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Petrography of the Midale subinterval in the Bottineau and Renville counties area, North Dakota

Morris J. McCollum

University of North Dakota

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PETROGRAPHY OF THE MIDAIS SUBINTERVAL
IN THE BOTTINEAU AND RENVILLE
COUNTIES AREA, NORTH DAKOTA

by

Morris J. McCollum
B.A. in Geology, DePauw University 1958

A Thesis
Submitted to the Faculty
of the
Graduate School
of the
University of North Dakota
in partial fulfillment of the requirements
for the Degree of
Master of Science

Grand Forks, North Dakota
June 1962
This thesis submitted by Morris J. McCollum in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota, is hereby approved by the Committee under whom the work has been done.

[Signatures]

Chairman

Dean of the Graduate School

384125
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ABSTRACT

About 250 thin sections of core samples from the Midale subinterval in the Bottineau-Renville Counties area of North Dakota (T161N-R164N and R76W-R86W) were studied petrographically. The Midale subinterval is the basal section of the Ratcliffe interval of the Madison Group of Mississippian age. In the area of study it is composed of interbedded fine grained limestones, pelletiferous and oolitic limestones, and primary anhydrite. Dolomitization of the limestones in varying stages is common and the dolomitized limestones are usually fine grained. Coarse crystals of secondary anhydrite are common as vug and fracture filling and as a replacement of the carbonates.

The Midale carbonates were deposited as part of a major evaporitic cycle which included the underlying evaporites of the Rival subinterval and the overlying evaporites of the Ratcliffe interval. Dolomitization of the limestones took place shortly after deposition by the circulation of magnesium-rich brines during the deposition of the interbedded and overlying evaporites. Following dolomitization and lithification, secondary anhydrite filled vugs and fractures and replaced calcite and dolomite.

Poreosity of the Midale carbonates is of the primary intergranular and intercrystalline types. Primary porosity was formed at the time of
deposition of the carbonates and was reduced by compaction and by vug filling dolomite and anhydrite. Secondary intercrystalline porosity is not well developed because the dolomites are fine grained and still retain intercrystalline calcite and argillaceous or organic material.
INTRODUCTION

This report is the result of a petrographic study of the MIdale subinterval in Bottineau and Housesville Counties, North Dakota (T161-N - T164-N and R76-W - R86-W). Figure 1 shows the location of the study area and Figure 2 shows the location of the studied wells.

Included in the report are discussions of the stratigraphy, petrography, and environment of deposition of the MIdale subinterval sediments. Photomicrographs are used to illustrate the grain to grain relationships and photomicrologs are used to illustrate the bed to bed relationships.

Previous workers on MIdale petrography were Fuller (1956), Towse (1957), Edie (1958), and more recently Anderson, Hansen, and Eastwood (1960). On the basis of Fuller's work the Madison Group in Saskatchewan was subdivided into time equivalent units defined by mechanical log markers. Towse reported on petrologic studies made of Madison Group carbonates in the Beaver Lodge Madison oil field in North Dakota. Edie discussed the sedimentation of the Madison Group carbonates and evaporites in the oil fields of southeastern Saskatchewan. The report by Anderson, Hansen, and Eastwood was concerned with the Mississippian Madison fields in northern Burke County, North Dakota adjacent to the area encompassed by this report. They discussed the stratigraphy and petrography of the MIdale and Rival subintervals, as well as the latest nomenclature of the Madison Group. Murray (1960)
1. Zach Brooks Drilling Co., Edwin Berentson No. 1
2. Ward Williston Drilling Co., North Westhope U.K1
   Central Life Ins. Co. No. 2
6. Northwest Drilling Co., John Dahl No. 1
7. Sohio Petroleum Co., Maurice Walsh No. 1
8. Sohio Petroleum Co., Clate H. Lindimood, Et. Ux. No. 1
9. H. Mack Cox, John A. Southam No.1
10. Calvert Drilling, Inc., Elmer Jesme No.1
11. The Carter Oil Co., D. E. Wright No.1
12. Cardinal Drilling Co., Marie Demars No.2
14. Cardinal, Great Plains, W.C. Kaufman,
   Jr. - Anna Kaeding No.1

**FIGURE 2 - WELL LOCATION MAP**
in a report on the origin of carbonate rock porosity used examples from the Midale in the Midale Oil Field of Saskatchewan.

ACKNOWLEDGEMENTS

The writer wishes to thank Dr. Wilson H. Laird, Mr. N. H. Kolanowski, Dr. Mark Rich, and Dr. F. D. Holland, Jr. of the Department of Geology, University of North Dakota, Grand Forks, North Dakota for their helpful suggestions and criticisms. Suggestions concerning stratigraphic relationships by Mr. E. B. Anderson and Mr. Clarence Carlison of the North Dakota Geological Survey, Grand Forks, North Dakota are greatly appreciated. Financial aid from the North Dakota Geological Survey as part of their continuing study of the geology of the state made this report possible.
METHODS

The study of the carbonate rocks of the Midale subinterval was done primarily through the use of thin sections prepared from cores and core chips sampled at readily visible lithologic changes. The average sampling interval was about two feet. In the case of thick beds, samples were taken, with a few exceptions, at intervals of not more than four feet.

Thin sections were studied to determine the mineralogy and texture. Because of the difficulty of differentiating the carbonate minerals in thin section, staining procedures were used to supplement the optical analysis. Experiments with several of the organic stains recommended by Friedman (1959) were conducted on known samples. The best results in quality and ease of use were obtained with Alizarine Red S. The stain was prepared by dissolving 0.1 gram of Alizarine Red S in 100 cubic centimeters of 0.2 percent hydrochloric acid. The samples were first etched in dilute (1:10) hydrochloric acid from thirty seconds to two minutes and then washed in running water. They were then immersed in the Alizarine Red S solution from one to three minutes; the calcite in the carbonate rocks was stained deep red while dolomite was only slightly affected and the other constituents were not affected at all. The pale purple stain imparted to the dolomitic rock was attributed to the small amount of calcium in dolomite.

Photomicrographs were made of each thin section and used in the preparation of photo-logs. The method used was modified after that
Porosity determinations were made from plugs drilled at one foot intervals along the sides of cores. The plugs averaged 1.6 centimeters in diameter and 2.5 centimeters in length. They were boiled in carbon tetrachloride in a Soxhelt extractor to remove small amounts of oil present in the pores of some of the samples, and then dried in an electric oven. A Washburn-Bunting type of porosimeter using mercury to displace the air in the pores of the rock was used to determine pore volume. Percent porosity was calculated by use of the formula:

\[
\text{Percent porosity} = \left( \frac{\text{core volume}}{\text{plug volume}} \right) \times 100
\]

The efficiency of this method is rather poor compared to those methods using mercury under pressure greater than one atmosphere, but it is a quick, relatively inexpensive method, and readily indicates relative porosity. Four wells do not have porosity determinations because only core chips were available for these wells.
CLASSIFICATION

The carbonate rocks of the Miocene subinterval are difficult to classify because of the large amount of recrystallization and replacement that has taken place. For this reason the writer has had difficulty preparing a classification broad enough to cover all of the rocks represented and yet sufficiently detailed to give an accurate and complete description. No attempt has been made to propose a new classification or introduce new terms, but rather to use a classification and terminology previously proposed which have had widespread acceptance. The resulting classification has been taken, in part, from those proposed by Carozzi (1960), Folk (1959), Pettijohn (1949) and Cayeux (1935, in Carozzi, 1960).

A carbonate rock has been defined by Carozzi as one containing more than 50% carbonate minerals. A classification of carbonate rocks used in this report is shown on Figure 3. The carbonate rocks may be subdivided on the basis of origin into the autochthonous or allochthonous limestones and dolomites (Carozzi, 1960). Autochthonous limestones and dolomites are those rocks which have formed as the result of precipitation, either directly from sea water or by the influence of organisms, with little or no transportation before deposition. Also included with the autochthonous rocks are those constituents in the rocks which have been deposited in place by recrystallization and replacement processes. Allochthonous limestones
and dolomites are those which have not formed in place, that is, those rocks whose constituents have undergone transportation before deposition and lithification. The grain size classification used in this report will follow that given by Folk (1959) and first proposed, in part, by Grabeu in 1904. The allochthonous carbonate rocks are divided into calcirudites, calcarenites, and calcilutites, in order of decreasing grain size as shown in Figure 4. This figure also shows grain size subdivisions of the autochthonous crystalline carbonate rocks. This grain size classification will also be used to describe the accessory minerals in the carbonate rocks.
The structural and textural features of the carbonate rocks will be indicated by the use of adjectives. A pelletalferous limestone or dolomite limestone contains a high percent of rounded, spherical to elliptical or ovoid aggregates of microcrystalline carbonate material. A carbonate rock containing a high percent of oolithes is termed either an oolitic limestone or an oolitic dolomite. Oolithes are less than 2 millimeters in diameter and are spherical to elliptical or ovoid constituents showing radial structure, concentric structure, or both.
An oolite with a nucleus and only one concentric layer was defined by Carozzi (1960) as a superficial oolite. Rounded, spherical to elliptical or ovoid constituents showing radial structure, concentric structure, or both and greater than two millimeters in diameter are called pisoliths. When a high percentage of pisoliths are present in a rock the rock is termed pisolitic.

Because of the difficulty in distinguishing between transported and non-transported fossils they will be grouped together as allochthonous unless definite evidence to the contrary is recognized. Rocks containing a high percent of fossils are termed fossiliferous.
HISTORY OF NOMENCLATURE

The rocks of the Middle subinterval formerly were not recognized as a separate lithologic unit but were included in the sequence of carbonate and evaporite deposits of the Charles Formation, Madison Group of Mississippian age. The Madison Group included the following formations in ascending order: Lodgepole Formation, Mission Canyon Formation, and Charles Formation. Collier and Cathcart (1922) named the Lodgepole and Mission Canyon Formations for surface exposures in the Little Rocky Mountain region of Montana. Later subsurface studies in Montana and North Dakota by Seager (1942) resulted in the inclusion of the Charles Formation in the upper part of the Madison Group.

The Lodgepole Formation, lowermost Madison, is mainly argillaceous and siliceous limestone. The Mission Canyon Formation is mainly bioclastic and pelitic limestone with interbedded anhydrite near the margin of the basin. The Charles Formation consists mostly of an evaporitic section containing interbedded anhydrites and limestones. Recently, subsurface studies in the Williston Basin have shown that these formations, instead of overlying each other, interfinger and are in part time equivalents (Carlson, Bakken, and Hime, 1960).

The widespread anhydrites of the Charles Formation form excellent markers and are considered to be time equivalents. Because of this these anhydrites and associated carbonates, as well as the Lodgepole and Mission Canyon limestones, were subdivided into several units by
Fuller (1956) for southeastern Saskatchewan. On the basis of Fuller's work the Saskatchewan Geological Society (1956) issued a series of stratigraphic cross sections proposing subdivisions of the Madison Group for southeastern Saskatchewan, which are, in ascending order: Bottineau beds, Tillston beds, Frohisher-Alida beds, Midale beds, Ratcliffe beds, and Poplar beds. These terms were used also by the North Dakota Geological Survey for a short time but the term bed, as used, did not conform to the American Code of Stratigraphic Nomenclature (Anderson, et. al., 1960).

The North Dakota Geological Society under the chairmanship of Smith (1960) proposed a stratigraphic column similar to that of the Saskatchewan Geological Society. The major difference was the substitution of the term interval (a marker defined unit) for the term bed, thereby conforming to the American Code of Stratigraphic Nomenclature. Minor differences are: the Frohisher-Alida interval was extended to include the basal part of the Midale beds and termed the Rival subinterval (anhydrite section in Bottineau and Renville Counties); the remainder of the Midale beds (carbonate section in Bottineau and Renville Counties) were included in the Ratcliffe interval and called the Midale subinterval; and the Ratcliffe interval was extended to include a lower portion of the Poplar beds thereby causing the Poplar interval to be thinner than the Poplar beds of Saskatchewan. This stratigraphic column has been accepted by the North Dakota Geological Survey (Anderson, et. al., 1960). The writer has chosen to use the nomenclature as proposed by Smith (1960) and all reference to the Midale subinterval in this report is the Midale subinterval as
defined by him. Figure 5, a correlation chart of the Madison Group in the Williston Basin, shows nomenclature used previously by the North Dakota Geological Survey and the nomenclature now accepted by that organization and used in this report. The previously used nomenclature is still in use for the Madison Group of the Williston Basin in Montana and in Saskatchewan as shown on Figure 5. A typical stratigraphic section for part of the Madison Group in the area of study is illustrated on Figure 6.
## Correlation Chart of the Madison Group of Mississippian Age in the Williston Basin

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<th>MONTANA and formerly entire Will. Basin</th>
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<td>FROBISHER-ALIDA INTERVAL</td>
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<td>LODGEPOLE FORMATION</td>
<td>BOTTINEAU Beds</td>
<td>BOTTINEAU INTERVAL</td>
<td></td>
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**Figure 5**
FIGURE 6 - STRATIGRAPHIC SECTION OF PART OF THE MADISON GROUP, MISSISSIPPIAN AGE
STRATIGRAPHY

NAME AND DEFINITION

The term Midale was first used by Fuller (1956) in describing approximately eighty feet of dolomitized limestone and argillaceous dolomite of Madison Age between two anhydrites in the Midale Oil Field of southeastern Saskatchewan. Because the Midale is not exposed at the surface, Fuller used the Shell Midale no. A-9-18 well (Loc. 9, Sec. 18, Twp. 6, Rge. 10, W. 2nd Meridian) as a reference section. This same section as described by Fuller is equivalent to the Midale subinterval, Madison Group, Mississippian Age of this report.

OCCURRENCE

The Midale subinterval in the area of study occurs in the subsurface in the western part of Bottineau County and most of Renville County. In the eastern part of Bottineau County it is missing because it has been truncated by the pre-Mesozoic unconformity. An east-west section, Figure 7, shows the subsurface Midale and its relation to the unconformity.

The Midale can be traced westward from the study area into the central part of the Williston Basin and northward into Saskatchewan. On the western side of the Williston Basin the Midale has not been definitely recognized.

Figure 2 includes a sketch map of the Midale subcrop after
Anderson and Carlson (1958). As this map was made when the terminology of the Saskatchewan Geological Society was being used in North Dakota, the Midale of the map also includes the anhydrite of the underlying Rival subinterval. This will not affect the utility of the map, however, because it will still show where the Midale of the studied wells is truncated by the unconformity.

**LITHOLOGY**

In Bottineau and Renville Counties the Midale subinterval is composed mostly of carbonates. Of the carbonates, fine grained limestones and dolomites predominate. Interbedded with the fine grained carbonates over most of the area are pelletaliferous and oolitic carbonates. Thin beds of primary anhydrite occur with the fine grained limestones and dolomites in the eastern part of the area as well as scattered crystals of secondary anhydrite.

**THICKNESS**

The thickness of the Midale subinterval varies from about 55 feet in the westernmost part of Renville County to about 40 feet in the central part of Bottineau County. Farther east and north in Bottineau County the Midale thins rapidly because of truncation by the pre-Mesozoic unconformity. It is missing in eastern Bottineau County and northeast of the study area in Saskatchewan.

**PALEONTOLOGY**

The rocks of the Midale subinterval in the study area contain few fossils. Because it was not part of the study, no attempt was made
to identify specific fossils. However, those fossils found appear to be mostly brachiopods, ostracodes, and bryozoans.

RELATIONS TO ADJACENT FORMATIONS

In Bottineau and Renville Counties the Midale subinterval is conformably underlain by anhydrites of the Rival subinterval and conformably overlain by anhydrites of the Batcliffe interval except where it has been truncated by the pre-Mesozoic unconformity, then it is unconformably overlain by rocks of Permo-Triassic age. Figure 6 shows the relationship of the Midale subinterval to intervals above and below.

CORRELATION

The Midale subinterval of the Madison Group of Mississippian Age is not exposed at the surface. It is equivalent to the upper part of the Midale beds of Mississippian Age in Saskatchewan (See Figure 5). The lower part of the Midale beds in Saskatchewan are termed the Frobisher anhydrite and they are equivalent to the Rival subinterval of Mississippian Age which underlies the Midale of this report.

In Montana the Midale has not been recognized but would be included in the lower part of the Charles Formation, Madison Group, Mississippian Age (See Figure 5).
PSYCHOGRAPHY

Detailed thin section study shows that the carbonate rocks of the Midaie subinterval in the Bottineau-Renville Counties area are composed primarily of fine grained limestones and dolomitic limestone. The amount of dolomitization that has taken place varies from bed to bed and varies within a bed from one place to another in the area. The limestones are often pelletiferous and sometimes colitic and fossiliferous. Associated with the carbonates are primary and secondary anhydrite. The reader is referred to the fence diagram, Figure 8, for distribution of the Midaie sediments. Plates I through IV illustrate textures of the rocks of the Midaie subinterval and Plate V illustrates the textures of the rocks below and above the Midaie.

The fine grained limestones are composed of aphanocrystalline anhedral calcite that often appears cloudy in thin section. These fine grained limestones are illustrated by a photomicrograph on Plate I-A. They were probably deposited as a lime mud that may have been a chemical precipitate or may have originated by the attrition of fossils or other carbonate particles. Although their extremely small grain size prevents determination of their origin they are considered to be autochthonous or chemically precipitated because of the absence of rock forming fossil fragments and their even texture. The cloudy appearance is probably caused by the fine crystal size of the calcite tending to scatter the light and by the presence of minute argillaceous or organic
particles in the intercrystalline areas. Selected insoluble residue studies showed the presence of argillaceous or organic material in the aphanocrystalline limestones.

Dolomitization of the relatively pure aphanocrystalline limestones is common and all stages in the development of dolomitization are seen in the Midale. Plate I-B illustrates a dolomitic limestone. Most of the intensely dolomitized limestones of the Midale are very finely crystalline and occasionally aphanocrystalline. They are shown on Plate I-C and the similarity between the fine grained limestones and the dolomites can be seen by comparing Plate I-C with Plate I-A which illustrates a fine grained limestone. If these dolomites represent dolomitized aphanocrystalline limestones, the resulting grain size after replacement is only slightly larger than the grain size before dolomitization. Most of the partially dolomitized aphanocrystalline limestones contain dolomite in the form of very finely crystalline usually subhedral, but sometimes subhedral to euhedral, crystals. Since these partially dolomitized limestones contain dolomite in the same form as it occurs in the intensely dolomitized limestones, the intensely dolomitized limestones were probably at one time aphanocrystalline limestones.

A few instances occur where dolomitization of the aphanocrystalline limestones resulted in a sucrosic texture. In the early stages of replacement subhedral to euhedral mostly finely crystalline dolomite rhombs were scattered throughout the limestone (illustrated on Plate I-D). These rhombs, as seen in a partially dolomitized limestone, contain numerous inclusions of carbonate which are usually more concentrated near the periphery of the crystal. The dolomite crystals
grow in number rather than in size forming a saccharoidal texture.

Pellets are important constituents of the Midale carbonates and two types have been recognized; distinct ovoid to elliptical pellets illustrated on Plate II-A and pellets with irregular indistinct outlines illustrated on Plate II-B. Both types of pellets range in size from about 0.03 mm. to about 1 mm. and both types are composed of aphanocrystalline cloudy calcite.

The ovoid to elliptical pellets are usually poorly sorted. They may constitute the entire rock except for a minimum of cement or they may be sparsely scattered in an aphanocrystalline limestone or dolomitic limestone matrix. In either case they usually have a fringe of very finely crystalline anhedral dolomite. This dolomite fringe serves as a cement in the more porous pelletiferous limestones. Some of these pellets occluding colites and smaller pellets are flattened on one or more surfaces and appear to have been reworked.

Pellets with irregular outlines are usually indistinct and grade into the surrounding matrix. They are recognized because the particle size of the pellets is finer than the particle size of the matrix. Some of the more poorly defined pellets may actually be nodules caused by differential dolomite replacement of the original matrix.

Except for the thick colitic section of the Midale in the Sohio Petroleum Co., Clute N. Lindemood, Et. Ud. No. 1 (NW, SE, Sec. 1, T162N, R66W) well, most colites are generally found associated with pellets and have approximately the same size range as the pellets. Plate II-C shows a photomicrograph of the association of pellets and colites. The colites usually have a center of radially arranged very
finely crystalline dolomite and alternating concentric layers of aphanocrystalline cloudy calcite and very finely crystalline anhedral dolomite. This type of colite is shown in a highly magnified photomicrograph on Plate II-D. Some colites, however, have centers of aphanocrystalline calcite and alternating concentric layers of very finely crystalline dolomite and aphanocrystalline calcite. The aphanocrystalline calcite center may have been a pellet. Superficial colites similar to the colites but with a crystalline dolomite center and only one concentric layer are present in some of the pelletiferous beds. These commonly show a black cross under crossed nicols due to the extinction pattern of the radially arranged crystals. The outer layer is usually much thinner than the center.

The colites from the Schio, Lindemood well differ from those found in other parts of the Midale in the study area. Many are greater than 2 mm. and therefore are pisolites. The nucleus of the colites and pisolites is commonly a broken fragment of a preexisting colite or pisolite. Many pisolites are composite, that is, they may have two or more centers around which the concentric bands developed. Later concentric layers then surrounded the two or more centers forming a composite pisolite. Surrounding the nucleus are concentric layers of very finely crystalline calcite alternating between elongated radially arranged crystals and anhedral relatively equidimensional crystals. The latter layer being much thinner than the former layer. The number of concentric layers is usually between ten and twenty. Some of the elongated crystals project through the layers of equidimensional crystals and the overall effect is a radial arrangement showing the typical black extinction cross under crossed nicols. Most pisolites and colites
have a greater number of concentric bands on three sides than on the
fourth. This results in an elliptical rather than spherical shape.
The matrix is usually very finely crystalline calcite that cements
the pisolites and oolites at their point of contact. With this
minimum of cement the rocks are very porous. Plate III-A shows the
large oolites and pisolites.

Dolomitization of the pelletiferous, oolitic and pisolitic
limestones appear to have started in the matrix. The dolomite in the
matrix is usually very finely crystalline to finely crystalline with
the finer crystals usually anhedral and the coarser crystals usually
subhedral to euhedral. The coarser crystals often contain inclusions.
If the matrix is vuggy, finely crystalline to medium crystalline
anhedral dolomite is usually found in the smaller vugs (see Plate
III-B). Selective replacement of the alternating layers in the oolites
took place and as dolomitization proceeded, the pellets and the
remaining layers of the oolites were probably replaced. Some of the
relatively pure dolomites were probably at one time pelletiferous, but
no evidence of this was found.

Fossils and fossil fragments are minor constituents of the
Middle in the Bottineau-Renville Counties area. Most fossils examined
appear to be either ostracodes or brachiopods. They usually occur as
single valves and fragments of valves but occasionally a whole fossil
is present (illustrated on Plate III-C). Fossils composed of calcite
were found in both limestones and dolomites. The very fine calcite
crystals of the fossil are usually elongated perpendicular to the shell
surface but occasionally the elongated calcite crystals were found in
alternate layers, one perpendicular to the shell surface and one
parallel to the shell surface. In the dolomites, the calcite of the shell has usually been replaced somewhat along the shell-matrix contact causing the contact to be transitional. The whole fossils have a center filling of finely crystalline to medium crystalline anhedral dolomite crystals. Replacement of fossils by dolomite usually obliterates the fossil structure and often the fossil is a center of dolomitisation. These replaced fossils are shown on Plate III-B. When the dolomite crystals have replaced the surrounding rock as well as the fossil, the outline of the fossil is seen because of cloudy inclusions remaining in the dolomite along the original shell boundary.

Two types of anhydrite — primary and secondary — are recognized as being associated with the carbonates in the Middale. Primary anhydrite, as shown on Plate IV-A is usually irregularly interbedded with the carbonates or included in the carbonates in large patches. Secondary anhydrite as shown on Plate IV-B, occurs in fractures, vugs, as scattered crystals in the carbonate, and projects into the carbonate along the primary anhydrite-carbonate contact.

Primary anhydrite is colorless to light gray, commonly subhedral to subhedral in lath-like crystals that may change abruptly to anhedral crystals with no regular crystal pattern. Carossi (1960) stated that the lath-like or "pile of brick" texture is typical of primary anhydrite and that the patchy texture occurs as a primary feature resulting from the action of currents and eddies on precipitated crystals.
Secondary anhydrite is usually in the form of coarsely crystalline subhedral to subhedral crystals, but may be anhedral. It is usually yellowish brown to dark brown. Fracture and vug filling anhydrite usually replaced outward from the fracture of vug (see Plate IV-C). The anhydrite contains inclusions of the material it has replaced except in the original fracture or vug. Secondary crystals often separate the carbonate and primary anhydrite and project into the carbonate along the carbonate-primary anhydrite contact as illustrated in a photomicrograph on Plate IV-D. The color changes from the light gray of the primary anhydrite to the yellowish browns of the secondary anhydrite. Crystal sizes are also different with the crystals of secondary anhydrite larger than the primary anhydrite crystals. These larger secondary anhydrite crystals contain varying amounts of inclusions of the carbonate while the smaller primary crystals are almost devoid of inclusions.

Replacement of carbonate by secondary anhydrite began, as in dolomitization, by replacement of the finest material first. The coarser material was surrounded by the anhydrite and was included. Evidence of this type of replacement are the calctes with alternating layers of aphanocrystalline calcite and very finely crystalline dolomite in which the finer calcite has been replaced while the coarser dolomite was left as inclusions in the anhydrite. Calcite is usually the first to have been replaced when calcite and dolomite are associated but this was attributed to the fact that dolomite usually has a larger crystal size than the calcite. However, calcite may have been more susceptible to replacement by anhydrite than dolomite.
The rocks immediately below and above the Midale are important because they define the limits of the Midale. The writer considers the intimate association of anhydrite and dolomite (illustrated on Plate V-A) commonly found below and above the carbonate to be Rival subinterval and Hatcliffe interval, respectively. The dolomite is usually found as disseminated crystals and irregular clusters or thin wavy lines in the anhydrite. The disseminated crystals are usually intercrystalline and subhedral to euhedral. The dolomite in clusters and thin wavy lines is usually aphanocrystalline, euhedral, and cloudy. Anhydrite usually predominates.

In areas where the Midale is truncated by the pre-Mesozoic unconformity (see Figure 2) the overlying rocks are sandstones, siltstones, and conglomerates of Perm-Triassic age. These clastics, illustrated on Plate V-B, are usually poorly sorted and are composed of quartz, anhydrite fragments, and dolomite fragments in an anhydrite or dolomite matrix. The dolomite fragments may be reworked rocks of Midale age.
PLATE I

PHOTOMICROGRAPHS OF LIMESTONES AND DOLOMITES
OF THE MIDDLE SUBINTERVAL

A. Fine grained limestone composed of aphanocrystalline calcite. Nicols crossed, X5l. (The Carter Oil Co., D. E. Wright No. 1, 5,394 feet)

B. Dolomitic limestone; lighter material is dolomite. Nicols crossed, X5l. (H. Mcc. Cox, John A. Southam No. 1, 4,495 feet)

C. Dolomite; fine grained with intercrystalline calcite and argillaceous or organic material. Nicols crossed, X5l. (Zach Brooks Drilling Co., Edwin Berentson No. 1, 3,410 feet)

D. Partial dolomitization (light - dolomite crystals) of a fine grained limestone. More advanced dolomitization and dissolution of unreplaced calcite would result in a saccharoidal dolomite. Nicols crossed, X4G. (Cardinal, Great Plains, W. C. Kaufman, Jr., Anna Mceding No. 1, 3,248 feet)
PLATE II

PHOTOMICROGRAPHS OF PELLETIFEROUS AND COLITIC TEXTURES OF THE MIDALS SUBINTERVAL.

A. Pelletiferous limestone; distinct pellets with a fringe of very finely crystalline anhedral dolomite. Nicols crossed, X24.5. (Ward Williston Drilling Co., North Westhope U. M1, 3,293 feet)

B. Pelletiferous limestone; indistinct pellets in slightly dolomitised matrix. Nicols crossed, X48. (H. Mack Cox, John A. Southern No. 1, 4,509 feet)

C. Dolomiticolitic pelletiferous limestone; the matrix of the pellets and calcites has been replaced by very finely crystalline dolomite. Nicols crossed, X24.5. (Ward Williston Drilling Co., North Westhope U. M2, 3,247 feet)

D. Colite with center of radial crystalline dolomite showing black extinction cross and alternating layers of sphenocrystalline calcite and very finely crystalline dolomite (white). Nicols crossed, X93. (Sohio Petroleum Co., Clute H. Lindenwood, R1. U2. No. 1, 4,658-59 feet)
PLATE III

PHOTOMICROGRAPHS OF OOLITIC AND FOSSILIFEROUS TEXTURES OF THE MIDALE SUBINTERVAL

A. Oolitic limestone. Nicols crossed, X24.5. (Schio Petroleum Co., Clute H. Lindemoon, Et. Ux. No. 1, 4,675-76 feet)

B. Pelletiferous and oolitic limestone; vugs have been filled by dolomite (white) and some of the matrix has been replaced by dolomite. Nicols crossed, X24.5. (Schio Petroleum Co., Clute H. Lindemoon, Et. Ux. No. 1, 4,658-59 feet)

C. Fossil (ostreode) with shell material composed of calcite and with a center of medium crystalline dolomite. Nicols crossed, X51. (H. Mack Cox, John A. Southam No. 1, 4,479 feet)

D. Fossiliferous dolomitic limestone; the fossil and some of the surrounding matrix has been replaced by dolomite. Nicols crossed, X48. (Ward Williston Drilling Co., North Westhope U. E2, 3,254 feet)

B. Secondary anhydrite crystals (light colored) in fine grained limestone. The secondary anhydrite contains inclusions of calcite and dolomite. Nicols crossed, X51. (Cardinal, Great Plains, W. C. Kaufman, Jr., Anna KAeding No. 1, 3,250 feet)

C. Fracture filled by anhydrite (light colored) with replacement of the bordering limestone by anhydrite. (limestone is dark colored) Nicols crossed, X51. (Northwest Drilling Co., John Dahl No. 1, 3,222 feet)

D. Primary anhydrite (small light colored crystals) and fine grained limestone (dark colored), with crystals of secondary anhydrite along the contact. Nicols crossed, X35.5. (Calvert Drilling Inc., Elmer Jones No. 1, 3,299 feet)
A. Intimate association of primary anhydrite (light colored) and dolomite (dark colored). Nicols crossed, X35.5. (Northwest Drilling Co., John Dahl No. 1, 3,235 feet)

B. Quartz (white) and anhydrite fragments (speckled white) in a matrix of dolomite. Nicols crossed, X35.5. (Ward Williston Drilling Co., North Westhope U. C3, 3,238 feet)
ENVIRONMENT OF DEPOSITION AND DIAGENETIC CHANGES

During deposition of the Madison Group sediments in the Williston Basin a change in environment occurred. The normal marine conditions prevailing during early Probianer-Alida time gradually changed to an environment characterized by the deposition of alternating carbonates and evaporites which transgressed upward with time toward the center of the basin. Before deposition of Midale sediments the sequence of evaporitic cycles were well developed, especially on the eastern flank of the Williston Basin. The carbonate section of the Midale subinterval in the area of study (located just east of the basin center) is part of an evaporite-carbonate cycle.

Preceding deposition of Midale sediments in the area of study was the deposition of the intimately associated anhydrite and dolomite near the end of Rival time. These sediments indicate a penesaline environment, which has been described by Sloss (1953) as an environment characterized by the deposition of evaporitic carbonates, chiefly dolomite, interbedded with anhydrite. The dolomite, therefore, is considered primary because of its intimate association with the anhydrite. Carozzi (1960) reported an anhydrite-dolomite rock containing dolomite in the form of rounded brown granules in thin layers and clusters giving a suggestion of bedding. He further reported that the dolomite did not show evidence of replacement by anhydrite. This description by Carozzi closely resembles the anhydrite-dolomite
occurring above and below the Midale in the area of study. Bie
(1958) reported a similar occurrence of primary dolomite associated
with anhydrite in the Ratcliffe interval in Saskatchewan.

Change in depositional conditions after Rival time caused
deposition of the fine grained limestone (usually dolomitised) found
at the base of the Midale. The interbedding of the fine grained
carbonates with pelletiferous and oolitic limestones and with primary
anhydrite suggests the presence of a normal marine environment in this
part of the Williston Basin that was, at relatively short intervals,
changed into a saline environment. This change to saline conditions
may have been caused by slight fluctuations in sea level, by climatic
variations, or by the formation of a temporary barrier that partially
restricted the sea. Conditions prevailing during deposition of the
pellets and ooliths probably were not much different from those
conditions prevailing during deposition of the fine grained limestone
because the pellets and ooliths often have a fine grained limestone
matrix or are "floating" in fine grained limestone. The absence of
highly fossiliferous beds in the limestone is probably because the
normal marine conditions bordered on saline conditions a large amount
of time causing the environment to be unsuitable for supporting animal
life. The few fossils present may have been washed into the area.

The oolitic and pisolitic section in the Midale of the Schio
Petroleum Co., Cline E. Linswood, Mt. Ux. No. 1 well is composed of
oolites and pisolites that grew in place. Accretion probably took place
slightly below wave base in a sea which had favorable conditions for the
precipitation of calcium carbonate. Evidence for the accretionary
formation of the oolites is: their usually ellipsoidal shape with a
greater number of layers on three sides than on the fourth; that some colites and pisolites are composite or have two and three centers; and that crystals often project through several layers. Carossi (1960) stated that colites that grew in place possibly had less accretion on the bottom or had less accretion on those parts in contact with other colites. The fragmented colite particles that often formed a nucleus for later colitization indicate occasional violent storm conditions that broke up the already formed colites and pisolites, redeposited them, and later accretion took place around them.

The close of Midale deposition was marked by the return of penesaline conditions which resulted in the deposition of primary dolomite with the anhydrites of the Ratcliffe interval.

The Madison Group in the Williston Basin is characterized by alternating deposits of carbonates and evaporites. This is similar to the major evaporitic cycle which, according to Bloos (1953), grades from normal marine conditions into a penesaline environment, thence to saline conditions and back into penesaline and normal marine completing the cycle. As stated before, the sediments of Rival age that underlie the Midale in the area of study are composed of evaporites with penesaline-type deposits immediately beneath the Midale. The Midale is dominantly carbonates and except where the Midale has been truncated by the pre-Mesozoic unconformity is overlain by penesaline-type sediments and evaporites of Ratcliffe age. The Midale, then, is part of a major evaporitic cycle characteristic of the Madison Group sediments. The evaporites interbedded with the carbonates in the Midale probably represent minor variations within the major cycle.
Major diagenetic changes that occurred in the rocks of the Midale subinterval are dolomitization and pore filling by dolomite with accompanying dissolution of calcite and pore filling and replacement by secondary anhydrite. According to Anderson, et. al. (1960) dolomitization of limestone beds immediately below primary anhydrite was most active for the Rival and Midale subintervals in the Burke County area just west of the area of study. This was found to be generally true in the Midale of the Bottineau-Renville Counties area also. They attributed this to circulation of saline waters through the porous carbonates at time of deposition of the overlying anhydrites. The nature of the original composition which was, according to Fuller (1956), argillaceous aided in dolomitization by permitting better circulation of the saline waters in the more porous argillaceous carbonates. Adams and Rhodes (1960) postulated that dolomitization of some limestones was caused by seepage refluxion. This process is based on a concentration of heavy brines in a restricted sea. The heavy brines, rich in magnesium and other elements, filled depressions and slowly seeped into the underlying carbonates dolomitizing them.

The time of dolomitization which resulted in the more coarsely crystalline dolomitic rocks is not known. Dolomitization may have begun shortly after deposition but probably developed more slowly as there are few completely dolomitized sucrosic dolomites. Most of the partially dolomitized limestones of this type are the porous and pelletiferous varieties in which the pores were first filled or the matrix of the pellets first dolomitised.
Formation of secondary anhydrite crystals appears to have
taken place some time after dolomitization, although Anderson, et. al.
(1960) reported two ages of the secondary anhydrite. The secondary
anhydrite crystals that formed first, according to them, contain
inclusions of the original texture of the limestone which has been
obliterated in the rest of the rock by dolomitization. No evidence
of this was found by the writer in the Middle of the Bottineau-Henville
Counties area. The secondary anhydrite observed by the writer filled
pores and fractures and replaced outward. Significant are the numerous
carbonate inclusions, usually more abundant near the periphery of the
anhydrite crystal which resembles the texture of the surrounding
carbonate. These anhydrite crystals associated with dolomitic lime-
stones contain dolomite in the same amount, shape, and crystal size as
it occurs in the surrounding carbonate. One instance was noted where
an anhydrite with alternating layers of calcite and dolomite was included
in an anhydrite crystal. The layers of the calcite had been replaced
by anhydrite but the dolomite, although slightly corroded, was not
replaced. This occurrence of secondary anhydrite evidently corresponds
to the later age of Anderson, et. al. (1960). They reported that the
anhydrite crystals were probably derived from solution of primary
evaporite possibly at the time of alteration of the gypsum to anhydrite
after deep burial.
POROSITY

Classifications of porosity in carbonate rocks have been proposed by Waldschmidt, et. al. (1936) and Murray (1960). Waldschmidt classified porosity on the basis of vugs and fossils. This indicated the type of porosity but not the origin of the porosity. Murray grouped the carbonate pore types into three categories: primary porosity resulting from depositional processes; sucrose dolomite with intercrystalline vugs formed during replacement; and secondary vugs formed by postdepositional processes. This classification indicates the origin of the porosity.

Both classifications can be used in part, to describe the porosity of the Midale carbonates in the study area. The porosity is mostly of the primary intergranular and secondary vug or intercrystalline type. Sucrose dolomites and fossiliferous limestones are rare. Photomicrographs on Plates VI and VII illustrate primary intergranular porosity and secondary intercrystalline porosity.

Primary intergranular porosity is exhibited to varying degrees in the aphanocrystalline, pelletiferous, and oolitic limestones (see Plate VI-A and B). Aphanocrystalline limestones are usually tightly compacted and the pore size would be very small. Porosity of pelletiferous limestones consists of vugs in the inter-pellet areas and depends upon sorting and packing of the pellets and the amount and type of cement. The pelletiferous limestones of the Midale are usually
poorly sorted and well cemented with aphanocrystalline calcite, but some have a minimum of cement and have high primary porosity. Vuggy primary porosity is portrayed very well in the thick colitic section of the Sohio Petroleum Co., Claito N. Lindemood, Et. Ux. No. 1 well. The colites are large, though poorly sorted, and are cemented only at their points of contact. Although no porosity determinations were made because only core chips were available from this well, the vugs are readily seen in hand sample. Thomas and Glaister (1960) illustrated a similar occurrence of excellent primary porosity of colitic limestones from the Middles of Saskatchewan.

Secondary vugs or intercrystalline porosity is mainly the result of replacement by dolomite. Dolomitization of the aphanocrystalline limestones probably reduced the pore size in most cases (see Plate VII-A). Murray (1960) pointed out that dolomitization of fine grained limestones, in the initial stages, reduces porosity because of compaction but after about 50 percent dolomitization porosity begins to increase. The increase in porosity is the result of the development of equigranular, subhedral to subhedral crystals with dissolution of the intercrystalline calcite (see Plate VII-B). Most of the Middles carbonates, however, are fine grained, not equigranular, and have calcite and argillaceous or organic material in the intercrystalline areas. Dolomitization of the pelletaliferous limestones appears to have increased the porosity as the resulting grain size is usually larger than the replaced material and the intercrystalline areas appear devoid of fine grained material. The intercrystalline porosity is not as well developed as the intercrystalline porosity in the sucroes dolomites, however.
Reduction in porosity of the Midale carbonate rocks is mostly the result of vug filling by anhydrite and dolomite. Vug filling of the Midale carbonates appears to be the first stage in the replacement by anhydrite and dolomite of the carbonates. Anhydrite is usually found filling the larger vugs while dolomite is more common in the fine pores. This is probably because dolomite was the first to replace the calcite and had not developed fully before anhydrite began filling the remaining vugs and replacing outward from the vug. According to Murray (1960) pressure solution is also an important mechanism in the reduction of porosity and pore size.
A. Primary vugs in an oolitic limestone. Nicols crossed, X24.5. (Sohio Petroleum Co., Clate R. Lindemood No. 1, 4,666-67 feet)

PLATE VII

PHOTOMICROGRAPHS ILLUSTRATING SECONDARY INTERCRYSTALLINE POROSITY OF THE MIDDLE SUBINTERVAL CARBONATES

A. Fine grained dolomite with very little intercrystalline porosity. Dissolution of the calcite in the intercrystalline areas would increase porosity. Nicols crossed, X51. (Cardinal Drilling Co., Marie DeMars No. 2, 3,413 feet)

B. Intercrystalline porosity in saccharoidal dolomite. Some secondary vugs have been filled by anhydrite (light colored). Nicols crossed, X35.5. (Ward Williston Drilling Co., North Westhope U. C3, 3,940 feet)
SUMMARY AND CONCLUSIONS

The Midale subinterval is the basal section of the Ratcliffe interval of Mississippian age. Its thickness varies from fifty-five feet in the western part of the Bottineau-Bennville Counties area to about forty feet in the central part of Bottineau County except where it has been truncated by the pre-Mississippian unconformity, then it thins rapidly eastward and is absent in the eastern part of Bottineau County. Below the Midale in the area of study are the anhydrites and associated primary dolomites of the Rival subinterval. Above the Midale are anhydrites and associated primary dolomites of the Ratcliffe interval, except where it has been truncated by the unconformity, then clastics of Permian-Triassic age overlie it.

In the area of study, the Midale is composed of interbedded aphanocrystalline limestone, colitic and pelletiferous limestones, and primary anhydrite. The aphanocrystalline limestones are composed of aphanocrystalline cloudy calcite and when dolomitized, the resulting grain size of the dolomites is only slightly larger than the grain size before dolomitization. Most colites are associated with pellets except in the westernmost part of the area where the Midale is composed of a thick section of vuggy colitic limestone. Each colite usually has ten to twenty concentric layers and appears to have been formed in place by accretion rather than to have been formed by agitation. The colites associated with the pellets usually have only three to five
concentric layers and often are superficial colites with only one concentric layer around the nucleus. Pellets occur in two forms — distinct ovoid to elliptical and indistinct with irregular outlines. Both types are composed of aphanocrystalline calcite. Some indistinct pellets may actually be mottling caused by differential dolomite replacement. Dolomitization of the colitic and pelletiferous limestones began in the matrix by vug filling, and continued by replacement of the finer calcite. The dolomite is in the form of very finely crystalline, usually anhedral crystals, to finely crystalline subhedral to subhedral crystals. The coarser crystals usually contain numerous carbonate inclusions.

Fossils are minor constituents in the Midale of the study area. Those present appear to be ostracodes and brachiopods. They are usually composed of very finely crystalline calcite but some are dolomitized. Some whole fossils have centers of crystalline dolomite.

Primary anhydrite is irregularly interbedded with the carbonates and is in the form of subhedral to subhedral lath-like crystals and anhedral crystals. Secondary anhydrite usually occurs in subhedral to subhedral crystals as vug and fracture filling and as scattered crystals in the carbonates. It replaces outward from the vug or fracture. The crystals that have replaced the carbonate contain numerous inclusions of the carbonate. Calcite is usually replaced before dolomite, probably because of its finer crystal size in most of the Midale rocks.

The Midale of the study area is part of a major evaporitic cycle which includes the underlying Rival subinterval and the overlying Ratcliffe interval. Saline conditions existed during deposition of
Rival anhydrites grading into a penasaline environment at the close of
Rival time. The normal marine conditions of the Midale were followed
by penasaline seas and then back to a saline environment during which
the anhydrites of the Ratcliffe interval were deposited. Minor vari-
actions in the cycle caused deposition of the primary anhydrites that
are interbedded with the Midale carbonates.

Major diagenetic changes are dolomitisation and pore filling
by dolomite and pore filling by secondary anhydrite. Dolomitisation
resulting in a fine-grained dolomite probably took place during deposi-
tion of the overlying primary anhydrite due to circulation of heavy
brines. The time of pore filling and replacement by dolomite resulting
in the more coarsely crystalline dolomitic rocks is not known.
Formation of secondary anhydrite crystals probably took place some time
after dolomitization as the anhydrite contains inclusions of dolomite.
The secondary anhydrite crystals may have been formed from solutions
derived from the alteration of gypsum to anhydrite after deep burial.

Porosity of the Midale carbonates is mostly of the primary
intergranular and secondary vug or intercrystalline type. The primary
porosity formed during deposition and was altered very little by dia-
genetic changes. Secondary intercrystalline porosity is mainly the
result of replacement by dolomite. Dolomitization of the aphanocrystal-
line limestones probably decreased the porosity because the grain size
after dolomitization was small and the intercrystalline areas are filled
with calcite and argillaceous or organic material. Dolomitization of
the pelletiferous limestones appears to have increased the porosity
because the resulting grain size is larger and the intercrystalline
areas appear to be devoid of fine grained material. Reduction in porosity is mostly the result of vug filling by anhydrite and dolomite.
REFERENCES CITED


APPENDIX I

PHOTOMICROLOGS
SW SE 21-163N-80W

% POROSITY

6 5 4 3 2 1 0 CROSSED NICOLS

LITHOLOGY

ELEV.: 1495 GR.

DOLO & ANHYD; intimately mixed.

ANHYD; argill. TOP MIDALE

DOLO; with argill. beds.

DOLO: with vug filling anhyd.

L.S.; dolo, with vug filling anhyd.

DOLO; calc, vuggy, with anhyd.

L.S.; dolo, chalky, with anhyd xtals.

L.S.; with irregularly interbd anhyd.

L.S.; dolo.

L.S.; dolo, with interbd dolo.

L.S.; dolo, pellt, dense.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
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<tbody>
<tr>
<td>3440</td>
<td>L.S.; dolo, with interbd anhyd.</td>
</tr>
<tr>
<td>3445</td>
<td>L.S.; with mottling of vuggy dolo.</td>
</tr>
<tr>
<td>3450</td>
<td>L.S.; with interbd anhyd &amp; anhyd xtals.</td>
</tr>
<tr>
<td>3455</td>
<td>L.S.; dense, with anhyd xtals.</td>
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DOLO; BOTTOM MIDALE DOLO & ANHYD; intimately mixed.
<table>
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<td>CROSSED NICOLS</td>
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</tr>
<tr>
<td>3240</td>
<td></td>
<td>BRECCIA; dolo fragments in qtz &amp; anhyd matrix.</td>
</tr>
<tr>
<td>3245</td>
<td></td>
<td>TOP MIDALE</td>
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<tr>
<td></td>
<td></td>
<td>DOLO; calc, with anhyd.</td>
</tr>
<tr>
<td>3250</td>
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<td>DOLO; calc, dense, with anhyd.</td>
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<td></td>
<td></td>
<td>L.S.; dolo, pellet, with anhyd xtal.</td>
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<tr>
<td>3255</td>
<td></td>
<td>DOLO; calc, with anhyd xtal.</td>
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<tr>
<td></td>
<td></td>
<td>L.S.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L.S.; dolo, pellet, with anhyd</td>
</tr>
<tr>
<td></td>
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<td>L.S.; dense</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L.S.; dolo, pellet, foss, with anhyd xtal.</td>
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<td>L.S.; dense, with anhyd xtal.</td>
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<td>L.S.; dolo, pellet, with anhyd xtal.</td>
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<td>L.S.; dolo, with interbd anhyd.</td>
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<tr>
<td></td>
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<td>DOLO &amp; ANHYD; intimately mixed</td>
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<td></td>
<td></td>
<td>DOLO; interbd argill beds and mottling of calc material.</td>
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<td></td>
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<td>L.S.; dolo, pellet, with anhyd</td>
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<td>DOLO; calc, with interxtaln anhyd.</td>
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<td>ANHYD; interbd dolo l.s.</td>
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<td>DOLO; with anhyd.</td>
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LITHOLOGY

CONGL; dolc fragments, qtz, & feldspar in dolc matrix.

DOLO; with anhyd.

L.S.; dolc, with fracture filling anhyd.

L.S.; with anhyd xtals.

L.S.; with anhyd.

L.S.; dolc, pellt, with fracture filling anhyd.

DOLO; calc, l.s. mottling.

DOLO; with anhyd.

DOLO; calc, with anhyd xtals.

L.S.; with anhyd.

L.S.; dolc, pellt, & anhyd.

L.S.; dolc.

L.S.; dolc, pellt, foss.

L.S.; dolc, with anhyd xtals

L.S.; dolc, with anhyd.
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<th>Lithology</th>
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<td>CROSSED NICOLS</td>
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<td>S.S.; qtz &amp; dolo fragments in dolo cement.</td>
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<td>3200</td>
<td>TOP MIDALE</td>
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<tr>
<td>3205</td>
<td>DOLO; with anhyd.</td>
</tr>
<tr>
<td>3210</td>
<td>DOLO; calc, pelll, with anhyd xtal</td>
</tr>
<tr>
<td>3215</td>
<td>L.S.; dolo, pelll, with anhyd xtal.</td>
</tr>
<tr>
<td></td>
<td>DOLO; with anhyd.</td>
</tr>
<tr>
<td></td>
<td>DOLO; calc, pelll, ocol.</td>
</tr>
<tr>
<td></td>
<td>L.S.; dolo, foss, with interb dolo.</td>
</tr>
<tr>
<td></td>
<td>L.S.; pelll, ocol, vuggy, foss.</td>
</tr>
<tr>
<td>SE NW 1/4-163N-80W</td>
<td>ELEV.: 1499 K.B.</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>% POROSITY</td>
<td>X 31.5</td>
</tr>
<tr>
<td>6 5 4 3 2 1 0 CROSSED NICOLS</td>
<td></td>
</tr>
</tbody>
</table>

- **ANHYD; with dolo and qtz.**
  - **TOP MIDALE**
  - **DOLO; anhyd in fractures.**
- **L.S.; with interbd dolo and with fracture filling anhyd.**
- **L.S.; dolo, pellit, with anhyd.**
- **L.S.; as above, but more dolo.**
- **DOLO; calc.**
- **L.S.; dolo, with anhyd.**
- **L.S.; dense.**
- **L.S.; with anhyd xtals.**
<table>
<thead>
<tr>
<th>% POROSITY</th>
<th>X31.5</th>
<th>LITHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 5 4 3 2 1 0 CROSSED NICOLS</td>
<td></td>
<td>DOLO; silty, with anhyd.</td>
</tr>
<tr>
<td>3225</td>
<td></td>
<td>TOP MIDALE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DOLO; with anhyd. interbd.</td>
</tr>
<tr>
<td>3230</td>
<td></td>
<td>DOLO; with anhyd xtals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L.S.; dolo, pelt, with anhyd.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DOLO; with anhyd xtals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DOLO; calc, with interbd anhyd and anhyd xtals.</td>
</tr>
<tr>
<td>3235</td>
<td></td>
<td>DOLO; chalky</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BOTTOM MIDALE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DOLO &amp; ANHYD; intimately mixed</td>
</tr>
<tr>
<td>Depth</td>
<td>Lithology</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>4320</td>
<td>DOLO; dense, with small amount of intimately mixed anhyd.</td>
<td></td>
</tr>
<tr>
<td>4325</td>
<td>TOP MIDDLE</td>
<td></td>
</tr>
<tr>
<td>4330</td>
<td>DOLO; chalky.</td>
<td></td>
</tr>
<tr>
<td>4335</td>
<td>DOLO; as above, but foss.</td>
<td></td>
</tr>
<tr>
<td>4340</td>
<td>DOLO; as above, but vuggy with vug filling anhydrite</td>
<td></td>
</tr>
<tr>
<td>4345</td>
<td>L.S.; dolo, pellet, oolit, slightly foss, with anhyd crystals.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L.S.; dolo.</td>
<td></td>
</tr>
</tbody>
</table>
L.S.; dolomitic limestone (DOLO; calcite, fossiliferous).

L.S.; dolomitized limestone (DOLO; calcite and fossiliferous). L.S.; dolomitic limestone, with interbedded dolomite, peloidaloolithic fossiliferous limestone (L.S.), with anhydrite crystals.

BOTTOM MIDALE

ANHYD & DOLO; intimately mixed.
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>4660</td>
<td>L.S.; dolos, vuggy with anhyd.</td>
</tr>
<tr>
<td>4665</td>
<td>L.S.; dolos, pebbles, oolots, vuggy, with anhyd in vugs.</td>
</tr>
<tr>
<td>4670</td>
<td>L.S.; as above, but larger oolites.</td>
</tr>
<tr>
<td>4675</td>
<td>L.S.; oolots, vuggy, with interbedded layers</td>
</tr>
<tr>
<td>4680</td>
<td>L.S.; pebbles, oolots, vuggy, some vugs filled by dolos.</td>
</tr>
<tr>
<td>4685</td>
<td>L.S.; oolots, vuggy.</td>
</tr>
<tr>
<td>Depth</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>4690</td>
<td>L.S.; vuggy, vugs filled by dolo &amp; anhyd.</td>
</tr>
<tr>
<td>4695</td>
<td>L.S.; pellt, vuggy, some vug filling by anhyd.</td>
</tr>
<tr>
<td>4700</td>
<td>L.S.; dolo, vuggy.</td>
</tr>
<tr>
<td>4705</td>
<td>L.S.; dolo, pellt, oolt.</td>
</tr>
<tr>
<td></td>
<td>L.S.; with calo dolo mottling</td>
</tr>
<tr>
<td></td>
<td>L.S.; dolo, vuggy, pellt.</td>
</tr>
</tbody>
</table>
H. MACK COX
JOHN A. SOUTHAM NO. 1

SE NW 23-161 N-84 W

ELEV.: 1651 KB

% POROSITY

CROSSED NICOLS

X31.5

LITHOLOGY

DOLO; with interbd anhyd & dol
TOP MIDALE
L.S.; with dolo mottling.

DOLO; calc.

L.S.; dolc, pellt, oolt, slightly foss, with anhyd
tails.

L.S.; dolc, with thin argill beds & fracture filling anhyd.

L.S.; dense.

L.S.; dolc, foss, pellt.
<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.S.</td>
<td>dolomitic, fossiliferous</td>
</tr>
<tr>
<td>L.S.</td>
<td>dolomitic, pellitic</td>
</tr>
<tr>
<td>DOLO</td>
<td>calcitic, fossiliferous</td>
</tr>
<tr>
<td>L.S.</td>
<td>dolomitic, dense</td>
</tr>
<tr>
<td>L.S.</td>
<td>dolomitic, pellitic</td>
</tr>
<tr>
<td>DOLO</td>
<td>calcitic</td>
</tr>
<tr>
<td>L.S.</td>
<td>dolomitic, pellitic, with anhydrite crystals</td>
</tr>
</tbody>
</table>
SW SW 20-163N-79W

% POROSITY
6 5 4 3 2 1 0 CROSSED NICOLS

ELEV.: 1497 K.B.

LITHOLOGY

3275

DOLO; vuggy, vugs filled by anhyd.

3280

L.S.; dolot, pellet, with anhyd crystals.

3285

L.S.; pellets, with anhyd crystals.
L.S.; dolot.

L.S.; dense, with anhyd.
L.S.; dolot.

L.S.; dense, with interbed anhyd and anhyd crystals.
**THE CARTER OIL CO.**
**D.E. WRIGHT NO. 1**

**NW NW 12-163N-81W**

**ELEV.: 1501 K.B.**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>3375</td>
<td>Dolostone, edy, silty, with anhyd.</td>
</tr>
<tr>
<td>3380</td>
<td>No samples</td>
</tr>
<tr>
<td>3385</td>
<td>L.S.; dense, with fracture filling anhyd.</td>
</tr>
<tr>
<td>3390</td>
<td>L.S.; as above</td>
</tr>
<tr>
<td>3395</td>
<td>Dolostone, with anhyd. crystals</td>
</tr>
</tbody>
</table>

**X31.5 Crossed Nicols**
<table>
<thead>
<tr>
<th>NW NE 12-163N-81W</th>
<th>ELEV.: 1507 K.B.</th>
</tr>
</thead>
<tbody>
<tr>
<td>% POROSITY</td>
<td>LITHOLOGY</td>
</tr>
<tr>
<td>6 5 4 3 2 1 0</td>
<td>CROSSED NICOLS</td>
</tr>
<tr>
<td>3390</td>
<td>CONGL; sdy, silty.</td>
</tr>
<tr>
<td></td>
<td>TOP MIDDLE</td>
</tr>
<tr>
<td>3395</td>
<td>DOLO; with interbd anhyd.</td>
</tr>
<tr>
<td>3400</td>
<td>DOLO; dense, with anhyd.</td>
</tr>
<tr>
<td>3405</td>
<td>DOLO; calc. vuggy, with anhyd</td>
</tr>
<tr>
<td>3410</td>
<td>DOLO; dense, with anhyd xtals</td>
</tr>
<tr>
<td>3415</td>
<td>L.S.; dolo, foss, with anhyd xtals</td>
</tr>
<tr>
<td></td>
<td>L.S.; dolo, dense.</td>
</tr>
<tr>
<td></td>
<td>L.S. &amp; DOLO; interbd.</td>
</tr>
<tr>
<td></td>
<td>L.S.; dense.</td>
</tr>
<tr>
<td></td>
<td>DOLO; calc, with anhyd xtals.</td>
</tr>
<tr>
<td></td>
<td>L.S.; with interbd dolo.</td>
</tr>
<tr>
<td></td>
<td>DOLO; argill.</td>
</tr>
<tr>
<td></td>
<td>L.S.; dolo.</td>
</tr>
<tr>
<td></td>
<td>L.S.; with anhyd xtals.</td>
</tr>
<tr>
<td>% POROSITY</td>
<td>X31.5</td>
</tr>
<tr>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>6 5 4 3 2 1 0 CROSSED NICOLS</td>
<td></td>
</tr>
<tr>
<td>3455</td>
<td>DOLO; with anhyd.</td>
</tr>
<tr>
<td>3460</td>
<td>DOLO &amp; ANHYD; intimately mixed.</td>
</tr>
<tr>
<td>3465</td>
<td>ANHYD; with interbd dolo &amp; dolo l.s.</td>
</tr>
<tr>
<td>3470</td>
<td>DOLO; with anhyd.</td>
</tr>
<tr>
<td>3475</td>
<td>L. S.; dolo, with anhyd.</td>
</tr>
<tr>
<td>NO SAMPLES</td>
<td>L.S.; interbd dolo l.s. &amp; anhyd.</td>
</tr>
<tr>
<td></td>
<td>L.S.; dolo, foss, with interb calc dolo &amp; with anhyd xtals.</td>
</tr>
<tr>
<td></td>
<td>NO SAMPLES</td>
</tr>
<tr>
<td></td>
<td>L.S.; dolo, pellt, with fracture filling anhyd.</td>
</tr>
<tr>
<td></td>
<td>L.S.; dolo, pellt, foss.</td>
</tr>
<tr>
<td></td>
<td>DOLO; foss.</td>
</tr>
<tr>
<td></td>
<td>L.S.; dolo, pellt, oolit.</td>
</tr>
<tr>
<td>Layer</td>
<td>Lithology</td>
</tr>
<tr>
<td>-------</td>
<td>-----------</td>
</tr>
<tr>
<td>3250</td>
<td>L.S.; dolomite, pellet, oolite, fossil</td>
</tr>
<tr>
<td>3255</td>
<td>L.S. &amp; anhydrite; interbed. L.S. is dolomite</td>
</tr>
<tr>
<td>3260</td>
<td>Dolomite; calcite, with interbed more calcite material</td>
</tr>
</tbody>
</table>
APPENDIX II

THIS SECTION DESCRIPTIONS
3406--
Dolomite; light brownish gray (5 YR 6/1), with intimately mixed anhydrite. The dolomite is composed mostly of very finely crystalline anhydral crystals with some finely crystalline subhedral rhombs. The anhydrite is finely crystalline and anhedral and appears to have replaced some of the dolomite.

3408--
Anhydrite; light gray (5G), anhedral, mostly very finely crystalline with some finely crystalline crystals. Argillaceous material associated with the anhydrite and concentrated in layers gives semblance of bedding.

3410--
Dolomite; yellowish gray (5 Y 8/1), with interbedded light brownish gray (5 YR 6/1), thin (1-3 mm.) argillaceous (?) beds. Iron staining is present on some bedding planes. Bedding not evident in this section. The dolomite is mostly aphanocrystalline but may be very finely crystalline and anhedral.

3411--
Dolomite; pinkish gray (5 YR 6/1), very dense, with void filling anhydrite. Dolomite is aphanocrystalline except for scattered subhedral rhombs up to 0.02 mm. The anhydrite is very finely crystalline and anhedral. Some intercrystalline argillaceous material is present in the dolomite but is absent in the anhydrite.

3414--
Limestone; yellowish gray (5 Y 6/1), dolomitic, composed of aphanocrystalline calcite, with dispersed very finely crystalline anhedral dolomite crystals. The dolomite often contains inclusions. There is some anhedral void filling anhydrite.

3416½--
Dolomite; yellowish gray (5 Y 6/1), highly calcitic, slightly vuggy. It is composed mostly of very finely crystalline anhedral dolomite crystals with intercrystalline aphanocrystalline calcite and scattered patches consisting of aphanocrystalline calcite. There is some void filling anhydrite.

3419--
Limestone; yellowish gray (5 Y 7/2), dolomitic, chalky, possibly pelletiferous, with coarsely crystalline dark yellowish brown 10 YR 2/2) subhedral anhydrite. The limestone is composed of aphanocrystalline calcite with varying amounts of very finely crystalline dolomite. The concentration of dolomite in certain areas gives a pellet-like appearance to the rock.
The anhydrite contains numerous carbonate inclusions, most of which are dolomite. These inclusions appear oriented much the same as in the surrounding carbonate indicating replacement of the limestone by the anhydrite. Occasional elongated areas of calcite appear to be recrystallized fossil fragments.

Limestones: as above, but pellets are more distinct and dolomite is medium crystalline and in greater amount.

Limestone: yellowish gray (5 Y 7/2), fragmental. The limestone fragments appear to be cemented with coarsely crystalline subhedral to subhedral anhydrite. The anhydrite is white to clear but becomes yellowish near anhydrite-limestone contact. It contains some carbonate inclusions. Dolomite replaces limestone around the fringes of the fragments and in fractures. The dolomite consists of finely crystalline to medium crystalline anhedral crystals.

Limestone: yellowish gray (5 Y 8/1), dolomitic, composed of aphanocrystalline calcite with dispersed crystals of very finely crystalline to finely crystalline dolomite.

Limestone: yellowish gray (5 Y 8/1), dolomitic interbedded with thin beds of finely crystalline dolomite. Bedding planes are iron stained. The limestone is composed of aphanocrystalline calcite with patches and crystals of anhedral dolomite ranging in size to 0.07 mm.

Limestone: yellowish gray (5 Y 8/1), dolomitic, dense, and pelletiferous. Pellets are composed of aphanocrystalline calcite and are in a matrix of very finely crystalline to medium crystalline anhedral dolomite. The pellets average 0.04 mm.

Limestone: yellowish gray (5 Y 7/2), dolomitic, and very light gray (7.5) anhydrite. Limestone composed of aphanocrystalline calcite contains dolomite in the form of very finely crystalline anhedral to subhedral crystals.
Limestone; yellowish gray (5 Y 6/1), with mottling of vuggy light olive gray (5 Y 6/1) dolomite. Some vugs in the dolomite are filled with coarsely crystalline anhydrite. The limestone is composed of aphanocrystalline calcite. Dolomite is not evident in thin section.

Limestone; as above, but without the mottling of dolomite. There are occasional distorted fossil fragments composed of fibrous calcite.

Limestone; as above.

Limestone; yellowish gray (5 Y 6/1), with two types of anhydrite. The limestone is composed of aphanocrystalline calcite and appears to have been vuggy, but the vugs have been filled with brownish gray (5 YR 4/1) coarsely crystalline subhedral anhydrite. The anhydrite replaced outward from the vug and the replaced limestone left numerous inclusions of calcite in the anhydrite. Finely crystalline very light gray (N8) anhydrite in lath-like crystals, usually subhedral, is irregularly interbedded with the limestone. Along the anhydrite-limestone contact coarsely crystalline anhydrite projects into the limestone. This anhydrite contains inclusions of the calcite.

Limestone; light olive gray (5 Y 6/1), dense with very light gray (N8) and brownish gray (5 YR 4/1) anhydrite as above. The limestone is composed of aphanocrystalline calcite with an occasional finely crystalline subhedral dolomite crystal.

Limestone; yellowish gray (5 Y 6/1), with brownish gray (5 YR 4/1) anhydrite. The limestone is composed of very finely crystalline to finely crystalline subhedral calcite. Anhydrite occurs as fracture filling and scattered crystals. The anhydrite that has filled fractures is medium crystalline and subhedral except along the anhydrite-limestone contact where the crystals are larger (to 0.02 mm.). The scattered crystals are coarsely crystalline and contain large amounts of calcite inclusions which are more numerous near the edges of the crystals. Scattered patches and crystals of carbonate are also associated with the finer anhydrite but are more intercrystalline than intracrystalline.

Dolomite; pale red (10 R 6/2), mostly subhedral and very finely crystalline. Some scattered subhedral finely crystalline crystals.

Dolomite and anhydrite; mottled grayish red (10 R 4/2) and medium light gray (N6). The two are intimately associated. Dolomite is very finely crystalline and subhedral while anhydrite is finely crystalline to medium crystalline. The anhydrite frequently occurs as elongated crystals in a parallel arrangement giving semblance of wavy bedding.
Breccia; fragments of aphanocrystalline dolomite in matrix of quartz sand and anhydrite.

Dolomite; dark yellowish brown (10 YR 4/2), slightly calcitic with very light gray (5G) anhydrite. The dolomite is very finely crystalline and anhedral. Coarsely crystalline anhydrite contains inclusions of the dolomite with most of the dolomite concentrated near the periphery of the anhedral anhydrite crystals. Finely crystalline corroded dolomite crystals are often found in the center of the anhydrite crystals.

Dolomite; as above, but pale yellowish brown (10 YR 6/2) and more dense in appearance.

Dolomite; dark yellowish brown (10 YR 4/2), with dark gray (5B) primary anhydrite. The subhedral to anhedral dolomite is very finely crystalline and porous. Many pores are filled with anhydrite which replaces outward from the pore area. In the anhydrite, except for those areas which were originally pores, there are numerous inclusions of the larger dolomite rhombs.

Dolomite; light olive gray (5 Y 6/1), slightly calcitic, dense, with light gray (5Y) primary anhydrite and dark yellowish brown (10 YR 4/2) secondary anhydrite. The dolomite is very finely crystalline and anhedral. Finely crystalline primary anhydrite in anhedral to subhedral crystals is without inclusions of dolomite while the secondary anhydrite contains numerous inclusions of the dolomite except where voids have been filled.

Limestone; pale yellowish brown (10 YR 6/2), dolomitic, pelletiferous, with coarsely crystalline secondary anhydrite. Pellets of aphanocrystalline calcite are in a matrix of very finely crystalline dolomite and aphanocrystalline calcite. Some fossil fragments have been replaced by dolomite which, in some instances, extends outward into the matrix.

Dolomite; pale yellowish brown (10 YR 6/2), slightly calcitic, with secondary anhydrite. The aphanocrystalline to very finely crystalline beds of dense dolomite are interbedded with more porous beds of the same material. Anhydrite crystals are abundant in the porous beds as a pore-filling material and replacement product.
Limestone; yellowish gray (5 Y 6/1), composed of equigranular aphanocrystalline calcite.

Limestone; pale yellowish brown (10 YR 6/2), dolomitic, pelletiferous, porous, with scattered dark yellowish brown (10 YR 4/2), secondary anhydrite crystals. The pellets are composed of aphanocrystalline calcite in a matrix of very finely crystalline porous dolomite. Very coarsely crystalline anhydrite fills pores and replaces carbonate around pore-filled area. Carbonate is included in the anhydrite except in the original pore.

Limestone; as above, with secondary anhydrite.

Limestone; yellowish gray (5 Y 7/2), dense, composed of aphanocrystalline calcite. Subhedral medium crystalline dolomite rhombs are sparsely scattered in the limestone.

Limestone; pale yellowish brown (10 YR 6/2), highly dolomitic, pelletiferous, fossiliferous, porous, with subhedral to subhedral secondary anhydrite crystals. The pellets (0.1 mm aver.) are composed of aphanocrystalline calcite in a matrix of aphanocrystalline calcite that contains finely crystalline dolomite rhombs. The dolomite is usually concentrated around the pellets except in the areas where pellets are absent, then it is in the form of scattered subhedral rhombs. Fossil fragments have been replaced by dolomite which usually has also replaced some of the surrounding matrix. Subhedral to subhedral medium crystalline anhydrite fills pores and projects into the surrounding carbonate replacing outward from the pore center.

Limestone; very pale orange (10 YR 8/2), dense with dark yellowish brown (10 YR 4/2) coarsely crystalline secondary anhydrite. The calcite of the limestone is aphanocrystalline and appears equigranular. Subhedral to subhedral anhydrite has replaced the limestone and contains inclusions of the limestone.

Limestone; pale yellowish brown (10 YR 6/2), otherwise as above, with secondary anhydrite and a few subhedral rhombs of dolomite in the limestone.

Limestone; pale yellowish brown (10 YR 6/2), highly dolomitic, pelletiferous, with coarsely crystalline dark yellowish brown (10 YR 4/2) secondary anhydrite. Pellets are composed of aphanocrystalline calcite. Dolomite composes most of the matrix surrounding the pellets. It is concentrated in a thin peripheral band around the pellets causing them to appear as pseudocollite. The dolomite is finely crystalline and anhedral.
Anhydrite fills pores and replaces outward from the pore center. Inclusions of the fine-grained limestone are rare, but corroded dolomite crystals are common in that part of the anhydrite which replaced the carbonate.

Limestone; yellowish gray (5 Y 7/2), highly dolomitic, with thin bands of coarsely crystalline dolomite and irregularly interbedded light gray (N7) primary anhydrite. Some coarsely crystalline anhydrite containing numerous carbonate inclusions, dolomite predominant, is also present. The aphanocrystalline calcite of the limestone is anhedral while the slightly larger very finely crystalline dolomite is usually subhedral. Finely crystalline primary anhydrite is without carbonate inclusions.

Dolomite and anhydrite; pale red purple (5 RP 6/2), intimately associated. Mostly irregular patches of anhedral aphanocrystalline dolomite in a matrix of fine-grained dolomite and anhydrite. Some parts composed of subhedral anhydrite containing inclusions of dolomite rhombs.

Dolomite; pale yellowish brown (10 YR 6/2), with some light gray (5Y) mottling of slightly calcitic dolomite. The dolomite is aphanocrystalline and equigranular with some interstitial argillaceous material.

Dolomite; interbedded moderate yellowish brown (10 YR 5/4) and pale yellowish brown (10 YR 6/2) beds. The moderate yellowish brown beds are composed of argillaceous (?) aphanocrystalline dolomite with some larger dolomite crystals. Beds of the pale yellowish brown color contain less argillaceous material and contain more finely crystalline dolomite rhombs.

Limestone; yellowish gray (5 Y 7/2), dolomitic, pelletiferous, with coarsely crystalline dark yellowish brown (10 YR 4/2) secondary anhydrite. Pellets, averaging 0.1 mm., are composed of aphanocrystalline calcite. The matrix around the pellets has been dolomitized to subhedral to subhedral finely crystalline dolomite. Inclusions of the carbonate are common in the anhydrite and outlines of partially replaced pellets are evident. The finer limestone appears to have been more readily replaced than the coarser crystalline dolomite.

Dolomite; grayish red (10 R 4/2), slightly calcitic, with interstitial very finely crystalline anhydrite and some patches of more coarsely crystalline anhydrite (secondary?). The aphanocrystalline dolomite and the anhydrite are anhedral.
3262--

Anhydrite, pale yellowish brown (10 YR 4/2), with a small amount of slightly dolomitic limestone. Mostly very finely crystalline anhydrite in a lath-like arrangement grading into finely crystalline anhydrite near aphanocrystalline limestone.

3263--

Dolomite, pale brown (5 YR 6/2) to pale red (5 R 6/3) with irregularly interbedded dark yellowish brown (10 YR 4/2) primary anhydrite. The dolomite is aphanocrystalline. The contact between the dolomite and very finely crystalline anhydrite is indefinite.
CONGLOMERATE; dark greenish gray (5 Y 1/1), composed of dolomite fragments, sand and silt size quartz and feldspar grains, and anhydrite all in a dolomite matrix.

Dolomite; pale yellowish brown (10 YR 6/2), with intercrystalline anhydrite. The dolomite is a mosaic of mostly finely crystalline anhedral to subhedral crystals. There appears to be considerable intercrystalline porosity except where the pores have been filled with anhydrite. The anhydrite is anhedral conforming to the shape of the pore.

Limestone; pale yellowish brown (10 YR 6/2), dolomitic, with fracture filling anhydrite. The limestone is composed of aphanocrystalline anhedral calcite with varying amounts of dolomite in the form of very finely crystalline anhedral crystals, finely crystalline subhedral to subhedral rhombs, and medium crystalline anhedral crystals. The very finely crystalline dolomite is scattered throughout with concentrations in irregular patches. The finely crystalline rhombs of dolomite have random orientation and contain many inclusions. The rhomb outlines are fuzzy and grade into the calcite. The medium crystalline dolomite usually is in gradational contact with the surrounding calcite and contains inclusions near the crystal periphery. Included near the crystal centers are opaque blobs. Fossils (ostracodes) with shells of fibrous calcite and internal fillings of crystalline dolomite are sparsely scattered throughout. Shells fragments composed of fibrous calcite are common. The medium crystalline to coarsely crystalline anhydrite contains numerous inclusions of calcite as well as dolomite rhombs and anhedral dolomite.

Limestone; yellowish gray (5 Y 7/2), composed of aphanocrystalline calcite. Coarsely crystalline pale yellowish brown (10 YR 6/2) anhedral anhydrite is present in layers and scattered crystals. Few to abundant inclusions of anhedral calcite are in the anhydrite along with subhedral to subhedral very finely crystalline dolomite (1) rhombs.

Limestone; yellowish gray (5 Y 7/2) with light gray (8/7) anhydrite. The limestone is composed of aphanocrystalline calcite. Medium crystalline anhydrite in lath-like crystals composes a large portion of the rock. Along the anhydrite-carbonate contact the anhydrite crystals are usually larger and often project into the carbonate. These larger crystals contain numerous calcite inclusions.
Limestone; light olive gray (5 Y 6/1), dolomitic, pelletiferous, with fracture filling anhydrite. Indistinct pellets (0.05 mm. aver.) composed of aphanocrystalline cloudy calcite are in a matrix of very finely crystalline to finely crystalline dolomite. The pellet outline is indistinct and grades into the dolomite. Some areas of aphanocrystalline calcite with dolomite contain fossil fragments composed of fibrous calcite and a few superficial colites with radial crystalline dolomite centers and one thin band of aphanocrystalline calcite.

Dolomite; light olive gray (5 Y 6/1), calcitic, with a mottling of highly dolomitic limestone. The dolomite is very finely crystalline and anhedral with intercrystalline anhedral finely crystalline calcite. The mottled portion has a higher percentage of calcite than dolomite.

Dolomite; light olive gray (5 Y 6/1), very finely crystalline, mostly anhedral but some subhedral rhombo. Anhydrite is present as anhedral finely crystalline to medium crystalline crystals and groups of crystals. The anhydrite contains numerous dolomite inclusions.

Dolomite; yellowish gray (5 Y 7/2), very slightly calcitic with scattered crystals of anhydrite. The dolomite is aphanocrystalline to very finely crystalline and, in places, appears pelletiferous due to the varying crystal size. The anhydrite is medium crystalline and contains numerous carbonate inclusions.

Limestone; pinkish gray (5 YR 8/1), composed of aphanocrystalline calcite with some scattered finely crystalline anhedral to subhedral anhydrite.

Limestone; yellowish gray (5 Y 7/2), dolomitic, vuggy, pelletiferous, with abundant moderate brown (5 YR 4/4) coarsely crystalline anhydrite. The pellets (0.04 mm. average) are composed of aphanocrystalline cloudy calcite. They are irregular in outline and closely packed. Between and around the pellets is very finely crystalline anhedral dolomite. Dolomite and whole pellets are included in the anhydrite.

Limestone; pinkish gray (5 YR 8/1), dolomitic and stylolitic, composed of aphanocrystalline calcite and scattered very finely crystalline to finely crystalline subhedral to subhedral dolomite. The larger dolomite crystals contain inclusions of calcite.
Limestone; yellowish gray (5 Y 7/2), dolomitic, pelletiferous, slightly fossiliferous, and stylolitic. Pellets are composed of aphanocrystalline calcite in a very finely crystalline to medium crystalline mostly anhedral dolomite matrix. The larger dolomite patches contain numerous calcite inclusions. Fossil fragments are composed of fibrous calcite. The whole fossils (ostracods) have centers of crystalline dolomite.

Limestone; yellowish gray (5 Y 7/2), dolomitic, with coarsely crystalline anhydrite. Appears to be an intimate mixture of aphanocrystalline calcite and dolomite. The bands of anhydrite contain numerous carbonate inclusions.

Limestone; yellowish gray (5 Y 7/2), slightly dolomitic, with patches of light gray (8/7) finely crystalline anhydrite and coarsely crystalline dark yellowish brown (10 YR 4/2) anhydrite. The limestone is composed of aphanocrystalline calcite with some very finely crystalline anhedral dolomite. The finer anhydrite is in lath-like crystals and almost devoid of carbonate inclusions. The larger anhydrite crystals contain numerous carbonate inclusions.
Sandstone; grayish red (10 R 4/2), with occasional fragments composed of very finely crystalline dolomite. The rounded quartz grains are cemented with dolomite.

Dolomite; light olive gray (5 Y 6/1), with light brownish gray (5 YR 6/1) patches of anhydrite. The dolomite is very finely crystalline, equigranular, and subhedral. The anhydrite in patches is mostly finely crystalline and subhedral to subhedral. Scattered crystals of anhydrite are medium crystalline and the anhydrite-carbonate contact is not definite. Carbonate inclusions are common in the anhydrite.

Dolomite; moderate yellowish brown (10 YR 5/4), calcitic, pelletiferous, with coarsely crystalline moderate yellowish brown (10 YR 5/4) anhydrite. The sparsely scattered pellets (0.75 mm. average) are composed of aphanocrystalline calcite. They are irregular in outline and bordered by a fringe of very finely crystalline dolomite. Non-pelletiferous areas are composed of aphanocrystalline to very finely crystalline dolomite. Anhydrite fills voids and replaces outward from the void. Most contacts of carbonate and anhydrite are gradational, grading from anhydrite without inclusions, to anhydrite with inclusions of very finely crystalline carbonate, to anhydrite with very finely crystalline to aphanocrystalline carbonate inclusions, and to carbonate.

Dolomite; yellowish gray (5 Y 7/2), calcitic with anhydrite, as above. The carbonate is composed of some aphanocrystalline calcite intimately mixed with aphanocrystalline to very finely crystalline dolomite and scattered patches of very finely crystalline dolomite.

Dolomite; pale yellowish brown (10 YR 6/2), calcitic, with scattered crystals of anhydrite. The dolomite is a mixture of very finely crystalline subhedral crystals and finely crystalline subhedral to subhedral rhombs. Aphanocrystalline calcite forms a lacy pattern throughout the rock. The medium crystalline anhydrite is subhedral and contains numerous inclusions of the dolomite, mostly near the crystal periphery.

Limestone; pale yellowish brown (10 YR 6/2), highly dolomitic, pelletiferous, with abundant coarsely crystalline dark yellowish brown (10 YR 4/2) anhydrite. Pellets composed of aphanocrystalline
calcite are surrounded by dolomite of varying size. The dolomite ranges from very finely crystalline subhedral crystals to finely crystalline subhedral to subhedral rhomb and subhedral crystals (to 0.02 mm.). The larger crystals often contain numerous inclusions. The very coarsely crystalline anhedral anhydrite contains abundant carbonate inclusions, from aphanocrystalline calcite to medium crystalline dolomite, as well as, pellets of calcite.

3208--
Dolomite; pale yellowish brown (10 YR 6/2), with a large amount of anhydrite in irregular patches. The dolomite is aphanocrystalline to very finely crystalline and anhedral with some finely crystalline subhedral rhombs. The patches of anhydrite are composed of finely crystalline ankerite to subhedral crystals with very "veins" of aphanocrystalline dolomite and scattered coarser crystalline dolomite rhombs. The dolomite is intercrystalline. Along the carbonate-anhydrite contact there are larger anhedral anhydrite crystals. These crystals contain numerous inclusions of the carbonate.

3209--
Dolomite; moderate yellowish brown (10 YR 5/3), extremely calcitic, porous, pelletaliferous, and slightly colitic. Pellets are composed of aphanocrystalline cloudy calcite with a fringe of very finely crystalline dolomite. The dolomitic fringe cements the pellets at the point of contact. Some pellets appear to penetrate into other pellets. The pellets vary greatly in size from 0.04 mm. to 0.5 mm. with a few up to 2 mm. and are usually elliptical in outline. Of the colites present some have very finely crystalline dolomite centers and some have centers of aphanocrystalline calcite. Both have subsequent alternating bands of calcite and dolomite. The colites with dolomite centers usually have smaller diameter centers than those colites with calcite centers. There are occasional pore filling patches of anhedral dolomite and dolomite that has replaced colites. The latter dolomite contains faint outlines of the concentric colite bands. A very small amount of void filling by anhydrite has taken place.

3211--
Limestone; light olive gray (5 Y 5/2), dolomitic, fossiliferous, with interbedded dolomite; grayish red (10 R 4/2). The limestone is composed of aphanocrystalline calcite with small patches of very finely crystalline dolomite and with finely crystalline anhedral to subhedral dolomite. The latter usually contains numerous inclusions. The fossils (ostracoda) have a shell of very finely crystalline calcite grading to an internal mosaic of finely crystalline anhedral calcite and occasionally some aphanocrystalline cloudy calcite.

3215--
Limestone; yellowish gray (5 Y 7/2), pelletaliferous, porous, colitic, slightly fossiliferous. The pellets vary greatly in size (0.04 mm. to 0.5 mm.) and shape. The larger pellets usually have
several flattened surfaces. Many pellets have fringes of very finely crystalline calcite. Some colites have centers of spherocrystalline calcite that appear to be a pellet and alternating bands of spherocrystalline calcite. These colites are usually irregular in shape. Other colites, less numerous, have crystalline calcite centers and alternating bands as the colites mentioned above. The larger pellets contain colites and fossil fragments. The fossil fragments are composed of fibrous calcite and some show layered structure. The fossils appear to be brachiopod valves. The pellet and colite matrix is mostly finely crystalline anhedral calcite that has taken the shape of the areas between the pellets.

Limestone; as above, but slightly dolomitic and containing medium crystalline anhedral anhydrite. The anhydrite fills vugs and contains inclusions except in the original vug area.
Anhydrite and calcitic dolomite; light gray (N7) and pale yellowish brown (10 YR 6/2) respectively, with anhedral to subhedral quartz. The three constituents form a pod-like outline in cross section with finely crystalline anhydrite in the center, medium crystalline anhedral quartz surrounding the anhedral to subhedral anhydrite, and aphanocrystalline calcite dolomite forming a thin shell. The quartz crystals increase in size toward the anhydrite and include subhedral dolomite rhombs.

Dolomite; mostly pale yellowish brown (10 YR 6/2) but becomes grayish red purple (5 YP 4/2) near the fracture filling light gray (N7) to pale reddish brown (10 YR 5/4) anhydrite. The dolomite contains inclusions of very finely crystalline cloudy material around the edges of the grains. The contact between the dolomite and anhydrite is not sharp. The anhydrite contains inclusions of the dolomite near the anhydrite-carbonate contact.

Limestone; yellowish gray (5 Y 7/2), with thin beds of dolomite and with fracture filling anhydrite. The aphanocrystalline calcite is mostly anhedral. The dolomite is subhedral to subhedral and finely crystalline.

Limestone; pale yellowish brown (10 YR 6/2), pelletiferous, dolomitic, with a small amount of anhydrite. The pellets are composed of aphanocrystalline calcite and average between 0.062 and 0.125 mm. in diameter. The scattered oolites have centers of crystalline dolomite, with alternating concentric bands of dolomite and calcite. Superficial oolites, with crystalline dolomite center and one thin, well defined concentric band show a black cross under crossed nicols typical of radially arranged crystals. The dolomite crystals in the matrix beyond the concentric band are in optical continuity with the dolomite inside the concentric band in the vicinity of the superficial oolite. The pellets, oolites, and superficial oolites are in a matrix of finely crystalline dolomite. Fossil fragments, present in small amounts, are composed of finely crystalline dolomite.

Limestone; dusky yellow (5 Y 6/4), as above, but contains more crystalline dolomite.

Limestone; as above, but no superficial oolites noticed.
Dolomite; yellowish gray (5 Y 7/2), with scattered patches of subhedral coarsely crystalline calcite. The dolomite is very finely crystalline. The calcite contains specks of an opaque substance and appears, in some instances, to be a structureless fossil fragment.

Dolomite; as above, but more calcitic. The calcite contains subhedral rhombs of dolomite.

Limestone; yellowish gray (5 Y 7/2), highly dolomitic, with a small amount of subhedral anhydrite. The anhydrite of the limestone contains irregular patches and subhedral crystals of dolomite. Superficial calcites with a radial crystal arrangement of dolomite in the center and a thin band of drusy material are present in small amounts. Fossil fragments composed of crystalline dolomite were found, but are rare. The dolomite in both the superficial calcites and the fossil fragments extends beyond their indistinct outline into the matrix with optical continuity.

Limestone; very light gray (N9), sublithographic in appearance, with an occasional subhedral rhomb of finely crystalline dolomite.

Limestone; as above, but yellowish gray (5 Y 7/2), fractured, vuggy, and without the dolomite crystals.

Limestone; light gray (N7) with dark yellowish brown (10 YR 4/2) anhydrite. The limestone is composed of anhydrite and anhydrite are present -- very finely crystalline anhydrite to subhedral anhydrite and coarsely crystalline subhedral to subhedral anhydrite. The finer grained is in the form of beds and irregular patches and the coarser grained occurs as scattered crystals which contain numerous inclusions of calcite.
Dolomite; yellowish gray (5 Y 7/2), very finely crystalline, silty, with patches of medium crystalline anhydrite.

Dolomite; yellowish gray (5 Y 7/2), with patches of light gray (N7) anhydrite. The anhydrite becomes pale yellowish brown at the anhydrite-carbonate contact. The dolomite is aphanocrystalline to very finely crystalline and anhedral. The light gray anhydrite is finely crystalline to medium crystalline and anhedral, while the pale yellowish gray anhydrite is coarsely crystalline.

Dolomite; moderate yellowish brown (10 YR 5/4), with abundant dark yellowish brown (10 YR 4/2) anhydrite. The dolomite is finely crystalline and mostly anhedral to subhedral. The anhydrite is composed of coarsely crystalline lath-like crystals.

Limestone; yellowish gray (5 Y 7/2), dolomitic, pelletiferous, with patches of light gray (N7) anhydrite becoming pale yellowish brown (10 YR 6/2) at the anhydrite-carbonate contact. There are also scattered crystals of the darker anhydrite. Pellets are composed of aphanocrystalline cloudy calcite in a matrix of very finely crystalline anhedral dolomite. Finely crystalline subhedral dolomite rhombs which contain numerous carbonate inclusions are scattered throughout the rock, including most of the anhydrite. The light gray anhydrite is medium crystalline and anhedral while the pale yellowish brown anhydrite is coarsely crystalline, subhedral to subhedral, and contains numerous carbonate inclusions. The inclusions seem to be mostly very finely crystalline dolomite although whole pellets are included in some anhydrite crystals.

Dolomite; dark yellowish brown (10 YR 4/2) to pale yellowish brown (10 YR 6/2) with dusky yellowish brown (10 YR 2/2) anhydrite in groups of crystals and in scattered crystals. The dolomite is finely crystalline and subhedral to subhedral with some intercrystalline finer grained carbonate. The anhydrite is mostly anhedral and medium crystalline with numerous carbonate inclusions.

Dolomite; yellowish gray (5 Y 7/2), calcitic, with light gray (N7) patches of anhydrite and pale yellowish brown (10 YR 6/2) crystals of anhydrite. The rock is composed mostly of finely crystalline subhedral to subhedral dolomite with some intercrystalline aphanocrystalline calcite. The light gray anhydrite is finely crystalline.
with few carbonate inclusions and the pale yellowish brown anhydrite is coarsely crystalline with numerous carbonate inclusions, most of which are the coarser dolomite crystals.

323,--
Dolomite; very light gray (N6), chalky, composed of aphanocrystalline to very finely crystalline anhedral dolomite.

323,--
Dolomite and anhydrite; pale red purple (5 RP 4/2), intimately mixed in places and in segregated patches. The dolomite is aphanocrystalline to very finely crystalline and the anhydrite is very finely crystalline to finely crystalline. Both are usually anhedral, except in areas where anhydrite predominates, then the dolomite is usually anhedral.
4310-11—
Dolomite; medium light gray (86), very dense with a small amount of intimately mixed anhydrite. The dolomite is aphanocrystalline to very finely crystalline and subhedral. There appears to be a small amount of argillaceous material in the intra-crystalline areas. The anhydrite occurs as isolated finely crystalline subhedral crystals or in "pods" as fibrous very finely crystalline subhedral crystals. Subhedral rhombs of very finely crystalline dolomite are associated with the pod-like anhydrite. Some inclusions of the finer grained dolomite are also found in the anhydrite.

4321-22—
Dolomite; as above.

4324-25—
Dolomite; light olive gray (5 Y 6/1), chalky, thinly bedded, composed of aphanocrystalline dolomite with some very finely crystalline subhedral dolomite crystals scattered throughout.

4326-27—
Dolomite; yellowish gray (5 Y 7/2), calcitic, chalky, with scattered patches (pellets?) of aphanocrystalline calcite. The dolomite is very finely crystalline to finely crystalline and mostly subhedral to subhedral. The intercrystalline areas of the dolomite contain aphanocrystalline calcite which appears to increase in amount toward the pellets. The larger dolomite crystals contain inclusions.

4330-31—
Dolomite; as above, but light olive gray (5 Y 6/1) and fossiliferous. Fossil fragments are composed of layers of calcite lying parallel to the shell surface. The outer layers are partially replaced by dolomite in subhedral to subhedral rhomb. Fossils appear to be fragments of brachiopods or ostracods.

4333-34—
Dolomite; as above, but yellowish gray (5 Y 8/1) and vuggy with vug filling by coarsely crystalline anhydrite. The anhydrite contains inclusions of dolomite rhombs and a slight amount of calcite near the anhydrite-carbonate contact.

4336-39—
Limestone; light olive gray (5 Y 6/1), dolomitie, pelletiferous, calcitic, and slightly fossiliferous with coarsely crystalline brownish gray (5 YR 4/1) anhydrite. The pellets are composed of cloudy aphanocrystalline calcite and average about 0.15 sm. in diameter. Most pellets are elliptical but some are spherical.
Mixed with the pellets are oolites and superficial oolites about the same diameter as the pellets. The oolites usually have a nucleus of aphanocrystalline calcite with alternating concentric bands of fibrous calcite and aphanocrystalline calcite. Superficial oolites usually have a center of radially arranged very finely crystalline dolomite (shades a black cross with nicols crossed) and one concentric band of aphanocrystalline calcite. Pellets and oolites have a fringe of very finely crystalline, mostly subhedral dolomite which becomes more coarsely crystalline away from the pellet or oolite. Small vugs between pellets and oolites contain subhedral finely crystalline to medium crystalline dolomite. Coarsely crystalline subhedral anhydrite contains inclusions of dolomite and of whole pellets. Most fossils are only fragments (brachiopod ?) of shells composed of fibrous calcite. Occasional whole or single valves of echinoids (?) are in the pellet matrix.

4342-43—

Limestone; light olive gray (5 Y 6/1), dolomitic, with thin beds (0.5 mm. aver.) of limestone containing carbonaceous (?) material. The limestone is composed of aphanocrystalline calcite with a large amount (30-40%) of dolomite in the form of subhedral rhombs and anhedral patches averaging 0.03 mm. Inclusions are abundant in the patches of dolomite. The thin beds of limestone are composed of the same aphanocrystalline calcite with carbonaceous material in the intercrystalline areas. There seems to be some finely crystalline anhedral quartz associated with the thin limestone beds.

4347-48—

Dolomite; yellowish gray (5 Y 8/1), calcitic, fossiliferous, in subhedral to euhedral rhombs that are mostly finely crystalline. The rhombs contain numerous inclusions. Intercrystalline areas contain irregular patches of calcite and dispersed calcite crystals. Brachiopod valves and bryozoas are common and composed of fibrous crystalline calcite usually containing dolomite rhombs or partially replaced by dolomite.

4352-53—

Limestone; yellowish gray (5 Y 7/2), composed of aphanocrystalline calcite. Very finely crystalline anhedral dolomite (?) crystals are scattered throughout.

4359-60—

Limestone; light olive gray (5 Y 6/1), dolomitic, pelletiferous, and fossiliferous. Pellets and irregular patches composed of aphanocrystalline cloudy calcite are in a matrix of very finely crystalline dolomite and aphanocrystalline calcite. Some very finely crystalline dolomite crystals are in patches up to 0.2 mm. A few superficial oolites with a center of radial crystalline dolomite (?) and one concentric band of cloudy aphanocrystalline calcite are scattered sparsely throughout. The fossil fragments (brachiopods) are composed of fibrous calcite.
Limestone; as above, with mottling of dolomite. The dolomite is composed of very finely crystalline to finely crystalline anhedral crystals with intercrystalline aphanocrystalline calcite. Each dolomite crystal appears to be composed of many small crystals.

Limestone; yellowish gray (5 Y 6/1), slightly dolomitic, fine grained and interbedded dolomitic pelletiferous dolitic fossiliferous limestone, and coarsely crystalline brownish gray (5 YR 4/1) anhydrite. The fine grained limestone is composed of aphanocrystalline calcite with scattered crystals of very finely crystalline to medium crystalline anhedral to subhedral dolomite. The pelletiferous limestone contains pellets composed of aphanocrystalline calcite, some ooliths with alternating bands of very finely crystalline clear calcite and aphanocrystalline cloudy calcite, and fossil fragments composed of fibrous calcite. All are in a partially dolomitized matrix composed of aphanocrystalline calcite and very finely crystalline anhedral dolomite. Some finely crystalline to medium crystalline dolomite appears to fill vugs. The anhydrite is anhedral and contains inclusions of anhedral to subhedral dolomite and aphanocrystalline calcite.

Anhydrite and dolomite; pale red purple (5 RP 6/2) to light gray (N7). The anhydrite is composed of anhedral to subhedral lath-like crystals, mostly very finely crystalline. It is intimately mixed with chalky dolomite composed of aphanocrystalline anhedral crystals.
4696-57--
Limestone; yellowish gray (5 Y 8/1), dolomitic, very vuggy, with 
vug filling by dolomite and anhydrite. The rock contains indistinct 
colites and pellets which are recognized by their peripheral fringes 
of more coarsely crystalline (0.02 mm. aver.) dolomitic material. 
The pellets are composed of aphanocrystalline to very finely 
crystalline calcite. The faint concentric structure of the colites 
is recognizable because of the concentration of very finely 
crystalline calcite in bands alternating with bands of aphanocryst-
talline calcite. The vugs filled by dolomite have a lining of finely 
crystalline euhedral to subhedral dolomite and the remainder of the 
vug has been filled by one or more crystals of medium crystalline 
euhedral to subhedral dolomite. Anhydrite as a vug filling is 
coarsely crystalline and usually one crystal fills the entire vug 
and occasionally replaces the calcite surrounding the vug. There is 
no lining of dolomite in the vugs that have been filled by anhydrite.

4698-59--
Limestone; yellowish gray (5 Y 8/1), dolomitic, pelletiferous, 
colitic, and vuggy with coarsely crystalline vug filling anhydrite. 
Some dolomite crystals have partially filled vugs. Colites with 
a center of radial crystalline dolomite (shows black cross under 
crossed nicols) have a surrounding thin band of semi-opaque material 
and outer concentric bands of radial crystalline dolomite alternating 
with bands of aphanocrystalline cloudy calcite. Superficial colites 
have only the radial center and thin band of semi-opaque material. 
The size of the colites and superficial colites averages 0.09 mm. 
Pellets composed of aphanocrystalline calcite are present in smaller 
amounts than the colites and superficial colites and are usually 
larger. The matrix is composed of aphanocrystalline cloudy calcite. 
The vug filling is much the same as above but large crystals of 
dolomite are included in the anhydrite. Anhydrite has replaced the 
calcite and partially replaced the dolomite. Colites are included 
in the anhydrite. The aphanocrystalline calcite bands of the colites 
have been replaced by the anhydrite leaving the very finely 
crystalline dolomite as inclusions.

4662-63--
Limestone; as above, but with larger colites present in small 
amounts. The large colites (0.1 mm. aver.) are elongated with an 
irregular concentric structure caused by alternating bands of very 
finely crystalline and aphanocrystalline calcite.
Limestone; yellowish gray (5 Y 8/1), colitic, vuggy, slightly pelletiferous with interbedded limestone composed of aphanocrystalline anhedral calcite. The colites are large (up to 1.5 mm.) and many have been fragmented. They consist of very finely crystalline radiating crystals of calcite that project through concentric bands of aphanocrystalline calcite. Many colites have a nucleus of an olite fragment. Some colites appear to have been abraded on one or more surfaces causing truncation of the outer concentric bands. There is some vug filling by medium crystalline anhedral dolomite. The pellets are composed of aphanocrystalline calcite. They are sparsely dispersed in the aphanocrystalline calcite matrix.

Limestone; as above, but colites are less distinct and the concentric bands of the colites are irregular. The pellets are poorly sorted.

Limestone; light gray (8/7), very vuggy, colitic, pelletiferous. The colites are smaller than above (average 0.5 mm.). They have between five and ten concentric bands of radial, very finely crystalline calcite alternating with aphanocrystalline cloudy calcite. The indistinct pellets are composed of cloudy aphanocrystalline calcite and most are smaller than the colites. The matrix is very finely crystalline anhedral calcite. Some of the numerous vugs have been filled by medium crystalline anhedral dolomite.

Limestone; light gray (8/7), very vuggy, colitic. The colites average 1 mm. in diameter but may be up to 1.5 mm. in diameter. They are composed of alternating bands of elongated very finely crystalline calcite and equidimensional very finely crystalline to aphanocrystalline calcite. The elongated crystals often project through the layers of equidimensional crystals. This gives an overall effect of radially arranged crystals. The nuclei of the colites is often a fragment of a preexisting colite. There are usually more concentric bands on three sides than on the fourth. The matrix is at a minimum, usually only present at the contacts between pellets. It consists of aphanocrystalline calcite.

Limestone; as above, but yellowish gray (5 Y 7/2) with some vug filling by coarsely crystalline anhedral anhydrite.

Limestone; as above.

Limestone; yellowish gray (5 Y 7/2), vuggy. Composed mostly of aphanocrystalline with some very finely crystalline calcite. There is vug filling by coarsely crystalline anhydrite and dolomite.
Limestone; yellowish gray (5 Y 7/2), pelletiferous, vuggy. The large pellets (to 0.01 mm.) of aphanocrystalline cloudy calcite and indistinct colites are in a matrix of sparry calcite. The calcite is oriented perpendicular to the pellet and colite surface giving a fibrous effect. The vugs are lined with this sparry calcite. Some vugs have been filled with medium crystalline anhydral anhydrite.

Limestone; yellowish gray (5 Y 8/1), dolomitic, vuggy. The limestone is composed of aphanocrystalline to very finely crystalline calcite. A few indistinct pellets (0.07 mm. aver.) are present. Almost all vugs have been filled with medium crystalline anhydral dolomite. The dolomite contains inclusions near the edges of the crystals.

Limestone; yellowish gray (5 Y 8/1), dolomitic, vuggy, pelletiferous, colitic. Pellets composed of aphanocrystalline cloudy calcite (average 0.01 mm.) and colites of radial aphanocrystalline calcite with concentric bands of cloudy material (1 mm. aver.) are in a matrix of aphanocrystalline calcite. The colites are very irregular and some are fragments of colites. Nucleus of colites are often fragments of pre-existing colites. Vugs are filled with coarsely crystalline anhydrite and dolomite. There is usually replacement of calcite around the perimeter of the vugs by the anhydrite and dolomite. Inclusions of the calcite in the anhydrite near the anhydrite-carbonate contact are numerous.

Limestone; yellowish gray (5 Y 8/1), dolomitic, pelletiferous, colitic, with stylocolites. The pellets are composed of aphanocrystalline cloudy calcite and are irregular in outline. Colites usually have a center of radial calcite which shows a black cross under crossed nicols. The concentric band immediately surrounding the center is usually composed of semi-opaque material. Succeding concentric bands are usually composed of aphanocrystalline calcite alternating with aphanocrystalline calcite containing cloudy material. Colites range in size from 0.09 mm. to 0.2 mm. The matrix is composed of finely crystalline calcite with some medium crystalline anhydral dolomite.

Limestone and dolomite; light gray (N8) dolomitic limestone mottled with yellowish gray (5 Y 8/1) calcitic dolomite. The limestone is pelletiferous and vuggy. Pellets are composed of aphanocrystalline cloudy calcite in a matrix of very finely crystalline dolomite. In places the limestone is almost entirely replaced by dolomite except for a lacy network of the aphanocrystalline calcite. Vugs are filled with coarsely crystalline anhydral dolomite. Fossils (ostracod valves) with a fibrous calcite shell and center of medium crystalline anhydral dolomite are common in the dolomite.
Limestone; yellowish gray (5 Y 6/1), highly dolomitic, vuggy, and pelletiferous. The irregular pellets vary greatly in size and are composed of aphanocrystalline calcite. They are in a matrix of very finely crystalline anhedral dolomite with some aphanocrystalline calcite. Finely crystalline to medium crystalline anhedral dolomite fills vugs.

Limestone; as above.
4461--

Dolomite; light gray (W7), slightly calcitic, with interbedded greenish gray (5 Y 6/1) intimately mixed anhydrite and dolomite. The dolomite is aphanocrystalline to very finely crystalline and subhedral to subhedral. The very finely crystalline anhydrite is also subhedral to subhedral and groups of the anhydrite crystals are in optical continuity appearing as one coarsely crystalline crystal with included dolomite rhombs.

4464--

Limestone; yellowish gray (5 Y 7/2), with an irregular network of argillaceous or ferruginous dolomite. The calcite of the limestone is aphanocrystalline and mostly subhedral. Finely crystalline to medium crystalline dolomite occurs in irregular patches up to 0.1 mm. which are often in optical continuity.

4470--

Limestone; yellowish gray (5 Y 6/1), dolomitic, pelletiferous, calcitic, with a few fossil fragments. Anhedral to subhedral coarse crystalline anhydrite containing carbonate inclusions is present in small amounts. The pellets and celestites are indistinct and most pellets are recognized only because the surrounding cement is composed of dolomite with a larger crystal size. The fossil fragments have been completely replaced by dolomite.

4473--

Limestone; as above. The celestites have crystalline dolomite centers and alternating concentric bands of aphanocrystalline calcite and finely crystalline dolomite. Some superficial celestites were recognized with dolomite centers and one concentric band of calcite.

4476--

Dolomite; light olive gray (5 Y 6/1) to medium gray (5/5), calcitic, with a larger amount of aphanocrystalline calcite in the light olive gray. The dolomite is very finely crystalline to coarsely crystalline occurring as subhedral to subhedral rhombs. The rhombs often contain inclusions.

4479--

Dolomite; light olive gray (5 Y 6/1), calcitic. The dolomite is anhedral to subhedral and very finely crystalline to finely crystalline. The larger crystals contain inclusions. Aphanocrystalline calcite occupies intercrystalline areas in the dolomite. Fossil fragments composed of fibrous calcite and quartz with a coarsely crystalline anhedral dolomite center are present in small amounts. An occasional crystal of anhydrite is associated with the dolomite in the fossil center. The long axes of the calcite and quartz
crystals are arranged parallel to the shell surface while the dolomite is arranged perpendicularly along the inside border of the shell. The fossils appear to be brachiopods.

4402—
Dolomite; light olive gray (5 Y 6/1), calcitic, with thin (1-3 mm) beds of irregularly interbedded more coarsely crystalline dolomite. The finer grained dolomite is mostly anhedral but contains subhedral to subhedral dolomite rhombs and patches of anhedral dolomite. The dolomite in the beds is mostly subhedral to subhedral and finely crystalline but the crystal size varies considerably.

4405—
Limestone; light olive gray (5 Y 6/1), highly dolomitic, with thin beds (1 mm.) of black argillaceous material. Dolomite is in the form of coarsely crystalline clusters in optical continuity and subhedral finely crystalline rhombs. The limestone is composed of aphanocrystalline calcite. Fossil fragments are present in small amounts. They are composed of fibrous calcite with the long axes of the crystals parallel to the shell surface. Other fossil fragments are composed of fibrous calcite and quartz that has replaced the calcite. The fossils are probably brachiopods. The quartz is composed of anhedral crystals oriented approximately the same as the calcite but with a smaller crystal size than the calcite. Veinlets of coarsely crystalline anhydrite fill fractures in the limestone.

4406—
Limestone; yellowish gray (5 Y 8/1), dense, composed of aphanocrystalline calcite. There are scattered finely crystalline rhombs of subhedral to subhedral dolomite.

4409—
Limestone; as above.

4411—
Limestone; very light gray (10B) to medium light gray (10B), dolomitic, and slightly fossiliferous. The limestone is composed of dense aphanocrystalline calcite and is, in places, pelletiferous and porous. Where it is pelletiferous, the pellets are poorly sorted, irregular in shape, and the space between the pellets is filled with coarsely crystalline anhedral dolomite. The dolomite contains numerous inclusions. The fossil fragments are composed of fibrous calcite with the long axes arranged perpendicular to the surface of the shell in most cases. The fossils are badly distorted but appear to be brachiopods with some gastropods. Extremely coarsely crystalline white anhydrite grading to a dark brown medium crystalline anhydrite is an important constituent in some parts of the rock. The white anhydrite appears to be a cavity filling with the dark brown anhydrite a replacement product of the calcite and dolomite at the edges of the cavity.
Limestone; medium light gray (N6), highly dolomitic, very slightly fossiliferous. The limestone is composed of aphanocrystalline anhedral calcite with very finely crystalline anhedral to subhedral dolomite crystals. The fossil fragments which are probably brachiopods are composed of dolomite.

Limestone; as above.

Limestone; yellowish gray (5 Y 8/1), slightly dolomitic, pelliferous. The pellets are composed of aphanocrystalline calcite in a matrix of aphanocrystalline calcite and very finely crystalline mostly anhedral dolomite. Coarsely crystalline dolomite which appears to be a group of smaller crystals in optical continuity is also present in the matrix. These large crystals contain inclusions. Olivites, with three or four concentric bands composed of a crystalline center and alternating layers of radially arranged dolomite, are present in small amounts. A few fossil fragments (brachiopods) composed of fibrous calcite with centers of crystalline dolomite were found.

Dolomite; light gray (N7), calcitic, slightly fossiliferous, composed mostly of dolomite in the form of very finely crystalline to finely crystalline subhedral to subhedral rhombo, and anhedral coarsely crystalline patches. There is some aphanocrystalline calcite in the intercrystalline areas and as inclusions in the rhombo and patches. Fossils (brachiopods) are composed of fibrous calcite and quarts.

Dolomite; medium gray (N3), dense. Composed of anhedral to subhedral very finely crystalline dolomite with intercrystalline argillaceous material.

Limestone; yellowish gray (5 Y 8/1), dolomitic, pelletiferous. The pellets are composed of aphanocrystalline calcite. Aphanocrystalline calcite and very finely crystalline to finely crystalline anhedral dolomite surround the pellets. Some more coarsely crystalline anhedral dolomite is between the pellets. Some fragments of fossils composed of fibrous calcite are associated with the pellets.

Limestone; yellowish gray (5 Y 8/1), slightly dolomitic, composed of aphanocrystalline calcite, and some very finely crystalline anhedral dolomite.
Dolomite; light olive gray (5 Y 6/1), calcitic, very finely crystalline to medium crystalline, mostly subhedral to subhedral. Aphanocrystalline calcite is in clusters and dispersed in the intercrystalline areas between the dolomite. Some inclusions were found in the larger dolomite rhombs.

Limestone; light olive gray (5 Y 6/1), dolomitic, pelletiferous, with coarsely crystalline dusky yellowish brown (10 YR 2/2) anhydrite. The pellets are groups composed of aphanocrystalline calcite in a matrix of aphanocrystalline calcite and very finely crystalline subhedral dolomite. The pellet-cement contact is gradational causing an indistinct pellet outline. The anhydrite contains inclusions of the dolomite and calcite with the dolomite being more numerous.
Dolomite; yellowish gray (5 Y 7/2), vuggy, with vugs filled by anhydrite. The dolomite is sparsely crystalline to very finely crystalline and mostly anhedral. The medium crystalline anhydrite conforms to the vug outline and is usually devoid of inclusions.

Dolomite; as above.

Limestone; pale yellowish brown (10 YR 6/2), dolomitic, pelletiferous, with scattered crystals of dark yellowish brown (10 YR 4/2) anhydrite. The indistinct pellets are composed of sphenocrystalline calcite and are recognized only by their finer grained texture in a matrix of very finely crystalline anhedral dolomite. Pellets are not everywhere present. Where not present the rock is composed of sphenocrystalline calcite and very finely crystalline dolomite, both anhedral. There are sparsely scattered anhedral crystals of calcite (0.05 mm. average) that usually contain numerous inclusions. The coarsely crystalline subhedral to euhedral anhydrite usually contains carbonate inclusions.

Limestone; with anhydrite, as above, but yellowish gray (5 Y 7/2).

Limestone; pale yellowish brown (10 YR 6/2), pelletiferous, composed of sphenocrystalline calcite mottled with slightly darker porous dolomitic limestone. The latter contains abundant dark yellowish brown (10 YR 4/2) coarsely crystalline anhydrite. The closely packed pellets are irregular in size and shape and are composed of dense sphenocrystalline calcite in a matrix of very finely crystalline dolomite. The anhydrite probably began as a vug filling and replaced outward. Some areas in the anhydrite are almost devoid of inclusions while other areas contain numerous inclusions.

Limestone; yellowish gray (5 Y 8/1), slightly dolomitic, composed of sphenocrystalline calcite and some dolomite that is very finely crystalline to finely crystalline and subhedral to euhedral. The larger dolomite crystals contain inclusions.

Limestone; as above.
Limestone; yellowish gray (5 Y 7/2), dense with very light gray (N8) finely crystalline anhydrite that becomes brownish along the anhydrite-carbonate contact. The limestone is composed of aphanocrystalline cloudy calcite with an occasional finely crystalline dolomite rhomb. The very light gray anhydrite has some areas of lath-like crystals in a parallel arrangement and other areas of equidimensional crystals. The crystal size increases close to the anhydrite-carbonate contact and scattered crystals project into the limestone. The coarser crystals contain numerous carbonate inclusions while the finer grained anhydrite was devoid of inclusions. There are also scattered crystals of medium crystalline anhydrite.

Limestone; yellowish gray (5 Y 7/2), highly dolomitic, composed of aphanocrystalline calcite and dolomite with an occasional finely crystalline dolomite rhomb that contains many inclusions.

Limestone; yellowish gray (5 Y 7/2), dense with patches of light gray (N7) finely crystalline anhydrite. Some coarser crystalline brownish anhydrite near the anhydrite-carbonate contact contains numerous carbonate inclusions. The limestone is composed of aphanocrystalline to very finely crystalline calcite.

Limestone; as above.
Dolomite; grayish red (10 R 4/2), sandy, silty, with patches of finely crystalline anhydrite. Rounded sand grains composed of feldspar and quartz and subangular silt size quartz grains are in a matrix of very finely crystalline dolomite.

Dolomite; yellowish gray (5 Y 7/8), vuggy in certain beds with vugs filled by anhydrite. The dolomite is aphanocrystalline to very finely crystalline and anhedral. The vug filling anhydrite is mostly finely crystalline and anhedral.

Dolomite; as above.

Dolomite; as above, but chalky and not as vuggy.

Dolomite; as above.

Limestone; yellowish gray (5 Y 6/1), dense, with moderate yellowish brown (10 YR 5/4) fracture filling anhydrite. The limestone is composed of aphanocrystalline calcite with an occasional subhedral dolomite rhomb.

Limestone; as above, with coarsely crystalline, brownish gray (5 YR 4/1) subhedral anhydrite in scattered crystals and layers parallel to bedding. There are numerous carbonate inclusions in the anhydrite.

Limestone; with anhydrite, as above.

Limestone; with anhydrite, as above.

Limestone; with anhydrite, as above.

Limestone; with anhydrite, as above.

Limestone; with anhydrite, as above.

Dolomite; pale red (10 R 6/2), composed mostly of aphanocrystalline anhedral crystals and some very finely crystalline subhedral to
cubedral rhombs. There are scattered finely crystalline
anhydrous anhydrite crystals which are probably vug fillings.
Conglomerate; brownish gray (5 YR 4/1). Fragments of medium crystalline anhydrite in a matrix of sandy, silty, carbonate.

Dolomite; light olive gray (5 Y 6/1), with scattered patches of finely crystalline anhydrite. The dolomite is aphanocrystalline to very finely crystalline and mostly anhedral. The anhydrite appears to be a vug filling as carbonate inclusions are rare.

Dolomite; pale yellowish brown (10 YR 6/2), dense, with scattered finely crystalline to medium crystalline anhydrite. The dolomite is aphanocrystalline to very finely crystalline and anhedral. Clusters of finer grained dolomite give a pelletal appearance to the rock. Crystals of the larger dolomite are included in the anhydrite in some places. Some anhydrite is composed of finely crystalline, mostly anhedral crystals. This type is usually devoid of inclusions.

Dolomite; pale yellowish brown (10 YR 6/2), calcitic, slightly vuggy with dark yellowish brown (10 YR 4/2) anhydrite. Dolomite is very finely crystalline and anhedral with scattered patches of aphanocrystalline calcite. Occasional finely crystalline anhedral dolomite rhombs are scattered in the dolomite. There are numerous patches composed of anhedral finely crystalline dolomite crystals. The anhydrite is mostly medium crystalline and subhedral.

Dolomite; yellowish gray (5 Y 7/2), dense with large amounts of disseminated anhydrite clusters and single crystals. The dolomite is anhedral to subhedral and mostly very finely crystalline. The anhydrite clusters are composed of medium crystalline, usually anhedral crystals. The crystals contain very few inclusions of dolomite and appear as vug fillings in possibly noncontemporaneous deposits.

Limestone; pale yellowish brown (10 YR 6/2), highly dolomitic, fossiliferous, with a small amount of medium crystalline dark yellowish brown (10 YR 4/2) anhydrite. The limestone is composed of aphanocrystalline calcite. It appears in segregated patches due to the arrangement of very finely crystalline anhedral dolomite crystals. Anhedral crystals of finely crystalline to medium crystalline dolomite containing numerous inclusions are scattered
throughout the rock. Their contact with the surrounding rock is usually irregular. Fossil fragments composed of fibrous calcite and whole fossils of calcite are situated with the long direction of the shell parallel to the bedding. The fragments appear to be brachiopod valves while the whole fossils may be Foraminifera.

Limestone; yellowish gray (5 Y 7/2), slightly dolomitic, dense, composed of spherocrystalline calcite and scattered crystals of anhedral to subhedral very finely crystalline dolomite.

Limestone; as above.

Limestone and dolomite; interbedded, yellowish gray (5 Y 7/2) and olive gray (5 Y 4/1) respectively. The limestone is composed of spherocrystalline calcite with anhedral to subhedral finely crystalline dolomite. The dolomite is composed of very finely crystalline, mostly anhedral to subhedral finely crystalline dolomite with some spherocrystalline calcite and anhedral finely crystalline quartz crystals. The beds of limestone are usually several centimeters thick while those of dolomite are several millimeters thick.

Limestone; yellowish gray (5 Y 8/1), dense, stylolitic. The limestone is composed of spherocrystalline calcite and contains some crystals of anhedral finely crystalline dolomite.

Limestone; as above.

Dolomite; yellowish gray (5 Y 8/1), calcitic, with some medium crystalline anhydrite. The dolomite is spherocrystalline to very finely crystalline with the smaller crystals usually anhedral and the larger crystals subhedral to subhedral. Patches of medium crystalline anhedral calcite are scattered throughout as well as some finer grained calcite. Concentrations of calcite in parallel layers gives a semblance of bedding.

Limestone; yellowish gray (5 Y 8/1) with interbedded olive gray (5 Y 4/1) argillaceous dolomite. The limestone is mostly spherocrystalline calcite and contains finely crystalline to medium crystalline anhedral dolomite. The dolomite crystals contain calcite inclusions. The interbedded dolomite is composed of very finely crystalline mostly anhedral dolomite.

Limestone; yellowish gray (5 Y 7/2), slightly vuggy, composed of spherocrystalline to very finely crystalline anhedral calcite.
There are a few scattered medium crystalline calcite crystals.

3.13--
Dolomite; greenish gray (7 G 6/1), argillaceous, composed mostly of very finely crystalline subhedral dolomite. Intercrystalline areas contain aphanocrystalline dolomite and argillaceous material. There are scattered crystals of finely crystalline subhedral dolomite.

3.15--
Limestone; yellowish gray (5 Y 7/2), dolomitic, composed of aphanocrystalline subhedral calcite and some very finely crystalline to finely crystalline subhedral to subhedral dolomite. There are also medium crystalline subhedral calcite crystals scattered throughout the limestone.

3.16--
Limestone; yellowish gray (5 Y 7/2), with a few scattered crystals of finely crystalline anhydrite. The limestone is composed of aphanocrystalline calcite with scattered patches of finely crystalline to medium crystalline subhedral calcite. Fossil fragments (brachiopods) of fibrous calcite are scattered throughout.
3451--
Dolomite; very light gray (N8), with light brownish gray (5 YR 6/1) anhydrite. Dolomite appears as fragments in an anhydrite matrix. The dolomite is composed of aphanocrystalline to very finely crystalline subhedral crystals with some subhedral rhombohedral crystals. Associated with the dolomite are crystals and patches of finely crystalline subhedral to subhedral anhydrite. The patches have no definite boundaries but grade into the dolomite. Dolomite in the form of subhedral to subhedral rhombohedral is abundant in the anhydrite. Coarsely crystalline anhedral quartz clusters are scattered in the anhydrite. The quartz contains inclusions of both dolomite and anhydrite.

3452--
Dolomite and anhydrite; pale yellowish brown (10 YR 6/2), intimately mixed with deep reddish brown (iron stained) patches throughout. The dolomite-anhydrite ratio varies. Where dolomite is prominent it is mostly in pellet-like clusters of aphanocrystalline crystals with some very finely crystalline subhedral to subhedral rhombohedral crystals. The anhydrite is usually finely crystalline to medium crystalline and subhedral in these areas with inclusions of the dolomite. In areas where anhydrite predominates, the clusters of dolomite are few but the rhombohedral persist in the intercrystalline areas of the finely crystalline to medium crystalline anhydrite.

3454--
Anhydrite; medium light gray (N6), very dense, with interbedded thin layers of dolomitic limestone and dolomite. There are also some layers of dolomite with crystals of coarsely crystalline anhydrite. The medium light gray anhydrite is finely crystalline to medium crystalline and usually anhedral. It contains many inclusions of subhedral dolomite rhombohedral. The thin wavy layers of carbonate grade from anhydrite with dolomite inclusions to very finely crystalline dolomite, usually anhedral, and to dolomitic limestone composed of aphanocrystalline calcite. The limestone often contains finely crystalline anhedral anhydrite crystals that have dolomite crystals included.

3456--
Dolomite; yellowish gray (5 Y 7/2), pelletiferous (?), with patches of anhydrite. The indistinct pellets are composed of aphanocrystalline-dolomite. Matrix is rare and most areas between pellets are composed of finely crystalline anhedral anhydrite. As the anhydrite contains very few dolomite inclusions, it appears to be a vug filling or contemporaneous deposit.
Limestone; yellowish gray (5 Y 7/2), dolomitic, with olive gray (5 Y 3/2), anhydrite. The limestone appears pelletiferous but may be mottled due to the selective replacement by dolomite. The pellet-like material is composed of aphanocrystalline calcite with surrounding very finely crystalline dolomite and aphanocrystalline calcite. Finely crystalline to medium anhedral dolomite appears to have filled vugs between pellets. Calcites, with centers of radial crystalline dolomite and alternating concentric bands of aphanocrystalline cloudy calcite and clear very finely crystalline dolomite, are scattered throughout. Some superficial colites with the radial crystalline dolomite center and only one band of calcite are present in small amounts. The pellets, colites, and superficial colites average about 0.04 mm. in diameter. Coarsely crystalline anhydrite contains many carbonate inclusions most of which are dolomites. The dolomite inclusions have the same pattern in the anhydrite as in the limestone.

Limestone; yellowish gray (5 Y 8/1) with light gray (8.7) anhydrite and interbedded dolomitic limestone, as above. The limestone is composed of aphanocrystalline cloudy calcite with irregularly interbedded finely crystalline anhedral anhydrite.

Limestone; yellowish gray (5 Y 8/1), dolomitic, fossiliferous, and somewhat pelletiferous, with interbedded calcitic dolomite. The limestone contains coarsely crystalline moderate brown (5 YR 4/4) anhydrite crystals. The indistinct pellets and part of the matrix is composed of aphanocrystalline calcite. Very finely crystalline with some finely crystalline dolomite makes up part of the matrix. The pellets are irregular and indistinct in most areas but may be sharply defined. Fossils are composed of fibrous calcite with long axes of the crystals perpendicular to the shell surface. The shell center is filled with interlocking crystals of finely crystalline anhedral dolomite. The fossils appear to be bechiopsids or ostracods. Coarsely crystalline anhydrite contains numerous inclusions of carbonate, most of which are the coarser dolomite crystals. Near the centers of some anhydrite crystals, inclusions are absent indicating replacement began by vug filling.

Limestone; very pale orange (10 YR 8/2), dolomitic, pelletiferous, fractured, with moderate brown (5 YR 4/4) anhydrite filling fractures. Irregular pellets of aphanocrystalline cloudy calcite are in a matrix of very finely crystalline anhedral dolomite and some aphanocrystalline calcite. Fossils (brachiopods) are composed of fibrous calcite. Some colites are present. They have a radially arranged center of clear crystalline dolomite and alternating concentric bands of the dolomite and aphanocrystalline cloudy calcite. The anhydrite contains numerous inclusions of carbonate except for thin lines traceable from one crystal to the next. These thin lines, without inclusions, are probably a fracture which was filled before replacement.
Limestone; pinkish gray (5 YR 6/1), dolomitic, pelletiferous, and fossiliferous. The pellets are composed of sphenocrystalline cloudy calcite. They are usually irregular and indistinct in outline and vary in size (0.01 mm. average). The pellet matrix is composed of very finely crystalline anhedral dolomite and sphenocrystalline calcite. Medium crystalline anhedral dolomite with numerous calcite inclusions and other cloudy inclusions are scattered throughout the rock. Fossil fragments of very finely crystalline calcite and whole fossils (ostracods) are also sparingly scattered throughout. The whole fossils usually have a center filling of finely crystalline anhedral dolomite.

Dolomite; yellowish gray (5 Y 7/2), slightly fossiliferous, composed of sphenocrystalline dolomite. Fossil fragments are not common. When present they are composed of fibrous calcite with the long axes of the calcite crystals usually parallel to the shell surface.

Limestone; yellowish gray (5 Y 8/1), dolomitic, pelletiferous, oolitic, and vuggy, with some medium crystalline anhydrite. The pellets, composed of sphenocrystalline calcite, are irregular in shape and size (0.05-0.1 mm. average). The oolites have a radial crystalline center which appears to be very finely crystalline anhedral dolomite with alternating concentric bands of cloudy sphenocrystalline calcite and very finely crystalline dolomite. The superficial oolites have the radial crystalline center but only one concentric band. Fossil fragments of fibrous calcite are sparsely scattered. The matrix of the pellets and oolites is mostly very finely crystalline anhedral dolomite. Some patches of finely crystalline anhedral dolomite appear to fill vugs. Anhydrite fills vugs and fractures and replaces outward. The anhydrite contains numerous carbonate inclusions except in the original vug or fracture area. Fractures may be traced from one anhydrite crystal to another by the absence of inclusions.
3246--
Limestone; yellowish gray (5 Y 7/2), highly dolomitic, pelletaliferous, slightly colitic, and fossiliferous. The pellets (0.04 mm. aver.) are indistinct in outline and are composed of aphanocrystalline cloudy calcite. Colites usually have a center of radia crystalline dolomite and one or more alternating bands of aphanocrystalline calcite and very finely crystalline dolomite. Fossil fragments are composed of fibrous calcite. The matrix is very finely crystalline anhedral dolomite.

3248--
Limestone; yellowish gray (5 Y 7/2), highly dolomitic, composed of aphanocrystalline cloudy calcite containing abundant finely crystalline subhedral dolomite rhombs. The rhombs contain numerous calcite inclusions.

3250--
Limestone; yellowish gray (5 Y 7/2), dolomitic, with thin beds of light gray (8/7) anhydrite. The limestone is composed mostly of aphanocrystalline cloudy calcite with some very finely crystalline anhedral dolomite and sparsely scattered finely crystalline subhedral dolomite rhombs. The rhombs contain numerous carbonate inclusions. The anhydrite is medium crystalline and usually anhedral. Along the anhydrite-carbonate contact the anhydrite becomes coarsely crystalline and darker in color. The coarser anhydrite contains numerous carbonate inclusions which consist of dolomite rhombs, very finely crystalline dolomite, and some aphanocrystalline calcite. The finer grained anhydrite contains very few inclusions.

3252--
Anhydrite; very light gray (R8), with some irregularly interbedded pale yellowish brown (10 YR 6/2) dolomitic limestone. The finely crystalline anhydrite is partially subhedral to subhedral in lath-like crystals and partially anhedral. The lath-like crystals appear to flow around the limestone. The limestone is composed of aphanocrystalline calcite and finely crystalline dolomitic crystals, as above. In the limestone are medium crystalline subhedral anhydrite crystals which contain numerous carbonate inclusions.

3254--
Limestone, yellowish gray (5 Y 7/2), otherwise as above, with patches of finely crystalline anhydrite and scattered coarsely crystalline anhydrite, as above.

3255--
Limestone; with anhydrite, as above.
3258--
Limestone; with anhydrite, as above.

3260--
Dolomite; yellowish gray (5 Y 7/2), calcitic, with thinly interbedded layers of more calcitic material. The dolomite is very finely crystalline and anhedral with intercrystalline aphanocrystalline calcite.

3263--
Anhydrite; medium light gray (5G), dense, with motting of grayish red purple (5 RP 4/2) dolomite. The anhydrite is very finely crystalline and anhedral and contains a lacy network of aphanocrystalline iron-stained dolomite.