6-1964

Paleoecology of *Pseudozaphentoides verticillatus* (Barbour) in the Plattsmouth Limestone (Pennsylvanian)

Robert Francis Diffendal Jr.

*University of Nebraska-Lincoln*

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PALOEKOLOGY OF 

PSUEDOZARPHENTOIDES VERTICILLATUE (BARBOUR).

IN THE PLATTSOUTH LIMESTONE (PENNNSYLVANIAN)

by

Robert Francis Diffendal, Jr.

A THESIS

Presented to the Faculty of

The Graduate College in the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Department of Geology

Under the Supervision of Dr. J. A. Fagerstrom

Lincoln, Nebraska

June 1964
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INTRODUCTION

Purpose of the Investigation

Fagerstrom and Eisela (1964) recently studied the Pennsylvanian rugose coral *Craterophyllum verticillatum* (Barbour, 1911). A complete redescription and reillustration of the coral was made on the basis of a large assemblage of specimens.

Previously, the known geographic distribution of *C. verticillatum* (Barbour), now *Pseudozaphrentoides verticillatus* (Barbour), was limited to the Nehawka, Nebraska area. This areal limitation coupled with a stratigraphic limitation to a small portion of the Plattsmouth limestone member of the Oread formation (See Table 1) has proved to be interesting from the standpoint of both distribution and possible paleoecologic interpretation.

The purpose of this paper is to (1) delineate precisely the exact areal distribution and stratigraphic position within the Plattsmouth limestone member of any occurrence of *Pseudozaphrentoides verticillatus* (Barbour) and (2) to study the abiotic and biotic aspects of the Plattsmouth limestone in order to offer some inferences as to the paleoecological significance of these occurrences.

Area of Study

The Plattsmouth limestone in Nebraska is exposed in numerous quarries along the sides of the Weeping Water valley and along the Missouri River.
bluffs from Plattsmouth, Nebraska south to the Queen Hill quarry. Within the Plattsmouth, corals rapidly diminish in number away from the Nehawka, Nebraska area so that the area of study was primarily in Nebraska. Quarries in Iowa and in northeastern Kansas were also studied in the hope of gaining additional paleoecologic evidence about the environments represented within the Plattsmouth limestone. The locations of the exposures studied are illustrated in Plate 1 and the legal descriptions are given in Table 2.

Thanks are given to Drs. J. A. Fagerstrom, M. D. Picard and S. B. Trenes for their helpful suggestions in the field and laboratory. R. R. Dunchett of the Nebraska Geological Survey offered assistance in locating some of the outcrops. Robert Eisele accompanied the writer initially in the field to acquaint him with the problems involved in the study. Professor John Davidson helped in the determination of plant material in the limestones. Special thanks go to Mrs. Lorna Carter for typing the manuscript.
<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>SERIES</th>
<th>GROUP</th>
<th>FORMATION</th>
<th>MEMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvanian</td>
<td>Douglas</td>
<td>Missouri</td>
<td>Des Moines</td>
<td>Atoka</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Morrow</td>
</tr>
</tbody>
</table>

**TABLE 1**

**STRATIGRAPHIC POSITION OF THE PLATTSOUTH LIMESTONE**

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>SERIES</th>
<th>GROUP</th>
<th>FORMATION</th>
<th>MEMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvanian</td>
<td>Wabaunsee</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Topeka</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Calhoun</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Deer Creek</td>
</tr>
<tr>
<td></td>
<td>Virgil</td>
<td>Tecumseh</td>
<td>Lecompton</td>
<td>Karwaka</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kereford ls.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Heunaner sh.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PLATTSOUTH Ls.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Heebner sh.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Leavenworth ls.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Snyderville sh.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weeping Water ls.</td>
<td></td>
</tr>
</tbody>
</table>
PLATE 1

INDEX MAP OF THE AREA STUDIED
<table>
<thead>
<tr>
<th>Location</th>
<th>Legal Description</th>
<th>Township</th>
<th>Range</th>
<th>Section</th>
<th>County</th>
<th>State</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>NW ¼, NE ¼, Sec. 18, T 10 N, R 13 E</td>
<td></td>
<td></td>
<td></td>
<td>Cass</td>
<td>Nebr.</td>
</tr>
<tr>
<td>B</td>
<td>NW ¼, NE ¼, Sec. 19, T 10 N, R 13 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>NE ¼, NW ¼, Sec. 20, T 12 N, R 11 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>NE ¼, NW ¼, Sec. 11, T 10 N, R 12 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>NW ¼, NW ¼, Sec. 2, T 10 N, R 11 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Center, Sec. 5, T 10 N, R 12 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Center, north line, NW ¼, NE ¼, NE ¼</td>
<td>Sec. 31, T 11 N, R 12 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Center, NE ¼, SW ¼, Sec. 9, T 11 N, R 11 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Center, west line, SW ¼, Sec. 6, T 9 N, R 13 E</td>
<td>Otoe Co., Nebr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>NW ¼, NE ¼, Sec. 13, T 10 N, R 12 E</td>
<td>Cass Co., Nebr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>NE ¼, SW ¼, Sec. 11, T 13 N, R 30 W</td>
<td>Montgomery Co., Iowa.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>SW corner, NW ¼, Sec. 7, T 10 N, R 13 E</td>
<td>Cass Co., Nebr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>NW ¼, SW ¼, Sec. 11, T 10 N, R 12 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>NW ¼, NW ¼, Sec. 11, T 11 N, R 11 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>SE ¼, Sec. 10, T 10 N, R 12 E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Plattsmouth limestone member of the Oread formation was named by Keyes (1899, p. 306). The type locality is along the Missouri River bluffs at Plattsmouth, Nebraska and originally included approximately thirty feet of strata. Condra (1927, p. 37) later restricted the member to its present stratigraphic limits. Most exposures average 16 feet in thickness, locally attaining thicknesses of as much as 30 feet.

Most detailed work on the Plattsmouth member in Nebraska has been done by students working on advanced degrees in geology at the University of Nebraska. Notable among these are, (1) Smedley (1933) who studied the entire Oread formation, (2) Braden (1953) who studied the Oread in the Forest City Basin, and (3) Irwin (1960) and Svendsen (1961) who did detailed microlithologic studies at a few areas of Plattsmouth exposure.

The Plattsmouth limestone is variable in gross physical aspects from one area to another. At the type locality it is light blue to gray in color. This color also is common in exposures in central Cass County, Nebraska. Coloration changes rapidly to medium gray at quarries south of the type locality. Beds vary in thickness from medium-bededded (10-30 cm.; Ingram, 1954) to thick-bededded (30-100 cm.) and appear to be controlled to some extent by the amount of argillaceous material present in the unit. Chert is present in variable amounts and at several stratigraphic levels within the Plattsmouth in all exposures studied. Pyrite, calcite and other minerals are found in variable amounts in veins and vugs. Macrofossils vary in quantity and appear in large local concentrations but are seldom abundant throughout the member.
Directly beneath the Plattsmouth limestone member lies the Heebner shale member of the Oread formation. This member was named by Condra (1927, p. 37) and has its type locality along Heebner Creek west of Nebraska, Nebraska. Commonly the lowermost portion of the member is a black, carbonaceous, very fissile shale. Few fossils are present. In the area of study it was exposed only at Queen Hill quarry and in quarries in the vicinity of Weeping Water.

Overlying the Plattsmouth in many areas is the Heumader shale member of the Oread formation. The Heumader was first named by Moore (1935, p. 167). In Nebraska the Heumader, where present, is quite variable in thickness, fossil content, and general composition. The color varies from green to dark gray. The most abundant fossils are fusulinids and crinoid debris. In the dark portions large aggregates of pyrite crystals are present.
Classification of Carbonate Rocks

In 1962 the American Association of Petroleum Geologists published its first memoir on the subject of carbonate classification. Among the numerous classification schemes in this memoir the one most serviceable for this study is that developed by Robert Folk (1962, p. 67).

Rocks with a carbonate content of over 50% with calcite and aragonite exceeding dolomite and siderite are termed limestones (Dunbar and Rodgers, 1957, p. 226). Folk (1962) classified limestones as type I, II, and III (See Table 3) on relative proportions of three basic constituents: (1) framework; (2) matrix; and (3) cement.

The framework of a carbonate rock according to Folk (1962) is composed of allochems. The term allochem embraces "...all the organized carbonate aggregates that make up the bulk of many limestones" (p. 63). Allochems are subdivided into (1) intraclasts, composed of eroded, weakly consolidated, penecontemporaneous carbonate fragments which are derived, moved and redeposited within a basin of deposition, (2) oolites, (3) fossils, and (4) pellets, generally thought to be fecal in origin (Folk, p. 65).

The matrix in a carbonate rock is a microcrystalline calcite ooze or micrite (Folk, 1962, p. 65). Micrite grains are 1-4 microns in diameter. Micrite "...is considered as forming very largely by rather rapid chemical or biochemical precipitation in sea water, settling to the bottom, and at times undergoing some later drifting by weak currents" (p. 66).

Cement in carbonate rocks is most often sparry calcite. Sparry calcite forms grains or crystals greater than 10 microns in diameter. According to Folk (p. 66-67) sparry calcite fills pores within the sediment by precipitation in place. It may be of primary or secondary origin.
<table>
<thead>
<tr>
<th>Type of Rock</th>
<th>Allochemical Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Allochemical</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rocks</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **TYPE I** (More than 50% spar) | Intraclasts - Intrasparite M  
                          | Oolites - Oosparite Io  
                          | Fossils - Biosparite Ib  
                          | Pellets - Palsparite Ip  |
| **TYPE II** (Less than 50% spar) | Intraclasts - Intrinsicite III  
                          | Oolites - Oomicrite IIo  
                          | Fossils - Bionomicrite IIb  
                          | Pellets - Pelmicrite IIp  |
| **Orthochemical**     |                          |
| **Rocks**             |                          |
| **TYPE III**          | 10% of Rock - Micrite IIIm  
                          | Allochems                   |
| **Autochthonous**     |                          |
| **Reef Rocks**        |                          |
| **TYPE IV**           | Bicolithite IV            |

Modified after Folk, 1962
Folk (1962) designated a number of carbonate types which will be used in this paper. Among the allochemical Type I limestones, intrasparite and biosparite facies are present within the Plattsmouth member. The biomicrite facies represents the Type III orthochemical rocks found within the Plattsmouth member. The distribution of these limestone types within the Plattsmouth are shown in Plate 2.

**Facies Represented in the Plattsouth Member**

**Intrasparite facies** - Intrasparite occurs in the Plattsouth limestone in a limited area around Weeping Water, Nebraska. Study of polished sections shows that the intraclasts are composed of mottled tan to pink biomicrite containing whole and broken fusulinids, ostracods, brachiopods, crinoid columns, and other fossil debris. Specimens of *Pseudozonotruncatedes* are found in this facies, but only in a highly fragmental and silicified form.

The displacement of fossil fragments and intraclasts appears to be minor. Commonly, large particles which would fit together are separated by only a few millimeters of sparry calcite. No sorting or rounding is apparent.

Folk (1962, p. 71) suggests that the origin of intraclasts is most important because they may imply "...shallow water, lowered wave base, or possible tectonic uplift." None of these mechanisms seems to explain the origin of the intrasparite in the Plattsouth member. The intrasparite facies grades laterally into a similar but undisrupted biomicrite facies. Treves (personal communication) suggested that the intrasparite facies was probably a product of a sub-sea slide. Field relationships suggest that this may be a valid idea. Apparently the biomicrite was in a semiconsolidated state when it slid westward into the local basin area surrounding Weeping Water, Nebraska.
PLATE 2

FENCE DIAGRAM
Biosparite facies - This facies is found within the area of study only in Nebraska and is best developed particularly in the central portion of Cass County. The biosparite facies is of importance because of the varied interpretations as to the origin of the rocks which comprise it.

The biosparite in the Plattsmouth member grades from poorly washed particles (where spar is only slightly predominant over micrite) at the junction between the biomicrite-biosparite facies contact to rounded particles near the top of the unit.

The fossils within this facies are normally broken into particles less than 1 mm. in diameter. These particles are well rounded and often have a micritic or recrystallized rim around them. Quite often the original fossil fragments are so completely recrystallized that they are almost unrecognizable.

Irwin (1960) has suggested that these rounded grains may be the result of the encrusting alga Osagia. Twenhofel (1919, p. 351). J. Harlan Johnson (1963, p. 27) described Osagia as colonies consisting "...of a mass of twisted tubes of varying sizes which form a laminated incrustation around a nucleus of a fossil fragment or other foreign substance."

Examination of thin sections of the biosparite facies revealed no tubes in the external rind around the grains. Dr. John Davidson of the Department of Botany, University of Nebraska, after examination of thin sections of the supposed algae, stated that there was no evidence for attributing the grain form to the work of algae (personal communication).

It has been assumed that Osagia was an active sediment builder during times of lower sea level when stronger wave and current action prevailed. It is true that biosparite by its very nature implies stronger current action, but this does not necessarily call for an algal mechanism of formation of the biosparite grains.
To the east of the central Cass County, Nebraska area, the rocks at the top of the Plattsmouth member are of the biomicrite facies. (See Plate 2.) Within this facies the fossils are often largely fragmental. It is just as conceivable to have wave or current erosion in this area with redeposition of rounded partially micrite covered fossil grains in quieter waters to the west where current or wave action was not quite so active.

In retrospect it should be pointed out in regard to the biosparite facies that all small bean-shaped carbonate grains are not necessarily of algal derivation.

**Biomicrite facies** - Most of the Plattsmouth limestone is a biomicrite using Folk's terminology. Biomicrite in this sense includes limestones in which the amount of matrix predominates over the amount of sparry calcite with the stipulation that the fossil to allochem ratio is 3:1 or more. Another stipulation is that at least 10% of the rock must be composed of biologically-derived particles.

Throughout this facies argillaceous material appears to be present in variable amounts. The biomicrite facies contains the largest amount of recognizable macroscopic fossils and also includes the largest number of *Pseudozaphrentoides verticillatus* (Barbour). The majority of chart nodules are found in this facies also.

The rocks of biomicrite facies indicate an environment of "...weak, short-lived currents or a rapid rate of formation of microcrystalline ooze" (Folk, 1962, p. 68).

**Micrite facies** - In a limited number of specimens from the Plattsmouth member in the outcrops studied in Iowa and Kansas less than 10% of the
rock is composed of allochemical constituents. Because of their micritic composition they have been placed in the micrite facies. (Type III ls.)

Micrite facies rocks are found five to seven feet from the top of the member in Iowa and six and nine feet from the top in Kansas. They are apparently quite limited in extent and comprise only a minor component of the total limestone studied. This limitation in areal extent in no way suggests, however, an inferior position of paleoecologic importance for this facies. Quite to the contrary, the micrite facies is quite important in paleoecologic and depositional interpretation.

Insoluble Residue Studies

Samples from localities K, L, M, R, and W (See Table 2 for exact locations) were tested for insoluble residue content and the data obtained along with that of Svendsen (1961) was used also for facies and environmental interpretation. Tables 4 and 5 depict the insoluble residues at these localities.

In most of the samples investigated, more than 90% of the insoluble residue falls in the silt to clay size range. The actual quantity of silt and clay in the limestone varies from 2-47%.

Quartz occurs in two forms, either well-rounded grains or euhedral crystals. The rounded grains imply transport from a distant sand source while the euhedral quartz often occurs in doubly-terminated clear crystals. These crystals are probably authigenic and thus of secondary origin. The crystalline quartz is more abundant than the rounded quartz grains in all samples. Unfortunately, no definite correlation could be determined between the abundance of quartz grains and their geographic distribution.
EXPLANATION OF TABLES

From left to right the table shows: (1) the sample number; (2) the original weight of the sample; (3) the total residue in grams; (4) the per cent that TRg. is of the original sample, Sg; (5) the amount of residue greater than silt size; (6) the per cent of the total sample which is attributable to quartz, chert, fossils, and accessory minerals; (7) the fossil content; (8) the corrected total residue (after removal of secondary constituents); (9) the corrected per cent of the total residue; and (10) the graphic representation of (9).
Various forms are placed in the chert category in the insoluble residue table. Chert appears as irregular forms and clusters, beekite rosettes and other odd shapes. Examination of polished sections and thin-sections shows that silicification is present in fossil fragments. Initially the fossils are irregularly silicified. The silica gradually coalesced until it completely replaced the entire fossil in some cases. After this stage is reached, further silicification replaces the spar within the fossils. The amount of silicification in specimens of the same species found side by side was not uniform. (See Plate 3, Fig. 1.) Some silicification of fossils was evident in almost all polished sections studied.

Chert is a major constituent in some of the limestones. It may be either primary or secondary in development. Pettijohn (1957, p. 439) points out that "...majority opinion seems to incline toward an epigenic formation of the nodular cherts and flints found in limestone and other carbonate rock. ...Supporting the epigenetic origin are (1) the occurrence of chert along fissures in limestone, (2) the very irregular shape of some chert nodules, (3) the presence of irregular patches of limestone within some nodules, (4) the association of silicified fossils and cherts in some limestones, (5) the presence of replaced fossils in some cherts, (6) the presence of textures and structures (especially bedding) in some cherts..., (7) the failure of some cherts to follow definite zones in limestone formations, and (8) the occurrence of silicified oolites formed by replacement of calcareous ones."

Hattin (1957, p. 111) expressed the view that compact non-calcareous chert was developed from a primary inorganic precipitate. He cited as evidence for this view the fact that most chert nodules are round and have sharp contact with the adjacent limestone. In more argillaceous limestones,
PLATE 3

SOME REPRESENTATIVE FOSSILS FROM THE PLATTSMOUTH LIMESTONE

Plate 3, figure 1: Silicified fossils from the Plattsmouth.

figure 2: Slab showing corals.

figure 3: Section through slab of fig. 2.

figure 4: Section showing echinoid ossicles and spines.

figure 5: Slab with fusulinids from locality M.

figure 6: Slab showing productid brachiopods with intact spines, from locality M.
however, he concluded, chert has irregular and gradational contacts (1957, p. 101). He also found (1957, p. 102) no evidence of the presence of chert in his algal and molluscan limestones (which are probably equivalent to the biosparite of this paper).

In some areas of the Plattsmouth limestone after fossils have been silicified as previously described they appear to act as centers for irregular accumulations of chert. This chert coalesces with that of other nearby centers and forms large irregular masses. There seems to be little or no control over direction of development or amount of additional chert added in these areas.

No chert within the area of study had less than three of Pettijohn's eight criteria of support for epigene (secondary) formation. All of the chert zones studied proved to be very discontinuous and not limited by carbonate or non-carbonate factors in the limestones. In light of these features, primary development of chert in the Plattsmouth limestone within the area studied probably is very minor if it occurred at all.

Another observation on the occurrence and origin of chert can be made from a study of the Plattsmouth limestone. Chert nodules do occur in some sections of the biosparite facies in contrast to Hattin's observations.

Predominant among the accessory minerals found in the insoluble residues was pyrite. It occurs either as euhedral masses or as replacements of fossil spicules, foraminifers, and gastropods. Much of the euhedral pyrite had cross-cutting relationships with the fossils, matrix, or cement in the limestone and appeared to be of secondary origin. Most of the examples of replacement of fossils appeared to be in the form of steinkerns in hollow chambers or cavities.
Other accessory minerals include magnetite, sphalerite, and collophane. Magnetite and sphalerite are commonly euhedral in form. Collophane occurs as tan, spongy anhedral masses. All of these minerals occur in minute traces in the residues and do not significantly alter the general composition.

Exclusive of plant remains, almost all of the fossil material in the residues appears to be either partially or wholly silicified. Only the triaxon sponge spicules originally were siliceous; the rest of the fossils were composed of CaCO₃. In light of these observations it seems probable that only the plant fragments and some of the sponge spicules made up the original insoluble fossil content within the Plattsmouth limestone.

Since the majority of the material within the greater than silt-sized fraction of the insoluble residues apparently is not of primary origin it has been excluded from the graphic representations of insoluble content seen in Tables 4 and 5.

The distribution of clay and silt in the Plattsmouth limestone is lowest in the vicinity of Weeping Water, Nebraska and increases to the east and south. Svensen (1961, Tables 3, 4, 5; p. 23-24, 26, 28) collected data on insolubles in the Plattsmouth limestone from three other localities in Nebraska, and his data fit very well into the general distribution pattern described above.
Specimens of the rugose coral *Pseudozaphrentoides verticillatus* (Barbour) are most abundant at the localities studied in an area of approximately eight to ten square miles from Nebauka, Nebraska west to Snyderville quarry (location S on Plate 1). Exposures east, west and south of this area indicate a rapid diminution in the number of individuals of this species.

In the areas where specimens of *P. verticillatus* were found, several other general tendencies exclusive of abundance were noted. The distance from the top of the Plattsmouth member to the coral-bearing strata, although irregular at each locality, showed a general tendency to increase from east to west. This change in position, however, was only about three feet from the eastern to westernmost localities. The corals were also limited to the biomicrite and intrasparite facies.

Most of the specimens of *P. verticillatus* were lying parallel to the bedding planes. Only a few were standing perpendicular to bedding. Wells (1957) has suggested that the general method of septal insertion in the solitary rugose corals may have been an aid in helping to keep them upright.

The fact that many of the corals did at one time stand perpendicular to the sea floor can be illustrated by several points. Many of the fallen corals which were not crushed by others before regrowth had started to reorient the calyx region. The lower portion of the calyx in contact with the sediments grew more rapidly than the upper portion. Wells (1957) suggested that this was due to negative geotropism growth habits after toppling. Secondly, many of the corals are completely covered by encrusting bryozoans. If the observation on the growth habits of toppled
corallites is correct then the bryozoans found between the corallite and the basal sediment must have developed at an earlier time when the coral was not in direct contact with the sediment at the point of encrustation.

There is a general tendency toward orientation of corallites in approximately north-south and east-west long axis directions. This orientation may be due to the influence of weak current activity in two but no transport. directions/ Stronger currents would probably have sorted the corals into size grades. Individuals a few centimeters long lay beside individuals up to 18 inches or more in length. This indicates that the area was probably a low energy environment.

The outcrops in the vicinity of Nehawka, Nebraska where P. verticillatus (Barbour) is the major constituent are composed of the following general materials. The framework is primarily of rugose corals, crinoid plates and columns, echinoid plates and spines, brachiopod shells (whole and partial), gastropods, fusulinids, bryozoans, and tabulate corals comprise lesser amounts of macroscopic framework constituents. Among the microfauna represented are ostracods, holothurian sclerites, and conodonts. The matrix is predominantly a tan to light brown micrite or finely divided lime mud with a few areas of coarser mud aggregates. The cement is in the form of sparry calcite which infills some of the shell, test, and corallite chambers. Some of the interiors of the shells are broken and infilled with micrite indicating a probable later origin for spar deposition. The framework consists of 50-70% of the rock with the matrix comprising most of the remainder.

Many of the fossils are broken, crushed & abraded which is probably the result of the work of scavengers or the compaction of lime mud or both.

The accumulation of P. verticillatus in the Nehawka, Nebraska area is most certainly not a reef. Nelson, Brown, and Brineman (1962, p. 242)
define a reef as "...a skeletal limestone deposit formed by organisms possessing ecologic potential to erect a rigid, wave-resistant, topographic structure." In opposition to this type of biogenetic deposit is a bank, which they define as "...a skeletal limestone deposit formed by organisms which do not have the ecological potential to erect a rigid wave-resistant structure" (1962, p. 212). The Nehawka, Nebraska deposit falls within the definition of a biogenetic bank accumulation.

Modern biogenetic banks may be either biohermal (mound or lens shaped - Cumings, 1932) or biostromal (tabular or planlar bodies) according to Baars (1963). In the case of the P. verticillatus biogenetic bank deposits, the term biostromal would probably be best fitting since the abundant coral deposits seldom are over two feet in thickness and usually attain a relief of only two to three feet over wide portions of the area studied.

Recent formation of biogenetic aggregational banks was studied by Baars (1963, p. 101-129). "Aggradational build-ups are composed of the in situ accumulation of skeletal debris in association with other particles types; they may or may not develop into mound-shaped deposits, but they are never transported and deposited by currents" (p. 111).

Baars (1963, p. 112) suggested that biogenetic banks are normally "...found in the more protected waters of the back shelf, in marked contrast to reefs, and appear to be ordinary carbonate sediments with varying amounts of lime mud and skeletal material." He further felt that the bank sediments "...accumulated together in a low energy environment completely unaffected by vigorous wave action." Baars (1963) further suggested that scavengers and mud eaters are common. Normally skeletal and pellet materials float in a mud matrix.
Fossils within the Plattsmouth

The fauna and flora of the Plattsmouth limestone in the area studied is summarized in Tables 6 and 7. Representatives of the phyla Protozoa, Coelenterata, Bryozoa, Brachiopoda, Mollusca, Arthropoda, Echinodermata, and the order Conodontophorida occur with Pseudozaphrentoides verticillatus (Barbour). Species from the phylum Porifera apparently are not associated with Pseudozaphrentoides. Plant debris and pollen were associated with a limited number of Pseudozaphrentoides specimens at the Iowa locality.

Fusulinids - Fusulinids are associated with P. verticillatus in the biogenetic bank area. They are also present in almost all areas and facies within the Plattsmouth member in greater or lesser abundance. Only within portions of the biosparite facies do they appear abraded or reworked.

Elias suggested (1937, p. 428) that from evidence of depth zonation it was possible to place the approximate depth of deposition of fusulinid limestones at from 160-180 feet. M. L. Thompson (1964, p. C387) stated that fusulinids "...seem to have been restricted to offshore open-water environments. ..." Dunbar (1957, p. 753) suggested that "...it appears that places on the sea floor dominated by fusulinids were avoided by most other organisms and further that species had preferred ecological niches." Dunbar (p. 753) further suggested that "...most of them lived in warm as well as shallow seas." "Not uncommonly they are associated with abundant corals," Dunbar stated, "but they are rarely found in crinoid limestones and almost never with mollusks." Within the Plattsmouth limestone, however, this lack of association does not hold true since not only do unabraded fusulines occur in the biosparite facies but they occur there in probably due to transport of the fusulinids, association with pelecypods. They are also quite commonly attached to
<table>
<thead>
<tr>
<th>Fossils Associated with Coral Bank</th>
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<tr>
<td><strong>Pseudozaphrentoides verticillatus</strong> (Barbour)</td>
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<tr>
<td>? <strong>P. ordinatus</strong> Ross and Ross</td>
</tr>
<tr>
<td><strong>Punctospirifer kentuckyensis</strong> (Shumard)</td>
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<tr>
<td><strong>Neospirifer triplicatus</strong> (Hall)</td>
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<tr>
<td><strong>Composita ovata</strong> Mather</td>
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<tr>
<td><strong>Composita alongata</strong> Dunbar and Condra, n. sp.</td>
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<tr>
<td><strong>Composita trilobata</strong> Dunbar and Condra, n. sp.</td>
</tr>
<tr>
<td><strong>Auloporoid coelenterate</strong></td>
</tr>
<tr>
<td><strong>Worthenia</strong> ? sp.</td>
</tr>
<tr>
<td><strong>Entaletes pumiloides</strong> Newall - juvenile</td>
</tr>
<tr>
<td><strong>E. hemispilicatus</strong> (Hall)</td>
</tr>
<tr>
<td>encrusting bryozoan</td>
</tr>
<tr>
<td><strong>Fenestrallina</strong> sp.</td>
</tr>
<tr>
<td>cryptostome bryozoan fragments</td>
</tr>
<tr>
<td><strong>Fusulinid - Triticites</strong> ?</td>
</tr>
<tr>
<td>crinoid remains</td>
</tr>
<tr>
<td>echinoid spines</td>
</tr>
<tr>
<td><strong>Echinoconchus moorei</strong> Dunbar and Condra, n. sp.</td>
</tr>
<tr>
<td>holothuroid sclerites</td>
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<tr>
<td>conodonts</td>
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<td>plant remains</td>
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TABLE 7

FOSSILS FOUND IN OTHER PORTIONS OF THE PLATTSOUTH MEMBER

**Amsura** sp.

**Syringopora** sp.

**Allorisma** sp.

**Fusulinids**

**Derbya** sp.

**Chonetes graminifer** Owen

**Echinoconchus** sp.

**Juresania nebrascensis** (Owen)

**Punctospirifer** sp.

**Neospirifer** sp.

**crinoids**

**echinoids**

**encrusting bryozoans**

**Hallopora** sp.

**Fenestrellina** sp.

**sponge spicules**

**plant pollen**

? **P. ordinatum** Ross and Ross

**Composita** sp.

**holothuroids**

**conodonts**

**Staffella** sp.
or are close to crinoidal debris associated with the coral bank in the biomicrite facies. In the exposures east of the bank along the Missouri River and in Iowa, fusulinids are found in highly argillaceous sediments (20-47% silt and clay) associated with plant pollen and debris.

Previous observations on the fusulinid limestone portions of the Plattsmouth member by Smedley (1933) and Braden (1958) do not appear to be consistent with the data collected in this study. Smedley's observation that insoluble residues in the fusulinid limestones averaged about 8% is low in comparison to the present study probably because of the limited areal extent of his study (Nebraska). Braden's observation (p. 49) that the upper 4 to 5 feet of the Plattsmouth is a fusulinid calcisiltite is incorrect in the Cass County area of Nebraska. Also, at no outcrop in the area of study in the upper 4 to 5 feet of the member are there "...30% or higher fusulinids" as Braden (p. 49) suggested. (Kereford ls. and Heumader sh. included in Plattsmouth member by these previous workers.) Not only are some of the conclusions of Braden and Smedley open to question but the observations by Dunbar and Elias are not consistent with the data collected in this study either. The importance of fusulinids as depth indicators in limestones of the mid-continent does not seem to hold true in many places within the Plattsmouth member.

Coelenterates - Wells (1957, p. 773) suggested that rugose corals "...(1) lived to a maximum depth of about 50 meters, (2) well within the lighted zone although there is no evidence that illumination was significant in their growth or well-being, (3) in temperatures with annual minima between 16° and 21° C, (4) in well-oxygenated, gently circulating water, and (5) on bottoms clear or relatively free from rapid accumulation of sediment, but not necessarily in clear, non-turbid waters." Hill (1948, p. 428)
suggested that rugose corals were most prevalent in areas from 90 to 110 feet in depth.

Present coral distribution is often invoked as a key for analogy with Paleozoic forms (Wells, 1957). Teichert (1958) described cold water, ahermatypic bank building corals which are living in waters to depths of 2,000 feet and at temperatures as low as -1.1° C. The fauna of these cold water banks includes 190 species representing the "...sponges 6, coelenterates 32, worms 18, bryozoans 7, brachiopods 4, echinoderms 48, crustaceans 32, mollusks 32, tunicates 7, fish 4" (Teichert, 1958, p. 1067-1069). Wells (1957, p. 773), however, suggested that "...there is no evidence that Paleozoic corals flourished in 'deep' water. All are found in sediments acknowledged to have been laid down in relatively shallow water close to or not far below the cumatic zone." (Cumatic zone probably is zone of abundant wave action.)

On the biogenetic bank near Nehawka three coelenterates appear to be moderately to very common. The largest number of coelenterate fossils are of the species P. verticillatus (Darbour). (See Plate 3, Figs. 2, 3.) The second most abundant form is a rugose coral which is larger and has a greater number of major septa (usually 36-38) than P. verticillatus. In cross section the coral has a wider disseptimentarium and in longitudinal section the tabulae are spaced closely and have a slight sag in the central region. This rugose coral may be assignable to the species P. ordinatus Ross and Ross. The least common coelenterate in the biogenetic bank is an auloporoid tabulate coral. This form commonly developed as a mat over some of the fallen rugose corals and other faunal forms comprising the biogenetic bank.
Bryozoa — Recent bryozoans, according to Shrock and Twenhofel (1953), live in shallow or deep, marine waters. Fossil species apparently lived on muddy or calcareous bottoms often attached to shells or hard parts of other organisms. Exclusive of their general habitat on stable, calcareous bottoms, little depth evidence can be determined without finding algal or shallow water sediment associations.

Duncan (1957) suggested that bottom character is a more important factor than depth in control of bryozoan distribution.

Elias (1937) suggested that bryozoans lived primarily in water of 75 to 160 feet. Braden (1953) thought that bryozoan occurrences indicated shallow water, argillaceous carbonate areas.

Bryozoans associated with the bank fauna are of two general types (1) the encrusting forms which cover any exposed hard part, and (2) the forms typified by Fenestrellina sp. The encrusting forms were apparently not selective in where they settled because they are found on hard parts of any of the fauna common to the biogenetic bank. The largest number of encrusting forms are found on corals and crinoid columns and appear to have grown while the hard parts were in an upright position. Commonly the fenestellid bryozoans were flattened into the matrix (micrite).

Brachiopods — Brachiopods are moderately common on the biogenetic bank but are less numerous than the coelenterates and echinoderms. Representatives of two superfamilies predominate over others, the Spiriferacea and the Rostrospiracea. Their shells are complete, show internal structure, and are occasionally cemented or attached to corals by encrusting bryozoans.

Members of the "Strophomena group" (Williams, 1956) are represented by productids. The productids are usually found cemented to the corals.
They apparently grew there while the coral was upright because they occasionally fully surround the coral. Their fragmental crushed nature is probably a result of later compaction.

Depth inferences by Elias (1937) place the brachiopods at depths of 90 to 160 feet. At the time of Elias's writing this was probably a good distribution, but current literature points out that only about 33% of living brachiopods are confined to shallow water (Cooper, 1957, p. 801). In reference to depth inferences, Shrock and Twenhofel (1953, p. 336) pointed out that "...it is probably not correct to infer depths for most fossil brachiopods if the inference is based entirely on the brachiopod itself. If the inference is drawn from the nature of the sedimentary materials enclosing the shells ... then it must be proved that the organisms lived where their shells were buried."

Molluscs - Only one species of mollusc was found in the area of the biogenetic bank. This was a gastropod. Portions of unidentifiable gastropods were seen in polished sections.

Durham (1947) proposed that the greatest concentrations of extant marine gastropods are found at depths less than 200 meters. Since Prosobranch gastropods are widely distributed today little inference can be made about their paleoecology without resorting to examination of associated faunal, floral and sediment relations.

Ostracods - A few smooth ostracod carapaces were found in the rocks constituting the coral bank deposits. These individuals could not be identified to genus or species.

Weller (1960, p. 200) suggested that ostracods are most common in shallow, slightly stagnant waters. Benson (1961, p. Q60) noted that the area of most abundant marine ostracods is that of the shallow sea shelf.
Ostracods with smooth shells inhabited fine-grained mud areas, while more highly ornamented forms lived in areas of coarser-grained sediments.

**Crinoids** - The presence of numerous large crinoid columnals and disarticulated plates of the dorsal cup associated with the corals of the biogenic bank suggests that the environment was probably suited for major development of both groups during their existence. The stems (most abundant fossil specimens in the bank deposits) are often encrusted by bryozoans. In one instance a small corallite had developed attached to the side of a fallen crinoid stem.

Weller (1960, p. 202) stated that "...they (crinoids) were more or less abundant in shallow water particularly where it was relatively free from detrital sediment and probably warm." Laudon (1957, p. 962) suggested that disarticulated crinoid debris found in beds lacking evidence of current action, indicated growth in shallow water outside the area of active long shore currents. Braden (1958) placed the crinoids in his "mixed fauna limestone facies" together with the corals and bryozoans. Since Braden used the zonation scheme of Elias (1937) this facies would probably be indicative of depths from approximately 90 to 140 feet.

**Echinoids** - Large, club-shaped spines and disarticulated ossicles are evidence of the presence of echinoids on the biogenic bank. These are often found quite closely associated in moderately large numbers suggesting lack of transport and possible partial redistribution of ossicles due to the action of other scavengers. (See Plate 3, Fig. 4.)

As members of the vagrant benthos, recent echinoids inhabit mainly shallow, fairly quiet waters and are capable of living on many types of bottom (Weller, 1961). They are, however, found widely in most other parts of the oceans. Hawkins (1943) suggested that Paleozoic echinoids
were primarily lagoon dwellers but Cooper (1957) thought that they probably lived in near-shore turbulent water.

Holothuroids - Several sclerites from holothuroids were picked from a few insoluble residue samples collected in a flank area of the bank. These sclerites were silicified and may represent an even larger number of living holothurians which originally inhabited the bank. The sclerites are in the form of tiny perforated plates.

Most holothuroids prefer mud bottoms and act mainly as scavengers (Moore, Lalicker and Fischer, 1952, p. 578). "The environment of fossil holothurians is marine and tropical to sub-arctic. Bathymetric range is sub-littoral to moderate..." (Frizzell and Exline, 1957, p. 983).

Conodonts - Some fragmental conodonts were also collected from the insoluble residues from the biogenetic bank deposits. These specimens were of the platform type.

Conodont paleoecology is still in a state of flux since exact affinities are not known and environments are debatable. They have been suggested to be remains of fish, worms, or molluscs. Hypotheses about their habitat have changed with investigation of different types of sedimentary rocks, and they are presently thought to have been shallow marine dwellers in near-shore areas (Ellison, 1957, p. 993).

Plants - Some finely disseminated cuticular material was found associated with the biogenetic bank rocks in insoluble residue samples. The presence of this material alone can be of no real value ecologically since it could have floated miles from its source before settling.
FOSSILS AND THEIR RELATION TO INSOLUBLE RESIDUES

The following observations on fossil distribution in relation to sediment type within the Plattsemouth member are drawn from the results of study of insoluble residues, polished sections and field study.

Fusulinids appear in limestones of varying argillaceous content and seem to be only slightly restricted by the quantity of clay and silt within the area of study. (See Plate 3, Fig. 5.) A Staffella-like fusulimid was found pyritized in sediments containing low amounts of insoluble clays and silts. Fusulinids were found in the biosparite, biomicrite, and intrasparite facies.

Sponge spicules are found in areas of low to moderate (usually less than 20%) amounts of insoluble clays and silts. This generally fits the ideas of Okulitch and Nelson (1957, p. 763) that Pennsylvanian sponges lived in clear, warm and shallow waters. The identifiable sponge material (Class Hyalospongea) was siliceous and came from insoluble residues. It can be safely assumed that a fair number of unsilicified sponge specimens were overlooked because of their minuteness and difficulty of identification in polished sections. All of the sponge specimens were found in the biomicrite facies.

Corals are not restricted to the biogenetic bank area in the Platts­mouth member. *Pseudozaphrentoides verticillatus* (Barbour) is largely restricted to the bank but a few specimens occur in western Iowa and as far west as Keeling Water, Nebraska. This species occurs in areas where the clay and silt content of the insoluble residues is from approximately 5 to 15% of the sample. The specimens assigned to *P. ordinatus* Ross and Ross occur not only with *P. verticillatus* but also are found in portions of the Plattsemouth member nearer the base than is *P. verticillatus*. 
P. ordinatus was found in areas containing less than 15% insoluble clay and silt. All corals are limited to the intrasparite and biomicrite facies. Specimens of *Syringopora* sp. are found in sections with a wide range in the quantity of insoluble residue. The most complete specimens are found in areas containing less than 15% insolubes.

Bryozoans are numerous throughout the Plattsmouth member and appear to have little relation to the quantity of insoluble material within the samples tested. The largest fragments and numbers of bryozoans appeared in samples containing more than 15% but usually less than 30% insoluble residue. Bryozoans were found in the biosparite, biomicrite and intrasparite facies but were primarily limited to the moderately argillaceous portions of the biomicrite facies. These specimens found in the biosparite facies were usually in the form of very tiny fragmental remains.

Brachiopods are found in all facies of the Plattsmouth member. Specimens of the "Spirifer group" (Williams, 1955) were the most widespread forms and were found in specimens with a range in insoluble residue content of approximately 5 to 40%. Members of the "Strophomena group" also showed considerable variation in the facies in which they occurred. Single valves and whole shells and fragments of productids (usually lacking spines) were found in the biosparite facies in areas having a low cement to matrix ratio. Productids with both valves articulated and spines almost completely intact were found in large numbers at Locality M in beds yielding samples with an insoluble residue content greater than 30%.

(See Plate 3, Fig. 6.) From study of the condition of shells found in the various facies, apparently many of those productids found in the biosparite facies were transported to some degree. It also seems probable that the productids did not dwell in areas of active current action.

Specimens of *Enteletes* sp. were common in the coral bank and associated
with the corals on the fringe areas of the bank but were lacking in other areas. Species of this genus probably had an affinity for less turbid and turbulent waters. The majority of brachiopods were found in the biomicrite facies.

Within the biosparite facies tube-like areas of more argillaceous biospar are found which run roughly perpendicular to bedding. These tubes are continuous for lengths up to two feet and end at various distances from the top of the unit. At the bottom of one of the tubes a pelecypod specimen of the genus *Allorisma* sp. was found embedded in a clay rich matrix. Hattin (1957) found a similar situation in his "algal" limestones. This facies usually contains less than 12% insoluble material. Apparently the clams are restricted to this facies of the Platte-mouth member. The limestone facies to which the pelecypods are restricted indicates that they lived in areas of moderately strong current with perhaps some wave action.

Gastropods are present in all of the facies of the Platte-mouth member. They are found in rocks with an insoluble residue content ranging from less than 5% (portions of the biosparite facies) to more than 35%. They are never abundant in any one area or section but seem to be distributed widely and almost uniformly throughout the area studied. Their great range and lack of apparent ecological control by turbidity fits into their present marine ecological niche of a wide-ranging group of the vagrant benthos.

One partial trilobite pygidium was found in the biosparite facies. Because of its abraded nature no inferences can be made as to its ecological affinities because it was probably transported from some other area prior to final burial.
Ostracods occur throughout the Plattsmouth member in all facies. Problems arise in drawing a paleoecologic conclusion about their presence since they seldom are encountered as complete specimens but usually appear as sections in the polished slabs. External appearance, so often important in their detailed ecology, therefore cannot be determined and precludes further study and identification.

Crinoids are common in all facies. In the biosparite facies they are very fragmental and usually have been rounded (and partially re-crystallized) so that their identification is difficult. Most of the crinoid remains in the more argillaceous biomicrite are quite small (single columnals and plates) and indicate either an amount of transport, or the action of scavengers, or both. More highly calcareous biomicrite, i.e., near the P. verticillatus bank, contains larger and more complete crinoid specimens; these specimens lack calices but are associated with disarticulated ossicles of the dorsal cup. The optimum conditions for satisfactory crinoid development apparently were approached in the area of the bank where turbidity was relatively low.

Echinoid and holothuroid remains are limited to the biomicrite facies. They are most commonly associated with the biogenicetic bank and its fauna. This occurrence in areas of firm bottom and low turbidity (due to increased influx of insolubles?) is typical.

Conodonts are present in small numbers throughout all facies studied. Their fragmental nature is probably due to the crushing techniques used in preparation of the samples for insoluble residue tests. Conodonts do not appear to be restricted by the amount of insolubles present within the rock; rocks with conodonts range from 2.3 to 46.7% insoluble. They may have been brought into areas by weak currents, or the organism that
produced them may have been pelagic or vagrant. Until their actual affinities are known their ecological significance will be difficult to assess.

Land plant remains are rare in central Cass County, Nebraska and at locality M in Kansas. They are moderately abundant in the exposures studied along the Missouri River and are very abundant at locality L in Iowa. The plant remains consist of pink cuticular material, black woody fragments, and small disc-shaped black pollen grains. Although their abundance increases in an eastward direction as does the insoluble content of the rocks it is doubtful if the abundance of insolubles is a controlling factor in the abundance of plant fragments. There is a relatively great amount of clay at the Kansas locality but there are few evidences of plant remains.

Scattered Pseudozaphrentoides verticillatus specimens were associated with finely disseminated plant fragments at the Queen Hill quarry. These plant fossils could either have been carried in by surface currents and dropped or by bottom currents. A combination of both factors might also be a possibility. It is impossible to determine exactly which of these possibilities was of greatest importance.
DEPOSITION of the Plattsmouth limestone indicates a marked change in the environment from the preceding Heebner shale. This change from shale to limestone is typical of a marine transgressive sequence. Braden (1958, Fig. 5) also suggested that this was the pattern of events.

Several minor changes in depositional pattern occurred which culminated in a major influx of clay and silt from the east. Individuals of the rugose coral species *Pseudozaphrentoides ordianatus* probably entered the area at the end of this influx. After this initial appearance a point was reached where almost 95% lime mud (micrite) was the major addition to the depositional matrix. Throughout this time *P. ordinatus* was probably present in or close to the area of study.

Following the deposition of very pure micrite there was a slow additional increase of argillaceous materials to a high of approximately 10% in the Nehawka, Nebraska area. Apparently this increase in clay offered the optimum conditions for *P. ordinatus* and *P. verticillatus*.

The fact that *P. ordinatus* and *P. verticillatus* are not abundant to the east or west of the biogenetic bank probably demonstrates that too much or too little clay influx (and therefore possibly current action) had a negative effect on their optimum developmental efficiency. Too much clay could also serve as a limiting factor by (1) fouling the coelenterate's feeding mechanism or by (2) covering the coral faster than it could grow and killing it. Too little clay could limit the coral because of the probable lack of currents carrying nutrients.

The area of deposition around Nehawka apparently fully satisfied the requirements necessary for formation of a biogenetic bank. Not only were the sediments of the right sort but the fauna within the area was probably
suited for rapid expansion into a new more satisfactory environ-
ment.

The biogenetic bank may have formed in fairly shallow water mod-
erately far from shore much as modern day shallow biogenetic banks in
but this bank is not associated with reefs.
the Bahamas. Since no algae were associated with the bank it is dif-
ficult to negate Teichert's argument (1958) in regard to deep, cold water
coral associations. If Paleozoic corals occupied niches much as those
of today, some of the rugosans (athermatypic forms) may have indeed lived
in deeper waters. Until some actual evidence is found of algae associa-
ted with this coral bank, it is suggested that a moderately deep mode
of life rather than one of shallow water be attributed to this occurrence.
Revelle and Fairbridge (1957, p. 244) suggest that even today most cal-
cium carbonate deposition occurs at moderately great depths (over 1000 feet).

After the development of the biogenetic bank, the water appears to
have shallowed gradually with minor fluctuations to a point where active
current or wave action could winnow out the fine muds and round the
fossils normally included in the biomicrite facies into those typifying
the biosparite facies. This process rather than algal formation of the
grains is probably the primary mode of formation since no algal struc-
tures could be seen surrounding the grains.

Since some form of regression seems evident toward the end of Platts-
mouth deposition the top of the member probably is not a time plane and
may even be partly erosional. Some of the biomicrite facies in the east
may have been eroded and redeposited in the areas to the west now com-
prising the biosparite facies.

During the time of deposition of the Plattsmouth limestone in Nebraska
and Kansas plant debris, clay and silt were being carried from a north-
easterly source westward across Iowa into adjacent eastern Nebraska,
SUMMARY

General conclusions in regard to the Plattsmouth member are as follows:

1. Braden (1958) implied that the framework of the biosparite facies was oolitic. Svendsen (1961) proposed an algal origin. At present it seems most probable that these "grains" were rounded secondarily and re-deposited.

2. Most of the chert in the Plattsmouth member is probably of secondary origin.

3. Plant fragments and pollen, and increased argillaceous content in the Iowa exposure, suggest a source for these materials from the east or northeast during deposition of the Plattsmouth member.

4. The biogenetic bank within the Plattsmouth may have formed in water deeper than usually suggested.

5. The area of bank development is centered just north of Nehawka, Nebraska, and trends in a westerly direction for about four miles. The bank is probably only a mile or two wide. Flanking the bank area on all sides is a wider periphery in which corals and the associated faunal elements are far less abundant. Few corals are found at a distance of ten miles or more to the east or west of the bank.

6. The biogenetic bank environment probably offered the maximum environmental stimulus for coral growth in the area during the time of deposition.
REFERENCES CITED


Smedley, W. O., 1933, A study of the Cread formation in Nebraska; Unpublished M. Sci., Univ. of Nebraska.

Svendsen, A. E., 1961, A microlithological study of the Plattsmouth, Bell, and Ervine Creek members (Upper Pennsylvanian) in southeast Nebraska and adjacent areas; Unpublished M. Sci., Univ. of Nebraska, 62 p.


EXPLANATION OF APPENDIX I

Specimens were collected and described from the top of the member downward, because the top was exposed in almost all quarries, while the base was exposed in only one quarry. Specimens were collected at one foot intervals, with the number 1 indicating the top of the unit, or 0 inches, unless otherwise noted. All slabs were oriented in a north-south direction.

The normal procedure for description of sections is to begin at the base and work up. As noted above, this was almost impossible; consequently, such things as relative amounts of argillaceous material between two specimens may be reversed from their usual descriptive order. For example, "specimen 2" might be said to have more argillaceous material than "specimen 1." In this instance the quantity of argillaceous material decreases upward.

Such features as preferred orientation of fossils, bedding, and argillaceous partings are only noted in the descriptions when they are present. Visual estimation was used in all cases for derivation of relative amounts of constituents.
APPENDIX I

Polished Section Descriptions

All specimens of the Plattsmouth limestone member,

Oread formation

**Location A** - Vance Balfour quarry, 1\(\frac{1}{2}\) miles NW of Nehawka, Nebr. NW \(\frac{1}{4}\), NW \(\frac{1}{4}\), Sec. 18, T 10 N, R 13 E, Cass Co., Nebr.

A1 - Tan, argillaceous biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Fossils include brachiopods, ostracods, a few crinoid columnals, infilled tubes. Much vein spar present. No definite bedding present. Approximately 6 feet below the top of the Plattsmouth.

A2 - Tan, argillaceous biomicrite. Framework 50-60%, matrix greater than cement, pore space more than 5%. Predominant fossils: corals, some crinoids, and shell debris. Silicification common in crinoids, coral walls, and other debris. Approximately 7 feet below top.

A3 - Tan, argillaceous biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Fossils include mostly fusulinids and some shell debris. Argillaceous material appears to be more abundant than fossils. Approximately 8 feet below top.

**Location B** - Abandoned quarry, 1 mile south-southwest of Nehawka, Nebr. NW \(\frac{1}{4}\), NE \(\frac{1}{4}\), Sec. 19, T 10 N, R 13 E, Cass Co., Nebr.

B1 - Brownish grey biosparite. Framework 55-65%, cement greater than matrix, pore space less than 5%. Framework consists of large and small rounded pellet-shaped materials, coarsest at top, with stringers of coarse
material into finer lower portions. Stringers appear more clay-rich than framework. Some differential compaction is apparent as evidenced by pellet breakage and movement along fractures. Pellets largely recrystallized. Upper portion of sample contains encrusting bryozoans; crinoid fragments abundant, brachiopods uncommon. Only one fusulinid found in entire slab. Silica occurs as patches throughout the upper half of the sample, and is limited to the framework. Iron enrichment occurs in grains along microfractures in lower half of specimen. Paragenesis appears to develop in the following way: (1) deposition of spar in interstices (2) replacement in some grains by calcite (3) silica and iron deposition; silica limited to fossil fragments.

B2 - Tan biosparite. Framework 55-65%, cement greater than matrix. Framework composed of rounded grains; upper half of specimen has coarser framework than lower half. Fossils include one recrystallized fusulinid and several poorly-preserved crinoid columnals. A limited amount of silica present which cross-cuts the spar.

B3 - Tan, argillaceous biosparite. Framework 55-65%, cement greater than matrix. Fossils include fusulinid fragments, one gastropod, crinoid and shell fragments. Silica minor, very patchy and limited to recrystallized fossil fragments.

B4 - Light tan, argillaceous biomicrite. Framework 50-60%, matrix greater than cement. Fossils difficult to distinguish but include one fusulinid, a few definite shell fragments, and an incomplete bryozoan zoarium. Very little silica, limited to fossil fragments.
B5 - Very light brown biomicrite. Framework 55-65%, matrix greater than cement. Fossil fragments more abundant than in specimen B4. Fragments mostly recrystallized. Fusulinids, crinoid debris, and one gastropod make up the major proportion of the sample.

B6 - Gray-brown biomicrite. Framework 40-50%, matrix greater than cement. Matrix mottled, suggesting segregation of materials. Framework coarser near bottom of sample than near top. Fossils include shell fragments, crinoid fragments, and a few parts of fusulinids. No vein fillings of spar present; some shell fragments replaced by spar. Some minor traces of silica in shell spar.

B7 - Tan, argillaceous, coral biomicrite. Framework 40-50%, matrix greater than cement. Argillaceous content greater than in B6. Fossils include corals, bryozoans, crinoid debris, fusulinids, single valves of brachiopods, and incomplete gastropods. Micrite pebbles are also present. Silica replacing corals and some secondary spar fills interstices between fossils. Spar also fills some brachiopod and ostracod shells; a few veins of spar present in micrite.

Location C - ½ mile south of Plattsmouth, Nebraska, along the Missouri River bluffs. NE ¼, NW ¼, Sec. 20, T 12 N, R 14 E, Cass Co., Nebr.

Cl - Very dark gray, argillaceous biomicrite. Framework 50-60%, matrix much greater than cement, pore space less than 5%. Fossils consist mainly of broken, encrusted biomicritic material and include gastropods, crinoids, brachiopods, fusulinid fragments, and a few bryozoan fragments. Spar is limited to recrystallized pellets. No other secondary mineralization apparent.
C2 - Tan, argillaceous biomicrite. Framework 65-70%, matrix greater than cement, pore space about 5%. Matrix is more argillaceous than in specimen Cl. Fossils include bryozoa, fusulinids, shell and crinoid fragments, mostly covered with micrite. Fairly high percentage of grapestone particles form nuclei for some larger grains. Some minor silica and irregular masses of pyrite present in fossil fragments. Vein spar not abundant.

C3 - Light gray to tan biomicrite. Framework 60-70%, matrix slightly greater than cement, pore space about 5%. Rounded fossil fragments larger near the top of specimen than toward the bottom. Fossils include predatory fragments and other shells. Fusulinids, gastropods, and bryozoa absent. Silica common in shell material with some spar filling around shells.

C4 - Light gray biomicrite. Framework 70%, matrix greater than cement, pore space less than 5%. Fossils include fusulinids, large predators with broken spines, bryozoans, ostracods, and crinoid fragments. Most fragments well rounded and small. Silica present in scattered grains, but less than in specimen C3.

C5 - Same as C4. Predators larger.

C6 - C7 - Individual fossil samples. Collected from forty-eight inches to fifty-four inches below top.

C8 - Light gray biomicrite. Framework 60-70%, matrix greater than cement, pore space less than 5%. Fossils include fusulinids and coral fragments. Some of the fossil fragments are slightly silicified but most are replaced by spar.
C9 - Very light gray biomicrite. Framework 65-75%, matrix greater than cement, pore space less than 5%. Crushed and distorted fusulinids and shells, productivity fragments, and crinoid fragments present in the fossiliferous portion of the rock. Silica and spar minor.

C10 - Light gray biomicrite. Framework 60-70%, matrix greater than cement, pore space less than 5%. Slightly stratified. In addition to many fusulinids, the fossils include some crinoid fragments, bryozoan fragments, and shell fragments.

C11 - Light gray biomicrite. Framework 60-70%, matrix greater than cement, pore space less than 5%. More pronounced stratification with argillaceous partings not present in C10. Bryozoans more prominent than fusulinids. Vein spar and silica minor.

Location D - Heebner Creek quarry, ½ mile southeast of Snyderville quarry, across Heebner Creek. NE ½, NW ¼, Sec. 14, T 10 N, R 12 E, Cass Co., Nebr.

D1 - Light tan biosparite. Framework 70-75%, cement greater than matrix, pore space about 5%. Fusulinids predominant over all other fossil groups. Other fossils include bryozoans, gastropods, brachiopods, and crinoids. Recrystallization occurs in some shell walls and spar deposition can be seen inside some of the shells. No large vein fillings present. Argillaceous stringers present throughout specimen.

D2 - Light tan biosparite. Framework 65-70%, cement greater than matrix, pore space 5-10%. Specimen composed mainly of rounded fossil grains; most grains completely recrystallized. No large veins of spar or silica present.
D3 - Tan biosparite. Framework 65-70%, cement greater than matrix, pore space about 15%. Some framework constituents definitely identifiable. There is an obvious increase in amount of pore space and amount of argillaceous material in comparison to specimen D2. Fossils include brachiopod shells, lacy bryozoan fragments, and crinoid fragments. Largest single fragments are crinoidal. One intact brachiopod shows trace of a loop seen as white carbonate in the spar filling the inside. No fusulinids present. Cement is spar which is also found in recrystallized centers of fossil debris. Minor amounts of silica deposited in some fossil debris.

D4 - Tan biomicrite. Framework 45-55%, matrix greater than cement, pore space about 10%. Rock largely composed of finely broken fossils and micrite with small veins of spar. Several clay-rich stringers present in the lower portion of the specimen. Fossils consist of fusulinids, crinoid and brachiopod debris, and some small whole brachiopods. Less than 1% silica seen; silica limited to fossil fragments.

D5 - Same as D4, except pore space is 5-10% and sphalerite is perhaps present.

D6 - Brown biomicrite. Framework 35-45%, matrix greater than cement, pore space less than 5%. Fossils consist of fusulinids, brachiopod fragments, and bryozoan fragments. Some recrystallization of fossil fragments has occurred; silica is secondary occurrence after the recrystallization.

D7 - Brown biomicrite. Framework 35-45%, matrix greater than cement, pore space less than 5%. Fossils include bryozoans, gastropods, fusulinids, crinoids, and brachiopods (whole and partial). Silicification of minor importance.
DB - Medium brown bimicrite. Framework 40-50%, matrix greater than cement, pore space 5-10%. Fossils include corals, fusulinids and other debris. One brachiopod shell is broken in several places, with vein spar filling the interior along the breaks. Silicification occurs in corals and irregularly in some other fossil fragments.

Location E - Hopper Brothers quarry, 1 mile west of Weeping Water, Nebr. NW 4, NW 4, Sec. 2, T 10 N, R 11 E, Cass Co., Nebr.

El - Tan biosparite. Framework 60-70%, cement greater than matrix, pore space less than 5%. Fossils include gastropods, fusulinids, and rounded shell fragments which are surrounded by spar. Numerous small stylolites and some free pyrite present. Silica replaces a few spar-replaced shell fragments. There is interstitial spar deposition between fossil particles.

E2 - Tan biosparite. Framework 60-70%, cement greater than matrix, pore space less than 5%. Same as El, except fossil particles slightly smaller.

E3 - Same as El, except fewer gastropods and more fusulinids, with approximately the same number of brachiopod fragments.

E4 - Same as El, but some crinoidal debris present. Fusulinids very common.

E5 - Same as El. More crinoidal material, whole shells and fragments, fewer fusulinids than in specimen El. More silica in fossil debris. Microstylolites common. Spar fills fossils, veins and tubes, replaces some of the shells while leaving a micritic interior.
E6 - Gray biomicrite. Framework 60-70%, matrix greater than cement, pore space less 5%. Slight influx of more argillaceous material in small stringers than in previous five specimens. Fossils include whole and partial brachiopods and crinoid fragments. One whole productid is present and is infilled with micrite; fusulinids absent. Vein spar not seen. Silica very minor and occurs in fossil debris.

E7 - Mottled tan to gray biomicrite. Framework 60-70%, matrix greater than cement, pore space less than 5%. Fauna includes fusulinids, and crinoid and brachiopod fragments. Spar is found in replacements of shells and in vein fillings. Partial silicification present in some crinoid fragments.

E8 - Same as E7, except fossils include one coral, some bivalves, and many fusulinids; crinoids and gastropods absent. Stylolites present. No evidence of silica or secondary mineralization.

E9 - Mottled tan to gray intrasparite. Framework 60-70%, cement less than matrix, pore space less than 5%. Some brecciation has occurred. Fossils include gastropods, crinoids, brachiopods, and some small fusulinids. Stylolites numerous; major stylolite shaly.

E10 - Same as E9, except some brachiopods have vestiges of internal structure. Fewer stylolites than in E9. Little or no silica present.

E11 - Same as E9, but no stylolites present. Some later vein filling has occurred.

E12 - Mottled intrasparite. Framework 75%, matrix greater than cement, pore space less than 5%. Intraclasts composed of micrite, cement-
ed by spar. Fossils fewer than in previous specimens, and also more highly broken. Vein fillings common. Some pyrite present in patches. Silica replaces some of the fossil fragments.

Location F - Abandoned quarry, 2 miles east of Weeping Water, Nebr. Center, Sec. 5, T 10 N, R 12 E, Cass Co., Nebr.

F1 - Tan biosparite. Framework 60-75%, cement greater than matrix, pore space less than 5%. Fossils include bryozoan fragments, fusulinids, and brachiopod fragments. Silica or vein spar not prominent. Stratification minor.

F2 - Tan biosparite. Framework 60-75%, cement greater than matrix, pore space less than 5%. Contains fewer fusulinids than F1; also contains bryozoans, brachiopod and crinoid fragments. Silica and vein spar minor.

F3 - Light gray to tan biosparite. Framework 65-75%, cement greater than matrix, pore space less than 5%. Fossils include brachiopod shell fragments, gastropods and crinoid fragments. Some of the allochems are composed of an aggregation of grains, i.e., grapestones. Recrystallization of allochem centers quite common. Some large crystals of secondary vein spar are present; little or no silica is present.

F4 - Light gray biomicrite. Framework 50-60%, matrix greater than cement, pore space less than 5%. Fusulinids, shell fragments, and crinoid fragments common. Vein spar present; minor amount of silica present in crinoid plates.

F5 - Tan biomicrite. Framework 45-55%, matrix greater than cement, pore space less than 5%. Fossils include brachiopods (whole and partial),
crinoidal debris, and ostracods. Most fossils composed of sparry calcite. Silica patchy; found usually in fossils. Some differential pressure phenomena present.

F6 - Light brown biomicrite. Framework 50-60%, matrix greater than cement, pore space less than 5%. Upper portion is shaly with broken fossil scraps. Fossils include brachiopod, fusulinid, bryozoan, and coral fragments and whole specimens. Fusulinids limited to top portion of specimen. Silica patchy and primarily found mostly in shell fragments and crinoid debris. Many irregular spaces replaced by spar in lower part of the specimen.

F7 - Mottled gray to tan intrasparite. Framework 65-75%, matrix greater than cement, pore space greater than 5%. Intraclasts cemented by secondary spar. Fossils include one coral almost completely replaced by secondary silica, fusulinids, and ostracods. Stylolites are present. Vein spar surrounds micritic material.

F8 - Mottled gray to tan intrasparite. Framework 65-75%, matrix greater than cement, pore space greater than 5%. Fewer fusulinids than specimen F7, some brachiopod shells, and undetermined fossil debris present. Silica present in some fossil fragments; vein spar surrounds micritic material.

Location G - Active quarry, 2 miles northeast of Weeping Water, Nebr. Center, north line, NW 1/4, NE 1/4, NE 1/4, Sec. 31, T 11 N, R 12 E, Cass Co., Nebr.

G1 - Tan pelsparite. Framework 65-75%, cement greater than matrix, pore space less than 5%. No distinguishable fossils. No vein fillings.
Trace of silica in center of some recrystallized pellets.

02 - Same as 01, except more silicification and larger particles. Some shell fragments. Minor spar vein filling.

03 - Tan biosparite. Framework 65-75%, cement slightly greater than matrix, pore space about 5%. Less sparry cement and more micritic material than 02. Fusulinids, shell fragments, and undetermined fossil fragments present. Silica replacement of fossil grains common.


05 - Gray biomicrite. Framework 50-60%, matrix greater than cement, pore space about 5%. Fossils include fusulinids, shell fragments, and some crinoidal debris. Vein spar common. Scattered deposition of silica in fossil fragments present.

06 - Mottled light gray to tan intrasparite. Framework 65-75%, matrix less than cement, pore space less than 5%. Fossils include fusulinids, gastropods, crinoid stem fragments, and brachiopod shells (whole and partial). Silica and veined calcite abundant.

07 - Same as 06. Corals present.

08 - Tan biomicrite. Framework 50-60%, matrix greater than cement, pore space less than 5%. Fossils include fusulinids, brachiopods, and numerous corals. Silicification present in corals and brachiopods. Some vein spar present.
G9 - Tan biomicrite. Framework 60-70%, matrix greater than cement, pore space 5%. Recognizable fossils include fusulinids, and bryozoan, crinoid, and brachiopod fragments. Some silica in recrystallized shell fragments. Spar occurs within shells. Spar fills veins. Of interest is a large fusulinid with a smaller fusulinid enclosed within it.

Location H - Queen Hill quarry, 6½ miles south of Plattsmouth, Nebr. Center, NE ½, SW ¼, Sec. 9, T 11 N, R 14 E, Cass Co., Nebr.

H1 - Gray biomicrite. Framework 60-70%, matrix greater than cement, pore space 5%. Fusulinids common as grain nuclei; possible fish scales and crinoid debris. Some vein spar, scattering of pyrite, silica minor.

H2 - Gray biomicrite. Framework 65-75%, matrix greater than cement, pore space greater than 5%. Same as H1, except framework particles are larger.

H3 - Light gray biomicrite. Framework 55-65%, matrix greater than cement, pore space greater than 5%. Fossils consist of crinoidal, brachiopod and fusulinid debris. Spar vein-filling present. Shaly partings contain larger fossil debris.

H4 - Light gray, fusulinid biomicrite. Framework 50-60%, matrix greater than cement, pore space 5%. Fusulinids and shell fragments common. Some argillaceous partings and irregular masses of pyrite present.

H5 - Same as H4; silica minor.

H6 - Light gray biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Fossils include crinoidal and brachiop-
pod fragments, few bryozoan and fusulinid fragments. Vein fillings minor, silica limited to crinoidal debris; no pyrite.

II7 - Gray biomicrite. Framework 35-45%, matrix greater than cement, pore space less than 5%. Fossils few; some small brachiopod spines. Spar minor; no bedding visible.

II8 - Gray, argillaceous biomicrite. Framework 60-70%, matrix greater than cement, pore space less than 5%. Fossils include fusulinids, brachiopods, crinoid debris; also minor intraclasts present. Vein spar absent, minor amounts of altered pyrite and silica.

Location I - Jordan Creek Section, 5 miles south-southeast of Nebraska. Center, west line, SW 1/4, Sec. 6, T 9 N, R 13 E, Otoe Co., Nebr.

I9 - Tan, fusulinid biomicrite. Framework 55-65%, matrix greater than cement, pore space less than 5%. Fusulinids are the only fossils present. Some pyrite and silica present, no vein spar.

I10 - Light tan biomicrite. Framework 65-75%, matrix greater than cement, pore space less than 5%. Contains crinoid fragments, shell fragments. No fusulinids. Some pyrite and silica.

I11 - Light tan biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Fossils include fusulinids and crinoidal debris; some vein spar and silica present.

I12 - Light brown, argillaceous biomicrite. Framework 35-45%, matrix greater than cement, pore space less than 5%. Fossils include ostracods, shell fragments, and fusulinids. Some silica replacing fossil fragments.
I5 - Brown, argillaceous biomicrite. Framework 50-60%, matrix greater than cement, pore space less than 5%. Fossils include corals, spar-filled "worm tubes," brachiopods, ostracods, fusulinids, bryozoans, and crinoid debris. Some silica and vein spar present. General structure of rock appears to be disrupted; fossils generally broken or distorted.

Location K - Abandoned quarry 1/4 mile west of Balfour farm. NW 1/4, NE 1, Sec. 13, T 10 N, R 12 E, Cass Co., Nebr. Top of member not exposed. Suspect actual top of member is 1-2 feet above the top of the outcrop.

K1 - Tan biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Recognizable fossils include brachiopods and fusulinids. Silica not abundant. Some secondary vein filling.

K2 - Light tan, argillaceous biomicrite. Framework 30-40%, matrix greater than cement, pore space less than 5%. Fossils include shell fragments and whole shells which have been largely recrystallized. Much secondary spar; no silica.

K3 - Same as K2.

K4 - Light tan biomicrite. Framework 45-55%, matrix greater than cement, pore space less than 5%. Fossils include brachiopods, crinoids, and bryozoans. Some secondary silica in fossil fragments. Possible sphalerite present.

K5 - Brown, argillaceous biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Fossils include fusulinids, shell debris, and crinoid fragments. Some altered pyrite present. Vein
spar common. Silica minor, found only in fossil fragments. Argillaceous material in stringers through rock.

K6 - Very argillaceous, brown biomicrite. Framework 50-60%, matrix greater than cement, pore space 5-10%. Fossils present include corals, brachiopods, and crinoid fragments. Coral fragments scattered through matrix; much of other fossil material is scattered, broken or abraded. Silica present in moderate amounts, confined mostly to corals. Most silica is patchy and replaces crinoidal material also.

Location L - Active quarry 1 mile SW of Stinnett, Iowa. NE 4, SW 1, Sec. 14, T 13 N, R 38 W, Montgomery Co., Iowa.

L1 - Light gray, argillaceous biomicrite. Framework 35%, matrix greater than cement, pore space less than 5%. Contains crinoids, fusulinids, shell fragments, and gastropods. Small amount of vein spar. Silica present.

L2 - Gray, argillaceous, fusulinid biomicrite. Framework 60-70%, matrix greater than cement, pore space 5%. Fossils present include fusulinids, crinoids, ostracods, and shell fragments. Numerous argillaceous partings present. Some silica in fossil fragments. Fusulinids silicified; walls not silicified but the spar infilling is.

L3 - Same as L2, but very little silica present.

L4 - Gray, argillaceous biomicrite. Framework 35-40%, matrix greater than cement, pore space 5%. Fossils include fusulinids, crinoids, shell fragments. Very little silica present. No vein spar.
L5 - Gray, argillaceous micrite to biomicrite. Framework 10-20%, matrix greater than cement, pore space less than 5%. Fossils few and difficult to distinguish. Thin laminations present.

L6 - Same as L5.

L7 - Gray, argillaceous biomicrite. Framework 30-40%, matrix greater than cement, pore space about 5%. Fossils include a few fusulinids, bryozoans, and crinoids. Large number of more argillaceous patches and stringers present. Some silica in shells. Roughly linear trend of more or less argillaceous area. Most of the fossils are broken.

L3 - Gray shale - not cut or described in detail. Approximately 3 inches thick.

L9 - Gray, very argillaceous biomicrite. Framework 40-50%, matrix much greater than cement, pore space less than 5%. Same in general as L7.

L10 - Same as L1 but no fossils.

L11 - Same as L1.

L12 - Same as L2, but nodular chert present. Specimen becomes less silicified downward; fusulinids not silicified. Chert is patchy; much pyrite present.

L13 - Same as L3, but fossils smaller and fusulinids less abundant.

L14 - Gray, argillaceous biomicrite. Framework 25-35%, matrix greater than cement, pore space less than 5%. Similar to L4 except for fewer fusulinids. Very little silica or spar; no vein fillings present.
Location M - Inactive quarry, 6 miles north of Blair, Kansas. Sec. 26, T 2 S, R 37 W, Doniphan Co., Kans.

M1 - Gray, very argillaceous biomicrite. Framework 45-55%, matrix greater than cement, pore space less than 5%. Fossils include many brachiopods, and much crinoid debris. Very little silica present; some vein calcite present.

M2 - Light gray biomicrite. Framework 70-75%, matrix greater than cement, pore space less than 5%. Fossils include bryozoans, fusulinids, shell fragments, gastropods, and some crinoid debris. Some spar filling present, minor secondary silica, some pyrite present, very argillaceous. One complete brachiopod showing cardinal process.

M3 - Gray, very argillaceous bryozoan biomicrite. Framework 60-70%, matrix greater than cement, pore space less than 5%. Many encrusting bryozoans, on brachiopod spines; bryozoans, crinoids and shell fragments also present. Little vein spar, some silica.

M4 - Gray biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Fossils include many brachiopod and bryozoan fragments; some remnant bedding present. Very little vein spar; large amount of silica replacing shells.

M5 - Light gray brachiopod biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Fossils include primarily productid brachiopods with some Composita and other forms. Large number of encrusting bryozoan around broken brachiopod spines. Moderate amount of argillaceous material; no vein spar, although large crystals are commonly deposited inside productids.
M6 - Gray, very argillaceous biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Fossils include encrusting bryozoans, gastropods, crinoidal fragments, shell fragments, and brachiopod spines. Shaly partings present, little spar or silica. Fossils distributed irregularly through spar. Larger bryozoans limited to shaly partings.

M7 - Gray, very argillaceous micrite. Framework 5-15%, matrix greater than cement, pore space less than 5%. Fossils include bryozoans, fusulinids and shell fragments.

M8 - Light gray fusulinid biomicrite. Framework 45-55%, matrix greater than cement, pore space less than 5%. Fossils include many fusulinids, some brachiopods, gastropods, and bryozoan fragments; fusulinids silicified. Some vein spar.

M9 - Light gray, argillaceous biomicrite. Framework 45-55%, matrix greater than cement, pore space 5%. Fossils include productids, fusulinids, crinoidal fragments, and bryozoans. Argillaceous partings present. Some fossils silicified; no vein spar.

M10 - Gray, argillaceous biomicrite to micrite. Framework 5-15%, matrix greater than cement, pore space less than 5%. Fossils include bryozoans, shell fragments, and crinoidal debris. Lenses of light micrite surrounded by biomicrite. Minor silica; no vein spar.

M11 - Gray, very argillaceous biomicrite. Framework 45-55%, matrix greater than cement, pore space less than 5%. Fossils include crinoids, brachiopod shells, fusulinids, and bryozoans. Most fossils broken. Silica deposited in many of the fossils. No vein spar present.
**M1.2 - Light gray biomicrite.** Framework 35-45%, matrix greater than cement, pore space less than 5%. Black shale partings at top and bottom of sample. Fossils include bryozoans and crinoid fragments. Little silica or vein spar present.

**M1.3 - Gray biomicrite.** Framework 50-60%, matrix greater than cement, pore space greater than 5%. Fossils include bryozoans, ostracods, and crinoid fragments. Possible "worm tubes" present. Little vein filling or silica present.

**M1.4 - Gray biomicrite.** Framework 50-60%, matrix greater than cement, pore space less than 5%. Fossils include crinoidal and bryozoan debris. No vein spar; minor amount of silica.

**M1.5 - Same as M1.3, but with more "worm tubes (?)" and brachiopod shells.** More argillaceous.

**M1.6 - Same as M1.4 but more argillaceous.**

**M1.7 - Light gray biomicrite.** Framework 45-55%, matrix greater than cement, pore space less than 5%. Fossils include broken bryozoans, ostracods, shells, and crinoid material. Some whole brachiopods, one fusulinid present. Some wavy relict bedding present. Some silica, no vein spar.

**M1.8 - Same as M1.4, but framework 40-50%, and more argillaceous.**

**Location O - Road cut 2 miles north of Nehawka, Nebraska. SW corner, NW 1/4, Sec. 7, T 10 N, R 13 E, Cass Co., Nebr.**

**O1 - Tan biosparite.** Framework 65-75%, cement greater than matrix, pore space less than 5%. Shell fragments rounded and encrusted; sty-
loliites present.

02 - Tan biosparite. Framework 65-75%, cement greater than matrix, pore space less than 5%. Fossils include gastropods, crinoids, fusulinid fragments, and shell fragments. Some fusulinids and other chambered debris have mud infillings, yet in other areas of sample argillaceous material is not abundant. Some of the fusulinid walls are replaced by limonite. Silica is patchy and occurs in crinoid and shell debris. Vein fillings are common.

03 - Tan biosparite. Framework 65-75%, cement greater than matrix, pore space less than 5%. Fewer fusulinids than specimen 02, and these are greatly abraded; rest of fossils same as 02.

04 - Tan bioomicrite. Framework 65-75%, matrix greater than cement, pore space 5%. Fossils include bryozoans, crinoid debris, shell fragments, and fusulinids. Some argillaceous partings; less silica than in previous samples. Little or no vein spar.

05 - Tan bioomicrite. Framework 55-65%, matrix greater than cement, pore space less than 5%. Few identifiable fossils other than fusulinids and shell fragments. Mottled appearance due to changes in matrix-cement ratios. Silica replacement patchy and restricted to shell fragments. Vein filling minor.

06 - Tan, argillaceous bioomicrite. Framework 60-70%, matrix greater than cement, pore space less than 5%. Fossils include productids and other brachiopods (including spines), fusulinids, crinoidal debris, and bryozoans. Silica patchy and occurs in fossil fragments; vein spar generally lacking.
07 - Light brown, argillaceous bionite. Framework 50-60%, matrix greater than cement, pore space 5-10%. Fossils include corals, crinoids, and shell fragments; most of fragments are abraded or crushed. Corals partially silicified.

08 - Tan bionite. Framework 40-50%, matrix greater than cement, pore space 5-10%. Fossils include corals, a few fusulinids, and shell and crinoid debris. Silicification present in crinoids and corals. Shaly partings present, some vein spar.

Location P - Inactive quarry 3/4 mile east of Stryderville quarry. NW 1/4, SW 1/4, Sec. 11, T 10 N, R 12 E, Cass Co., Nebr.

P1 - Tan biosparite. Framework 65-75%, matrix less than cement, pore space 5%. Fossils include fusulinids, gastropods, and shell and crinoid debris. Silica is not present. No vein spar.

P2 - Tan biosparite. Framework 65-75%, matrix less than cement, pore space less than 10%. Fossils include same as P1; coarser grains present than specimen P1. No silica present. No vein spar present.

P3 - Tan biosparite. Framework 65-75%, matrix less than cement, pore space less than 10%. Fossils include crinoidal debris and some shell fragments. No vein spar or silica present.

P4 - Same as P1.

P5 - Light tan biosparite. Framework 55-65%, matrix greater than cement, pore space 5%. Many possible "worm tubes" filled with spar; also ostracods, brachiopods, and crinoid debris. Silica minor, vein spar common.
P6 - Tan biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Predominant fossils are fusulinids with crinoidal and brachiopod debris. Little vein spar or silica.

P7 - Very light gray to tan biomicrite. Framework 50-60%, matrix greater than cement, pore space less than 5%. Fossils include corals, and brachiopod and crinoid fragments; some thin, shaly partings and much broken fossil material. Vein filling prominent. Many shells infilled with spar. Silica found mostly as patches in corals and shell material.

Location R - Ace Hill quarry - active quarry along the Missouri River, 3 miles south of Plattsmouth, Nebraska. NW 1/4, NW 1/4, Sec. 1, T 11 N, R 14 E, Cass Co., Nebr.

R1 - Gray, argillaceous biomicrite. Framework 50-60%, matrix greater than cement, pore space less than 5%. Fossils include bryozoans and shell fragments. Much pyrite and some silica present. Major portion shows no bedding. Shaly partings present.

R2 - Gray, argillaceous biomicrite. Framework 65-75%, matrix greater than cement, pore space less than 5%. Fossils include gastropods, brachiopods, fusulinids, crinoid and bryozoan fragments. Silica minor; pyrite present, no major vein spar.

R3 - Gray, argillaceous biomicrite. Framework 50-60%, matrix greater than cement, pore space less than 5%. Fusulinids, bryozoans, and shell and crinoid debris common. No silica or vein spar.

R4 - Same as R3.
R5 - Gray, argilaceous biomicrite. Framework 10-20%, matrix greater than cement, pore space less than 5%. Fossils same as R2. Silica minor, no vein spar. Shaly partings present.

R6 - Brown, argilaceous, thinly-laminated biomicrite. Framework 32-40%, matrix greater than cement, pore space 5-10%. Fossils include few gastropods, crinoid debris, and brachiopod fragments. Some silica present, vein spar present.

R7 - Same as R6; chert present.


R9 - Same as R6.

R10 - Gray, very argilaceous biomicrite. Framework 40-50%, matrix much greater than cement, pore space 10%. Fossils include crinoids, fusulinids, and other fragments. Argilaceous partings present.

Location S - Active quarry. Snyderville quarry, 5 miles east, 1 1/2 miles south of Weeping Water, Nebr. SE 1/4, Sec. 10, T 10 N, R 12 E, Cass Co., Nebr.

S1 - Light tan biosparite. Framework 65-75%, cement greater than matrix, pore space less than 5%. Fossils included in grains are shell and crinoid fragments, largely recrystallized. No vein fillings. Silica minor and in fossil fragments only.
32 - Light tan biosparite. Framework 55-65%, cement greater than matrix, pore space 5%. Other features same as 31.

33 - Tan to light gray biosparite. Framework 65-75%, cement greater than matrix, pore space less than 5%. Fossils include productids (whole and partial), Syringopora, gastropods, and shell fragments. Pyrite locally abundant. Spar fills whole shells. Silica minor.

34 - Light tan micrite to biomicrite. Framework 10-20%, matrix greater than cement, pore space greater than 5%. Fossils include shell fragments and crinoid debris. Spar fills minor veins. No silica or other minerals noted.

35 - Light tan biomicrite. Framework 20-30%, matrix greater than cement, pore space greater than 5%. Fossils include fusulinids and crinoid and shell fragments. Few minor shaly partings present. No silica or spar present.

36 - Light tan biomicrite. Framework 35-45%, matrix greater than cement, pore space 5%. Fossils include corals, brachiopods, fusulinids and crinoid debris. Irregular masses of pyrite present in vugs. Minor vein filling by spar. Silica limited to patchy areas in corals.

37 - Light gray biomicrite. Framework 50-60%, matrix greater than cement, pore space less than 5%. Fossils include corals, fusulinids, and brachiopod and crinoid fragments. Spar vein fillings minor. Argillaceous partings present. Silica replaces crinoid and coral hard parts.

Location W - Active quarry. Sryderville quarry, 5 miles east, 1 1/2 miles south of Neeping Water, Nebr. 33 1/2, Sec. 10, T 10 N, R 12 E, Cass Co., Nebr.
W1 - Light gray bioclastic. Framework 65-75%, cement greater than matrix, pore space less than 5%. Fossils include crinoid and shell fragments. No vein filling or silica.

W2 - Same as W1, except fusulinids and gastropods present.

W3 - Same as W1, except more shell debris present. Some thin argillaceous partings at base.

W4 - Same as W1, except pyrite present. Spar present in veins.

W5 - Same as W1, except fusulinids, larger crinoid fragments, and pyrite present.

W6 - Light gray biomicrite. Framework 45-55%, matrix greater than cement, pore space less than 5%. Fossils include fusulinids, and crinoid and shell fragments. Spar-filled tubes present. Some silica and microstylolites present.

W7 - Same as W6, except with gastropods. Some argillaceous partings near top.

W8 - Light gray biomicrite. Framework 45-55%, matrix greater than cement, pore space less than 5%. Similar to W7, except more argillaceous.

W9 - Light tan to gray biomicrite. Framework 45-55%, matrix greater than cement, pore space 5%. Dominant fossils are fusulinids. Shaly partings, pyrite and some silica present. Vein spar not prominent.

W10 - Light brown biomicrite. Framework 40-50%, matrix greater than cement, pore space less than 5%. Fossils include bryozoans, shell fragments, and crinoid debris. Pyrite present. Minor amount of silica
in fossils. No vein spar.

III - Light tan biomicrite. Framework 35-45%, matrix greater than cement, pore space less than 5%. Fossils include brachiopods, ostracods, shell fragments and crinoid debris, and some possible worm tubes. Pyrite present. Vein spar present. Some silica replaces fossils.
Thin-sections, acetate peels, and insoluble residues were made with only minor changes from the techniques advocated by Irwin (1958) and Svensen (1961). It was found that polished-sections and thin-sections are far better for examination of carbonates than are acetate peels in many instances.

Procedure for insoluble residues was changed in the following respects. Acetic acid was used in order to have the phosphatic materials in the samples. All size grades after crushing were employed in making the final residue, because previous selective fractionation may have lost some important minor constituents in the finer portions of the sample.

Insoluble residue products were weighed on a single pan platform balance calibrated to weigh to tenths of a gram. Samples were weighed on individual filter papers, so that no contamination could occur.

It is suggested that in a study of carbonates, thin-sections be employed initially to facilitate proper understanding of the rocks involves, since what may appear to be a very fine-grained matrix may actually be composed of a major amount of sparry calcite. Since this is environmentally important and may be overlooked in polished sections or peels, it is a necessity to determine its appearance and proportions in the rocks before major study begins.