorter, and has less inflated chambers.

Genus NEOBULIMINA Cushman and Wickenden, 1928

Neobulimina canadensis Cushman and Wickenden
Plate 3, Figure 6

Neobulimina canadensis - Cushman and Wickenden, Cushman Lab. Foram. Research Contr., vol. 4, p. 13, pl. 1, figs. 1, 2, 1928.
Cushman, Tennessee Div. Geol. Bull. 41, p. 48, pl. 8, figs. 1a-c, 1931.
Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 9, pl. 2, figs. 9, 10, 1936.

Cushman, idem., vol. 20, p. 93, pl. 14, figs. 12, 13, 1944.
Cushman and Deaderick, Jour. Paleontology, vol. 18, p. 337, pl. 53, figs. 9, 10, 1944.
Cushman, U.S.G.S. Prof. Pap. 206, p. 125, pl. 52, figs. 11, 12, 1946.
Cushman and Parker, U.S.G.S. Prof. Pap. 210-D, p. 132, pl. 29, figs. 32, 33, 1947.

Test small, widest near the middle, initial extremity pointed, apertural end rounded, 2½ to 3 times as long as broad, early stage triserial, adult biserial; chambers numerous, quite indistinct in triserial stage, inflated and subglobular in adult biserial stage, wall calcareous, very coarsely perforate, reticulate in early part of some specimens; aperture a broad, high opening at base of final chamber, in a distinct depression. Length of figured specimen .30 mm., breadth .11 mm.

This species has a long range in the Upper Cretaceous, being found in beds ranging from Eagle Ford to Navarro age in Texas. It was quite common in the Fort Hays member at every locality examined during this investigation.

This species differs from Neobulimina irregularis Cushman and Parker in having more regular chambers that are less globular, and in having stronger ornamentation in the early part of the test.

Neobulimina cf. N. irregularis Cushman and Parker
Plate 3, Figure 7

Neobulimina irregularis - Cushman and Parker, Cushman Lab. Foram. Research Contr., vol. 12, p. 9, pl. 2, figs. 8a, b, 1936.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 38, pl. 5, fig. 12, 1937.
Cushman, U.S.G.S. Prof. Pap. 206, p. 125, pl. 52, fig. 13, 1946.

Test small, very elongate, sides nearly parallel except for initial end which tapers rapidly, early stage triserial,

later irregularly biserial; chambers distinct, globular; sutures distinct, depressed, strongly so in later portion of test; aperture elongate, extending from inner margin of last chamber; wall quite coarsely perforate. Length of illustrated specimen .23 mm., breadth .06 mm.

Loetterle recorded this species from both the Fort Hays and Smoky Hill members. However, in this study only two rare occurrences in the Smoky Hill were noted.

Subfamily VIRGULININAE

Genus VIRGULINA d'Orbigny, 1826

Virgulina tegulata Reuss
Plate 3, Figure 8

Virgulina tegulata - Reuss, Verstein bohm Kreideformation, pt. 1, p. 40, pl. 13, fig. 81, 1945.
Cushman, Cushman Lab. Foram. Research Sp. Pub. 9, p. 4, pl. 1, figs. 8-12, 1937; Cushman Lab. Foram. Research Contr., vol. 20, p. 12, pl. 2, fig. 26, 1944; idem. vol. 20, p. 93, pl. 14, fig. 14, 1944.
Cushman and Deaderick, Jour. Paleontology, vol. 18, p. 338, pl. 53, fig. 11, 1944.
Cushman, U.S.G.S. Prof. Pap. 206, p. 126, pl. 53, figs. 1-4, 1946.

Loxostoma tegulatum - Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 40, pl. 7, fig. 3, 1937.

Test elongate, slender, very gently tapering to bluntly pointed initial end, slightly compressed, periphery broadly rounded, slightly lobulate, test somewhat twisted in early portion, earliest stage coiled, then biserial; chambers distinct, slightly inflated, gradually increasing in size as added, higher than broad nearly throughout; sutures distinct, slightly depressed, somewhat oblique, aperture elongate, ovate, extending from base of final chamber to terminal margin; wall smooth, finely perforate. Length of illustrated specimen .35 mm., breadth .10 mm.

This species occurs in beds of Austin, Taylor and lower Navarro age. Loetterle reported it from the Fort Hays limestone at several localities in Kansas, Nebraska and South Dakota. In this investigation it was found to be rare in the Fort Hays member at several localities.

This species appears to be very similar to Loxostoma tegulatum (Reuss) but from Cushman's (1937c, pl. 20, figs. 17, 18) figures the later species appears to have much more oblique sutures and broader and shorter chambers, especially in the early portion of the test.

Virgulina sp. #1
Plate 3, Figures 9a, b

Test small, very elongate, slightly compressed, sides gently tapering in early portion to sharply rounded initial end, nearly parallel in later portion, somewhat lobulate, early part of test slightly twisted; chambers distinct, slightly inflated, biserial nearly throughout, earliest portion coiled; sutures distinct, slightly depressed, nearly horizontal; aperture elongate, in a distinct depression at the inner margin of the last formed chamber. Length of figured specimen .33 mm., breadth .11 mm.

The small specimens referred to here occur throughout the Niobrara and are quite abundant in the Fort Hays of some localities. They most closely resemble Virgulina minuta Cushman from the lower Cretaceous of Texas, but the sutures of the later species are strongly oblique and the chambers are somewhat more inflated.

Genus LOXOSTOMA Ehrenberg, 1854

Loxostoma clavatum (Cushman)
Plate 3, Figures 10a, b

Bolivina clavata - Cushman, Cushman Lab. Foram. Research Contr., vol. 2, p. 87, pl. 12, figs. 5a, b, 1927.

Loxostoma clavatum - Cushman, Jour. Paleontology, vol. 6, p. 340, pl. 51, figs. 8a, b, 1932; Cushman Lab. Foram. Research Sp. Pub. 9, p. 171, pl. 20, figs. 6-8, 1937; Cushman Lab. Foram. Research Contr., vol. 20, p. 94, pl. 14, fig. 16, 1944; U.S.G.S. Prof. Pap. 206, p. 130, Pl. 54, figs. 4-9, 1946.

Test elongate, rapidly tapering to blunt initial end, subcircular in apertural view, periphery broadly rounded, biserial throughout, early portion often twisted; chambers numerous, early ones somewhat indistinct, later ones distinct, somewhat inflated and overlapping, with blunt finger-like projections along lower margin; early sutures somewhat indistinct, nearly horizontal, later ones distinct, oblique, strongly crenulate; aperture elongate, tending to become terminal in adult but extending from terminal margin to near base of chamber in most specimens; early portion of test ornamented by longitudinal rows of pits, wall in adult smooth except for finger-like projections, perforate. Length of figured specimen .45 mm., breadth .15 mm.

This species occurs in beds of Austin, Taylor and lower Navarro age but is largely limited to the lower Taylor. In this material it occurred only in the uppermost Smoky Hill.

This species is closely related to Loxostoma cushmani Wickenden, although the typical forms of each are quite distinctive. Through stronger development of the finger-like projections along the basal margins of the chambers and enlargement of the test in the adult, this species grades into Bolivina explicata Cushman and Hedberg, which may be a Loxostoma.

Loxostoma cushmani Wickenden
Plate 3, Figure 11

Loxostomum cushmani - Wickenden, Royal Soc. Canada Trans., 3rd ser., vol. 26, sec. 4, p. 91, pl. 1, figs. 6a, b, 1932.

Loxostomum clavatum - Cushman (not Cushman, 1927), Jour. Paleontology, vol. 6, p. 340, pl. 51, figs. 8a, b, 1932.

Loxostoma cushmani - Cushman, Cushman Lab. Foram. Research Sp. Pub. 9, p. 171, pl. 20, figs. 9-13, 1937. Cushman and Deaderick, Cushman Lab. Foram. Research Contr., vol. 18, p. 63, pl. 15, figs. 11-13, 1942. Cushman, idem., vol. 20, p. 12, pl. 2, fig. 28, 1944; idem., vol. 20, p. 94, pl. 14, fig. 17, 1944; U.S.G.S. Prof. Pap. 206, p. 129, pl. 53, figs. 24-31, 1946.

Test elongate, four or five times as long as broad, very gradually tapering to blunt initial end, subcircular in end view, periphery broadly rounded, early portion biserial, adult irregularly uniserial; chambers somewhat indistinct in early portion, becoming very distinct in adult, inflated and somewhat overlapping; sutures rather indistinct in early portion, later very distinct and much depressed, with distinct crenulations; aperture rounded or oval, becoming terminal; wall smooth and finely perforate in adult, with fine longitudinal costae in early portion. Length of illustrated specimen .58 mm., breadth .16 mm.

This is a very common species in the Upper Cretaceous of America, occurring in beds of upper Austin and Taylor age. In the material examined in the investigation it was found to be common in the upper part of the Smoky Hill member. The specimens from the Smoky Hill and lower Pierre of Kansas, Nebraska and South Dakota referred to Loxostoma applinae (Plummer) by Loetterle probably belong to this species as L. applinae is an Eocene form.

This species is closely related to Loxostoma clavatum (Cushman) and in some localities the difference between the two is more or less bridged over by intermediate forms. In its typical form L. clavatum is much more tapered, is biserial throughout, and shows stronger development of the sutural crenulations.

Family ELLIPSOIDINIDAE

Genus PLEUROSTOMELLA Reuss, 1860

Pleurostomella austinana Cushman
Plate 3, Figure 12

Pleurostomella austinana - Cushman, Cushman Lab. Foram. Research Contr., vol. 9, p. 64, pl. 7, fig. 13, 1933.

Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 40, pl. 6, fig. 4, 1937.
Cushman, U.S.G.S. Prof. Pap. 206, p. 131, pl. 54, figs. 19-21, 1946.

Test slender, very elongate, subcircular in cross section, initial end sharply rounded, biserial throughout but very loosely so in adult, chambers distinct, inflated, increasing gradually in size as added, becoming much higher than broad in adult; sutures distinct, strongly depressed, oblique, aperture subelliptical, at side of final chamber near apex; wall smooth, very finely perforate. Length of figured specimen .64 mm., breadth .12 mm.

This species has been reported from the Austin chalk of Texas, and Loetterle reported it from the Fort Hays and lower Smoky Hill in Kansas, Nebraska and South Dakota. A few rare occurrences of this species in the Fort Hays member were noted during this investigation.

Genus NODOSARELLA Rzehak, 1895

Nodosarella gracillima Cushman
Plate 3, Figure 13

Nodosarella gracillima - Cushman, Cushman Lab. Foram. Research Contr., vol. 9, p. 64, pl. 7, figs. 14a, b, 1933; idem., vol. 20, p. 13, pl. 2, fig. 32. 1944, U.S.G.S. Prof. Pap. 206, p. 134, pl. 55, figs. 19-21.

Nodosaria sp. - Morrow, Jour. Paleo., vol. 8, p. 197, pl. 29, figs. 2, 3, 1934.

Test narrow, elongate, tapering very gradually from greatest breadth at apertural end to rounded initial extremity, circular in end view, earliest stage biserial, later uniserial; chambers of biserial part indistinct, distinct in uniserial stage, increasing rapidly in height but only slightly in breadth as added, slightly inflated in later portion; sutures distinct in uniserial stage, horizontal, somewhat depressed; aperture semielliptical, at one side of final chamber near the end; wall smooth except for depressed sutures, finely perforate. Length of figured specimen .52 mm., breadth .10 mm.

This species is found in the upper Austin and lower Taylow of the Gulf Coast region. Morrow reported it from the basal Niobrara of Kansas and in this investigation it was found in the Fort Hays from the drill core at Fort Randall Dam.

Family ROTALIIDAE

Subfamily DISCORBINAE

Genus VALVULINERIA Cushman, 1936

Valvulineria plummerae Loetterle
Plate 3, Figures 14a, b, c

Valvulineria plummerae - Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 41, pl. 6, figs. 5, 6, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 13, pl. 3, fig. 1, 1944; idem., vol. 20, p. 95, pl. 14, fig. 20, 1944; U.S.G.S. Prof. Pap. 206, p. 137, pl. 57, fig. 4, (not figs. 3a-c), 1946.

Test trochoid, about 2½ whorls visible on dorsal side, only final whorl visible on ventral side; dorsal side flat or slightly convex at the center, ventral side convex, periphery broadly rounded, slightly lobulate; chambers distinct, somewhat inflated, 7 to 10 in the final whorl, increasing gradually in size as added, final chamber has a lobe-like extension on ventral side which covers umbilicus; sutures distinct, ventrally radiate, slightly curved, depressed throughout, gently curved on dorsal side, depressed only in later portion of test; aperture somewhat indistinct, a low slit extending from periphery to umbilicus; inner margin of final chamber quite broad, nearly flat; shell wall smooth, finely perforate. Diameter of illustrated specimen .25 mm., thickness .16 mm.

The type of this species is from the Fort Hays limestone of Nebraska. Loetterle found it in the Fort Hays and lower Smoky Hill. It has been reported from the lower Cretaceous of Texas and from beds of Austin, Taylor and Navarro age. In this material it was observed in the Fort Hays at most localities and one rare occurrence in the Smoky Hill was noted.

Genus GYROIDINA d'Orbigny, 1826

Gyroidina depressa (Alth)
Plate 3, Figures 15a, b, c

Rotalina depressa - Alth, Haidinger's naturew. Abh., vol. 3, p. 266, pl. 13, fig. 21, 1850.

Gyroidina depressa - Cushman and Church, California Acad. Sci. Proc., 4th ser., vol. 18, p. 515, pl. 41, figs. 4-6, 1929.
Cushman, Tennessee Div. Geology Bull. 41, p. 54, pl. 9, figs. 7, 8, 1931.
Sandidge, Jour. Paleontology, vol. 6, p. 283, pl. 43, figs. 16-18, 1932.
Wickenden, Jour. Paleontology, vol. 6, p. 206, pl. 29, figs. 9a-c, 1932.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 42, pl. 6, figs. 7a-c, 1937.
Cushman and Hedberg, Cushman Lab. Foram. Research Contr., vol. 17, p. 97, pl. 23, figs. 11, 12, 1941.
Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 95, pl. 14, figs. 23a-c, 1944.
Cushman and Deaderick, Jour. Paleontology, vol. 18, p. 339, pl. 53, figs. 19, 20, 1944.
Cushman, U.S.G.S. Prof. Pap. 206, p. 139, pl. 58, figs. 1-4, 1946.

Rotalia cretacea - Carsey, Texas Univ. Bull. 2612, pl. 48, pl. 1, figs. 1a, b, 1926.

Test trochoid, biconvex, dorsal side only slightly convex, showing 2 to 3 whorls, ventral side quite convex, showing only the final whorl, umbilicate, periphery rounded, sometimes quite sharply so, becoming lobulate in the later stages; chambers numerous, 10 to 12 in final whorl, last few becoming slightly inflated; sutures on ventral side radiate, nearly straight, becoming slightly depressed in later part, slightly curved on dorsal side, flush with the surface; aperture a low slit at base of final chamber on ventral side; wall smooth, finely perforate. Diameter of figured specimen .18 mm., thickness .10 mm.

This species ranges nearly throughout the upper Cretaceous of the Gulf Coast region. Loetterle reported it as

being rare in the Fort Hays and quite common in the lower Pierre of Kansas, Nebraska and South Dakota. In this study it was found only in the Fort Hays from the drill core at Fort Randall Dam.

Gyroidina nitida (Reuss)
Plate 3, Figures 16a, b, c

Rotalina nitida - Reuss, Geognostische Skizzen Bohemen, vol. 2, pt. 1, p. 214, 1844.

Gyroidina nitida - Morrow, Jour. Paleo., vol. 8, p. 197, pl. 30, figs. 1a-c, 1934.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 42, pl. 6, figs. 8a-c, 1937.
Frizzell, Jour. Paleo., vol. 17, p. 351, pl. 57, figs. 6a-c, 1943.
Cushman, U.S.G.S. Prof. Pap. 206, p. 140, pl. 58, fig. 5, 1946.

Test trochoid, 2½ to 3 whorls visible on dorsal side, only final whorl visible from ventral, dorsal side flat to slightly convex, ventral strongly convex, umbilicate, peripheral margin sharply to broadly rounded, lobulate in some specimens; chambers quite distinct, early ones on dorsal side indistinct on some specimens, 4 to 6 in final convolution, slightly inflated, increasing regularly in size as added; sutures slightly curved, later ones somewhat depressed, radially disposed on ventral side, early ones on dorsal side indistinct in some specimens; aperture a low slit at base of final chamber, extending from periphery to umbilicus. Diameter of figured specimen .31 mm., thickness .21 mm.

This species occurs in the Fort Hays member at most localities and appears to be restricted in the Niobrara to this lower member.

Family GLOBIGERINIDAE

Subfamily GLOBIGERININAE

Genus GLOBIGERINA d'Orbigny, 1826

Globigerina cretacea d'Orbigny
Plate 4, Figures 1a, b

Globigerina cretacea - d'Orbigny, Mem. Soc. Geol. France, ser. 1, vol. 4, p. 34, pl. 3, figs. 12-14, 1840.
Morrow, Jour. Paleontology, vol. 8, p. 198, pl. 30, figs. 7, 8, 10a, b, 1934.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 44, pl. 7, figs. 1, 2, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 22, p. 17, pl. 3, fig. 5, pl. 4, figs. 5, 6, 1946.

Test a low trochoid spire, 2½ to 3 whorls visible on dorsal side, only final whorl visible from ventral, with a large, deep umbilicus on ventral side, periphery broadly rounded, strongly lobulate, chambers distinct, spherical, generally five and sometimes six in final whorl, increasing quite rapidly in size as added; sutures distinct, strongly depressed; aperture from each chamber large, opening into the umbilicus, with a distinct, smooth lip, the umbilical cavity of most specimens is filled with foreign material obscurring the apertures; surface ornamented by numerous fine spines which are more strongly developed in the early stages. Diameter of figured specimen .48 mm., thickness .30 mm.

This is a very common and widespread species in the upper Cretaceous and occurred throughout the material examined in this investigation.

There has been a great deal of confusion in the literature dealing with the genus Globigerina and as a result it is a very difficult one to work with. The specimens collected from this material show a great deal of variation and it is probable that more than one species is represented. However, until the literature dealing with the genus is clarified, it is deemed advisable not to separate them.

Genus GLOBIGERINELLA Cushman, 1927

Globigerinella aspera (Ehrenberg)
Plate 4, Figures 2a, b

Phanerostomum asperum - Ehrenberg, Mikrogeologie, pl. 30, figs. 26a, b, pl. 32, pt. 2, fig. 42, 1854.

Globigerinella aspera - Cushman, Tennessee Div. Geology Bull. 41, p. 59, pl. 11, figs. 5a, b, 1931.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 45, pl. 7, figs. 4a, b, 1937.
Nauss, Jour. Paleontology, vol. 21, p. 337, pl. 48, figs. 9a, b, 1947.

Test planispirally coiled, nearly bilaterally symetrical, subcircular in outline, periphery broadly rounded, strongly lobulate throughout; chambers distinct, strongly inflated, increasing uniformly in size as added, 6 to 8 in the final coil; sutures distinct, strongly depressed throughout; aperture a high arched opening at base of final chamber, extending downward on each side, with a distinct lip which broadens into a flange on each side; wall finely spinose, especially in early portion. Diameter of illustrated specimen .28 mm., thickness .14 mm.

This species is quite common in the upper Cretaceous of America. Loetterle reported it from the Niobrara formation in Kansas, Nebraska and South Dakota. It occurred throughout the Niobrara of most localities examined but is much more common in the Smoky Hill.

This small species is very distinct in its typical form but through a lengthening of the final chambers it grades into Hastigerinella. Globigerinella involuta (White) is more evolute and has the entire test more loosely coiled.

Genus HASTIGERINELLA Cushman, 1927

Hastigerinella simplex Morrow
Plate 4, Figures 3a, b

Hastigerinella simplex - Morrow, Jour. Paleontology, vol. 8, p. 198, pl. 3, figs. 6a, b, 1934.

Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 46, pl. 7, figs. 5a, b, 1937.
Cushman, U.S.G.S. Prof. Pap. 206, p. 148, pl. 61, fig. 10, 1946.

Test slightly trochoid, becoming planespiral in the adult, chambers of early whorls small, globular, quite indistinct, those of final whorl very distinct, four or five in number, last two or three becoming elongate, final one very strongly elongate, with a broadly rounded outer end; sutures distinct, depressed; aperture a high, arched opening at base of final chamber, extending onto ventral side, with a slight, very thin lip, somewhat indistinct; wall finely spinose, spines becoming quite coarse at the tips of the adult chambers. Diameter of figured specimen .30 mm., thickness .10 mm.

Morrow described this species from the Greenhorn limestone of Kansas. Loetterle reported it as occurring throughout the Niobrara at several localities in Kansas, Nebraska and South Dakota. In this study it was found to be rare in the Fort Hays member at Fort Randall Dam.

This is a very simple species of the genus and probably represents an early stage in its development. It does not have the final chambers nearly as elongate as those of Hastigerinella watersi Cushman, nor does it have the bulbuous tips on the final chambers as on the later species.

Family HANTKENINIDAE

Genus SCHACKOINA Thalman, 1932

Schackoina trituberculata (Morrow)
Plate 4, Figure 4

Hantkenina trituberculata - Morrow, Jour. Paleo. vol. 8, p. 195, pl. 29, figs. 24, 26-28, 1934.

Schackoina trituberculata - Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 47, pl. 7, figs. 7a, b, 1937.
Cushman, U.S.G.S. Prof. Pap. 206, p. 148, pl. 61, figs. 13-16, 1946.

Test very small; consisting of three and sometimes four globular chambers in an irregular planespiral arrangement, chambers increasing rapidly in size as added; with one to three tubular spines projecting from each chamber, if only one, it is at periphery, if two, placed symmetrically at each side of periphery, and if three, with the peripheral one smaller than those at the sides; aperture an arched opening at base of final chamber, generally indistinct. Diameter of illustrated specimen .19 mm., thickness .10 mm.

This species was reported from the Smoky Hill member by Morrow and Loetterle. It was found in the Fort Hays from Fort Randall Dam as well as in some samples of the Smoky Hill during this study. Because of the extremely small size of this species it has probably been overlooked in many samples.

Family GLOBOROTALIIDAE

Genus GLOBOTRUNCANA Cushman, 1927

Globotruncana canaliculata (Reuss)
Plate 4, Figures 5a, b

Rosalina canaliculata - Reuss, Akad. Wiss. Wien, Mathnaturwiss. Kl., Denkschr., vol. 7, pt. 1, p. 70, pl. 26, fig. 4, 1854.

Globotruncana canaliculata - Cushman, Cushman Lab. Foram. Research Contr., vol. 3, p. 116, pl. 23, figs. 11a-c, 1927; Jour. Paleontology, vol. 6, p. 343, pl. 51, figs. 14a-c, 1932.

Cushman and Deaderick, Cushman Lab. Foram. Research Contr., vol. 18, p. 65, pl. 15, figs. 23-27, 1942.

Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 14, pl. 3, fig. 8, 1944.

Cushman and Goudkoff, Cushman Lab. Foram. Research Contr., vol. 20, p. 62, pl. 10, figs. 10a, b, 1944

Cushman, U.S.G.S. Prof. Pap. 206, p. 149, pl. 61, figs. 17, 18, 1946.

Test flattened, dorsal and ventral sides nearly parallel or somewhat convex, periphery broad and sharply truncate;

chambers distinct, overlapping, about 5 to 7 in final whorl, increasing in size as added, with definite dorsal and ventral keels, dorsal face of each chamber flat or slightly concave, ventral face flat or slightly convex; sutures distinct, raised and beadlike, tangential on dorsal side, curved on ventral side, curved along periphery forming dorsal and ventral keels; aperture opening into umbilicus from ventral margin of last chamber, with a distinct lip; chamber faces smooth, perforate. Diameter of figured specimen .44 mm., thickness .20 mm.

This species is widely distributed in the Cretaceous of America and has a long vertical range. In this material it was found in both the Fort Hays and Smoky Hill but was extremely rare.

The sharply truncate periphery with distinct dorsal and ventral keels, and the flattened character of the test distinguish this species from others of the genus.

Globotruncana marginata (Reuss)
Plate 4, Figures 6a, b, c

Rosalina marginata - Reuss, Verstein Bohm Kreideformation, pt. 1, p. 36, pl. 8, figs. 54, 74; pl. 13, fig. 68, 1845.

Globotruncana marginata - Thalman, Eclogae Geol. Helvetiae, vol. 27, p. 414, 1934.
Cushman, U.S.G.S. Prof. Pap. 206, p. 150, pl. 62, figs. 1, 2, 1946.

Globigerina marginata - Loetterle (?), Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 44, pl. 7, figs. 3a-c, 1937.

Test somewhat compressed, slightly biconvex, periphery, truncate, distinctly lobulate throughout; chambers distinct, 5 to 7 in final convolution, inflated, with definite dorsal and ventral keels which are more strongly developed in later chambers, chambers somewhat offset and with overlapping appearance; sutures distinct, depressed, slightly curved dorsally, straight on ventral side; aperture an arched opening on ventral side of final chamber, opening into small umbilical cavity, with a narrow lip; surface coarsely perforate and

somewhat spinose, more strongly so in early portion of test. Diameter of figured specimen .28 mm., thickness .41 mm.

This species has more inflated chambers than any others of the genus giving it an appearance somewhat like Globigerina. However, the truncate periphery and definite dorsal and ventral keels place it in this genus.

This species is most common in beds of Austin and lower Taylor age. Loetterle found it to be quite abundant in the Smoky Hill and rare in the Fort Hays. It was found throughout the Niobrara in this material but never in any abundance.

Genus GLOBOROTALITES Brotzen, 1942

Globorotalites micheliniana (d'Orbigny)
Plate 4, Figures 7a, b, c

Rotalina micheliniana - d'Orbigny Soc. Geol. France Mem., 1st ser., vol. 4, p. 31, pl. 3, figs. 1-3, 1840.

Globorotalia micheliniana - Cushman, Cushman Lab. Foram. Research Contr., vol. 7, p. 45, pl. 6, figs. 8a-c, 1931; idem., vol. 20, p. 15, pl. 3, fig. 13, 1944; U.S.G.S. Prof. Pap. 206, p. 152, pl. 63, figs. 2a-c, 3a-c, 1946.

Gyroidina micheliniana - Cushman, Jour. Paleontology, vol. 6, p. 342, pl. 51, figs. 12a-c, 1932.

Gyroidina alabamensis - Sandidge, Jour. Paleontology, vol. 6, p. 283, pl. 43, figs. 13-15, 1932.

Globorotalites micheliniana - Cushman, Foraminifera, Ed. 4, pl. 35, fig. 13, 1948.

Test conical in side view, dorsal side slightly concave to slightly convex, ventral side high with deep umbilicus; periphery sharp, sometimes slightly keeled; surface smooth; chambers somewhat indistinct, 6 or 7 in final whorl; sutures somewhat indistinct, flush with surface, strongly oblique on dorsal side, arched opposite to direction of coiling on ventral side; aperture elongate, extending from near periphery to umbilicus along basal margin of final chamber; inner margin of final chamber somewhat broad and flattened. Diameter of figured specimen .26 mm., height .19 mm.

The types of this species are from the White Chalk of the Paris Basin. In America it is largely confined to beds of Taylor age although it is occasionally found in Austin and Navarro beds. It occurred rarely in the Fort Hays from the drill core at Fort Randall Dam.

This species and Globorotalites subconica Morrow are very similar but the later species is somewhat smaller, has concave sides, a more flaring periphery, and more distinct early chambers on the dorsal side.

Globorotalites umbilicata (Loetterle)
Plate 4, Figures 8a, b, c

Globorotalia umbilicata - Loetterle, Nebraska Geol. Survey Bull., 2nd ser. Bull. 12, p. 43, pl. 6, figs. 9a-c, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 96, pl. 14, figs. 19a-c, 1944; U.S.G.S. Prof. Pap. 206, p. 153, pl. 63, figs. 1a-c, 1946.

Test low, broadly conical in side view, dorsal face concave, ventral face lowly conical with a broad, open umbilicus; periphery sharp, not keeled, lobulate; chambers distinct, 7 to 9 in last whorl, elongate, curved, last few somewhat inflated, only those of last whorl visible on ventral side, all visible dorsally; sutures strongly curved opposite to direction of coiling, distinct and depressed on ventral side, especially between last few chambers, somewhat indistinct and less depressed on dorsal face; aperture low, elongate, extending from near periphery to umbilicus along base of last formed chamber; inner margin of last chamber broad; wall smooth, perforate. Diameter of figured specimen .30 mm., height .16 mm.

The type of this species is from the Niobrara chalk of Nebraska. It is found at numerous localities in beds of Austin age and at a few localities in beds of lower Taylor age. In this material it was very common in the Fort Hays at every locality and was rare in a few samples of the Smoky Hill member.

This species differs from Globorotalites subcanica Morrow and G. micheliniana d'Orbigny in the lower ventral side,

lobulate periphery, broader and more open umbilicus, more strongly curved sutures, and more depressed sutures on ventral side.

Family ANOMALINIDAE

Subfamily ANOMALININAE

Genus ANOMALINA d'Orbigny, 1826

Anomalina henbesti Plummer
Plate 4, Figures 9a, b, c

Anomalina complanata - Cushman (not Reuss), Tennessee Div. Geol. Bull. 41, p. 60, pl. 11, figs. 7a-c, 1931.
Anomalina henbesti - Plummer, Texas Univ. Bull. 3501, p. 290, pl. 5, figs. 7-10, 1932.
Cushman and Goudkoff, Cushman Lab. Foram. Research Contr., vol. 20, p. 60, pl. 10, fig. 11, 1944.
Cushman, U.S.G.S. Prof. Pap. 206, p. 155, pl. 64, figs. 2a-c, 1946.
Planulina complanata - Loetterle (not Reuss), Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 48, pl. 8, figs. 1a-c, 1937.
Anomalina semicomplanata - Cushman, Cushman Lab. Foram. Research Contr., vol. 14, p. 68, pl. 12, figs. 1a-c, 1938; idem., vol. 16, p. 29, pl. 5, figs. 9a-c, 1940.

Test trochoid in young, becoming planispiral in the adult, equally biconvex to somewhat flattened dorsally, dorsal side with a rounded node of clear shell material at the center, sometimes obscuring the early whorls, becoming slightly involute in final whorl, ventral side with a coil of clear shell material at the center, becoming slightly evolute in later part, periphery sharply rounded, becoming lobulate in final portion; chambers numerous, 9 to 12 in final whorl, increasing gradually in size as added, later ones becoming somewhat inflated; sutures distinct, slightly limbate, gently curved, becoming slightly depressed in later stages; aperture an arched opening at base of final chamber, extending as a narrow slit to the umbilicus on the ventral side, with a slight lip; wall smooth except for the slightly depressed sutures and thickening at the center on each side, coarsely perforate. Diameter of illustrated specimen .30 mm., thickness .10 mm.

Loetterle reported this species from the Fort Hays limestone of Kansas, Nebraska and South Dakota, and it has been reported as widely distributed in beds of upper Taylor and lower Navarro age in the Gulf Coast area. It occurred in the Fort Hays at every locality examined during this study but was never very abundant.

Genus PLANULINA d'Orbigny, 1826

Planulina kansasensis Morrow
Plate 4, Figures 10a, b, c

Planulina kansasensis - Morrow, Jour. Paleontology, vol. 8, p. 201, pl. 3, figs. 2, 12, 15, 1934.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 49, pl. 8, figs. 2a-c, 1937.
Cushman, Cushman Lab. Foram. Research Contr., vol. 16, p. 34, pl. 6, figs. 8a-c, 1940; U.S.G.S. Prof. Pap. 206, p. 157, pl. 64, figs. 12a-c, 1946.

Test much compressed, dorsal and ventral sides nearly flat, somewhat trochoid, dorsal side completely evolute, showing 2½ to 3 whorls, central area covered by clear shell material of varying thickness, ventral side nearly involute, becoming slightly evolute in later part, with a thick coil of clear shell material at the center, periphery sharply rounded, very slightly lobulate; chambers quite distinct, numerous, 8 to 11 in final whorl; sutures distinct, gently curved backward, slightly depressed in later part of test; aperture rather indistinct, peripheral and extending onto ventral side, with a slight, thin lip; wall smooth, perforate. Diameter of figured specimen .36 mm., thickness .10 mm.

The type of this species is from the basal Niobrara of Kansas. Loetterle reported it as abundant in the Fort Hays limestone of Kansas, Nebraska, and South Dakota, and less common in the Smoky Hill. It has the same distribution in this material although the specimens from the upper part of the Smoky Hill are questionably referred to this species.

Phylum ARTHROPODA

Class CRUSTACEA

Order OSTRACODA

Family CYTHERELLIDAE

Genus CYTHERELLA Jones, 1849

Cytherella bullata Alexander
Plate 5, Figures 1a, b

Cytherella obesa - Alexander (not Jones, Kirkby and Brady, 1884), Univ. Texas Bull. 2907, p. 51, pl. 1, figs. 3, 6, 1929.

Cytherella austinensis - Alexander, Univ. Texas Bull. 2907, p. 51, pl. 2, figs. 4, 6, 1929.

Cytherella bullata - Alexander, Jour. Paleo., vol. 6, p.101, 1932; Am. Mid. Nat., vol. 13, p. 305, pl. 28, figs. 3, 4, 1932.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 50, pl. 8, figs. 4a, b, 1937.

Loetterle described this species as follows:

"Carapace ovate in lateral view, the female higher than the male, greatest height at or very slightly posterior to the middle; anterior end broadly rounded, posterior rounded but more narrowly than anterior, lower and narrower in the male; dorsal margin gently arched, obscurely angled at the middle, angle more pronounced in the male, ventral margin faintly convex; right valve overlaps left around entire margin, amount of overlap somewhat greater dorsally than elsewhere, very slight in the post-ventral quarter of the margin; in dorsal view carapace of female widest at a point about one-third the length from posterior end, of the male at or slightly posterior to the middle, broadly rounded posteriorly, especially in the female." Length of illustrated specimen .60 mm., height .38 mm., thickness of right valve .19 mm.

Alexander described this species from the upper Austin chalk of Texas and Loetterle reported it as rare in the Fort Hays. A right valve from the Fort Hays at Spirit Mound was the only specimen of this species found in this material.

Family CYTHERIDAE

Genus BRACHYCYTHERE Alexander, 1933

Brachycythere sphenoides (Reuss)
Plate 5, Figures 2a, b

Cythere sphenoides - Reuss, Denkschr. K. Akad. Wiss. Wien., vol. 7, p. 141, pl. 26, fig. 2, 1854.
Alexander, Univ. Texas Bull. 2907, p. 81, pl. 7, figs. 9, 14, 1929.

Brachycythere sphenoides - Alexander, Jour. Paleo., vol. 7, p. 205, pl. 25, figs. 3, 14; pl. 26, fig. 7; pl. 27, fig. 19, 1933.
Loetterle, Nebr. Geol. Survey Bull., 2nd ser., Bull. 12, p. 53, pl. 9, figs. 1a, b, 1937.

Loetterle described this species as follows:

"Carapace in side ovate, height equal to more than two thirds the length, greatest height just anterior to the center, with a prominent tubercle near antero-dorsal margin; anterior end broadly and obliquely rounded, finely denticulate, posterior end acute, rounded and denticulate along post-ventral quarter, dorsal margin strongly arched, broadly angled anterior to the center, obscurely angled in the post-dorsal quarter, ventral border slightly convex, dorsal and ventral edges converging strongly toward the posterior end, just above ventral border of each valve is a broad, alate lateral expansion; left valve overlapping right; hinge of the right valve consisting of an anterior tooth and postjacent socket, with a long crenulate tooth at posterior end of hinge; left valve with anterior socket and postjacent tooth connected by a narrow bar to the long crenulate socket at posterior end of hinge; in dorsal view anterior and posterior ends compressed, valves wider through the ventrolateral expansion." Length of illustrated specimen .74 mm., height .50 mm., thickness .40mm.

This species is common throughout the Austin chalk of Texas and extends upward through the lower half of the Taylor. Loetterle found it to be common in the Fort Hays member of the Niobrara and in the chalk zone of the lower Pierre. From this material it was present only in the Fort Hays at Spirit Mound and Fort Randall Dam.

Genus CYTHEREIS Jones, 1849

Cythereis coryelli Loetterle
Plate 5, Figures 3a, b

Cythereis coryelli - Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 55, pl. 9, figs. 3a, b, 1937.

A single right valve of this species from the Fort Hays member in the Fort Randall Dam drill core shows the characters of the species very well. Loetterle described it from the Fort Hays of Nebraska and did not observe it outside of this member. His description is as follows:

"Carapace thin and fragile, in side view elongate-ovate, height equal to about one-half the length, highest near anterior end, converging slightly toward posterior end; anterior border broadly and evenly rounded, smooth, with a narrow marginal rim, posterior end obliquely truncate above, rounded and finely denticulate below; dorsal margin straight, ventral margin gently convex downward and converging toward posterior end; sides ornamented by a prominent, large tubercle anterior to the center and a second, smaller tubercle posterior to and slightly above the center, beginning near the antero-ventral margin a sharp ridge extends posteriorly and upward, widening rather rapidly and terminating posteriorly in a sharp node, a second ridge extends along the dorsal margin, widening posteriorly, the post-dorsal junction is marked by a short, flat spine directed posteriorly; in dorsal view ends subacute, carapace widest at node-like termination of ventral ridge; surface reticulate, slightly depressed and more finely reticulate in the area posterior to the large sub-central tubercle." Length of figured specimen .48 mm., height .25 mm.

Cythereis foersteriana (Bosquet)
Plate 5, Figures 4a, b

Cypridina foersteriana - Bosquet, Mein. Soc. Roy. Sci. Liege, vol. 4, p. 364, pl. 2, figs. 4a-d, 1847.

Cythere foersteriana - Alexander, Univ. Texas Bull. 2907, p. 82, pl. 6, figs. 1, 11, 1929.

Carapace in side view elongate, oblong-ovate, greatest height near anterior border; anterior end broadly rounded, finely denticulate, with a thickened marginal rim which terminates dorsally in thickened knob; posterior end very narrow, angled at about middle, coarsely denticulate below angulation; dorsal and ventral margins slightly convex converging rapidly towards posterior end, left valve the larger, slightly overlapping the right around entire margin, surface ornamented by three longitudinal ridges beginning anterior to middle and terminating near posterior end, dorsal ridge with a prominent depression just below its anterior end, sometimes with 3 or 4 smaller pits behind this one; in dorsal view carapace is strongly biconvex, widest slightly posterior to middle, anterior and posterior ends much compressed. Length of illustrated specimen .66 mm., height .41 mm., thickness of left valve .19 mm.

This species is much more narrow posteriorly than Cythereis semiplicata Reuss and has the post-ventral margin denticulate. The ornamentation is also slightly different, this species lacking the knoblike termination of the middle ridge and having one to four pits just below dorsal ridge.

Alexander reported this species from the lower Taylor of Texas. It was rare in the Fort Hays at Spirit Mound and in Sec. 8, Clay County.

Cythereis niobrarensis Morrow
Plate 5, Figures 5a, b

Cythereis niobrarensis - Morrow, Jour. Paleo., vol. 8, p. 203, pl. 31, figs. 6, 10a-c, 1934.
Loetterle, Nebraska Geol. Survey Bull., 2nd ser., Bull. 12, p. 54, pl. 9, figs. 2a, b, 1937.

Carapace in side view elongate, sub-ovate, highest near anterior end; anterior end broadly rounded, denticulate, with a thickened marginal rim; posterior end sharply angled at middle, slightly rounded and denticulate below, curving sharply upward above angulation and joining dorsal margin at nearly a right angle; dorsal margin slightly concave, curving upward and joining anterior margin in an angular junction, ventral margin straight, dorsal and ventral margins converge slightly posteriorly; surface coarsely reticulate and ornamented by

three rows of fine nodes, dorsal one begins near middle and terminates just in front of post-dorsal juncture in a large sharp spine, central one curves downward anterior to middle and terminates beneath large prominent tubercle, a third row begins near anterio-ventral margin and runs obliquely upward posteriorly, terminating in a large spine just anterior to post ventral juncture; carapace strongly biconvex in dorsal view, anterior and posterior ends strongly compressed. Length of figured specimen .63 mm., height .32 mm., thickness .30 mm.

This very distinctive form is the most common ostracod in the Fort Hays member of the Niobrara. It was found at every locality examined during this study and Loetterle found it to be widespread in his material. In most of Loetterle's Kansas and Nebraska specimens the rows of spines have developed into ridges.

Cythereis subgracilis Morrow
Plate 5, Figures 6a, b

Cythereis subgracilis - Morrow, Jour. Paleo., vol. 8, p. 204, pl. 31, figs. 9a-c, 1934.

Carapace in side view elongate, subovate, highest near anterior margin; anterior margin broadly and evenly rounded, with a thickened marginal rim, posterior end roundly angled at middle, rounded and denticulate below, somewhat truncate above angulation; ventral margin straight, dorsal margin curving slightly upward in anterior portion, dorsal and ventral margins converge slightly posteriorly; surface finely reticulate, ornamented by three rather indistinct ridges, median one strongest posteriorly, terminates at about middle in a prominent, broadly rounded knob, dorsal ridge short, beginning posterior to middle, curving angularly downward near post dorsal margin and joins median ridge, third ridge begins near anterior end, parallels ventral margin to post-ventral juncture where it angles abruptly upward and joins median ridge; carapace in dorsal view strongly biconvex, thickest posterior to middle, anterior and dorsal ends strongly compressed. Length of illustrated specimen .50 mm., height .28 mm., thickness .21 mm.

The type of this species is from the basal Niobrara in Ellis Co., Kansas, the only locality at which Morrow found it. It was very rare in the Fort Hays at Spirit Mound and from the drill core at Fort Randall Dam.

Table I - Showing Distribution and Relative Abundance of Species

	Fort Hays				Smoky Hill							
FORAMINIFERA	1	2	3	4	5	6	7	8	9	10	11	12
Spiroplectammina semicomplanata (Carsey)	T											
Gaudryina (Siphogaudryina) austinana Cushman		R		T								
Gaudryina (Pseudogaudryina) nebrascensis Loetterle	T											
Dorothia cf. D. filiformis (Berthelin)		R		T								
Dorothia pupoides (d'Orbigny)	A	R	R	R			T					
Robulus munsteri(Roemer)	C		R	T								
Robulus navarroensis (Plummer)	R			T								
Robulus sp.	C	R		R			T					
Lenticulina aff. L. sublaevis Morrow	C	R		R			T					
Planularia umbonata Loetterle	R	T		T								
Planularia sp. #1			R									
Marginulina bullata Reuss	T											
Marginulina sp. #1	R											
Dentalina aculeata d'Orbigny	R	R	R									
Dentalina granti (Plummer)	T											
Dentalina lorneiana d'Orbigny	T											
Dentalina niobrarensis Loetterle	R		T									
Dentalina reflexa Morrow	R			T								
Nodosaria zippei Reuss	C											
Nodosaria sp. #1	T			T								
Saracenaria triangularis (d'Orbigny)	R											
Vaginulina texana Cushman	R											
Palmula suturalis (Cushman)	C			T								
Frondicularia extensa Morrow	T											
Frondicularia undulosa Cushman	R			T								
Kyphopyxa christneri (Carsey)	T	T		R								
Globulina lacrima Reuss var. subsphaerica (Berthelin)	R	T	T									
Ramulina cf. R. aculeata (d'Orbigny)	R		T									
Bullopora sollasi (Chapman)	R			T								
Gumbelina globulosa (Ehrenberg)	C	C	R	A	A	A	C	C	C	C		
Gumbelina moremani Cushman			R	R								R
Gumbelina plummerae Loetterle		T		R	C	R	R	R	R	R	R	R
Gumbelina pseudotessera Cushman	R	R	R			R	R					

Table 1 (continued)

	Fort Hays				Smoky Hill							
	1	2	3	4	5	6	7	8	9	10	11	12
Ventilabrella austinana Cushman	C											
Bolivinitella elevi (Cushman)	R											
Eouvigerina aculeata Cushman	T	R	C	C								
Eouvigerina plummerae Cushman	C	R	C	R								
Bulimina reussi Morrow	A	R		T								
Neobulimina canadensis Cushman & Wickenden	R	C	C	R								
Neobulimina irregularis Cushman & Parker								R			T	
Virgulina tegulata Reuss	R	T	T	T								
Virgulina sp. #1		C	C	C			R	R				
Loxostoma clavatum (Cushman)					T							T
Loxostoma cushmani Wickenden					R	R		R	R	R	R	R
Pleurostomella austinana Cushman	R	T		T								
Nodosarella gracillima Cushman				T								
Valvulineria plummerae Loetterle	A	R	R						T			
Gyroidina depressa (Alth)				T								
Gyroidina nitida (Reuss)	C		R	R								
Globigerina cretacea d'Orbigny	C	A	C	A	A	A	C	C	C	A	C	A
Globigerinella aspera (Ehrenberg)		R	R	R	C	C	A	C	C	C	C	C
Hastigerinella simplex Morrow				R								
Schackoina trituberculata Morrow				T			R	T				
Globotruncana canaliculata (Reuss)		T							T			R
Globotruncana marginata (Reuss)	T		R	T	T							
Globorotalites micheliniana d'Orbigny				R								
Globorotalites umbilicata (Loetterle)	A	C	C	C			R		T			
Anomalina henbesti Plummer	C	R	T	T								
Planulina kansasensis Morrow	A	A	C	C	R	T	C	T	T	T		R
OSTRACODA												
Cytherella bullata Alexander	T											
Brachycythere sphenoides (Reuss)	R			R								
Cythereis coryelli Loetterle				T								
Cythereis foersteriana (Bosquet)	T		T									
Cythereis niobrarensis Morrow	R	T	R	R								
Cythereis subgracillis Morrow	R			T								

Table 1 (continued)

LEGEND

Explanation of Letters

A - Abundant
C - Common
R - Rare
T - Trace

Explanation of Numbers

1. Fort Hays Member from Spirit Mound
2. Fort Hays Member from Cedar Co., Nebraska
3. Fort Hays Member at Sec. 8, Clay Co.
4. Fort Hays Member at Fort Randall Dam
5. Smoky Hill Member from "Old Cement Plant"
6. Smoky Hill Member from Sec. 22, Yankton Co.
7. Smoky Hill Member from Cedar Co., Nebraska
8. Smoky Hill Member from Sec. 36, Brule Co.
9. Smoky Hill Member from Sec. 17, Lyman Co.
10. Smoky Hill Member from Sec. 15, Brule Co.
11. Smoky Hill Member from Sec. 29, Brule Co.
12. Smoky Hill Member from Fort Randall Dam

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Plates 1 through 5

Plate 1

Figure 1. Spiroplectammina semicomplanata (Carsey) (p. 17) Fort Hays member, Spirit Mound, Clay Co., S.D. X 105

2. Gaudryina (Siphogaudryina) austinana Cushman (p. 18) Fort Hays member, Cedar Co., Nebraska. X 110

3. Gaudryina (Pseudogaudryina) nebrascensis Loetterle (p. 18) Fort Hays member, Spirit Mound, Clay Co., S.D. a. front view, b. side view. X 55

4. Dorothia cf. D. filiformis (Berthelin) (p. 19) Fort Hays member, Cedar Co., Nebraska. a. front view, b. side view. X 50

5. Dorothia pupoides (d'Orbigny) (p. 20) Fort Hays member, Spirit Mound, Clay Co., S.D. a. front view, b. side view. X 70

6. Robulus munsteri (Roemer) (p. 21) Fort Hays member, Fort Randall Dam Site, S.D. a. side view, b. apertural view. X 55

7. Robulus navarroensis (Plummer) (p. 21) Fort Hays member, Fort Randall Dam Site, S.D. a. side view, b. apertural view. X 70

8. Lenticulina cf. L. sublaevis Morrow (p. 23) Fort Hays member, Fort Randall Dam Site, S.D. a. side view, b. apertural view. X 45

9. Planularia umbonata Loetterle (p. 23) Fort Hays member, Spirit Mound, Clay Co., S.D. a. side view, b. apertural view. X 100

10. Planularia sp. #1 (p. 24) Fort Hays member, Spirit Mound, Clay Co., S.D. a. side view, b. apertural view. X 130

11. Marginulina bullata Reuss (p. 25) Fort Hays member, Spirit Mound, Clay Co., S.D. a. side view, b. apertural view. X 110

12. Marginulina sp. #1 (p. 25) Fort Hays member, Spirit Mound, Clay Co., S.D. a. side view, b. apertural view, X 50

13. Dentalina aculeata d'Orbigny (p. 26) Fort Hays member, Cedar Co., Nebraska. X 110

14. Dentalina cf. D. granti Plummer (p. 26) Fort Hays member, Spirit Mound, Clay Co., S.D. X 50

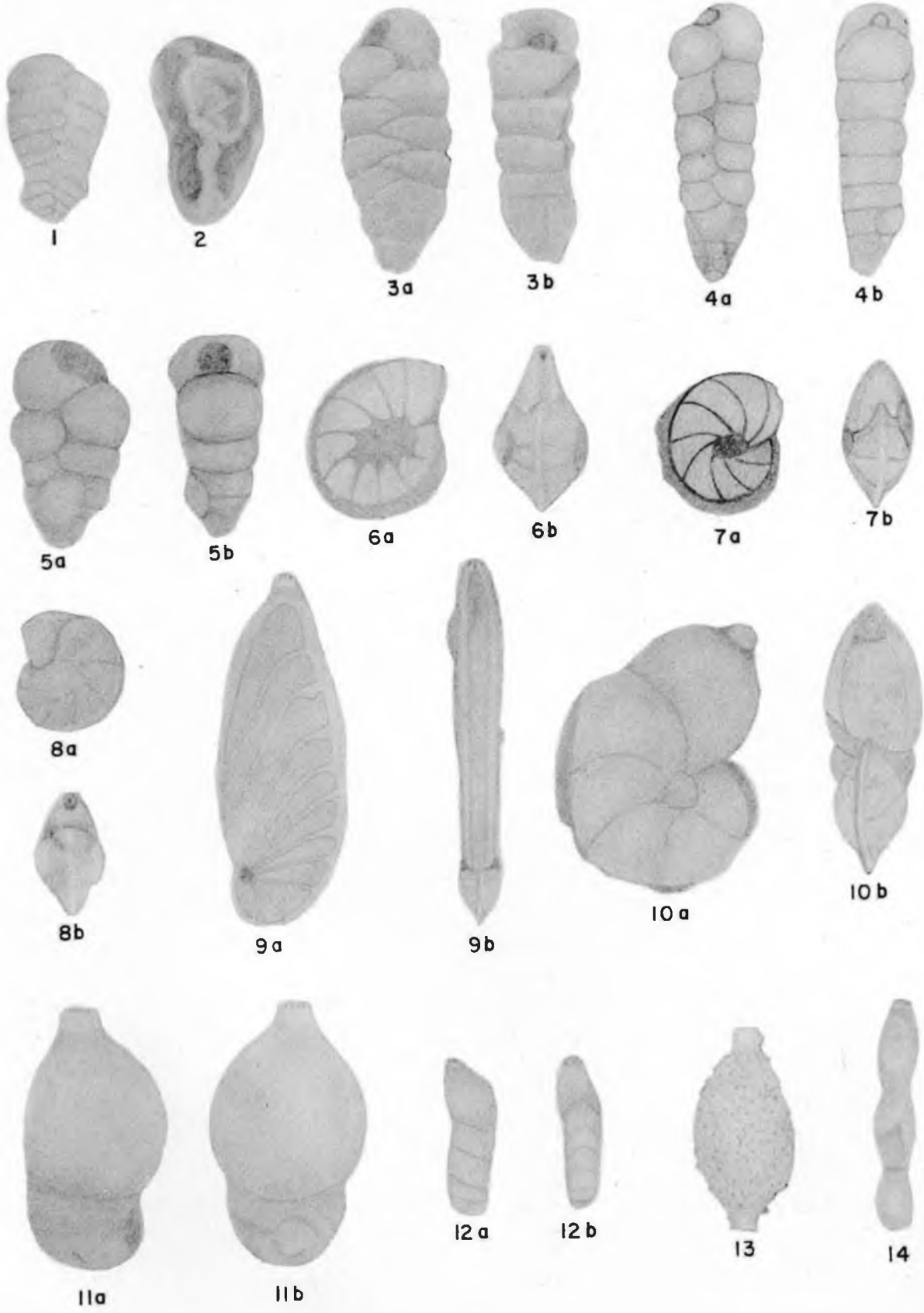
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Plate 1

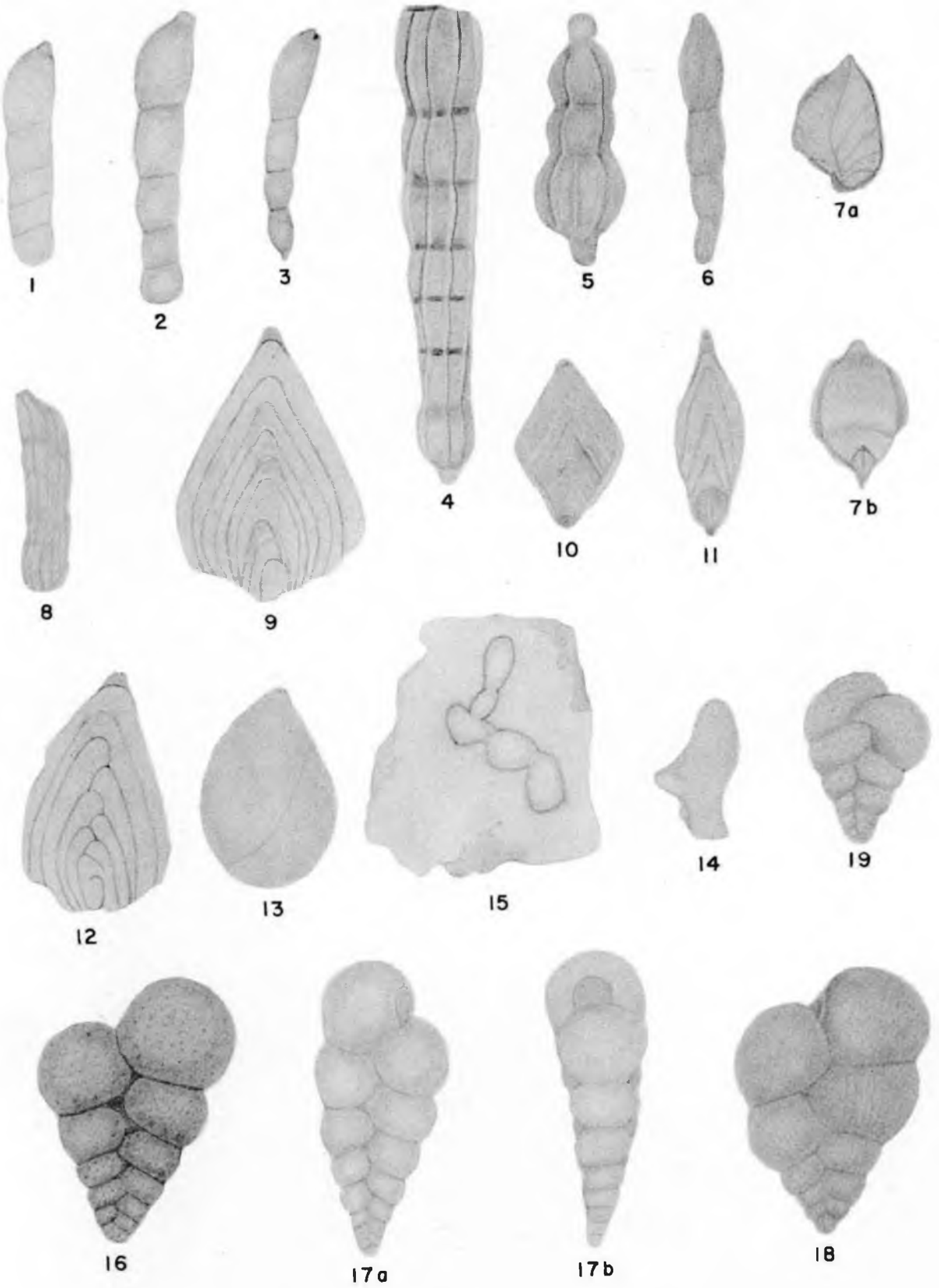

Plate 2

Figure 1. Dentalina lorneiana d'Orbigny (p. 27) Fort Hays member, Spirit Mound, Clay Co., S.D. X 50

2. Dentalina niobrarensis Loetterle (p. 28) Fort Hays member, Spirit Mound, Clay Co., S.D. X 80

3. Dentalina reflexa Morrow (p. 28) Fort Hays member, Fort Randall Dam Site, S.D. X 50

4, 5. Nodosaria zippei Reuss (p. 29) Fort Hays member, Spirit Mound, Clay Co., S.D.
4. Microspheric form. x 37.5
5. Megalospheric form. x 80

6. Nodosaria sp. #1 (p. 30) Fort Hays member, Fort Randall Dam Site, S.D. X 110

7. Saracenaria triangularis (d'Orbigny) (p. 30) Fort Hays member, Spirit Mound, Clay Co., S.D. a. side view, b. apertural view. X 45

8. Vaginulina texana Cushman (p. 31) Fort Hays member, Spirit Mound, Clay Co., S.D. X 55

9. Palmula suturalis Cushman (p. 32) Fort Hays member, Spirit Mound, S.D. X 35

10. Frondicularia extensa Morrow (p. 32) Fort Hays member, Spirit Mound, Clay Co., S.D. X 48

11. Frondicularia undulosa Cushman (p. 33) Fort Hays member, Fort Randall Dam Site, S.D. X 50

12. Kyphopyxa christneri (Carsey) (p. 34) Fort Hays member, Fort Randall Dam Site, S.D. X 45

13. Globulina lacrima var. subsphaerica (Berthelin) (p. 35) Fort Hays member, Spirit Mound, Clay Co., S.D. X 110

14. Ramulina aff. R. aculeata (d'Orbigny) (p. 36) Fort Hays member, Spirit Mound, Clay Co., S.D. X 55

15. Bullopora sollasi (Chapman) (p. 36) Fort Hays member, Spirit Mound, Clay Co., S.D. X 20

16. Gumbelina globulosa (Ehrenberg) (p. 37) Smoky Hill member, Quarry of Old Cement Plant, Yankton County, S.D. X 130

17. Gumbelina moremani Cushman (p. 38) Smoky Hill member, Fort Randall Dam Site, S.D. a. front view, b. side view. X 110

18. Gumbelina plummerae Loetterle (p. 39) Smoky Hill member, Quarry of Old Cement Plant, Yankton Co., S.D. X 140

19. Gumbelina pseudotessera Cushman (p. 40) Fort Hays member, Cedar Co., Nebraska. X 125

Plate 3

Figure 1. Ventilabrella austinana Cushman (p. 40) Fort Hays member, Spirit Mound, Clay Co., S.D. X 110

2. Bolivinitella eleyi (Cushman) (p. 41) Fort Hays member, Spirit Mound, Clay Co., S.D. a. front view, b. side view. X 105

3. Eouvigerina aculeata Cushman (p. 42) Fort Hays member, Fort Randall Dam Site, S.D. a. front view, b. side view. X 115

4. Eouvigerina plummerae Cushman (p. 43) Fort Hays member, Sec. 8, T. 93 N., R. 52 W., Clay Co., S.D. a. front view, b. side view. X 110

5. Bulimina reussi Morrow (p. 43) Fort Hays member, Spirit Mound, Clay Co., S.D. X 115

6. Neobulimina canadensis Cushman & Wickenden (p. 44) Fort Hays member, Fort Randall Dam Site, S.D. X 125

7. Neobulimina cf. N. irregularis Cushman & Parker (p. 45) Smoky Hill member, Sec. 36, T. 105 N., R. 71 W., Brule Co., S.D. X 120

8. Virgulina tegulata Reuss (p. 46) Fort Hays member, Spirit Mound, Clay Co., S. D. X 130

9. Virgulina sp. #1 (p. 47) Fort Hays member, Cedar Co., Nebraska. a. front view, b. side view. X 110

10. Loxostoma clavatum (Cushman) (p. 47) Smoky Hill member, Quarry of Old Cement Plant, Yankton Co., S.D. a. front view, b. side view. X 120

11. Loxostoma cushmani Wickenden (p. 48) Smoky Hill member, Quarry of Old Cement Plant, Yankton Co., S.D. X 100

12. Pleurostomella austinana Cushman (p. 49) Fort Hays member, Spirit Mound, Clay Co., S.D. X 60

13. Nodosarella gracillima Cushman (p. 50) Fort Hays member, Fort Randall Dam Site, S.D. X 100

14. Valvulineria plummerae Loetterle (p. 51) Fort Hays member, Spirit Mound, Clay Co., S.D. a. dorsal view, b. peripheral view, c. ventral view. X 100

15. Gyroidina depressa (Alth) (p. 52) Fort Hays member Fort Randall Dam Site, S.D. a. dorsal view, b. peripheral view, c. ventral view. X 130

16. Gyroidina nitida (Reuss) (p. 53) Fort Hays member, Fort Randall Dam Site, S.D. a. dorsal view, b. peripheral view, c. ventral view. X 100

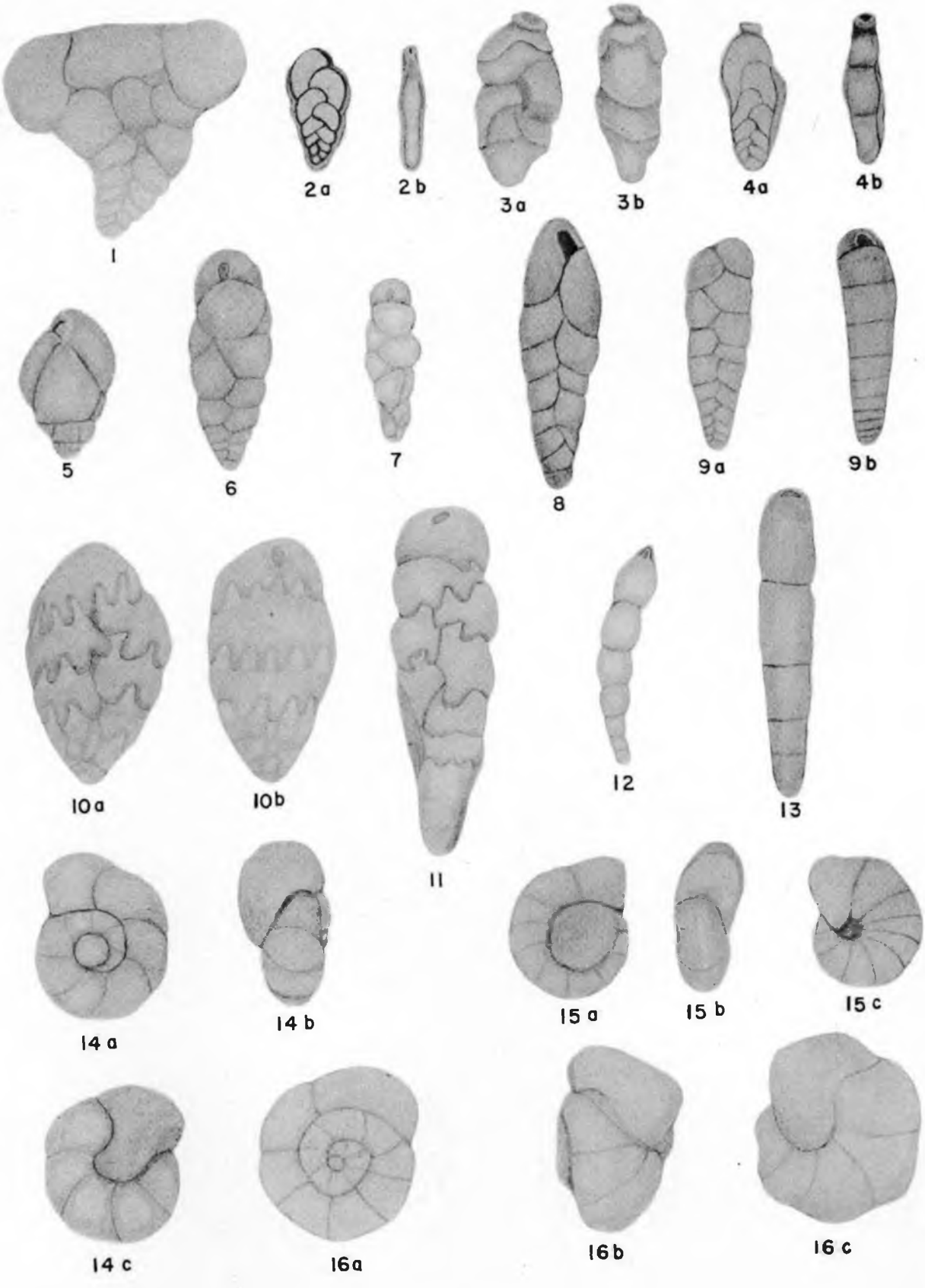
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Plate 3

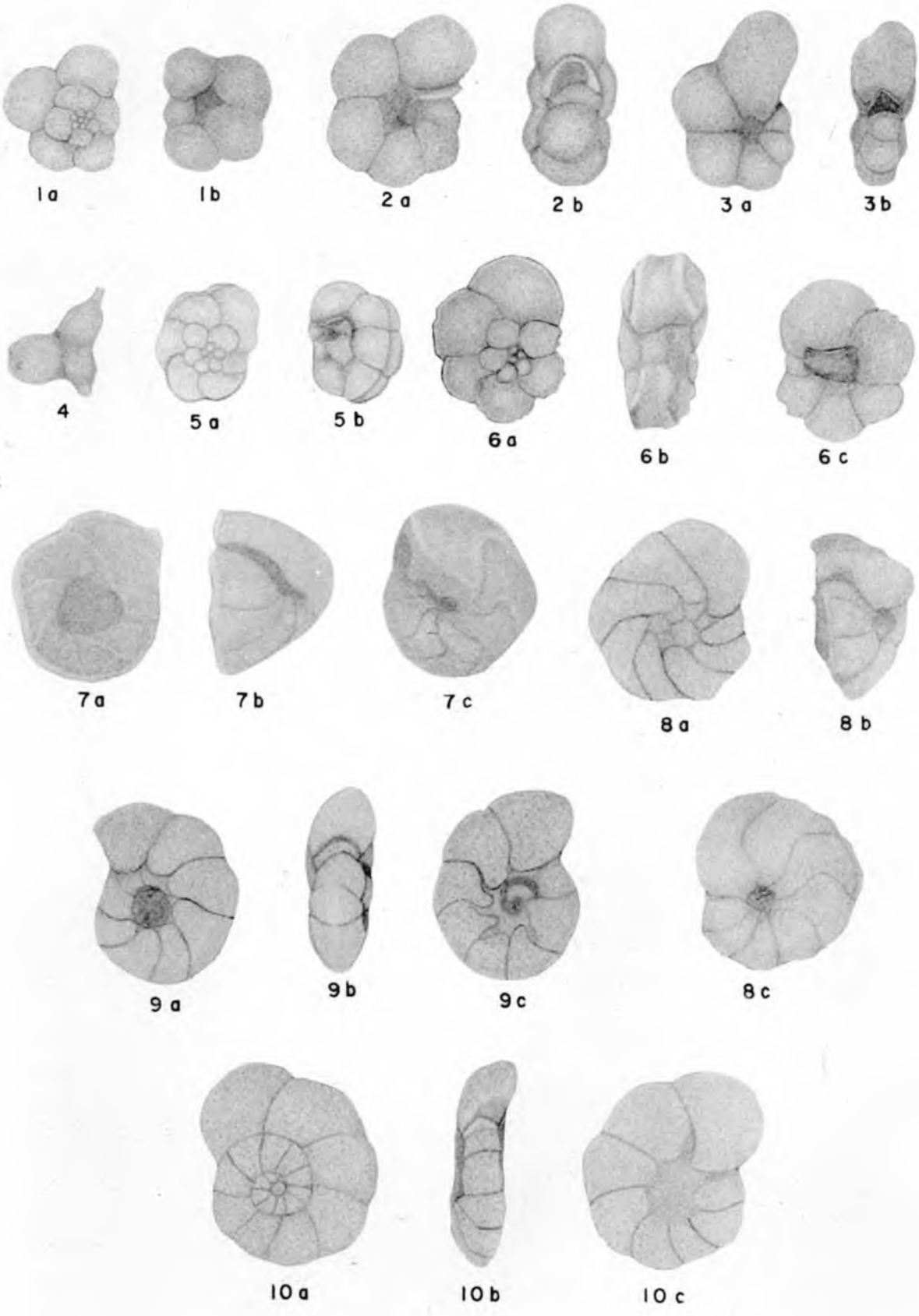
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Plate 4

Plate 4

Figure 1. Globigerina cretacea d'Orbigny (p. 54) Fort Hays member, Fort Randall Dam Site, S.D. a. dorsal view, b. ventral view. X 45

2. Globigerinella aspera (Ehrenberg) (p. 55) Smoky Hill member, Quarry of Old Cement Plant, Yankton Co., S.D. a. side view, b. peripheral view. X 110

3. Hastigerinella simplex Morrow (p. 55) Fort Hays member, Fort Randall Dam Site, S.D. a. side view, b. peripheral view. X 100

4. Schackoina tritubercülata (Morrow) (p. 56) Fort Hays member, Fort Randall Dam Site, S.D. X 100

5. Globotruncana canaliculata (Reuss) (p. 57) Fort Hays member, Cedar Co., Nebraska. a. dorsal view, b. ventral view. X 50

6. Globotruncana marginata (Reuss) (p. 58) Fort Hays member, Sec. 8, T. 93 N., R. 52 W., Clay Co., S.D. a. dorsal view, b. peripheral view, c. ventral view. X 100

7. Globorotalites micheliniana (d'Orbigny) (p. 59) Fort Hays member, Fort Randall Dam Site, S.D. a. dorsal view, b. peripheral view, c. ventral view. X 110

8. Globorotalites umbilicata (Loetterle) (p. 60) Fort Hays member, Spirit Mound, Clay Co., S. D. a. dorsal view, b. peripheral view, c. ventral view. X 100

9. Anomalina henbesti Plummer (p. 61) Fort Hays member, Spirit Mound, Clay Co., S.D. a. dorsal view, b. peripheral view, c. ventral view. X 105

10. Planulina kansasensis Morrow (p. 62) Fort Hays member, Spirit Mound, Clay Co., S.D. a. dorsal view, b. peripheral view, c. ventral view. X 100

Plate 5

Figure 1. Cytherella bullata Alexander (p. 63) Fort Hays member, Spirit Mound, Clay Co., S.D. a. side view of right valve, b. ventral view of right valve. X 45

2. Brachycythere sphenoides (Reuss) (p. 64) Fort Hays member, Spirit Mound, Clay Co., S.D. a. side view of right valve, b. dorsal view. X 40

3. Cythereis corvelli Loetterle (p. 65) Fort Hays member, Fort Randall Dam Site, S.D. a. side view of right valve. b. dorsal view of right valve. X 55

4. Cythereis foersteriana (Bosquet) (p. 65) Fort Hays member, Spirit Mound, Clay Co., S.D. a. side view of left valve, b. dorsal view of left valve. X 55

5. Cythereis niobrarensis Morrow (p. 66) Fort Hays member, Spirit Mound, Clay Co., S.D. a. side view of left valve, b. dorsal view. X 50

6. Cythereis subgracillis Morrow (p. 67) Fory Hays member, Spirit Mound, Clay Co., S.D. a. side view of right valve, b. dorsal view. X 50

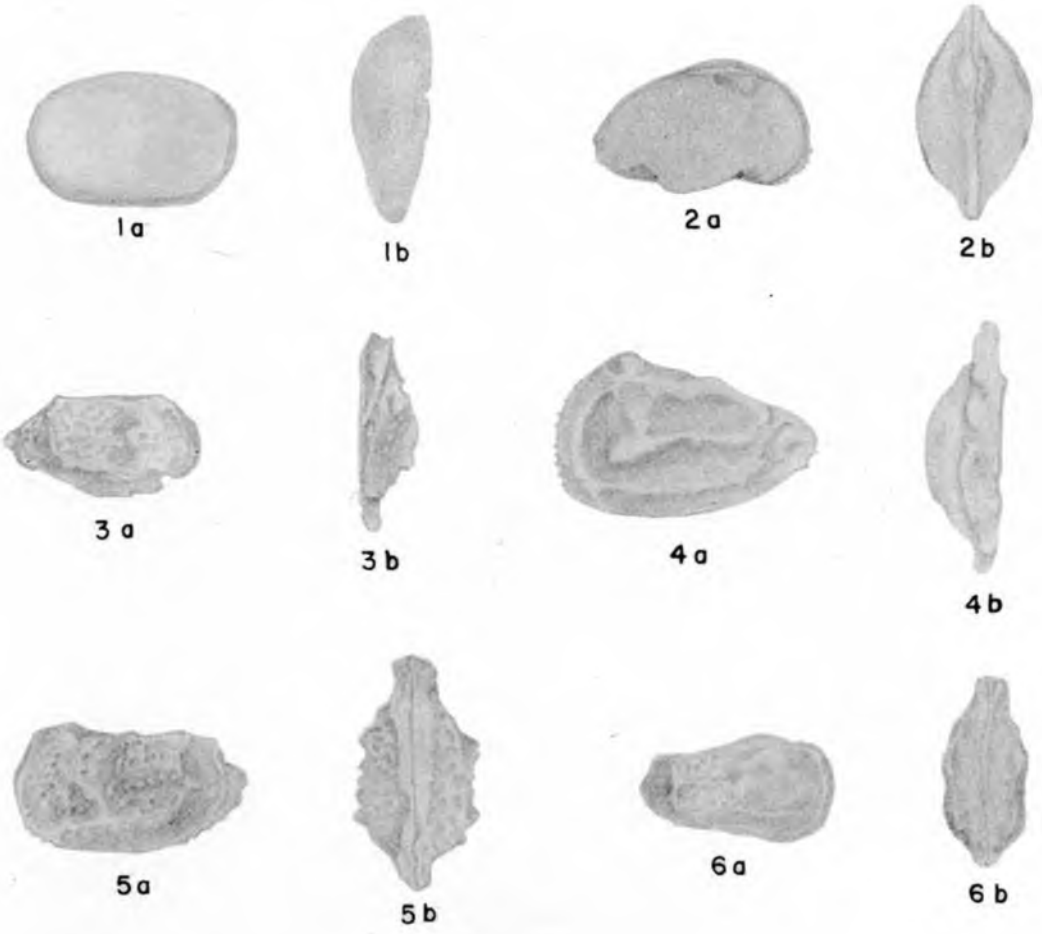

Plate 5