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Stratigraphy and sedimentation of shallow marine carbonates and sandstones Amsden formation (Pennsylvanian) Tendoy Mountains Montana

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STRATIGRAPHY AND SEDIMENTATION OF SHALLOW MARINE CARBONATES AND SANDSTONES, AMSDEN FORMATION (PENNSYLVANIAN), TENDOY MOUNTAINS, MONTANA

By

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Chapter 1

INTRODUCTION

The Amsden Formation in the Tendoy Mountains represents a significant phase of marginal marine carbonate sedimentation that was gradually inundated by quartz sands of the Quadrant Formation. The area presents a useful working model for the gradual encroachment of sand into a carbonate environment. The primary objective of this study is to analyze the lithology and stratigraphy of the upper part of the Amsden Formation and interpret the environments of deposition.

During the course of the study, the Amsden Formation was divided into lower, middle, and upper members; fifteen sections were measured across the middle and upper members, and two reference sections were taken of the entire exposed lower member.

Thirteen rock types and nine associated subtypes have been identified, and represent all of the exposed rocks studied by the author in the Tendoy Mountains. These rocks represent environments ranging from shallow open marine to supratidal, and include marine lagoons, channel carbonates, channel sandstones, and blanket sand tongues. Fluctuating sea level, possibly modified by topographic elements, caused these environments to shift laterally, and consequently change vertically. The general trend is one of southward progradation of sands across carbonate sediments.

The following discussion outlines a brief history of nomenclature of the Amsden Formation in the Tendoy Mountains, descriptive and interpretive aspects of the rock types, and the depositional history of these rocks, as interpreted from the stratigraphic relationships of the various rock types.

The reader is referred to the Appendix for field and laboratory procedures and section locations.

Chapter 2

AMSDEN FORMATION

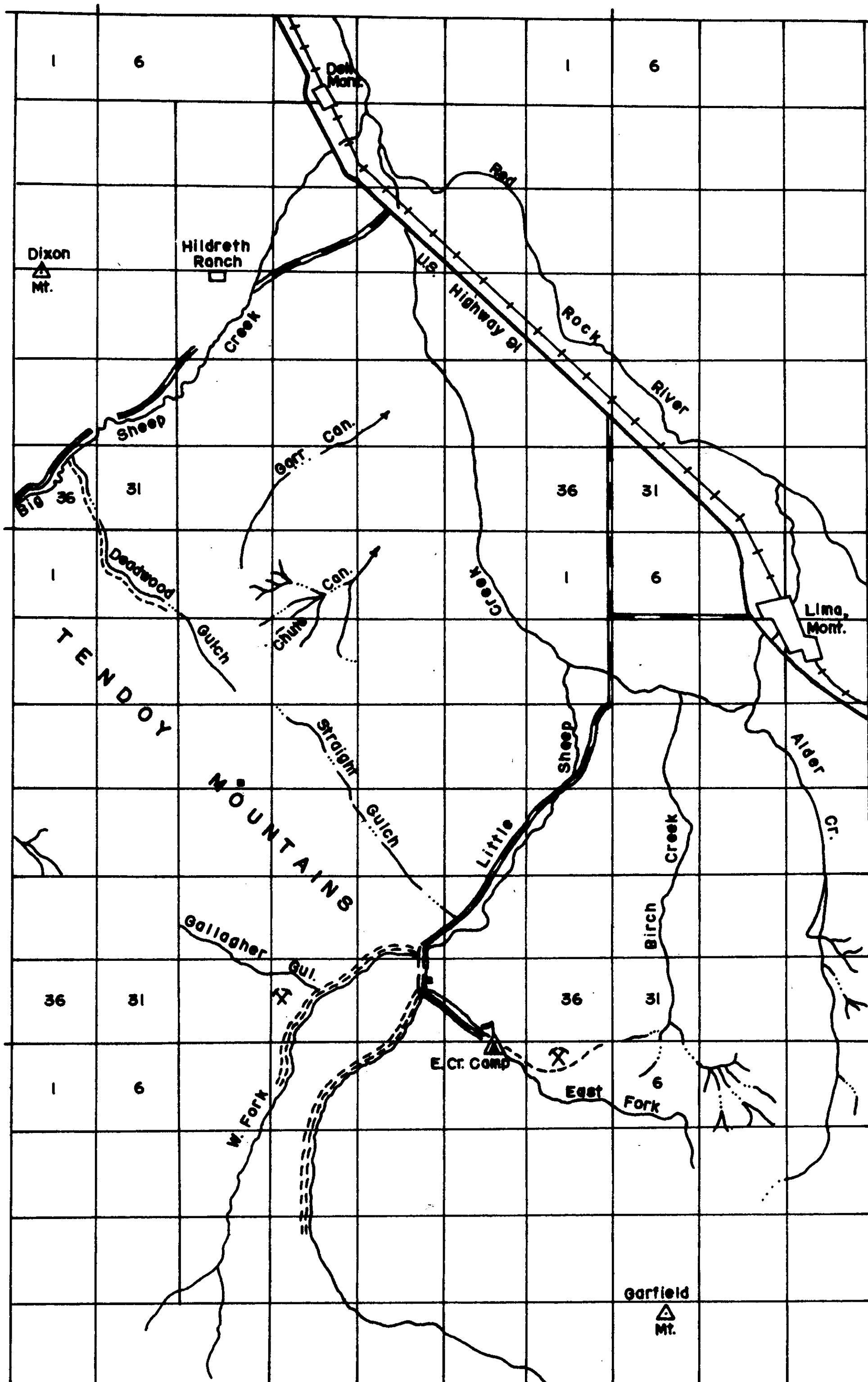
GEOLOGIC SETTING

Westerly dipping Paleozoic rocks are exposed along the east flank of the Tendoy Range, west of Lima, and Dell, Montana (Figures 1 and 2). The Amsden Formation is exposed about midway up the eastern flank of the range, forming a topographic bench that rises above a valley formed by less resistant strata of the Big Snowy Group (Scholten, 1955).

Scholten (1955) and others describe the Paleozoic rocks in this part of Montana to represent the "Montana shelf" portion of the Cordilleran geosyncline. Maughan and Roberts (1967) indicate that the Mississippian and Pennsylvanian rocks of the Tendoy Mountains were deposited in the Montana Trough, a narrow east-west seaway, subsequently altered by faulting and erosion, that extended from central Montana to eastern Idaho. This trough or embayment has been considered by many geologists to be a remnant of the seaway connecting the Cordilleran geosyncline and the Big Snowy Basin in central Montana.

PREVIOUS INVESTIGATIONS

Because of the availability in the literature of discussions regarding development of nomenclature for the Amsden Formation, only



SHEEP CREEK ACCESS MAP
FIGURE 1

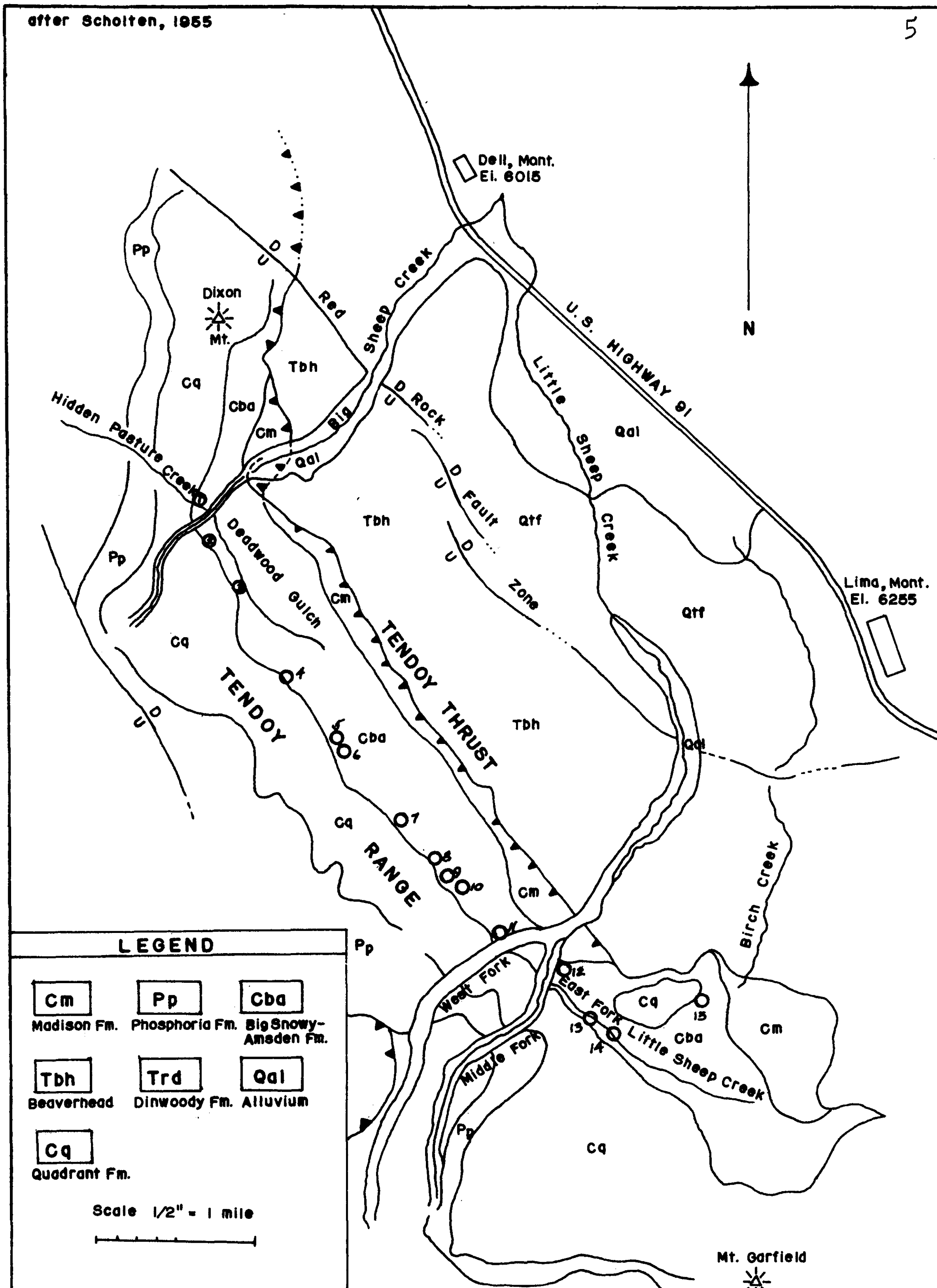


FIGURE 2

GEOLOGIC MAP OF BIG AND LITTLE SHEEP CREEKS, TENDOY MOUNTAINS, BEAVERHEAD COUNTY, MONTANA those papers that consider the Tendoy Mountains are presented in this paper. The reader is referred to Mundt (1956), Willis (1959), and Easton (1962), for complete chronological discussions of nomenclature.

Sloss and Moritz (1951) published the first comprehensive study of the Paleozoic rocks of southwestern Montana that included the Tendoy Mountains. These authors apply the name Amsden Formation to rocks with "a basal unit of shale, siltstone, and shaly dolomite, bright red or purplish in color, ...(that) grade up to and are succeeded by a fossiliferous limestone member which is thin bedded at the base and more massive above". The authors mention that the Amsden Formation becomes more sandy upward, grading into sandstones of the Quadrant Formation.

Scholten (1955) described the Amsden Formation in the Tendoy Mountains as "more than 200 feet of...limestones and shales". He also notes that, except for local abrupt contacts, the Amsden-Quadrant boundary is generally gradational in the Tendoy Mountains. The Big Snowy-Amsden contact is described as poorly exposed, with a "local occurrence of a conglomerate with limestone pebbles in the basal unit that suggests a disconformable contact". Elsewhere in his paper, Scholten refers to the Amsden Formation as dolomite and sandy dolomite.

Maughan and Roberts (1967), in a study of Upper Mississippian and Pennsylvanian sediments, elevated the name Amsden to group rank. As defined by them, the Amsden Group includes the Tyler

Formation, Alaska Bench Formation, and Devils Pocket Formation, in ascending order. As defined, the Amsden Group at the type section at Amsden Creek in north central Wyoming is composed of "a lower red shale that locally is a sandstone at the base, a medial limestone member, and an upper red shale member that includes interbedded carbonate rock and sandstone". The authors refer to a thick sequence of rocks equivalent to the Tyler Formation that exist in the Tendoy Mountains, but do not indicate the exact lithology except to note in the correlation chart that it is shale, with subordinate sandstones near the base. Also in the correlation chart, they include the Alaska Bench equivalent at a section measured at Big Sheep Creek. At this locality, Maughan and Roberts apparently include the Devils Pocket Formation in the basal Quadrant Formation. Although the authors elevated the Amsden Formation to group rank, they recommend that rocks equivalent to the Amsden Group in western Montana "continue to be recognized as the Amsden Formation".

PRESENT STUDY

The nomenclature used in this study corresponds to the suggestion of Maughan and Roberts (1967), and the rocks under study are referred to in this paper as the Amsden Formation. This study focuses on the stratigraphic relationships in the upper part of the Amsden Formation. As such, a discussion of the entire Amsden Formation and its correlation outside the study area is beyond the scope of this paper.

However, the author believes that the Amsden Formation in the Tendoy Mountains can be divided into three members (Figure 3) based on outcrop characteristics and lithology. These are, (1) a lower member, recessive, very thin bedded, laminated limestone and shaly limestone; (2) a middle member, thicker bedded and more resistant than the lower member, composed predominantly of fossiliferous and cherty limestone; (3) an upper member, composed of interbedded limestone, silty limestone, siltstone, dolomite, and sandstone, thinly bedded and less resistant than the middle member.

The middle member is lithologically similar to rocks referred to as Alaska Bench by Gilmour (1967) and Easton (1962); Maughan and Roberts (1967) refer to an "Alaska Bench equivalent" present at Big Sheep Creek in the Tendoy Mountains, and also refer to a "Tyler Formation equivalent", indicating that they believe these two formations are present at Big Sheep Creek.

I believe that the lower member and middle member proposed above may be correlative with the Tyler Formation and Alaska Bench Formation, respectively, as defined by Maughan and Roberts (1967). The upper member may be correlative with the Devils Pocket Formation. Elevation of these members to formation status, however, should await further mapping and detailed paleontologic studies of these rocks.

Section 8

L. Sand Subtype III
K. Sand Subtype II
J. Sand Subtype I
I. Silty Micrite Rock Type (Interval X) Base of Upper Member
H. Carbonate Mound Rock Type (Interval IX)
G. Intervals VII and VIII
F. Interval VI - Carbonate Sand Rock Type
E. Interval V
D. Productid-Bryozoan Crinoid Subtype (Interval IV)
C. Interval III
B. Millerellid-Brachiopod (Interval II) Base of Middle Member
A. Lower Member (Interval I)

Figure 3

Chapter 3

ROCK TYPES

The rock types discussed below represent descriptively defined, individually distinct bodies of rock that reflect individual environments of deposition. One of the major intentions of this study is to establish the stratigraphic framework for the Amsden Formation in the Tendoy Mountains so that other geologists may use that framework for future studies of the Amsden Formation in nearby areas. Consequently, each rock type has identifiable aspects of lithology, fauna, texture, and color, and is recognizable in the field.

In the following discussion each rock type is identified and described, and then the environment of deposition is interpreted.

The environment of deposition has been interpreted by examining all the factors that compose the rock type and make it distinct. These factors, such as fossils, allochems, matrix, bedding, sedimentary structures, and color, often limit the rock type to a certain range of environmental tolerance. For example, rocks containing intraclasts, mat algae, and ostracods, most probably were deposited in an intertidal marine or brackish environment, especially if associated above and below by other rocks with shallow water features. After a range of environmental tolerance was interpreted in this manner, recent literature was examined to substantiate or question the interpretation.

When the constituents are not characteristic of a certain environmental range, the interpretation relies on the relationship of the rock type to another, usually adjacent rock type, whose environment can be more readily determined. For example, if an unfossiliferous and structureless micrite is adjacent to a mat algal unit, the former is interpreted to represent intertidal, or perhaps supratidal, sedimentation.

By separating the descriptive from the interpretive aspect of the discussion it is hoped that the reader may utilize the stratigraphic units without being obligated to accept the environmental interpretations of the writer. In this way, perhaps these rocks may be identified and utilized in nearby areas regardless of different opinions about their respective depositional environments. Thirteen rock types and nine associated subtypes have been identified and are described below.

BRACHIOPOD-CRINOID CHURNED MICRITE ROCK TYPE

This rock type is identified by the dominance of strophomenid brachiopods and crinoid fragments in a light tan, dense micrite, that weathers to resistant, light gray beds 6" - 12" thick. In addition to the above fossils, these rocks contain a diverse fauna, that includes fragments of echinoids, spines, bryozoans and ostracods. Endothyrid foraminifers and encrusting foraminifers are present but not abundant. The matrix is churned, and fossils lack any consistent orientation. Brachiopod and crinoid fragments are selectively silicified, standing in relief on the outcrop. Tan chert nodules and stringers are always present.

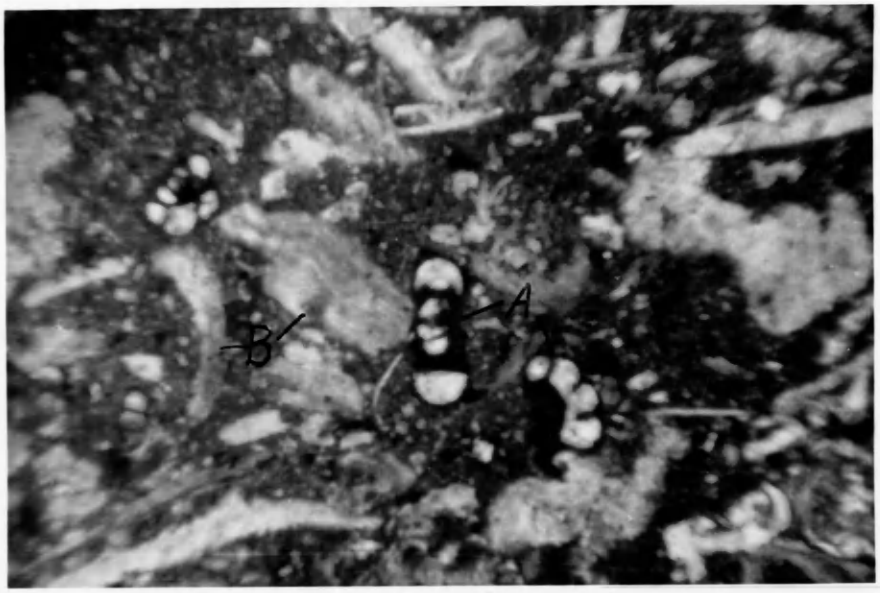
Environmental interpretation. This rock type is limited to the south end of the study area, where it often lies between beds of pelletal mud. It is limited to the lower and middle members.

The high faunal diversity suggests that the environment of deposition was normal marine, with high productivity and normal salinity. The light color of the matrix indicates a well-oxygenated environment. The churned nature of these rocks is probably evidence of an abundant infauna that burrowed and disrupted the sediment.

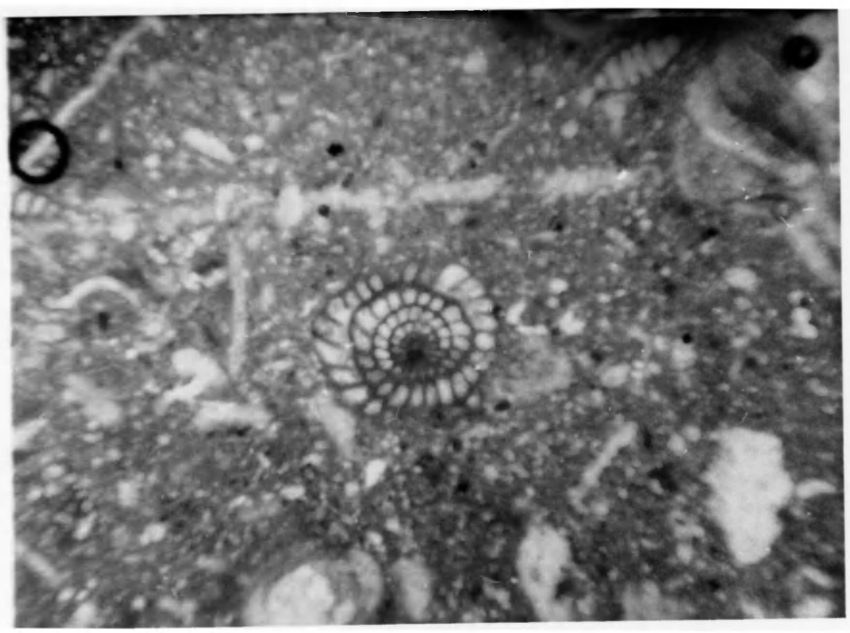
The relationship of this rock type to pelletal sediments indicates that it was deposited adjacent to the pelletal sediments, perhaps slightly seaward in the subtidal environment.

MILLERELLID-BRACHIOPOD-CRINOID ROCK TYPE

This rock type is essentially similar to the previous rock type, but has millerellid foraminifers. It is identified in the field by the presence of millerellids (Figure 4), and its characteristic massive, resistant outcrops 5' - 7' thick, composed of individual beds 1' - 2' thick (Figure 3). It forms the basal unit of the middle member, and overlies the less-resistant strata of the lower member. Its occurrence is limited to the south end of the study area; it changes progressively northward to the Pelletal Rock Type,



Millerellid-Brachiopod-Crinoid Rock Type
A. Endothyrid foraminifers
B. Brachiopod fragments



Millerellid-Brachiopod-Crinoid Rock Type

Figure 4

which in turn passes northward to the Mat Algal Rock Type. The matrix is churned and the fossils fragmented, except at section #15, where it is a packed millerellid, strophomenid brachiopod micrite.

Environmental interpretation. The environment of deposition for this rock type is interpreted to be the same as the preceding rock type. The presence of millerellids and the occurrence of the brachiopod rich unit at section #15 perhaps indicates a burst of productivity for a short time during a transgressive phase.

BLACK MICRITE ROCK TYPE

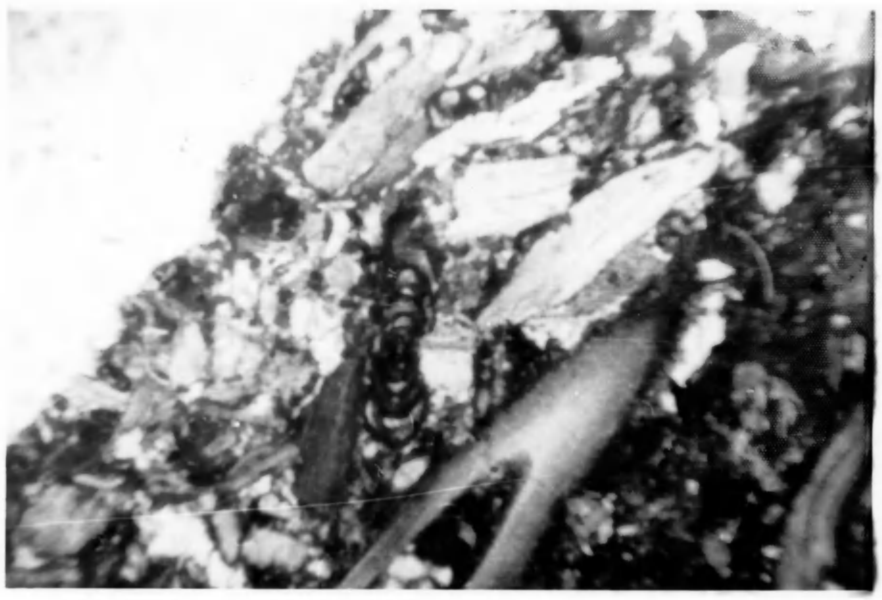
The Amsden Formation rocks in the study area contain a variety of gray weathering, black limestones that are readily identified in the field by their black color on the fresh surface. Within this rock type, three distinct subtypes have been identified and are discussed below.

Productid-Bryozoan-Crinoid Subtype

This subtype is identified by its very black color on the fresh surface, and the presence in large numbers of productid brachiopods, fenestrate bryozoans, and crinoid fragments (Figure 5). Other fossils include echinoid fragments, neotremate brachiopod fragments, encrusting foraminifers, and spines. Scattered phosphatic fragments are common, but minor. At sections #1 and #2, this subtype is composed of 3" - 6" beds, interbedded with fissile, black, calcareous shale. Fossils are well preserved; brachiopods and bryozoans are

Productid-Bryozoan-Crinoid Subtype - Black Micrite Rock Type

Figure 5



Millerellid-Productid Rock Type

Figure 6

whole, with many bryozoans draped across productid brachiopod shells. Neotremate brachiopod shells are abundant, particularly in the interbedded shale. At sections #1 and #2, these rocks are overlain by the Gastropod-Plant Fragment Subtype of the Silty Micrite Rock Type. At section #2, this subtype appears to be grading laterally into the Silty Micrite Rock Type.

In the south part of the study area, notably at sections #7 through #14, rocks of this subtype form a massive, resistant outcrop 8' - 12' thick, composed of beds 1' - 3' thick (Figure 3). In these sections, the matrix is churned, with all fossils fragmented, except productid brachiopods. In the south, this subtype is directly overlain by the Pelletal Rock Type; at section #15 this subtype is absent.

All rocks of this subtype contain nodules and stringers of black chert, which stand out prominently against the light gray-weathering beds.

Environmental interpretation. In both the northern and southern parts of the study area, this subtype contains abundant marine fossils, indicating a marine environment of deposition.

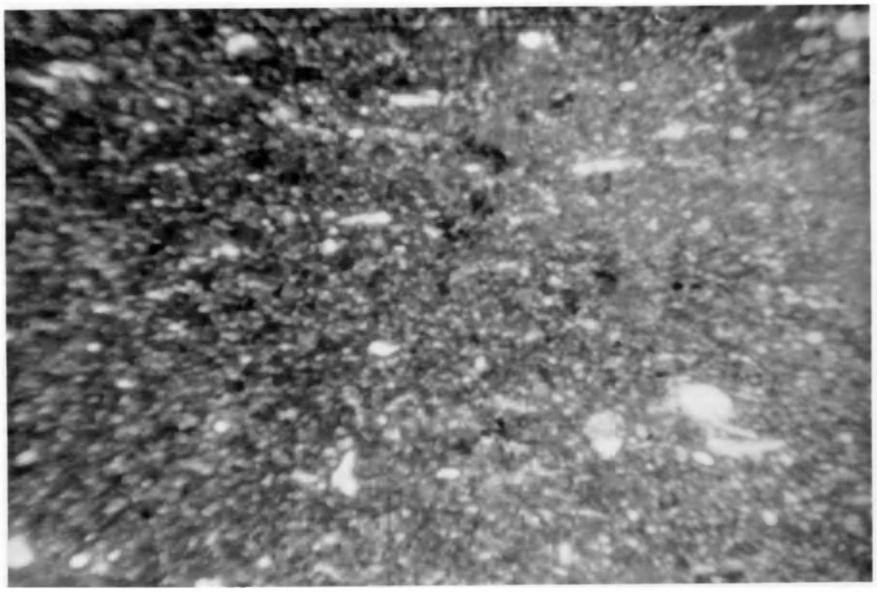
In the north, the relationship of this subtype with the overlying Gastropod-Plant Fragment Subtype and the underlying calcareous shale indicates that the most probable depositional environment is a marine lagoon or a restricted bay. The preservation of bryozoan fronds and the interbedded nature of these rocks with Shale Rock Type indicate quiet water with periodic gentle fluctuations in sea level, which is consistent with the above interpretation.

In the south, this subtype is overlain by pelletal rocks, interpreted to be subtidal to intertidal. An active infauna, burrowing and churning the sediment fragmented the fossils and disrupted the original bedding. The normal marine fossil assemblage and the relationship of this subtype to subtidal or intertidal marine sediments suggests that in the south part of the study area, these rocks were deposited in an open marine environment, seaward from the Pelletal Rock Type. The dark color suggests restriction below the interface, possibly due to a topographic depression on the marine sea bottom.

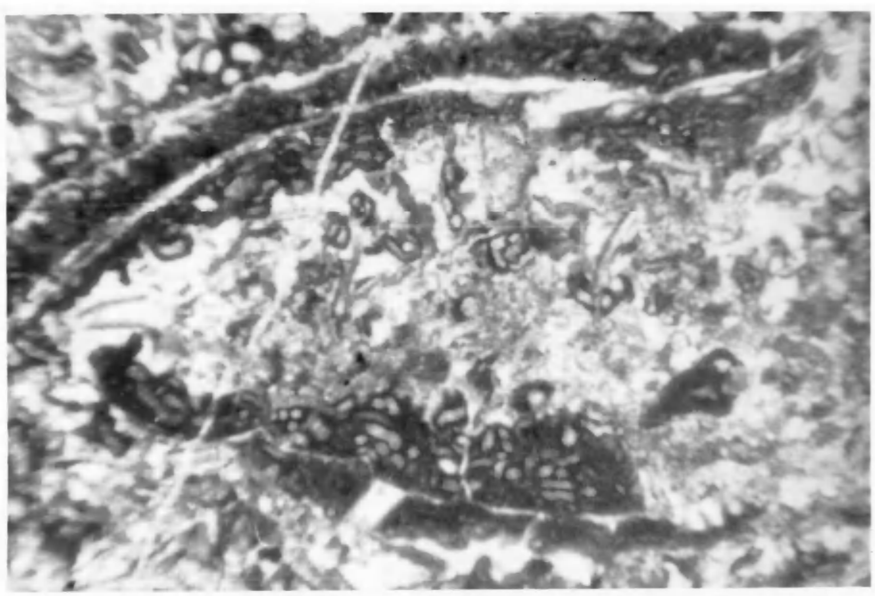
Dark Fragmental Subtype

This subtype is identified by the black color of the fresh surface, fetid odor, thin bedding (¼" - 3"), and a varied fauna dominated by encrusting foraminifers and a variety of different brachiopods (Figure 7). Rocks of this subtype are exclusively recessive, light gray weathering beds with small nodules and thin stringers of black chert standing in relief on the weathered surface.

The faunal constituents vary markedly from bed to bed, and from measured section to measured section. Present are rostrospiriferid and orthid brachiopods, crinoid and echinoid fragments, phosphatic fragments, foram-algal consortiums, neotremate brachiopod caps, and gastropods. In some beds, faunal constituents consist exclusively of fine fragmented hash; in others, fossils are whole,



Dark Fragmental Micrite Subtype
Black Micrite Rock Type



Dark Fragmental Micrite Subtype
Black Micrite Rock Type
Apterinellid foraminifers and brachiopod fragments

Figure 7

primarily the brachiopods.

Rocks of this subtype commonly are laminated with streaks of light tan micrite or have spots of light tan micrite on the upper surfaces of individual beds. Near the top of the rock type unit, this tendency becomes more pronounced, so that laminations of light tan micrite are interspersed with the black. In certain places, the light tan micrite dominates at the top of the rock type unit where it resembles the Silty Micrite Rock Type, suggesting a close affinity.

Rocks of this subtype are rich in organic matter, and often contain clay or silt.

Environmental interpretation. The brachiopods, crinoids and echinoids indicate that deposition was in a marine environment. The general association of encrusted fragments, foram-algal consortiums, organic-rich sediment and thinly bedded sparsely fossiliferous units suggests a quiet water, restricted marine environment; the dark color and fetid odor is attributed to reducing conditions below the sediment-water interface. The laminae and spots of light tan micrite near the top of beds reflect a thin, recurrent zone of oxidation at the sediment water interface.

The abrupt changes in fauna vertically and laterally in these rocks suggests fluctuating environmental conditions, probably related to minor sea level changes or currents.

Along the west coast of the United States, the writer has observed black organic mud in the intertidal zone that grades shoreward into lighter colored supratidal mud. The uppermost surface of the black mud is oxidized. These recent sediments are comparable to this subtype, and suggest that the Dark Fragmental Subtype was deposited in the intertidal and slightly subtidal zones.

Laminated Spiculitic Subtype

This subtype is limited to the north end of the study area, and represents the rocks of the lower member in that part of the area. These rocks are very thin bedded (1/16" - 3"), recessive, gray weathering, shaly limestone, generally very dark gray to black on the fresh surface, with stringers and nodules of black chert. Bedding surfaces usually contain siliceous sponge spicules. On the fresh surface, these rocks commonly have light tan, silty laminations. Fossils are sparse and are limited to finely broken brachiopod and crinoid fragments. Near the top of the lower member, gastropods are present, the rocks are burrowed, and the amount of brachiopod and crinoid material increases slightly. Near the top of the lower member at section #1, rocks directly above this subtype are cut by a channel filled with sediments of the Millerellid-Productid Rock Type (Figure 8).

Environmental interpretation. The scarcity of fossils creates some difficulty in establishing the most probable environment of deposition. Gastropods near the top of the lower member, although limited in occurrence, suggest a shallow water environment. The undisturbed silty laminae through much of this subtype and the fine size of fragments reflect quiet water characteristics. The slight upward increase in the size and diversity of fossils, together with

RELATIONSHIP BETWEEN CHANNEL AND CHANNEL MARGIN, SECTION IA

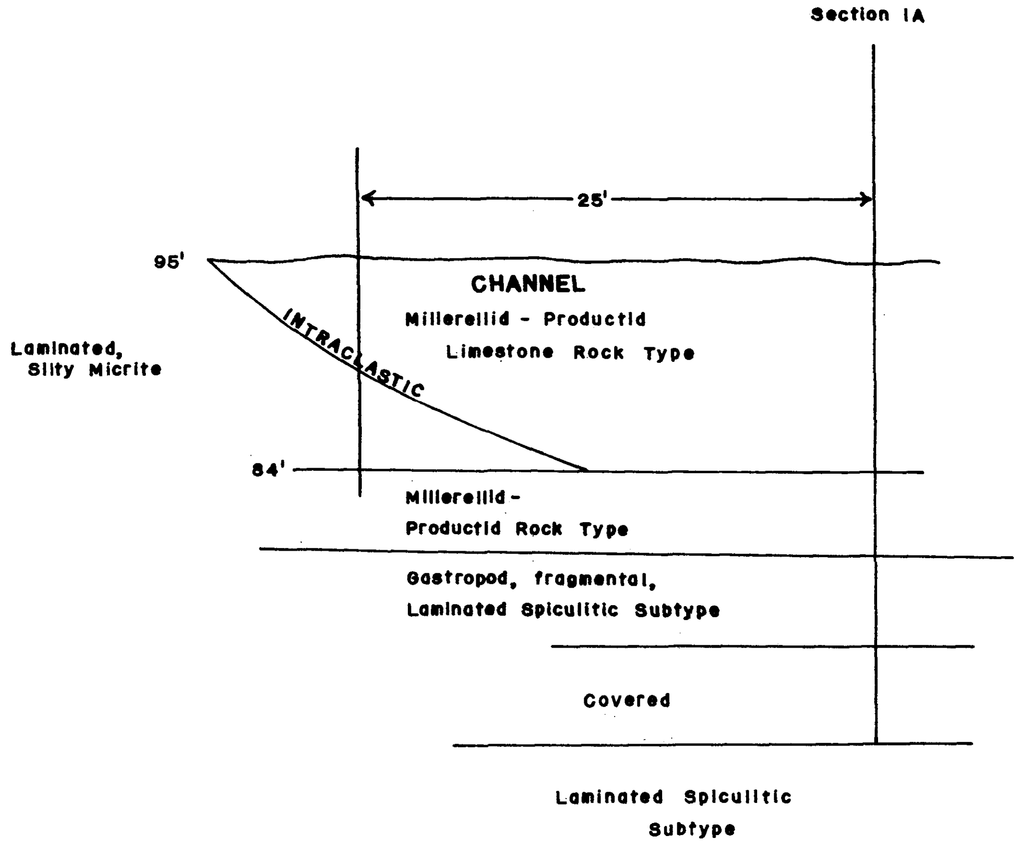


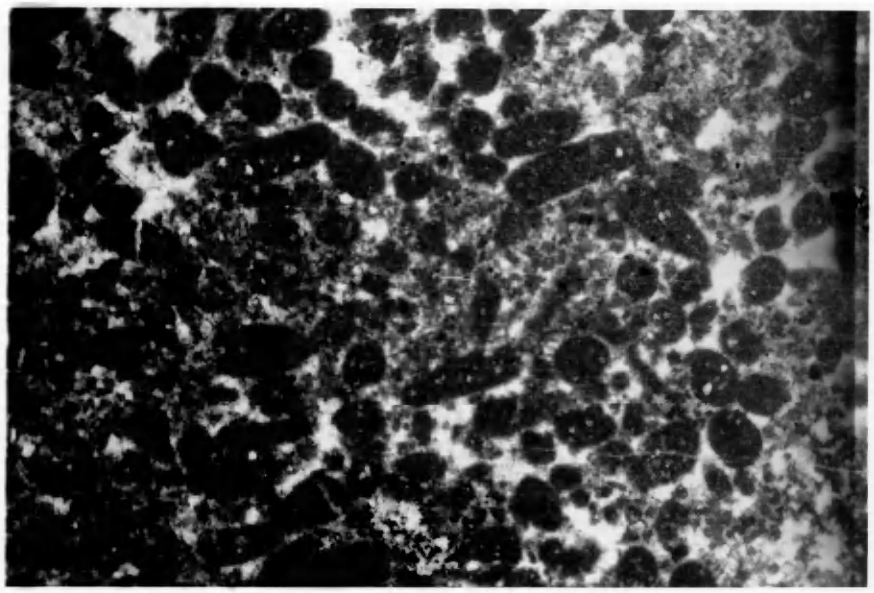
FIGURE 8

the channel of normal marine carbonate present in the upper part of the lower member, indicates very shallow water sedimentation, with a very gradual inundation by marine waters near the top of the lower member. This subtype correlates southward with rocks of the lower member in section #8 - #15, belonging to the Pelletal, Mat Algal and Millerellid-Brachiopod-Crinoid Rock Types, which are interpreted to represent intertidal and subtidal sedimentation. This correlation, in combination with the suggested shallow water features, indicates that the Laminated Spiculitic Subtype represents deposition in or above the intertidal zone. The general lack of fossils in the lower part and the lack of burrowing is indicative of an environment not conducive to normal marine biological processes; therefore, the author believes that this subtype represents predominantly supratidal sedimentation, and in cases where fossils and burrowing are present, may have ranged into the intertidal zone.

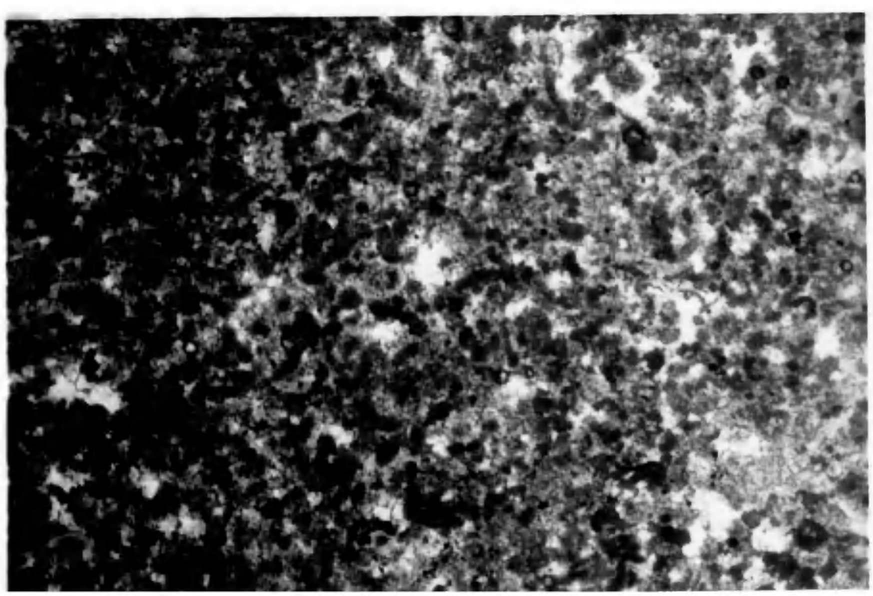
PELLETAL ROCK TYPE

The Pelletal Rock Type is identified in the field by the reddish-brown weathering color and by the abundant ostracod tests in gray or tan micrite. These rocks generally weather to slightly recessive beds, 1" - 3" thick. Chert is rare.

Microscopically, the Pelletal Rock Type is composed of pelletal lime mud in a sparry calcite matrix (Figures 9 and 10), or of micrite formed by compacted pellets. Articulated and disarticulated ostracod tests are characteristic and are commonly filled with sparry calcite

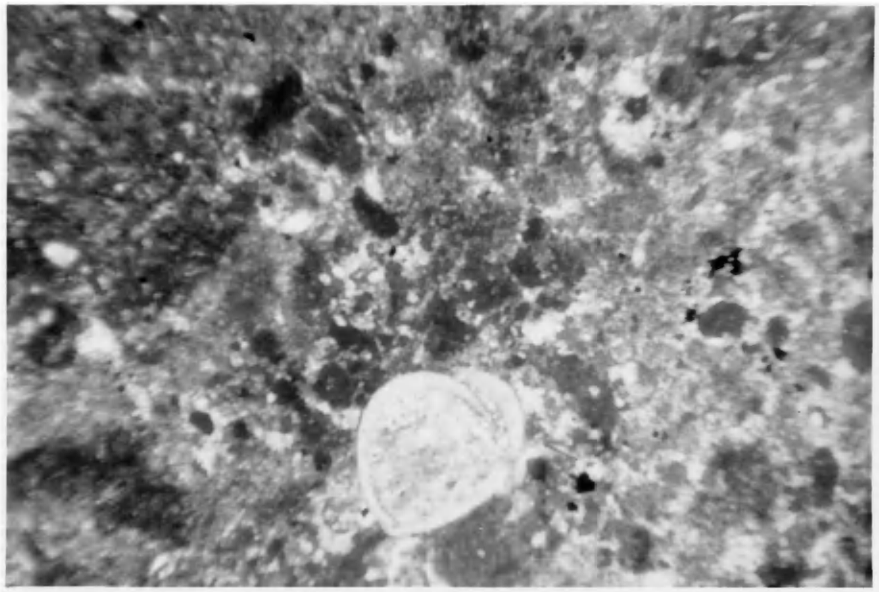


Pelletal Rock Type

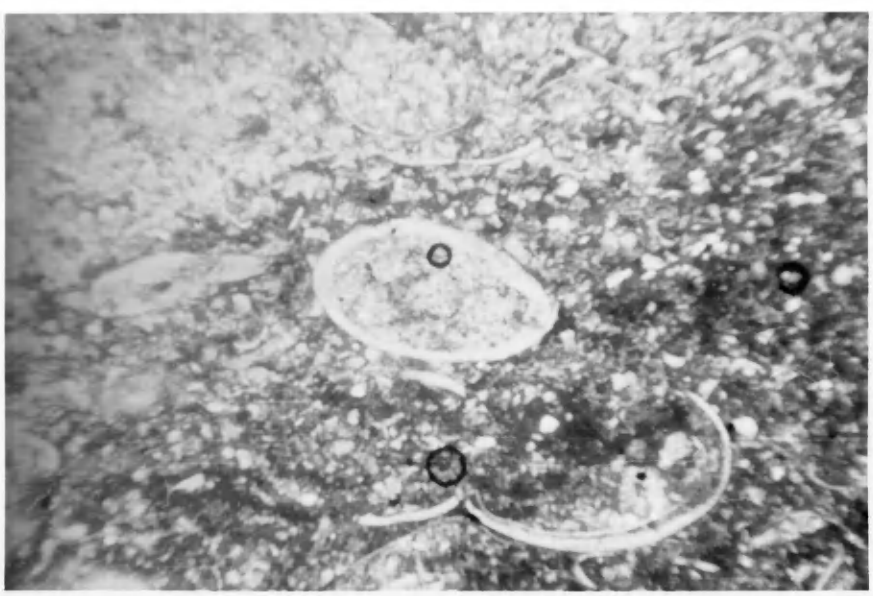


Pelletal Rock Type

Figure 9



Pelletal Rock Type
A. Pellets
B. Spar filled ostracode



Pelletal Rock Type

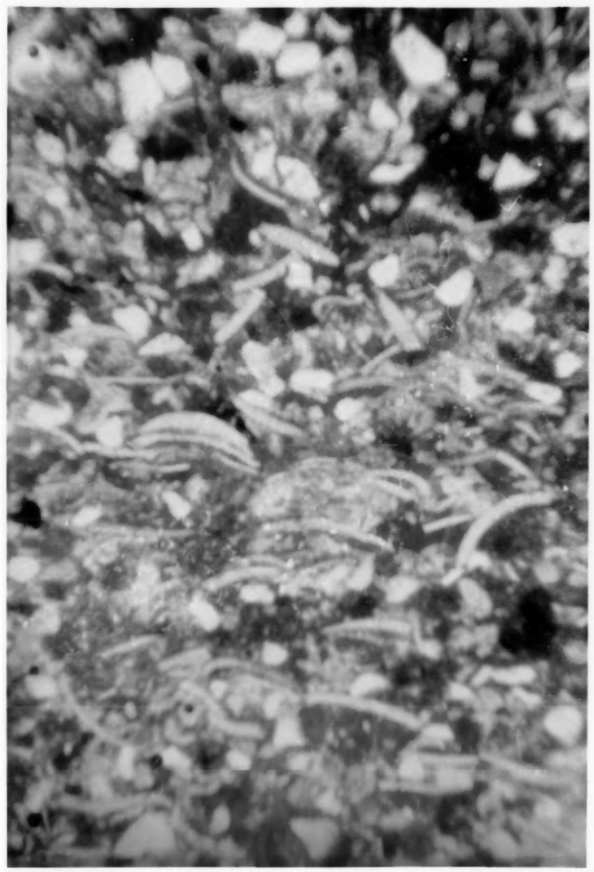
Figure 10

or collophane. Other fossils include fragments of crinoids, brachiopods, and echinoids, and encrusting foraminifers. These rocks are extensively burrowed. Mat algae are very common, and are closely related to the Pelletal Rock Type. Some beds of pelletal mud are capped by the Mat Algae. Other beds contain intraclasts of mat algae. In addition to mat algae intraclasts, there are intraclasts of pelletal micrite and silty micrite. Sand-sized quartz grains are common and constitute from 1 to 40% of the rock.

Environmental interpretation. Pelletal rocks commonly underlie either mat algae, silty micrite, or sandstone; they are also associated with the Brachiopod-Crinoid Churned Micrite Rock Type, and occasionally pass laterally into the Carbonate Sand Rock Type. These relationships, together with the generally low faunal diversity, indicate that the Pelletal Rock Type probably represents shallow marine deposition, ranging from the subtidal to supratidal environments, with emphasis on the intertidal zone. The composition of the intraclasts indicates that it is an adjacent deposit to the Mat Algal and Silty Micrite Rock Types.

Ostracod Fragmental Subtype

This subtype is similar in appearance to the Pelletal Rock Type, but differs in containing abnormally large ostracod fragments packed closely together (Figure 11). Crinoid and brachiopod fragments, superficial oolites, phylloid algal fragments, intraclasts,



Ostracod Fragmental Subtype
Pelletal Rock Type

Figure 11

and unidentifiable broken fragments occur in varying amounts. Quartz sand grains are very common, forming a consistently higher percentage than in the pelletal rock type in general.

Environmental interpretation. This subtype is interpreted to be a result of a higher energy environment than the parent rock type; it may represent local zones of wave swash, or it may represent remnant deposits on prograding surfaces in the intertidal zone, caused by sea level fluctuations.

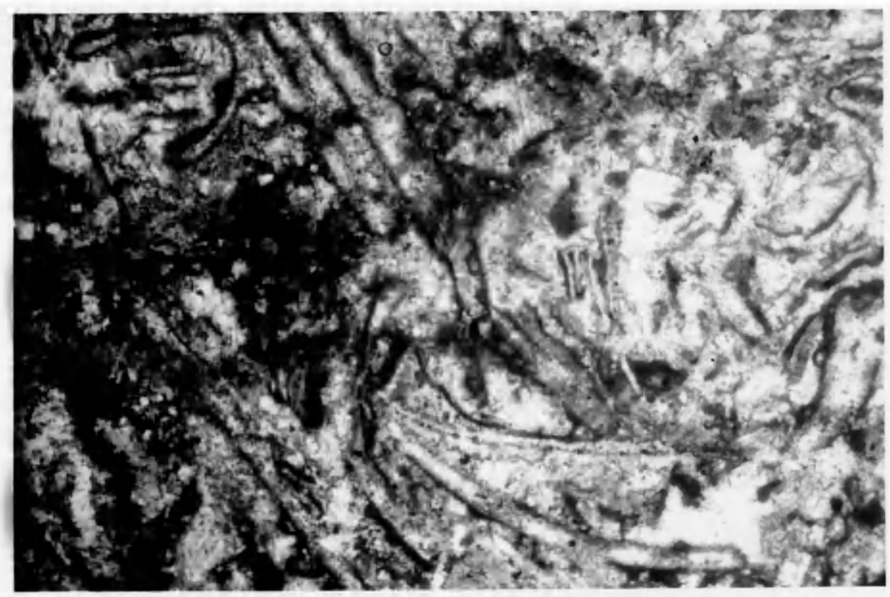
MAT ALGAL BIOLITHITE ROCK TYPE

Overlying both the Pelletal Rock Type and the Sand Rock Type, and often underlying the Sand Rock Type is a laminated, thinly bedded, sparry, reddish brown weathering unit formed by mats of blue-green algae (Figure 12). Articulated ostracod carapaces are abundant in this rock type and are usually bound by algal threads passing around them. Quartz sand grains and micrite intraclasts are often present and also are bound by the algae. The mats exhibit mudcracks, soft-sediment deformation, and birds-eye structure. The latter consist of round, spar-filled holes formed by gas bubbles (Shinn, 1968). Soft sediment deformation is evident from partially torn up algal intraclasts, redeposited and bound by algae, and by contorted bedding planes. Mudcracks are only locally developed.

Environmental interpretation. Although blue-green algae can exist in a variety of environments, they most commonly form mats in

Mat Algal Biolithite Rock Type
(Note ostracod and "birds-eye" texture)

Figure 12



Algal Plate Biosparite Rock Type
Micrite coated Ivanovia? blades

Figure 13

the intertidal zone. Wolf, (1965), limits their probable range from the intertidal zone to a depth not greater than 20 feet. The textural characteristics cited above, taken together with the stratigraphic position of the algal mats, indicates that in the study area the mats represent intertidal to supratidal deposits.

ALGAL PLATE BIOSPARITE ROCK TYPE

This rock type is recognized by significant amounts of phylloid algal plates (Figure 13), (Pray & Wray, 1963), that closely compare to the genus Ivanovia. Recrystallization has obliterated the internal organic structures, thus precluding positive identification. The outlines have been preserved by micrite coatings, and encrustations by blue green algae and sedentary foraminifers. Assignment to the phylloid algae is based on comparison with known phylloid algae in other studies.

This rock type is difficult to identify in the field; it forms a resistant gray weathering bed about one foot thick.

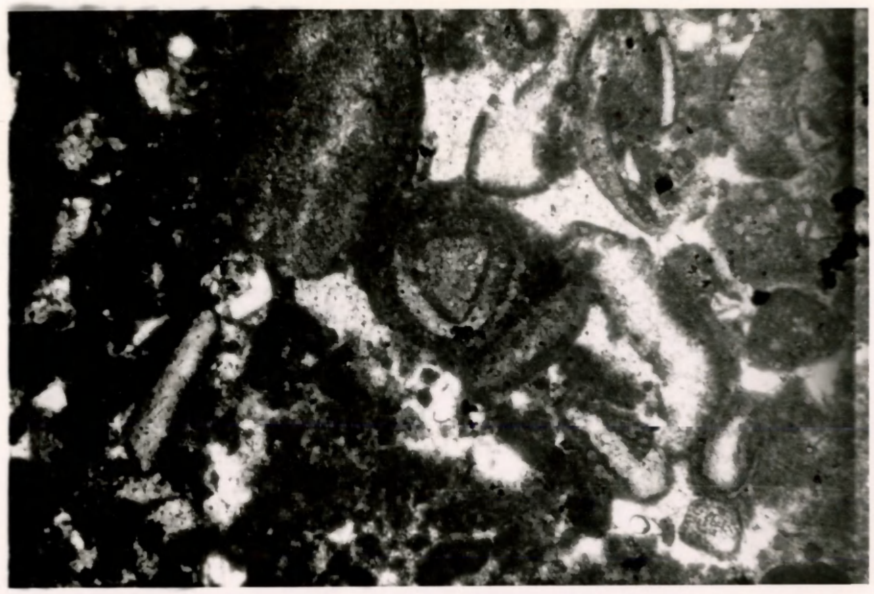
Environmental interpretation. Pray and Wray (1963), conclude that phylloid algae maintained an upright position and occurred in shallow marine environments less than 50 feet deep, but below critical wave base. In the study area this rock type occurs only at one locality within the Dark Fragmental Subtype of the Black Micrite Subtype. At this locality it is interpreted to represent a patch or a clump of phylloid algae within, or slightly seaward, from the intertidal zone. It is included here as a rock type because the

Carbonate Sand and Carbonate Bank Rock Types contain fragments similar to phylloid algae, indicating that phylloid algae may have been quite widespread in the Amsden Sea. It may be more abundant in adjacent areas.

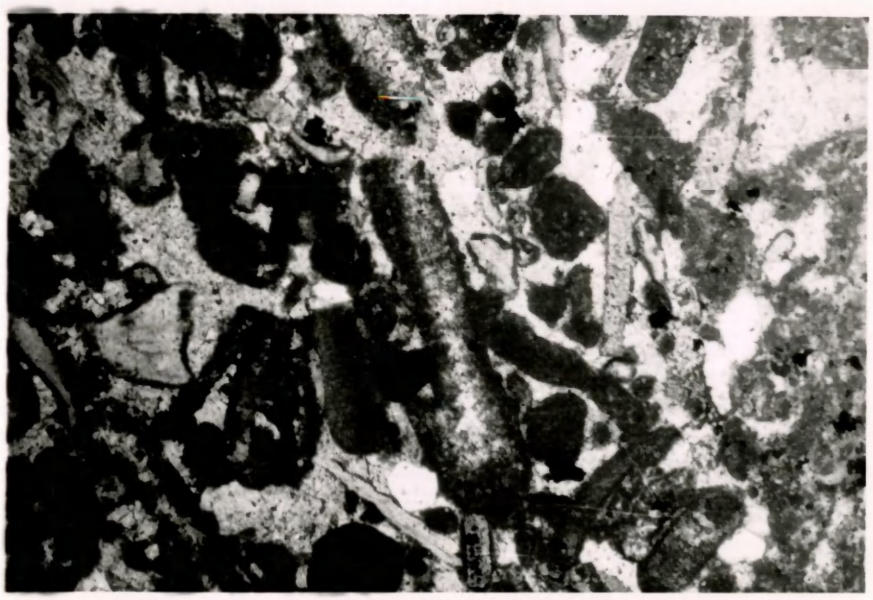
CARBONATE SAND ROCK TYPE

This rock type is composed of phylloid algal fragments and algal plates of uncertain affinity, brachiopod, bryozoan, and echinoid fragments, superficial ooliths and large intraclasts (Figure 14). Most allochems have been rounded and are cemented by sparry calcite. Overall sorting is good with most indigenous finer fractions winnowed from the site of deposition. Most allochems are coated by micrite or sedentary foraminifers. Intraclasts are composed of large rounded fragments of blue green algae or unfossiliferous micrite. Quartz sand grains are common, constituting up to 50% of the rock locally. This rock type is overlain either by the Sand Rock Type or by the Blue Green Algal Rock Type, and may pass laterally to the Pelletal Rock Type. It generally forms a gray-weathering resistant bed 1' - 2' thick.

<u>Environmental interpretation.</u> These rocks are interpreted to result from a high energy shallow marine environment that was capable of rounding and coating the various allochems and winnowing finer fractions. The high proportion of rounded algal fragments indicates that an important source was algal patches and shoals in the



Carbonate Sand Rock Type



Carbonate Sand Rock Type
Algal plates, lumps, pellets, intraclasts and fossil fragments in sparry matrix.

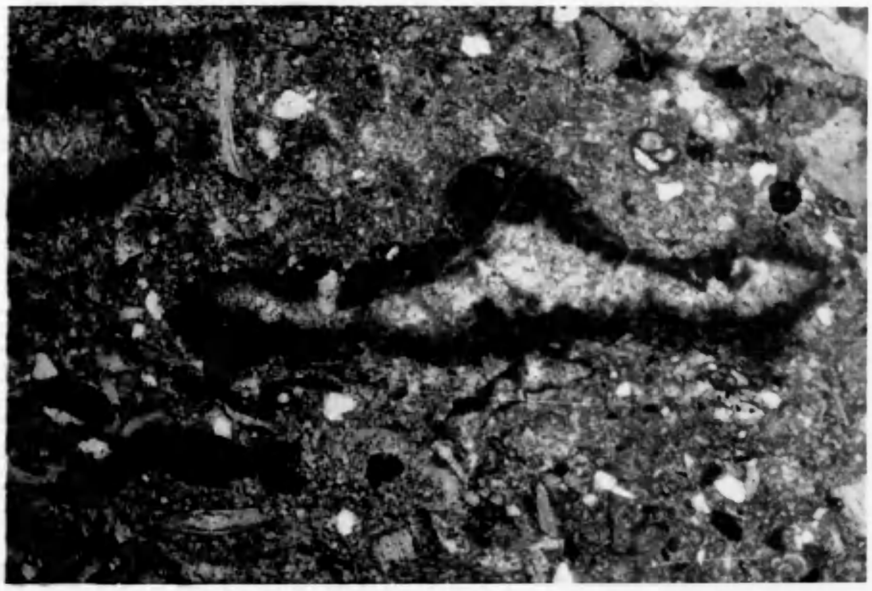
Figure 14

Amsden Sea. During periods in which critical wave base dropped, organisms and sediment were torn up and spread across the shallow sea bottom. Ball (1967) reports similar sediment in Florida and the Bahamas, where it is confined to the intertidal zone, in channel deposits, tidal bars, and as sheet deposits.

CARBONATE BANK ROCK TYPE

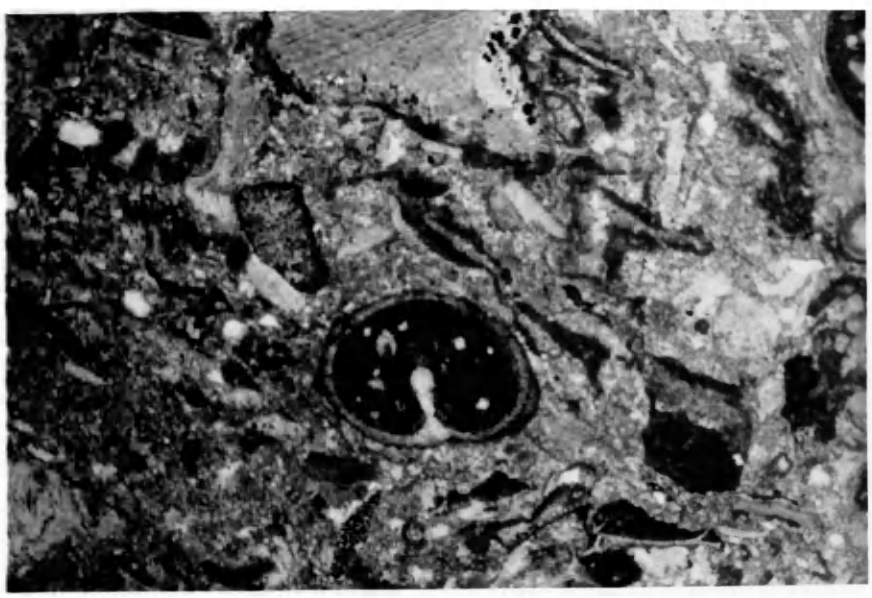
This rock type occurs only at section #8; southward, it passes abruptly to the Dark Fragmental Subtype of the Black Micrite Rock Type at sections #9 and #10. Northern limits cannot be determined due to incomplete exposures.

This rock type is composed of yellowish-brown micrite containing rostrospiriferid brachiopods, phylloid algal fragments, gastropods, fragments of crinoids, echinoids, and brachiopods, encrusting foraminifers, and numerous large intraclasts (Figure 15). Allochems are commonly coated by micrite or sedentary foraminifers. Bryozoan fragments are present but form a minor part of the faunal assemblage. Rostrospiriferid brachiopods are the only unfragmented brachiopod; most others are fragmented, and the matrix is commonly churned. The intraclasts are from the Black Micrite Rock Type. These rocks form a resistant series of beds 6" - 18" thick. They weather to brownish-yellow, with brown chert nodules and silicified rostrospiriferid brachiopods standing on relief on the weathered surface.



CARBONATE BANK ROCK TYPE

A. Algal coated brachioped fragment; B. Endothyrid foraminifer; C. Echinoid fragment; D. Coated algal plate; E. Fine quartz sand grains.



CARBONATE BANK ROCK TYPE

A. Mudfilled gastropod; B. Crinoid fragment; C. Coated algal blade; D. Spine; E. Intraclast.

Figure 15

Environmental interpretation. This rock type contains a faunal assemblage quite similar to that of the Dark Fragmental Subtype in sections #9 and #10, but differs in color, thickness of bedding, and its abundant intraclasts. The large intraclasts suggest that the sediments forming this rock type were frequently exposed to high energy conditions that tore up clumps of sediment and redeposited them.

The abrupt lateral change from the light colored, intraclastic sediments of this rock type to the dark colored, quiet water sediments of the Dark Fragmental Subtype suggests that the Carbonate Bank Rock Type was deposited as a local feature that stood in slight relief over surrounding sediments. It is interpreted to be a mound or bank, growing partly through organic processes, and partly by accumulation of transported sediments.

SILTY MICRITE-SILTSTONE ROCK TYPE

This rock type ranges from approximately 3% silt, 97% micrite to 90% silt, 10% micrite. Siltstone forms only a minor percentage.

These rocks form thin bedded, recessive, gray, or yellowish to brownish-yellow outcrops. Marine fossils occur in the Silty Micrite lithology and decrease as the rocks become more silty. Fossils include ostracods, crinoid, echinoid and brachiopod fragments, apterinellid foraminifers, algal fragments, and very thin sparry shell fragments that may be pelecypods. Plant fragments, carbonaceous material, and gastropods are locally present. Fossil fragments are generally very small.

These rocks often exhibit fine laminations of sparry calcite and micrite. Mudcracks are locally developed; narrow, v-shaped channels cut into beds 3" - 4" across and 5" - 6" deep occur in this rock type at section #8, and are filled with intraclastic micrite. These rocks are locally dolomitized in many of the sections. Although dolomitization is irregular, it increases in the northern sections. In sections #1 through #6, this rock type is predominantly dolomitized silty micrite.

This rock type generally occurs in the upper member in sections #7 through #15, while in the north part of the study area in sections #1 through #6, it occurs lower in the section, beginning in the lower part of the middle member.

Environmental interpretation. Silty micrites probably represent deposition in a variety of environments ranging from the subtidal area to the supratidal zone, including tidal pools, lagoons, and marine marshes. The shallow water features such as channels and mudcracks, together with the fine size of marine fossil fragments and fine grain size, indicates that they were deposited predominantly in quiet intertidal areas. The small, almost dwarfed fauna possibly indicates a brackish influence.

The siltstones do not contain diagnostic features; but when siltstone is present, it is usually associated with silty micrite and is thus interpreted to represent similar environmental conditions.

Dolomitization in the south part of the study area is local and thus probably late diagenetic. In the north, however, dolomitization is more widespread and may represent early diagenetic dolomitization.

The increase in clastic material northward and its occurrence lower in the formation to the north indicates that the source for the clastic material in this rock type was situated north of the study area.

Gastropod-Plant Fragment Subtype

In sections #1 and #2, directly above the Productid-Bryozoan-Crinoid Subtype of the Black Micrite Rock Type, is a recessive, very thinly bedded, yellowish-gray weathering silty micrite, containing plant fragments and gastropods. This is a good Paleozoic example of an ecological relationship observed widely in the recent environment. In recent sediments this relationship between gastropods and plant fragments is most common in marine marshes and tidelands. At section #1, this subtype is interpreted to represent infilling of a lagoon or restricted bay; its relationship to the underlying Black Micrite Rock Type and shales is consistent with this interpretation.

SAND ROCK TYPE

This rock type includes all rocks in which 50% of the constituents are sand sized clastic quartz grains, or which have a dominant sandstone aspect. Four distinct types of sand bodies are present in the Amsden Formation, as follows:

1. Thin, commonly intraclastic, locally occurring sandstone beds, generally less than one foot thick.

2. Thin bedded (1" - 3") sandstone units ranging from 3' - 7' in thickness. Small scale ripple cross beds represent the only observable sedimentary structures. This type occurs only in sections #8 through #14.

3. Near the top of the Amsden Formation in sections #8 through #15 is a thin to medium bedded (1" - 24"), very well cross-laminated sandstone unit ranging in thickness from 7' - 15' (Figures 16 and 17).

4. In the north end of the study area, (sections #6 - #1), two sandstone units are channeled into underlying carbonates (Figures 18 and 19). One of these units contains festoon cross-strata.

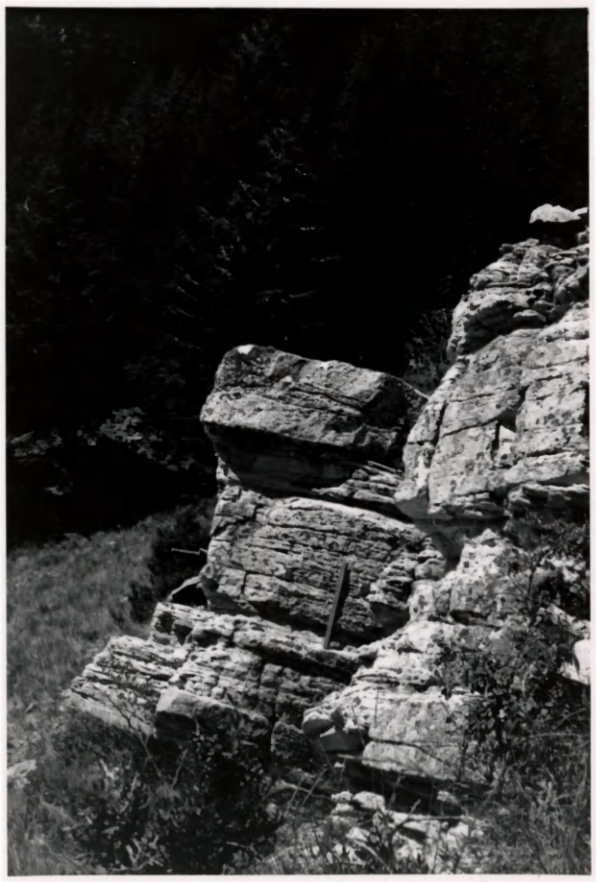
For purposes of discussion, these four varieties are named Subtype I, II, III, and IV, respectively.

Mineralogy

The mineralogy of the sandstones is consistent from subtype to subtype; hence mineralogy of the subtypes will be treated together. The reader is referred to the measured sections in Plates 5 - 19 for detailed mineralogic descriptions of each subfacies. Quartz grains constitute 60 - 75% of the rock and represent the dominent mineralogy; associated grains include minor amounts of detrital chert, zircon,

Figure 16

Various views of bedding and cross stratification
Sand Subtype III



Sand Subtype III

Figure 17

Sand Subtype IV
Showing Lower Member
Carbonate Sand Bed
Figure 18

Festoon Cross-Stratification
Sand Subtype IV

Channel cut in Pelletal Rocks
section 5; Sand Subtype IV

Figure 19

tourmaline, leucoxene, fossil fragments, and carbonate intraclasts. Feldspar is conspicuous by its absence.

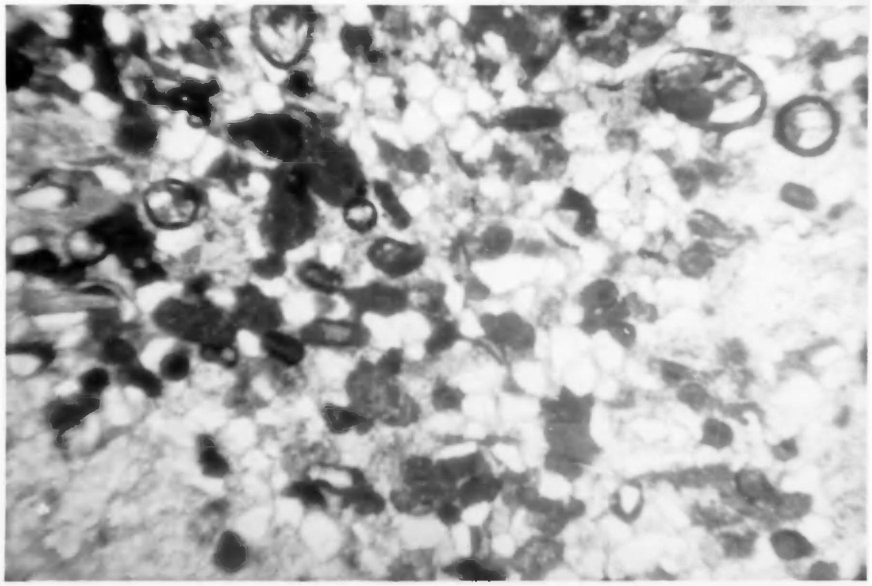
Quartz: Roughly 70% of the quartz grains possess straight or slightly undulose extinction. Composite quartz and vein quartz (Folk, 1961) constitute about 10% each. The remaining 10% occurs as partial silica overgrowths around grains. Grains vary from round to angular, and range from medium silt to medium sand size.

Heavy Minerals: Heavy minerals constitute less than 1% of any sandstone sample. Zircon, tourmaline, and leucoxene are most common; hematite and magnetite occur rarely. Grain size of the heavy minerals average .08 - .12 mm, near the average grain size of the quartz grains.

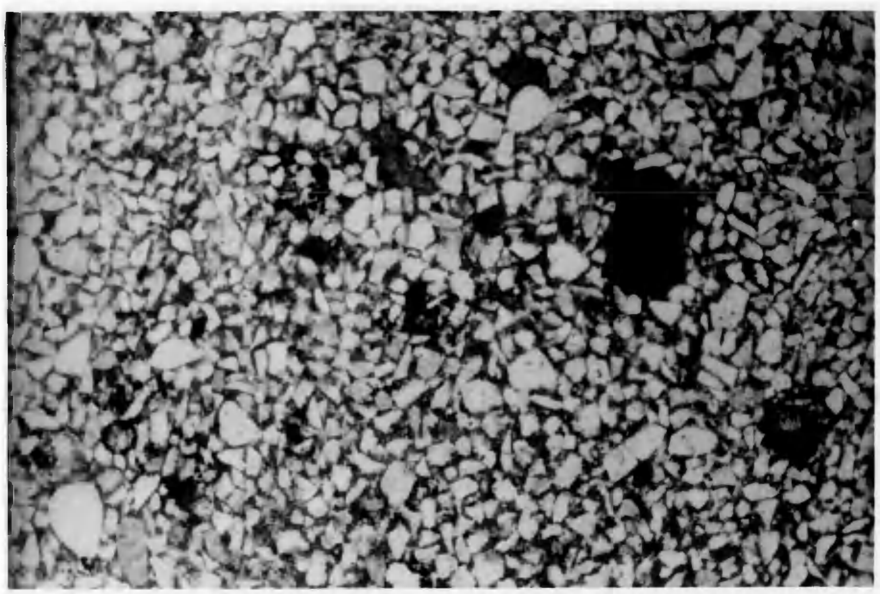
Intraclasts: Intraclasts of sandy micrite, unfossiliferous micrite, pelmicrite, and apterinellid-bearing micrite occur locally, usually near the base and top of the sandstone units. The intraclasts are angular and range from coarse sand to pebble size, thus they are often larger than the average grain size of the sample (Figure 20). Intraclasts constitute up to 15% of the rock locally.

Fossil Fragments: Fossil fragments occur only in minor percentages. Crinoid, brachiopod, and ostracod fragments, algal fragments, and sedentary foraminifers occur as detritus.

Matrix and Cement: Subtypes I, II, and III are carbonate cemented, either by dolomite or calcite. The cement is fine grained and locally comprises up to 50% of the rock. Some beds have a dolomite cement, others a calcite cement, still others are cemented by



Intraclastic Sandstone
Sand Subtype II



Intraclastic Sandstone
Sand Subtype III

Figure 20

both calcite and dolomite. The fact that there is no consistent pattern suggests that the original cement was calcium carbonate that has been incompletely dolomitized.

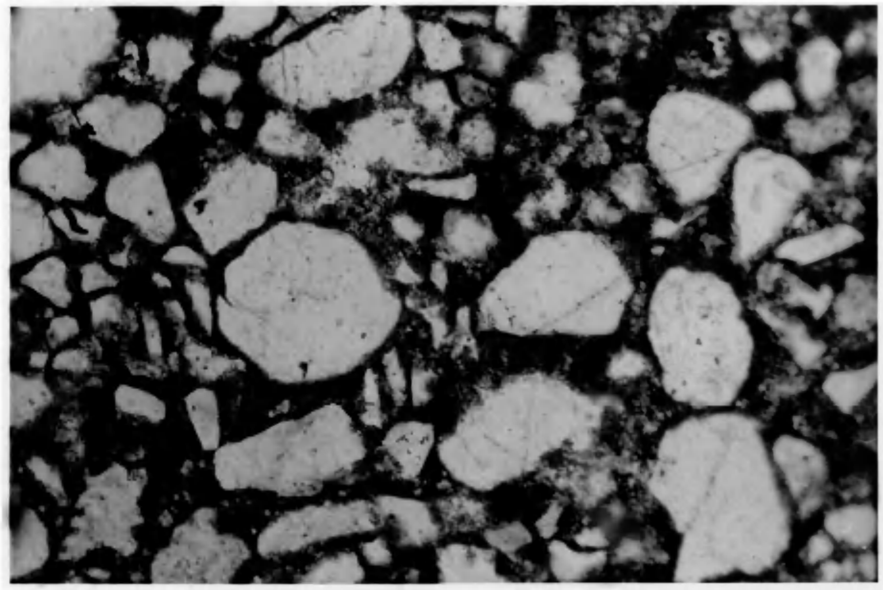
Sand Subtype IV, which exists in only the north end of the area, is also cemented by dolomite and calcite, but also contains considerable clay.

The partial silica overgrowths that locally comprise up to 10% of the quartz appear to be reworked overgrowths from an older recycled sandstone, as evidenced by the following: (1) the overgrowths seldom completely surround single sand grains, (2) some overgrowths appear to have been abraded, (3) in rare instances, two partially overgrown quartz grains are separated by a carbonate intraclast, indicating that an overgrown quartz grain and an intraclast were deposited in grain and grain contact, and (4) it is likely that the finest quartz fraction represents overgrowths that have separated from a quartz sand grain (Figure 21).

Sedimentary Structures

Sand Subtype I. This subtype forms single beds less than one foot thick, with no apparent stratification. It commonly occurs in the middle and upper members in the south end of the study area, and is devoid of sedimentary structures. It usually sharply overlies shallow marine or intertidal carbonates.

Sand Subtype II. This subtype is thin bedded, from 1" - 3", and contains small cross beds up to 3 inches in height. Cross beds



Sand Subtype III

Figure 21

Contact between Subtype III Sand and overlying Mat Algal Rock Type

Figure 22

up to 4 inches high occur locally. The top set beds rest on the beveled surface of the fore-set bed. Three dimensional faces of those cross-strata are generally not exposed in this subtype, thus precluding directional analysis.

Sand Subtype III. This subtype is well cross bedded and is similar to the overlying Quadrant sandstone beds. Top set beds rest on the beveled surfaces of slightly concave fore-set beds (Figure 23); the fore-set beds are tangential to the bottom set beds (Figures 16 and 23). The surfaces of the sand beds are locally channeled and irregular, filled with cut and fill structures (Figure 23). Cross strata of this subtype have two predominant directional components, based upon 20 measurements obtained from three localities. These are, N38°W, 20° SW, and N78°W, 22° SW. Cross strata conform to two size variations; the smaller set measures 14 inches along the inclined bed, and 4½ inches in height; the larger set measures 27 inches along the inclined bed, and 9 inches in height. These figures establish a height-width ratio of 1:3. Degree of inclination of the cross strata averages 20°; they are commonly concave upward.

At two localities, symmetrical ripple marks are present near the top of the sand unit. Orientation of the long axes of these ripples is N30°W, conforming well with the N38°W orientation of certain cross-strata.

The upper few feet becomes thicker bedded locally, ranging up to three feet thick. Evidence of burrowing and "worm trails" observed in the field indicates that near the top of the unit

Cut and Fill Structure
Sand Subtype III

Cross Stratification
Sand Subtype III

Figure 23

original stratification was destroyed locally by burrowing organisms. This subtype appears to be conformable with underlying and overlying carbonate units.

Sand Subtype IV. This subtype occurs only in the northern part of the study area, where it forms channel deposits cut into underlying sediments. These sands may be overlain by the Carbonate Sand Rock Type, Mat Algal Rock Type, or the Pelletal Rock Type.

At sections #5 and #6, direct evidence of channeling was observed in two sand units (Figure 19). The lower sand exhibits well developed festoon cross-stratification (McKee & Weir, 1953), (Figures 18 - 19), while the upper sand is very thinly bedded, with minor festoon cross strata at this locality. At sections #5 and #6, these sands are deposited in channels cut into the Pelletal Rock Type. At section #2, a sand unit equivalent to the lower sand of sections #5 and #6 appears to be deposited in a channel cut into the Silty-Micrite-Siltstone Rock Type.

It is difficult to determine if the sand was deposited contemporaneously with adjacent sediments, or if it was deposited in previously eroded channels. At section #5, there is evidence of interbedding with adjacent pelletal rocks; however, the pelletal rocks may represent a levee and could have formed at any time. The writer concludes that the channels formed contemporaneously with adjacent sediments, primarily because of the consistent position of channel sands directly above correllatable Carbonate Sand beds, indicating a specific period of channel formation. Had the channels been cut in older sediments, downcutting would be irregular across the area and the base of the channels should not everywhere be limited to a specific level. The lower contact of these sands is very intraclastic, with intraclasts composed of pelletal micrite or silty micrite.

Mechanical Analysis

The change upward from the thinly bedded, poorly cross-laminated rocks of subtype II to the thicker bedded, well cross-laminated rocks of subtype III represents increasing energy conditions at the site of deposition. In thin section, however, there is little apparent difference between the grain characteristics of these two subtypes. Mechanical grain analysis was performed on single samples of each subtype in an attempt to bring out subtleties not evident in thin section.

A single sample of subtype II and a single sample of subtype III were disaggregated with concentrated hydrochloric acid and seived, using a $\frac{1}{2}\ \phi$ pan interval. Due to the clay in the cement in subtype IV and the ensuing difficulties in disaggregating such a sample, this subtype was not analyzed by mechanical methods.

A single sample of a sand body is not necessarily a true representation of the characteristics of the entire sand body. However, in the case of subtypes II and III, no important differences in mineralogy, grain size, or percentage of matrix could be detected at the outcrop, in rock slabs, or thin section, from any sample collected at any point in either subtype. Both samples are from the middle of their respective rock units, collected from the middle of a bed. Mechanical analysis did uncover some differences between the two samples, and the information is presented below.

Discussion. The sand sample of subtype II has an average mean grain size of 2.68 ϕ. The curve is slightly leptokurtic (KG = 1.13) indicating that the central portion is better sorted than the tails. Skewness value is +.203, or finely skewed. If this sample is representative, the combination of positive skewness and leptokurtism suggests exposure to an efficient sorting environment followed by transport to a low energy depositional site (Folk and Mason, 1951).

The sand sample of subtype III has an average mean grain size of 2.95 ϕ. The curve is platykurtic, indicating that the tails are better sorted than the central portion of the curve. Skewness value is -.1108, or slightly coarse skewed. Overall sorting is better in subtype III (O_I = .399) than in subtype II (O_I = .475). Volumetrically, subtype II contains a higher percentage of silt size grains (3.23% of sample) than does subtype III (.41% of sample).

Grain roundness was estimated by comparing 100 grains from each ½ ϕ pan with Powers (1953) roundness scale. Values from 0 (very angular) to 6 (well rounded) were assigned to the Powers grades, after Folk (1961). The average gross value for subtype II is angular; average for subtype III is subangular. Plotting roundness against grain size in subtype III produces a trend with the larger grains more rounded and the smaller grains more subangular. The same analysis on subtype II produces no trend; most of the grains in all fractions fall in the angular class. This is an important difference between the two subtypes; it indicates that the environment of deposition had some effect on grain roundness in the subtype III sample, but no effect on the sample of subtype II.

The combined data suggests that the sample of subtype II passed through an efficient sorting environment and was deposited in a low energy environment by weak currents. Subtype III is a product of the same transporting medium, but was deposited in a higher energy environment that was capable of partially rounding the coarser grains and removing some of the finer grains from the population.

Environmental Interpretation. Sand Subtype IV. Field evidence at sections #5 and #6 indicates that these sands were deposited in channels within shallow marine and intertidal carbonate sediments. Ball (1967) describes carbonate sand deposits in Florida, deposited in channels cut into intertidal and supratidal sediments, resulting in a series of bars and channels. The channels are subject to current velocities that are sufficient to locally transport and wash sediment but too weak to carry sediment basinward.

This interpretation can be applied to the channel deposits of this subtype. In this case, however, the channels contain quartz sand, which is interpreted to have been derived from a terrestrial sand body that existed outside of the study area, perhaps an eolian sand body. These channel sands occur lower in the formation than do subtypes II and III; this observation, together with a northerly increase in the clastic nature of the Silty-Micrite-Siltstone Rock Type, strongly indicate that the source area for these sands was north of the study area.

Sand Subtype III. This subtype occurs only in the south part of the study area in sections #8, #12, #13, #14, and #15, and is apparently present but covered in sections #9 through #11. The discontinuous nature of the outcrops precluded direct field examination to support the above statement. However, this subtype appears very similar at each outcrop and is interpreted to represent a single movement of sand over the south end of the area.

This subtype conformably overlies the Mat Algal, Pelletal, Silty Micrite, and Fossiliferous Dolomite Rock Types, and is conformably overlain by Mat Algal and Pelletal rocks. This relationship to predominantly intertidal sediments indicates that deposition was in shallow marine to intertidal environments.

The dominant type of cross-stratification is unidirectional and planar (McKee & Weir, 1953). Therefore this sand was probably not a fluvial, channel, or eolian deposit, nor was it affected significantly by differential tidal currents such as in marine passes or across bars.

The consistent indication that a shoreline of the Amsden Sea was very close to the north end of the study area, together with unidirectional transport from the north, suggests that this subtype represents progradation over a low energy intertidal area. The nature and size of cross-strata indicates that bed forms were sand waves, and that Sand Subtype III was transported as megarippled sand sheets over the area.

Although direct evidence is lacking, I believe that this subtype may be the result of a shallow marine fan, building seaward from the north, and fed by a distributary river mouth.

Sand Subtype II. The low amplitude of ripple cross-strata and the finer grain size of this subtype when compared to subtype III, indicates that it represents a lower energy equivalent to Sand Subtype III. The sand is probably winnowed from the higher energy environment and deposited as rippled sand sheets in the shallow marine environment or on an intertidal sand flat.

Sand Subtype I. This subtype is interpreted to represent isolated patches of sand in a variety of environments. Its occurrence at any locality is perhaps due to local conditions of topography and energy conditions that caused the sand to be accumulated in one locality rather than being dispersed and scattered throughout the environment.

ROCK TYPES OF SECTIONS 1 AND 2

Two previously discussed subtypes and two rock types occur only at sections #1 and #2 in the study area. These lithologies are separated for discussion because they strongly indicate that sections #1 and #2 existed as a depressed area in the supratidal environment that received periodic influxes of marine waters. The fact that these lithologies do not occur immediately south of section #2 indicates that this depression was limited in extent; it probably represents a marine lagoon.

Previously discussed subtypes are: Productid-Bryozoan-Crinoid Subtype of the Black Micrite Rock Type (northern variety), and the Gastropod-Plant Fragment Subtype of the Silty Micrite-Siltstone Rock Type. Both of these subtypes are interpreted to be lagoonal in origin. The following discussion deals with the two additional rock types present at one or both of these measured sections.

Shale Rock Type

This rock type is composed of recessive, fissile, calcareous black and green fossiliferous shales, occurring only in the vicinity of sections #1 and #2, where it overlies Sand Subtype IV and underlies the Productid-Bryozoan-Crinoid Subtype. Observable fossils consist of ostracods and tiny bryozoan fronds (½" in height).

Environmental interpretation. Although ostracods are not completely indicative of a marine environment, their association with bryozoans indicates that the environment was marine. The predominance of clay in the environment and the small size of the bryozoans indicates very quiet water having restricted circulation with marine waters that precluded development of a diverse and robust fauna. It is therefore interpreted that this rock type represents deposition in a marine lagoon behind supratidal sediments; the lagoon was not directly connected with marine waters, but was most likely inundated by tidal overflows during minor marine transgressions.

Millerellid-Productid Limestone Rock Type

This rock type occurs only in section #1, where it weathers to light gray, resistant beds, 1' - 2' thick. Fossils include productid, rostrospiriferid and spirifer brachiopods, millerellid foraminifers, crinoid and echinoid fragments, and some encrusting foraminifers (Figure 6). The matrix is micrite, often slightly recrystallized, with varying amounts of silt and clay. Tan chert stands in relief on the weathered surface.

These occur at three positions in section #1 (Plate II). The lower two beds do not exist at section #2; the uppermost bed is directly correllatable with a bed of the Carbonate Sand Rock Type at section #2. All three beds sharply overlie rocks of the Silty Micrite Rock Type and Laminated Spiculitic Subtype of the Black Micrite Rock Type.

Environmental interpretation. The above mentioned fossils indicate that these rocks were deposited in a marine environment. However, underlying and overlying rocks are interpreted to represent intertidal to supratidal deposition, creating an apparent discrepancy in expected superposition of marine environments.

The lowermost exposure is channeled into the underlying sediments and is interpreted to represent a tidal channel cut into intertidal sediments during a marine incursion phase. Since it overlies the lower member and contains millerellids, it can be related to the deposition of the Millerellid-Brachiopod-Crinoid Rock Type in the south part of the study area. The upper two beds were not well enough exposed to determine the nature of the deposits relative to underlying rocks. However, the very sharp boundaries at the upper and lower surfaces of these upper two beds indicates that they, too, probably represent either channels, or possibly lagoonal deposits formed during marine incursions.

Presence of millerellids in the upper most bed is less easily explained than it was for the lower exposures. There are no units in any of the other measured sections that contain millerellids and that can be related to this bed. It must be assumed, therefore, that if the upper beds are channels, that they are related to a depositional environment not present in any of the sections measured.

Conclusions. These subtypes and rock types of section #1 and #2 indicate marine sedimentation in sharp vertical association with intertidal and supratidal sediments. They are limited in their occurrence to sections #1 and #2, and do not occur north of section #2. All four lithologies are interpreted to represent shallow marine sedimentation, as lagoonal or channel carbonate deposits.

The environment in the vicinity of sections #1 and #2 represents a depressed area in the intertidal-supratidal environment into which shallow marine waters entered during periods of marine incursions. The disappearance of these lithologies south of section #2 indicates that the depressed area terminates in the vicinity, or a short distance south, of section #2. At this position, particularly sections #3 and #4, the interval is occupied by siltstone (dolomitic) which is interpreted to represent supratidal sedimentation.

SANDY FOSSILIFEROUS DOLOMICRITE ROCK TYPE

This rock type is limited to the south part of the study area, where it often underlies either the Carbonate Sand Rock Type or Sand Subtype II and III. Although principally a dolomite, the matrix grades laterally from clayey, silty, or sandy dolomicrite to sandy micrite. Dolomitization may be complete at one section, completely lacking in another, and at yet another dolomite may occur in irregular patches. For this reason, these rocks probably represent a clayey, silty, or sandy micrite that was subsequently dolomitized.

Fossils are predominantly silicified brachiopod and crinoid fragments, but may include minor amounts of ostracods, echinoid fragments, algal plates, and encrusting foraminifers. Many beds are unfossiliferous.

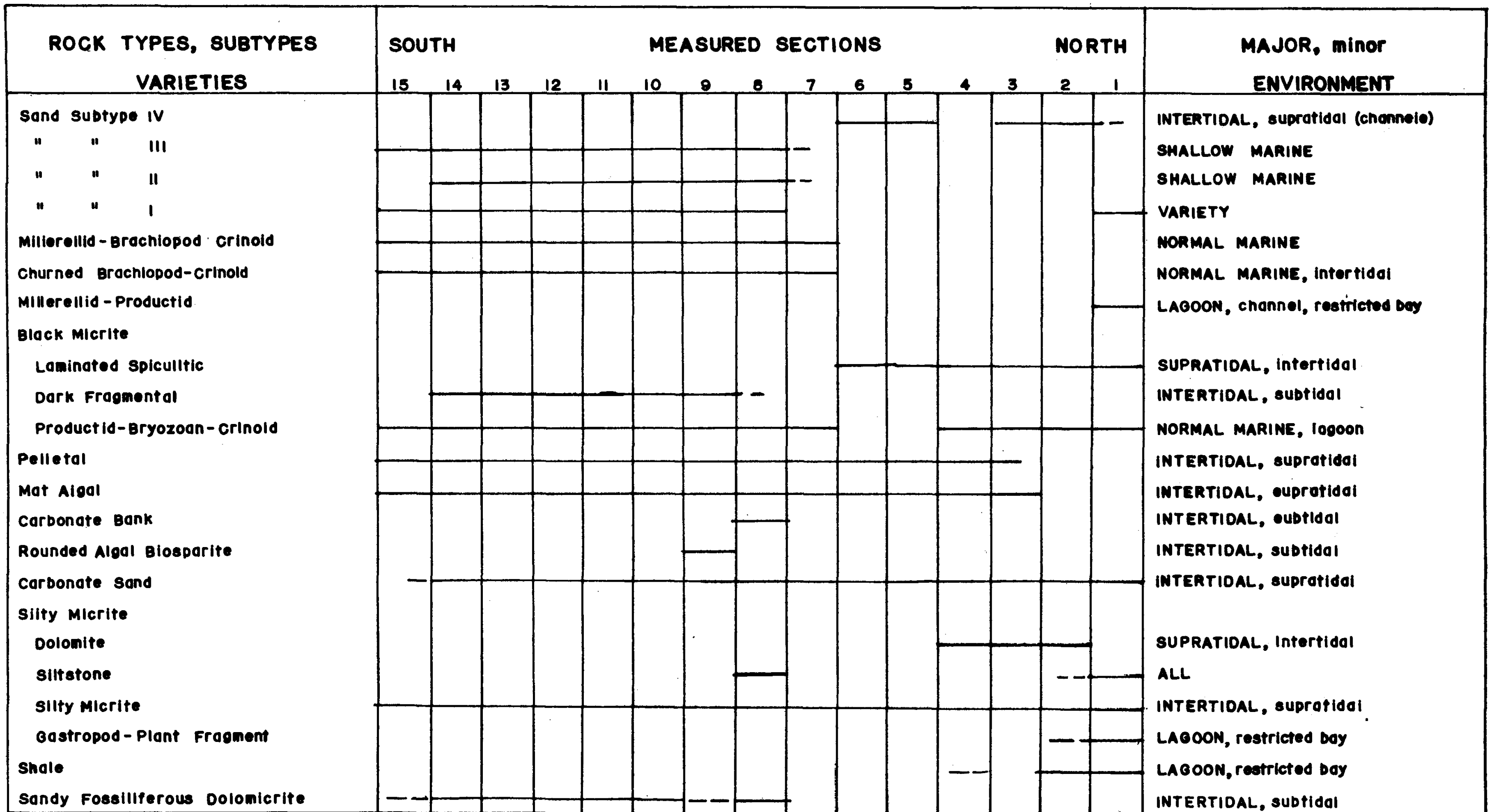
These rocks weather to recessive, yellowish beds, 2" - 12" thick, light brownish-gray to yellowish-gray on the fresh surface. Exposures are generally poor.

Environmental interpretation. The few fossils preserved indicate that this rock type was deposited in a marine environment. No diagnostic indicators were found to establish a specific environment. Although poorly exposed, it is usually associated vertically with two lithologies that are interpreted to represent shallow, near shore marine sedimentation. Therefore, it is interpreted to represent deposition in the shallow open marine environment, slightly seaward from a beach or carbonate shoal, with sedimentation and faunal diversity influenced by the incursion of fine terrigenous matter into the environment. The presence of fine grained clastics in large amounts indicates that deposition probably occurred slightly below effective wave base.

SUMMARY OF ROCK TYPES

The thirteen rock types and nine associated subtypes discussed above are representative of all the exposed rocks in the study area.

Figure 24 lists the rock types, their major indicated environment, and their dominant positions in the study area. It may be seen from Figure 24 that there are changes in dominance of rock types between sections #6 and #7, and between sections #2 and #3. Rock types present in sections #7 through #15 are predominantly open marine and intertidal sediments; sections #3 through #6 have predominantly intertidal and supratidal sediments, while sections #1 and #2 are predominantly lagoonal and intertidal-supratidal.



COMPARATIVE OCCURRENCE
OF ROCK TYPES AND ENVIRONMENTS

FIGURE 24

It is important to note here the main differences in rock types between the north half (Plate II) and the south half (Plate I) of the study area. Between these areas a major change occurs in predominance and occurrence of rock types and subtypes. These changes and their significance are discussed below.

Lower Member

Rocks of the lower member change dramatically northward from a Mat Algal-Pelletal-Brachiopod-Crinoid Churned Micrite Rock Type association in sections #7 through #15 to the Laminated Spiculitic Subtype in sections #1 through #6.

Millerellid-Bearing Rocks

The Millerellid-Brachiopod Rock Type of sections #7 through #15 changes progressively northward to the Pelletal Rock Type at section #4, then to the Mat Algal Rock Type at section #3.

Clastic Content

In sections #1 through #6, there is an increase in clastics in rocks of the middle member, notably in the form of channel sands and silty dolomite. In sections #7 through #15, sandstones (excepting Sand Subtype I) are limited to the upper member, and show evidence of ripple and megaripple simple cross-strata, and conformable association with marine intertidal sediments.

In general, the above considerations lead the author to conclude that three major environmental provinces, governed by paleoslope topography, remained fairly stationary and affected Amsden sedimentation markedly. Sections #7 through #15 existed primarily in the shallow open marine-intertidal province; sections #3 through #6 were primarily in the intertidal-supratidal province; sections #1 and #2 were depressed areas behind or within the supratidal province, receiving sediment during transgressive periods or spring tides.

The increase in clastics northward and their occurrence lower in the stratigraphic column in the north indicate that clastics moved from north to south across the area. This conclusion is further supported by cross bedding directions in Sand Subtype III. The direction of sand movement indicates that the immediate source was north of the study area.

Chapter 4

DEPOSITIONAL HISTORY

By integrating the rock types into their stratigraphic framework, the depositional history of these rocks can be interpreted. To facilitate discussion of this history, the stratigraphic sections have been divided into intervals (Plates I and II). The boundaries of intervals may not necessarily represent true time surfaces. They do, however, represent significant vertical changes in depositional environment that can be generally correlated from section to section.

To aid in the understanding of the depositional history, the reader is referred to Plates I and II, and Text-Figures 25 through 28. The latter are plan views of my conception of general distribution of sediments during one or more stages in each interval. It must be emphasized that these Text-Figures are general and conceptual, and are presented as an aid to visualize a possible distribution of sediments during each interval.

INTERVAL ONE

This interval includes the rocks of the Lower Member. During Interval One a thick sequence of the Pelletal and Mat Algal Rock Types developed in sections #7 through #15. Brief marine incursions occurred here during this interval noted by the periodic appearance of the Churned Brachiopod Crinoid Micrite Rock Type (Figure 25, 1).

In sections #1 through #6, the Laminated Spiculitic Subtype of the Black Micrite Rock Type was deposited in an area interpreted as predominantly supratidal. This subtype is usually unfossiliferous, but brief appearances of crinoid, bryozoan, and brachiopod fragments indicate that this northern area was also affected by periodic marine incursions.

Near the end of Interval One there was a progressive but gradual marine incursion. This event is indicated by development of the Churned Brachiopod-Crinoid Micrite Rock Type in the south part of the study area. In the north this gradual incursion apparently affected only section #1 where gastropods and marine fossil fragments appear in the Laminated Spiculitic Subtype, followed by deposition of the Millerellid-Productid Rock Type in a tidal channel. Adjacent to the channel the Silty Micrite Rock Type is present and is interpreted to represent sedimentation in the intertidal environment. In the other northern sections, notably sections #2 through #6, the Laminated Spiculitic Subtype apparently continued as the dominant sediment, indicating that this area remained supratidal during the last phase of Interval One. It is likely that section #1 represents a topographically depressed area in the supratidal province, connected in some manner with the marine environment.

INTERVAL TWO

This interval (Figure 25, 2) records the culmination of the marine incursion that began in the preceding interval. At the beginning of Interval Two, the Millerellid-Brachiopod-Crinoid Micrite Rock Type developed rapidly across sections #7 through #15, while in the north the Mat Algal Rock Type and the Pelletal Rock Type developed at sections #3 and #4, representing the intertidal zone. At section #1, this event is recorded by development of the Millerellid-Productid-Micrite Rock Type in what is interpreted to be either a tidal channel or lagoon. Section #2, and sections #5 and #6 do not contain a record of this event; rocks occupying this interval at these sections belong to the Laminated Spiculitic Subtype, indicating that these three sections either remained above sea level during this interval, or that the Laminated Spiculitic Subtype continued to be deposited during Interval Two.

INTERVAL THREE

At the beginning of Interval Three (Figure 25, 3), deposition of the millerellid bearing sediments of the preceding interval ceased abruptly, perhaps due to rapid withdrawal of marine waters from the study area. At section #1, the base of this interval is marked by ten inches of burrowed clayey dolomite containing broken fossil fragments, directly overlying the Millerellid-Productid Micrite Rock Type. At section #4, the base of this interval is occupied by the Pelletal

Rock Type, while at sections #10 and #11, part of the interval is occupied by intraclastic, sandy and silty, pelletal micrite. At section #15, this interval is occupied partly by the Pelletal Rock Type with an upper bored surface, and partly by sandy, fossil hash zones. Since this interval is poorly exposed, it is difficult to determine the entire sequence of events. However, the scoured intraclasts within this interval indicate that Interval Three involved a rapid marine withdrawal that exposed the area and formed a surface with scattered tidal pools in which the Pelletal Rock Type formed. Clastics present in this interval were probably windblown. Due to the marine nature of the following interval, the remainder of Interval Three is assumed to represent another marine incursion over the study area.

INTERVAL FOUR

This interval (Figure 25, 4) records the development of the Productid-Bryozoan-Crinoid Subtype of the Black Micrite Rock Type in sections #7 through #14, #4, and #3. Sections #2, #5, and #6 contain some exposures of the Laminated Spiculitic Subtype at this interval, and are interpreted to have either remained above sea level, or to have continued receiving sediment of the Laminated Spiculitic Subtype during this interval. Siltstone and silty micrite developed in section #1 during Interval Four.

Section #15 did not receive sediment during Interval Four; a sandy, fossil hash zone directly above Interval Three at this location indicates that the vicinity of section #15 had become emergent at the beginning of Interval Three. The absence of sediment at section #15 during this and later intervals strongly suggests that this emergence was severe, elevating the immediate area relative to surrounding areas. This emergence may be indicative of similar events in and adjacent to the study area, and perhaps explains the rapid withdrawal of marine waters from the area at the beginning of Interval Three.

At the end of Interval Four, a minor marine withdrawal from the north end of the study area caused the Silty Micrite Rock Type to develop over the Productid-Bryozoan Crinoid Subtype at sections #3 and #4.

INTERVAL FIVE

This interval and Interval Seven represent a complex sedimentary history that involves development of carbonate sand bodies, a probable supratidal and lagoonal area, and channel sandstones. Incomplete exposures complicate the two intervals further. The distribution of sediments of Interval Five is first described, followed by an interpretation of the relationships between rock types.

Descriptive

Interval Five (Figure 25, 5a & 5b) began with development of the Pelletal Rock Type in sections #7 through #14, and the Carbonate

Sand Rock Type at sections #1 through #6. At section #15, this basal deposit is represented by a brachiopod rich bed.

Following deposition of this basal Pelletal-Carbonate Sand unit, Pelletal and Mat Algal Rocks were deposited in sections #7 through #14 (5b), while at sections #5, #6, and #2, channel sands developed. Sections #3 and #4 received silty dolomite during this later part of the interval. Section #15 received sandstone, silty micrite and silty dolomite during the last part of this interval.

Interpretive

Interval Five began with a period of higher energy wave agitation that spread Carbonate Sand across the northern area; this increased current activity was limited to sections #1 through #6, and section #15. Section #15 remained as a slight topographic rise on which brachiopods proliferated in a nutrient-rich, current swept area. Sections #7 through #14 represent quieter intertidal sedimentation, in which Pelletal and Mat Algal sediments formed throughout the interval.

The silty dolomites at sections #3 and #4 are interpreted to represent supratidal sedimentation, either as an island or as a peninsular extension of an emergent area. Section #1 is interpreted as a lagoonal area behind this feature.

Development of channel sands occurred in the intertidal zone; at sections #5 and #6 adjacent sediments were primarily pelletal muds, perhaps representing levee and interdistributary sediments. At section #2, adjacent sediments are not exposed, but were probably silty micrite. Origin of the sand is not certain; eolian spill-overs outside the study area may have been the source, or the sand may have been derived from fluvial systems draining a nearby emergent area.

Sand was confined to the channels due to low energy conditions in the intertidal environment; spillovers were not observed. The pelletal rocks of sections #8 through #14 are only slightly sandy (3 - 10%), indicating either that sand was widely dispersed seaward from the channel mouths, or that the channels continued past these sections, and that sections #8 through #14 represent interdistributary areas between channels.

Section #15 does contain clastics during this interval, attributed to higher energy conditions caused by the higher topographic nature of this area relative to sections #8 through #14.

As interpreted, the relationship of these rock types to one another is similar to the relationships found by Ball (1967) in platform interior sand blankets at Andros Island. In his study, Ball noted channels cutting supratidal islands, with pelletoidal carbonate sands forming adjacent to the islands in the intertidal zone.

The pelletal muds adjacent to the channels at sections #5 and #6 would be the low energy analogy to the intertidal carbonate sands of Ball. The dolomites at sections #3 and #4 are analogous to the islands in Ball's study. Text-Figure 25, 5a & 5b, depicts the author's conception of general sediment distribution during Interval

Five.

Interval Five ended with the development of the Mat Algal Rock Type in sections #8 through #14.

INTERVAL SIX

Interval Six (Figure 26, 6) represents a rapid marine incursion which spread the Carbonate Sand Rock Type over sections #2 through #15. At section #1, the Millerellid-Productid Rock Type was deposited in a lagoon or restricted bay.

INTERVAL SEVEN

During Interval Seven (Figure 26, 7), the Pelletal and Mat Algal Rock Types spread over sections #5 through #14; section #15 either did not receive sediment during this interval, or was deposited and later eroded. At sections #3 and #4, this interval is not exposed, but from dolomite float the vicinity is interpreted to have remained supratidal. At sections #5 and #6, a channel once again formed, cut into the adjacent Pelletal Rock Type.

Sections #1 and #2 received a thin fossiliferous sand deposit, interpreted to represent eolian flat or channel spillover.

INTERVAL EIGHT

This interval (Figure 26, 8) marks the end of exposed channel sand deposition and the beginning of differential subsidence and emergence in the south part of the study area.

Channel sand at sections #5 and #6 disappeared, either due to meandering of the channel course or to a depletion of the sand source. The beginning of Interval Eight at these sections is marked by development of Mat Algal and Pelletal Rocks, alternately deposited with the Silty Micrite Rock Type. At section #3, Mat Algal, Pelletal and Silty Micrite Rock Types were alternately deposited during Interval Eight. Section #3 continued to receive dolomite in the supratidal environment, while at sections #1 and #2, the lagoonal aspect became more accentuated, and black shale, representing the Shale Rock Type was deposited.

In the south part of the study area, important changes began to occur during this interval. Section #8 continued to receive pelletal mud, while adjacent to section #8, sections #9, #10, and possibly section #11 began receiving the black organic sediments of the Dark Fragmental Subtype of the Black Micrite Rock Type. Dark colored pelletal muds were deposited at sections #13 and #14; section #15 either did not receive sediment during this interval, or sediment was deposited and later eroded.

Sediments at section #8 during this interval are intraclastic and sandy, with minor sandstone development. The nature of the sediment at this section, together with the abrupt change southward into the Black Micrite Rock Type indicates that during, and possibly previous to Interval Eight, shoaling conditions developed at section #8.

INTERVAL NINE

This interval (Figure 26, 9) records development of the Carbonate Bank Rock Type on the shoal formed during the previous interval, while southward, the Dark Fragmental Subtype continued to be deposited at sections #9 and #10; sections #13 and #14 continued to receive pelletal mud. Sections #4 through #7 are covered above Interval Eight. At sections #1 and #2 the Productid-Bryozoan-Crinoid Subtype of the Black Micrite Rock Type was deposited in the continuing lagoonal or restricted bay environment; section #3 apparently continued to receive the silty dolomites of the supratidal environment. This interval is interpreted to represent a marine incursion over much of the area.

INTERVAL TEN

This interval (Figure 26, 10a & 10b) records development of the Silty Micrite Rock Type over much of the area. At sections #1 and #2, the Gastropod-Plant Fragment Subtype of the Silty Micrite Rock Type represents infilling of the lagoonal area. Rocks representing this interval at sections #3 through #7 are not exposed. At sections #8, #9, and #10, the Silty Micrite Rock Type developed. At sections #13 through #15 the majority of Interval Ten is not present. The end of Interval Ten (10b) is marked by the spreading of Sand Subtype I over much of the area.

Below this sand, it is evident from Plate I that there is considerable thinning of interval at sections #13, #14, and #15. This thinning is believed to represent tilting of the south part of the area sometime previous to the development of Sand Subtype I over the area. No direct evidence could be found to indicate if sediment had been deposited and later eroded, or if the thinning is due to non-deposition previous to, or during Interval Ten. At sections #13 and #14, sediments representing Intervals Nine and most of Ten are not present, while at section #15, Intervals Seven, Eight, Nine, and most of Ten are absent. Previous to development of Sand Subtype I at the end of Interval Ten, the effects of the tilting in the south had diminished, and the depositional interface became a reasonably level surface.

INTERVAL ELEVEN

Interval Eleven (Figure 27, 11) represents invasion of the study area by shallow marine waters. At sections #13 and #14, the Dark Fragmental Subtype of the Black Micrite Rock Type was deposited, while at sections #8, #9, #10, and #15, the Silty Micrite Rock Type formed.

North of section #8, there are no exposures for this and later intervals. From indirect evidence, such as the predominance of float from the Quadrant Formation, and the short distance upward to where the Quadrant Formation actually outcrops above the top of Interval Ten, it is assumed that during the preceding marine withdrawal, clastics had moved into the vicinity of sections #1 through #5.

INTERVAL TWELVE

Interval Twelve (Figure 27, 12a & 12b) began with a period of increased wave agitation and a drop in wave base that spread the Carbonate Sand Rock Type over sections #8, #12, and #13. This deposit perhaps represents sediment derived from areas farther offshore, torn up by a drop in wave base, and spread across the intertidal area during a period of severe tidal fluctuation.

Following deposition of the Carbonate Sand Rock Type, rippled sand sheets of Sand Subtype II moved into sections #8, #13, and #14 (12b). This event is interpreted as regressive, representing the initial progradation of sand sheets into the area.

INTERVAL THIRTEEN

This interval (Figure 27, 13a & 13b) depicts a brief inundation, in which the Pelletal Rock Type moved across the south part of the study area. Following this event, Sand Subtype II moved into the vicinity of section #8, and the Fossiliferous Dolomite Rock Type formed to the south (13b). At section #15, this interval is not exposed.

INTERVAL FOURTEEN

Interval Fourteen (Figures 27 and 28, 14a & 14b) began with development of a very thin deposit of the Mat Algal and Pelletal Rock Types at section #8, while the Fossiliferous Dolomite Rock Type remained in the sections to the south.

Following this event, Sand Subtype III, representing a prograding sand sheet, moved across sections #8 through #15 (14b).

INTERVAL FIFTEEN

Interval Fifteen (Figure 28, 15) records the last major marine carbonate movement found in the study area. This interval began with development of the Mat Algal Rock Type over Sand Subtype III, followed by the Pelletal and Silty Micrite Rock Types at sections #8 through #12, and by the Pelletal Rock Type and Dark Fragmental Subtype at sections #13 and #14.

Presence of these rocks indicates that a marine incursion re-established the south part of the study area as a marine carbonate intertidal area. It is important to note that, within these marine carbonates, virtually no sand grains are present, even though the area was most likely surrounded by sand at this time.

The top of Interval Fifteen marks the upward limit of exposed Amsden rocks in the area. The Quadrant Formation is only a few feet above the top of this interval, and it is apparent that following Interval Fifteen, the area was dominated by sand deposition.

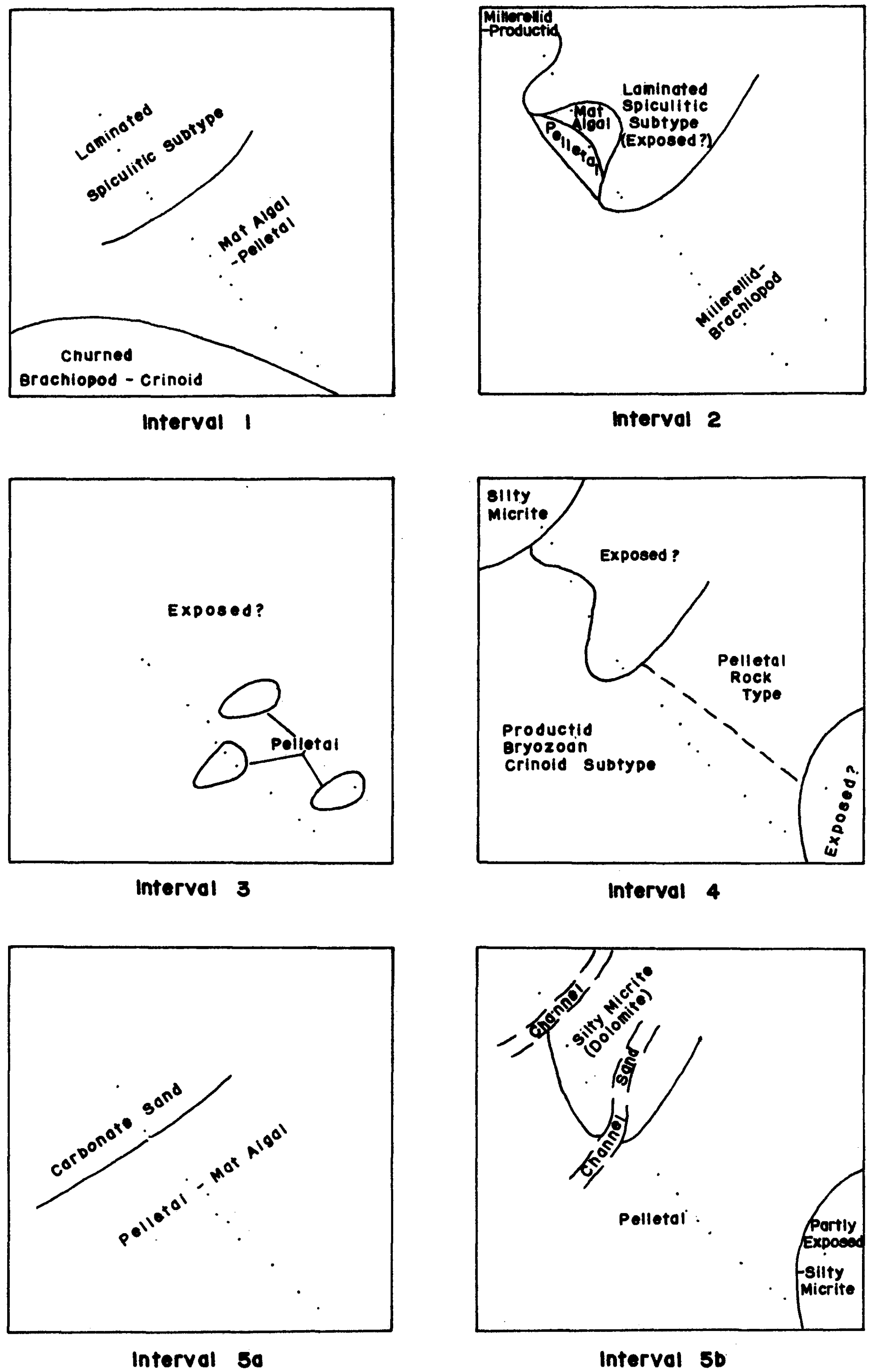

Laminated
Spiculitic Subtype
Mat Algal
-Pelletal
Churned
Brachiopod - Crinoid
Interval 1
Millerellid
-Productid
Laminated
Spiculitic
Subtype
(Exposed?)
Mat
Algal
Pelletal
Millerellid-
Brachiopod
Interval 2
Exposed?
Pelletal
Interval 3
Silty
Micrite
Exposed ?
Pelletal
Rock
Type
Productid
Bryozoan
Crinoid Subtype
Exposed?
Interval 4
Carbonate Sand
Pelletal - Mat Algal
Interval 5a
Channel
Silty Micrite
(Dolomite)
Sand
Channel
Pelletal
Partly
Exposed
-Silty
Micrite
Interval 5b

FIGURE 25

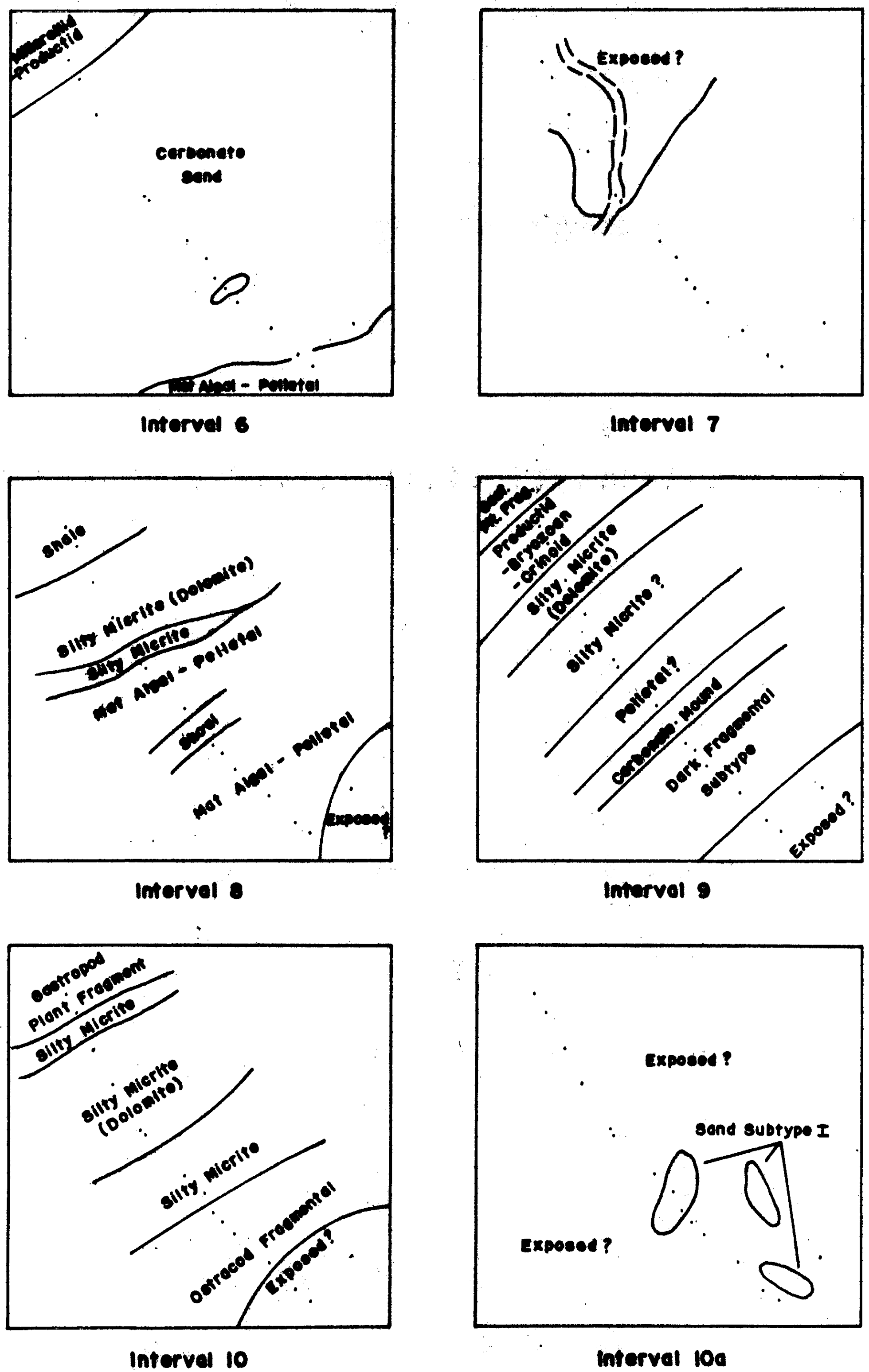

Productid
Carbonate Sand
Algal - Pelletal
Interval 6
Exposed ?
Interval 7
Shale
Silty Micrite (Dolomite)
Silty Micrite
Mat Algal - Pelletal
Mat Algal - Pelletal
Exposed ?
Interval 8
Pt. Frag.
Productid
-Bryozoan
-Crinoid
Silty Micrite (Dolomite)
Silty Micrite ?
Pelletal ?
Carbonate Mound
Dark Fragmental Subtype
Exposed ?
Interval 9
Gastropod
Plant Fragment
Silty Micrite
Silty Micrite (Dolomite)
Silty Micrite
Ostracod Fragmental
Exposed ?
Interval 10
Exposed ?
Sand Subtype I
Exposed ?
Interval 10a

FIGURE 26

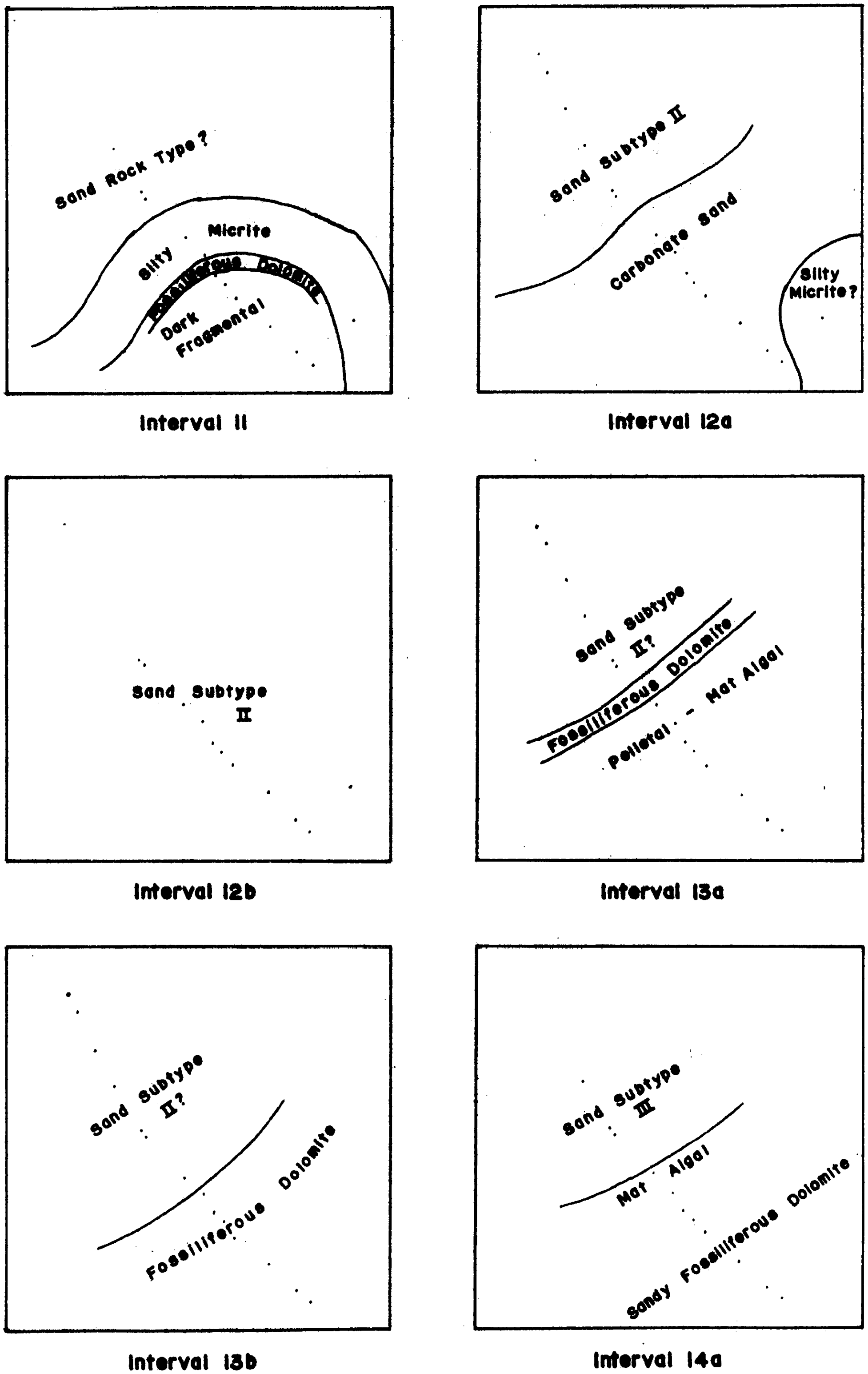
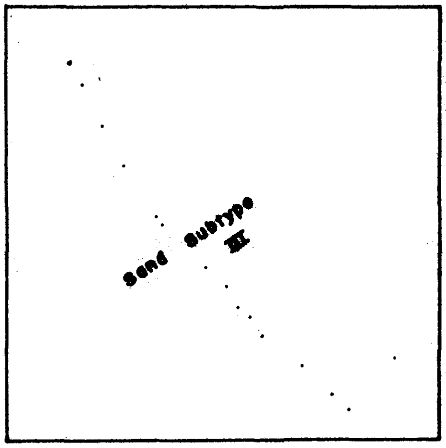
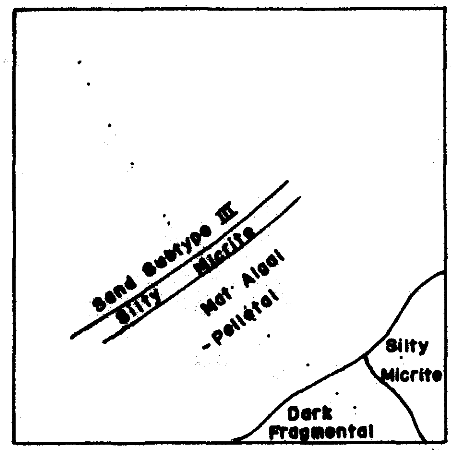

Sand Rock Type?
Silty Micrite
Fossiliferous Dolomite
Dark Fragmental
Interval 11
Sand Subtype II
Carbonate Sand
Silty Micrite?
Interval 12a
Sand Subtype II
Interval 12b
Sand Subtype II?
Fossiliferous Dolomite
Pelletal - Mat Algal
Interval 13a
Sand Subtype II?
Fossiliferous Dolomite
Interval 13b
Sand Subtype III
Mat Algal
Sandy Fossiliferous Dolomite
Interval 14a

FIGURE 27



Interval 14b



Interval 15

FIGURE 28

Chapter 5

SUMMARY

The Pennsylvanian Amsden Formation in the Tendoy Mountains, Beaverhead County, Montana, contains subtidal, intertidal, and supratidal carbonate rocks that intertongue with, and grade upward to shallow marine quartz sandstones of the Quadrant Formation.

Carbonate rocks were divided into eleven rock types and five associated subtypes. Sandstones were included as one rock type and divided into four subtypes. Environment of deposition was interpreted for each rock type and subtype on the basis of color, texture, allochems, fossils, and sedimentary structures.

Carbonate rock types include the following: churned brachiopod-crinoid (subtidal); millerellid-brachiopod-crinoid (subtidal); millerellid-productid (lagoon, channel, restricted bay); pelletal (intertidal, subtidal); mat algal (intertidal, supratidal); carbonate bank (subtidal-intertidal); rounded algal biosparite (subtidal, intertidal); carbonate sand (intertidal, supratidal); sandy fossiliferous dolomicrite (subtidal, intertidal); silty micrite (restricted intertidal, supratidal) -- gastropod-plant fragment subtype (lagoon, restricted bay); black micrite -- productid-bryozoan-crinoid subtype (restricted open marine) -- dark fragmental micrite subtype (subtidal, intertidal) -- laminated spiculitic subtype (supratidal, intertidal).

Sandstone subtypes include the following: subtype I (isolated patches of sand); subtype II (rippled sand sheets, intertidal sand flat); subtype III (megarippled sand sheets, intertidal and shallow marine); subtype IV (channel sands, intertidal and supratidal).

Distribution of rock types indicates that the south part of the area represents predominantly subtidal and intertidal sedimentation, while the north part of the area represents predominantly intertidal, supratidal, and restricted bay or lagoon sedimentation. Sands appeared first in the north and moved southward across the area, representing progradation into the carbonate environment.

Normal marine carbonate sequences tend to grade upward to restricted intertidal pelletal, mat algal, and silty lime mud sequences that formed during periods of sand progradation. Four carbonate transgression - sand progradation sequences can be recognized in the Amsden Formation.

Sand subtypes II and III represent rippled and megarippled sand sheets prograding into the intertidal and slightly subtidal marine environments. These sands may have originated from distributary river mouths in the north.

REFERENCES CITED

Adams, J. E., and Rhodes, M. L., 1960, Dolomitization by seepage refluxion: Am. Assoc. Petroleum Geologists Bull., v. 44, no. 12, p. 1912-1920.

Ball, M. M., 1967, Carbonate sand bodies of Florida and the Bahamas: Jour. Sed. Petrology, v. 37, no. 2, p. 556-591.

Easton, W. H., 1962, Carboniferous formations and faunas of central Montana: U. S. Geol. Survey Prof. Paper 348, 126 p.

Evans, Graham, 1965, Intertidal flat sediments and their environments of deposition in the wash: Geol. Soc. of London Quart. Jour., v. 121, p. 209-245.

Folk, R. L., 1959, Practical petrographic classification of limestones: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 1, p. 1-38.

Folk, R. L., 1961, Petrology of sedimentary rocks: Austin, Texas, Hemphill's

Folk, R. L., and Mason, C. C., 1951, Stages of textural maturity in sedimentary rocks: Jour. Sed. Petrology, v. 21, no. 3, p. 127-130.

Gebelein, C. D., 1961, Distribution, morphology, and accretion rate of recent subtidal algal stromatolites, Bermuda: Jour. Sed. Petrology, v. 39, no. 1, p. 49-60.

Gilmour, E. H., 1967, Carbonate petrology and paleontology of the Alaska Bench Formation, central Montana: Unpub. Ph.D. Dissert., Univ. of Montana, 152 p.

Johnson, J. H., 1961, Limestone building algae and algal limestones: Johnson Pub. Co., Boulder, Colo., 297 p.

Laporte, L. L., 1967, Carbonate deposition near mean sea level and resultant facies mosaic: Manlius Formation (Lower Devonian) of New York State: Am. Assoc. Petroleum Geologists Bull., v. 51, no. 1, p. 73-101.

Maughan, E. K., and Roberts, A. E., 1967, Big Snowy and Amsden Groups and the Mississippian-Pennsylvanian Boundary in Montana: U. S. Geol. Survey Prof. Paper 554-B, 27 p.

McKee, E. D., and Weir, G. W., 1953, Terminology for stratification and cross-stratification in sedimentary rocks: Geol. Soc. America Bull., v. 64, p. 381-390.

McKee, E. D., and Sterrett, T. S., 1961, Laboratory experiments on form and structure of longshore bars and beaches, in Geometry of sandstone bodies - A symposium, J. A. Peterson and J. C. Osmond, eds.: Am. Assoc. Petroleum Geologists, Tulsa, Oklahoma, p. 13-28.

Mundt, P. A., 1956, A regional study of the Amsden Formation: Unpub. Ph.D. Dissert., Stanford Univ.

Off, Theodore, 1963, Rythmic linear sand bodies caused by tidal currents: Am. Assoc. Petroleum Geologists Bull., v. 47, no. 2, p. 324-341.

Opdyke, N. D., and Runcorn, S. K., 1960, Wind direction in the western United States in the late Paleozoic: Geol. Soc. America Bull., v. 77, p. 959-972.

Pray, L. C. and Wray, J. L., 1963, Porous algal facies, (Pennsylvanian) Honaker Trail, San Juan Canyon, Utah, in Shelf carbonates of the Paradox Basin: Four Corners Geol. Soc. 4th Field Conf., p. 204-234.

Rich, Mark, 1961, Stratigraphic section and fusulinids of the Bird Spring Formation, near Lee Canyon, Clark County, Nevada: Jour. Paleontology, v. 35, no. 6, p. 1159-1180.

Sabins, Floyd F., Jr., 1962, Grains of detrital secondary and primary dolomite from Cretaceous strata of the Western Interior: Geol. Soc. America Bull., v. 73, no. 10, p. 1183-1196.

Scholten, Robert, et al, 1955, Geology of the Lima region, southwestern Montana and adjacent Idaho: Geol. Soc. America Bull., v. 66, p. 345-404.

Shinn, E. A., 1968, Practical significance of birds-eye texture in carbonate rocks: Jour. Sed. Petrology, v. 38, p. 215-233.

Shinn, E. A., and Lloyd, M. R., 1969, Anatomy of a modern carbonate tidal flat, Andros Island, Bahamas: Jour. Sed. Petrology, v. 39, no. 3, p. 1202-1238.

Sloss, L. L. and Moritz, C. A., 1951, Paleozoic stratigraphy of southwestern Montana: Am. Assoc. Petroleum Geologists Bull., v. 48, p. 1063-1090.

Stevens, C. H., 1966, Paleoecologic implications of Early Permian fossil communities in eastern Nevada and western Utah: Geol. Soc. America Bull., v. 77, no. 10, p. 1121-1130.

Todd, T. W., 1964, Petrology of Pennsylvanian rocks, Bighorn Basin, Wyoming: Am. Assoc. Petroleum Geologists Bull., v. 48, no. 7, p. 1063-1090.

Visher, G. S., Saitta, S. B., and Phares, R. S., 1971, Pennsylvanian delta patterns and petroleum occurrences in eastern Oklahoma: Am. Assoc. Petroleum Geologists Bull., v. 55, no. 8, p. 1206-1230.

Williams, J. S., 1962, Pennsylvanian System in central and northern Rocky Mountains, in Pennsylvanian System in the United States, C. C. Branson, ed.: Am. Assoc. Petroleum Geologists, Tulsa, Oklahoma, p.

Willis, R. P., 1959, Upper Mississippian-Lower Pennsylvanian stratigraphy of central Montana and Williston Basin: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 8, p. 1940-1966.

Wolf, Karl H., 1965, "Grain dimunition" of algal colonies to micrite: Jour. Sed. Petrology, v. 35, no. 2, p. 420-427.

APPENDIX I

Field and Laboratory Procedures

Field Procedures

Each stratigraphic section was measured with a five foot Jacob staff and brunton compass. Samples were taken at changes in lithology or at one foot intervals. A profile section was sketched at the outcrop of each section to show the topographic aspect of beds, thickness and character of bedding, lithology, faunal content, and exact location of samples.

At critical or well exposed sections the rocks were marked with paint at each five foot interval and numbered as to footage above the base of the section. The use of paint provided a record of the measured section in the field, and allowed the writer to return at later dates to precise points within a section for additional sampling and descriptive work.

Sections #1, #2, #5, #8, #10, #12, #13, and #15 were sampled in detail for laboratory analysis, for they contained the major rock types. After studying these rocks in the laboratory, the writer returned to the field to measure and describe sections #3, #4, #7, #9, and #11. These sections were taken for correlating sections and were described in the field.

Sections 1A and 15A were taken as reference sections of the lower member and were field described.

Laboratory Procedures

Lithic samples were slabbed, etched in dilute hydrochloric acid, and stained for calcite, dolomite, and potash feldspar (Sabins, 1962). Staining facilitated differentiation of calcite from dolomite and feldspar from quartz; it was particularly useful for determining the mineralogy and percentage of cement in sandstone.

All slabs were first examined with a binocular microscope; representative rock types and samples containing fragments and fossils of uncertain identity were selected for thin sectioning. Approximately 90 thin sections were cut and examined during the course of the study. Data obtained from thin sections were combined with field and other laboratory data, and correlations were reexamined using this combined information. After allochems were identified in slab and thin section, they could be identified in hand samples with reasonable certainty, allowing additional sections to be measured and described in the field.

Two sandstone samples (section #14, 75 feet and 54 feet) were disaggregated with hydrochloric acid and examined by mechanical analysis. Statistical parameters were computed from formulae given in Folk (1961).

APPENDIX II

Measured Section Locations

Topographic maps and large scale geographic maps are not available for the Tendoy Mountains. The best maps available for the area are ½" = 1 mile geographic maps published by the United States Forest Service, similar to Figure 1 of this paper, showing township and range, section, and approximate locations of trails and roads. Consequently, accurate placement of measured sections met with considerable difficulty. I have located each measured section to the nearest quarter-section, township and range, and it is hoped that they are accurately placed.

Section 1 and 1A
Approximate Center of SE¼ of NW¼, section 36
T-13-S, R-10-W, MPM
Access: Big Sheep Creek Road
Hidden Pasture Trail

Proceed southwest along Big Sheep Creek Road to junction with Hidden Pasture Trail (marked on right by Forest Service sign). Proceed on foot northwesterly on Hidden Pasture Trail for approximately 200 yards. Amsden Formation outcrops are on the right; measured sections are about 30 yards to the right of trail.

Section 2 and 2A
Approximate Center of SE¼ SW¼, section 36
T-13-S, R-10-W, MPM
Access: Big Sheep Creek Road
Deadwood Gulch Road

At the intersection of Deadwood Gulch and Big Sheep Creek Road, turn southeast onto Deadwood Gulch Road, cross Big Sheep Creek, through fence, and park next to Forest Service corrals. Proceed on foot southwesterly along Big Sheep Creek until reaching cliff. Proceed southeasterly along base of cliff for about 200 yards, or until reaching first easily climbed portion of cliff. Section #2A was measured at this position. Section #2 is directly above; the first massive, resistant limestone bed at the top of the cliff is the base of Section #2.

Section 3
Approximate Center of SE¼ of SW¼, section 36
T-13-S, R-10-W, MPM
Access: Big Sheep Creek Road
Deadwood Gulch Road

Proceed southeasterly along Deadwood Gulch Road, approximately 1¼ miles, until reaching a cattle guard and barbed wire fence. Follow fence west up steep slope, and continue along it until you are just below the zone of heavy timber. Section #3 outcrops in a large clearing just below heavy timber and can be seen for some distance while climbing.

Section 4
Approximate Center of NE¼ of NW¼, section 7
T-14-S, R-9-W, MPM
Access: Big Sheep Creek Road
Deadwood Gulch Road

Section #4 is best reached by proceeding southeasterly along strike from section #3, staying just below the timber. Proceeding in this direction approximately one and one-quarter miles, you will climb and descend a northeast-trending ridge. Beyond this ridge is another similar ridge. Climb, staying close to the timber. Section #4 is located just over the peak of the ridge, on the southeast side.

Section 5 and 6
Approximate SW¼ SW¼ NW¼, section 17
T-14-S, R-9-W, MPM
Access: Little Sheep Creek Road
West Fork Road, Little Sheep Creek
Unnamed Logging Road to White Pine Ridge

At the intersection of the West Fork and Middle Fork of Little Sheep Creek, take the West Fork Road 2.4 miles where it intersects with a logging road on the right. Proceed on logging road 7.4 miles to fork in road. Bear right and proceed .6 miles to the east side of meadow on top of the ridge. Proceed on foot northwest along barbed wire fence until fence turns west. Continue northwest about 200 yards until reaching edge of heavy timber and Quadrant Sandstone outcrops. Turn northeast and walk downhill about 200 yards until reaching edge of heavy timber and Quadrant Sandstone outcrops. Turn northeast and walk downhill about 200 yards, reaching promontory above very steep slope. Sections #5 and #6 are on promontory, facing northeast.

Sections 7 through 11
Access: West Fork Road, Little Sheep Creek

These sections are described in reverse order, as this is the order in which they are encountered while proceeding along the only access. Figure 29 is a picture of sections #8, #9, and #10, and will facilitate finding these sections.

Section 11
Approximate SW¼ NW¼ SW¼, section 27
T-14-S, R-9-W, MPM

At the intersection of the West Fork and Middle Fork of Little Sheep Creek proceed on the West Fork approximately one-half mile to intersection of Amsden-Quadrant contact with the road. Proceed on foot northwesterly to resistant Limestone ledges. Section #11 is in the center portion of the outcrop.

Section 10
Approximate Center of NE¼, section 28
T-14-S, R-9-W, MPM

Approximately one-quarter mile past the intersection of the West Fork and Middle Fork of Little Sheep Creek, an indistinct truck trail intersects with the West Fork Road on the right. Proceed northwesterly along truck trail about one-half mile until reaching the first level terrace. Proceed on foot southwesterly to outcrops (see Figure 29) which are on south facing slope in gully.

Section 9
Approximate NW¼ NW¼ NE¼, section 28
T-14-S, R-9-W, MPM

Proceed from section #10 northwesterly along strike approximately one-quarter mile (see Figure 29).

Section 8 & 8A
Approximate Center of SW¼ of SW¼, section 21
T-14-S, R-9-W, MPM

Return to vehicle and continue northwest on truck trail (see section #10 description) to high topographic saddle, where road ends. Section #8 is on the ridge to the southwest (see Figure 29).

Section 7
Approximate SE$\frac{1}{4}$ SE$\frac{1}{4}$ NE$\frac{1}{4}$, section 20
T-14-S, R-9-W, MPM

From section #8, proceed on foot northwest along strike for about one-half mile. You will descend into a deep, heavily forested, northeast trending gully, and upon emerging from the gully, will enter a small clearing. Section #7 is in the center of the clearing and is partially obscured by grass and soil.

Section 12
Center SE$\frac{1}{4}$ NE$\frac{1}{4}$, section 34
T-14-S, R-9-W, MPM
Access: Middle Fork Road, Little Sheep Creek
East Fork Road, Little Sheep Creek

Proceed by car to the intersection of East Fork and Middle Fork Roads. Turn southeast on the East Fork Road and continue for one-eighth mile. Park on road near abandoned cabin. Proceed on foot north behind cabin approximately 70 yards to the top of the low ridge. Section #12 is on the northeast flank of the ridge.

Section 13
Approximate Center of SE$\frac{1}{4}$ of SW$\frac{1}{4}$, section 35
T-14-S, R-9-W, MPM
Access: East Fork Road, Little Sheep Creek

This section is difficult to find because of heavy timber. Proceed southeast along East Fork Road until reaching boundary fence of Forest Service campground. Proceed southwest along fence and climb about 100 yards up hill. Section #13 is on the northwest side of fence in a very minor clearing.

Section 14
Approximate NW¼ of NW¼ of NE¼, section 2
T-15-S, R-9-W, MPM
Access: East Fork Road, Little Sheep Creek

Section #14 is located behind the East Fork Forest Service Campground. Proceed to the campground and park in turn-around. Proceed on foot southwest to base of ridge behind campground. Proceed southeast along base of ridge approximately 200 yards. At this point you will be at the southeast edge of a large clearing on the slope. Base of section #14 is about 30 yards directly up the hill. These beds are very difficult to find and are partially covered by grass and soil.

Section 15 & 15A
Center of NE¼ of SE¼, section 36
T-14-S, R-9-W, MPM
Access: East Fork Road, Little Sheep Creek
Unnamed Mine Road

About one-quarter mile northwest of campground boundary, the East Fork Road intersects with an unnamed trail on the northwest side of road. Turn onto this road and cross Little Sheep Creek, bear right and drive southeast on truck trail. Bear left on all forks, past an abandoned gypsum mine. Just beyond mine, take right fork of road, and continue until you reach the saddle at the head of Birch Creek. Looking to the northwest, up a prominent ridge, section #15A begins about one-third of the way up the hill. Section #15 begins at the readily visible massive outcrop near the top of the ridge.

APPENDIX III

Explanation of Plates

Plates I and II

Plates I and II are correlating plates showing the character of bedding and correlation of rock types for the middle and upper members. Numbers on the left exterior side of the sections correspond to painted marks at the outcrop. At section #15 it will be noted that the base of the section is at 16.5 feet. The section was originally begun below the base of the middle member. After the lower member was measured (#15A), data for the lower part of section #15 was included in #15A.

Sections #8 and #10 are extended at the base by addition of sections #8A and #10A. The original sections were begun too high in the column; when the error was discovered, sections #8A and #10A were measured directly below the original sections and up to the original sections.

Section #2 is extended at its base by section #2A (lower member). Section #2A is 25 yards north of section #2; it was measured to demonstrate that the lowermost part of section #1 is not present at section #2.

Rock Types

In the column immediately to the right of footage numbers, rock types, subtypes, and varieties are indicated by number and letter. These correspond to those in the legend under the heading of each plate.

Plates 3 - 19

These plates are data sections of each measured section, and include pertinent data regarding lithology, fossils, and texture.

Sections #6, #7, #9, and #11 are correlating sections. Their lithologies are similar enough to adjacent sections that it is not necessary to present detailed data, and consequently, data sections were not constructed. These four sections are, however, profiled on Plates I and II.

Sections #1A and #15A are reference sections of the lower member. They were not originally intended to be included in this study, but were included for reference and perspective. Data presented for sections #1A and #15A on Plates 3 and 4 is compiled from field descriptions of hand specimens, and does not include petrographic data.

Plates 5 - 19 are data sections containing detailed field and laboratory data. Columns to the right of the profile include Type of Sample (field description, thin section, or slab), Rock Color (fresh color only, corresponding to code numbers in GSA Rock-Color Chart, 1963), Chert Color, and Rock Type. Numbers in the Rock Type column correspond to those on Plates I and II.

Descriptions to the right of the columns first indicate the general lithology of the sample, then the kind and percentage of allochems, cement, and textural features such as burrows, etc. Finally the textural name (biosparite, pelmicrite) is applied utilizing the classification of Folk, (1959).

Allochems that are fragmented are so designated. Unfragmented fossils are listed by name and percentage.

Percentage figures indicate percent of rock, and are visual estimates.

Cement is listed as a percentage of the rock in terrigenous admixtures only. The term "micrite and silica cemented" means that the rock is cemented primarily by microcrystalline calcite, and that the terrigenous grains have some relict overgrowths.

Allochems that are not followed by percentage figures indicates that they occur in amounts less than 1%.

In sandstones, first the cement is listed, then intraclasts, fossils, grain size, sorting, rounding, and heavy minerals. Again, when not followed by a percentage, constituents are less than 1% of the rock.

For example:

TS	N1	Blk	3A	Limestone; Productid brachiopod and brachiopod fragment (20%), crinoid and echinoid fragment (5%), phosphatic fragment, apterinellid, pelmicrite intraclast, bryozoan fragment (3%), churned biomicrite.

This description identifies a black limestone with black chert, examined by thin-section, and assigned to the Productid-Bryozoan-Crinoid Subtype of the Black Micrite Rock Type, composed of 20% whole productid brachiopods and other brachiopod fragments, 5% crinoid and echinoid fragments, 3% bryozoan fragments, with constituents less than 1% as follows: intraclasts of pelletal micrite, phosphatic fragments, apterinellid foraminifers, all occurring in a churned microcrystalline calcite matrix.

For sandstones:

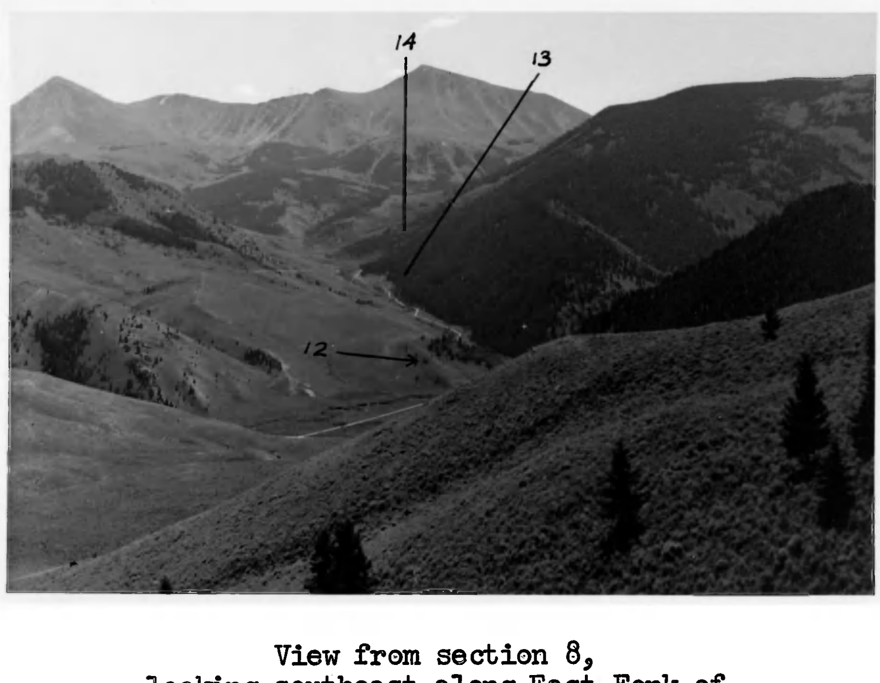
TS	5Y6/1	—	10C	Sandstone; Micrite and silica cemented (25%), fine to medium grained (.08 - .24 mm), subround to subangular, bimodally sorted, pelmicrite intraclast (1%), chert, leucoxene, Quartz Sandstone.

This description identifies a light olive gray sandstone, with no chert stringers or nodules, belonging to Sand Subtype III, composed of 25% cement, 75% terrigenous particles. Cement is micrite, and grains have relict silica overgrowths. Sand grains are fine to medium sized, ranging from .08 to .24 millimeters, subround to subangular with bimodal sorting. In addition to quartz grains, the sample contains intraclasts of pelletal micrite, and traces of detrital chert and leucoxene.

These data sections are presented in this manner to be easily carried in the field, and are intended for use in the field by anyone wishing to acquaint themselves with these rocks. Petrographic data is presented so that identification of fragments may be more quickly learned through comparison of hand specimens with these descriptions.

Sections 8, 9, 10 and 11
View looking north, along strike

Figure 29



View from section 8,
looking southeast along East Fork of
Little Sheep Creek; showing sections 12, 13 and 14

Figure 30

PLATE I

CROSS SECTION B-B' SHOWING INTERVALS AND ROCK TYPES, SECTIONS 7 - 15

WILLIAM J. STRICKLER, JANUARY, 1972

LEGEND

ROCK TYPES:

1. BRACHIOPOD CRINOID CHURNED MICRITE ROCK TYPE
2. MILLERELLID - BRACHIOPOD CRINOID ROCK TYPE
3. BLACK MICRITE ROCK TYPE
   - A. PRODUCTID - BRYOZOAN - CRINOID SUBTYPE
   - B. FRAGMENTAL SUBTYPE
   - C. LAMINATED SPICULITIC SUBTYPE
4. PELLETAL ROCK TYPE
   - A. OSTRACOD FRAGMENTAL SUBTYPE
5. MAT ALGAL BIOLITHITE ROCK TYPE
6. ALGAL PLATE BIOSPARITE ROCK TYPE
7. CARBONATE SAND ROCK TYPE
8. CARBONATE BANK ROCK TYPE
9. SILTY MICRITE - SILTSTONE ROCK TYPE
   - A. SILTY MICRITE
   - B. SILTSTONE
   - C. DOLOMITE
   - D. GASTROPOD PLANT FRAGMENT SUBTYPE
10. SAND ROCK TYPE
    - A. SUBTYPE I
    - B. SUBTYPE II
    - C. SUBTYPE III
    - D. SUBTYPE IV
11. SHALE ROCK TYPE
12. MILLERELLID - PRODUCTID LIMESTONE ROCK TYPE
13. SANDY FOSSILIFEROUS OOLDMICRITE ROCK TYPE

X - CHERT Y - SANDY INTRACLASTIC MICRITE Z - HASH BED

(8) SECTION NUMBER (8A) AUXILIARY SECTION

VERTICAL SCALE: 1" = 5 FEET
HORIZONTAL SCALE: 8" = 1 MILE

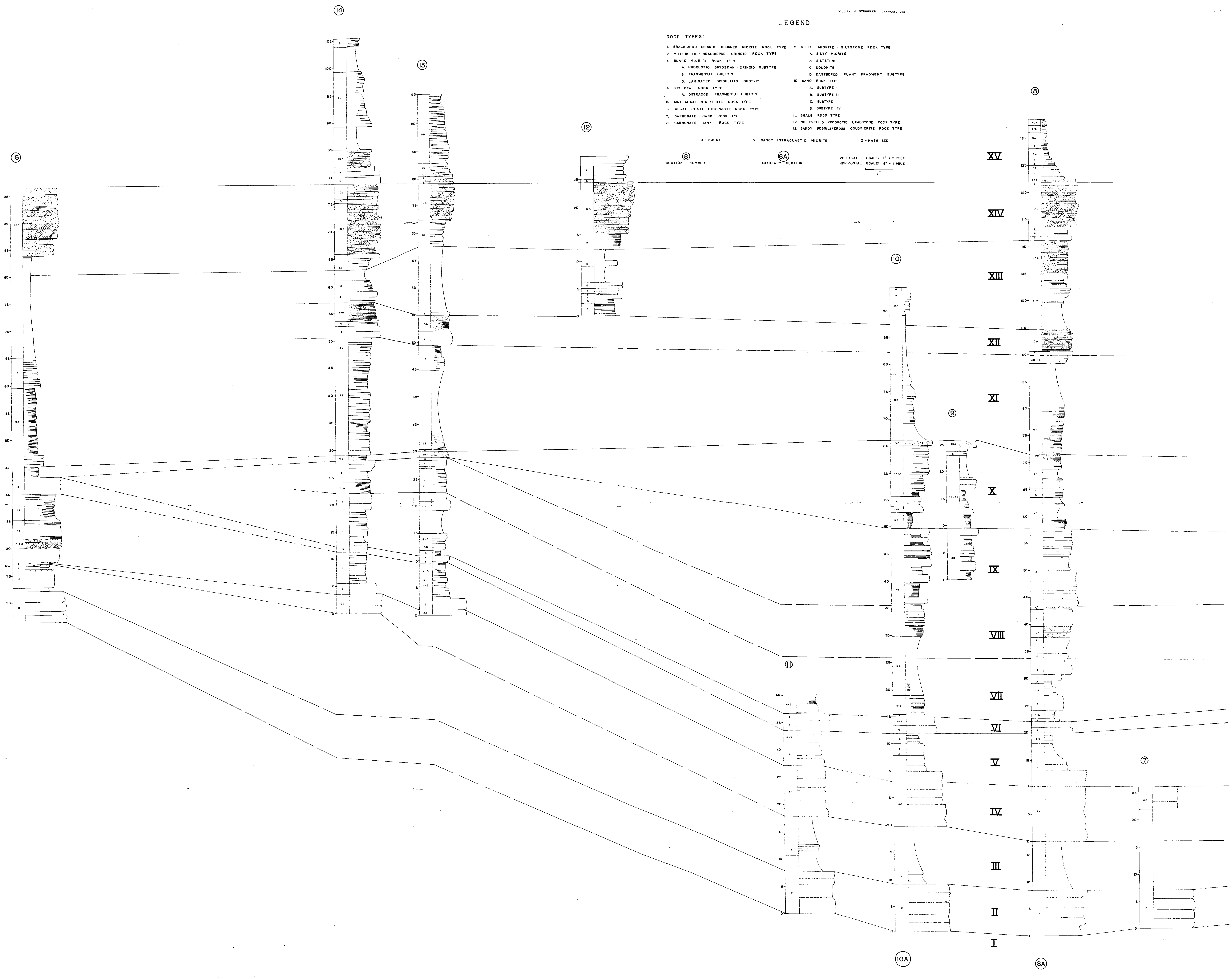


PLATE II

CROSS SECTION A-A' SHOWING INTERVALS
AND ROCK TYPES, SECTIONS 1 - 6

WILLIAM J. STRICKLER, JANUARY, 1972

LEGEND

ROCK TYPES:

1. BRACHIOPOD CRINOID CHURNED MICRITE ROCK TYPE
2. MILLERELLID - BRACHIOPOD CRINOID ROCK TYPE
3. BLACK MICRITE ROCK TYPE
   - A. PRODUCTID - BRYOZOAN - CRINOID SUBTYPE
   - B. FRAGMENTAL SUBTYPE
   - C. LAMINATED SPICULITIC SUBTYPE
4. PELLETAL ROCK TYPE
   - A. OSTRACOD FRAGMENTAL SUBTYPE
5. MAT ALGAL BIOLITHITE ROCK TYPE
6. ALGAL PLATE BIOSPARITE ROCK TYPE
7. CARBONATE SAND ROCK TYPE
8. CARBONATE BANK ROCK TYPE
9. SILTY MICRITE - SILTSTONE ROCK TYPE
   - A. SILTY MICRITE
   - B. SILTSTONE
   - C. DOLOMITE
   - D. GASTROPOD PLANT FRAGMENT SUBTYPE
10. SAND ROCK TYPE
   - A. SUBTYPE I
   - B. SUBTYPE II
   - C. SUBTYPE III
   - D. SUBTYPE IV
11. SHALE ROCK TYPE
12. MILLERELLID - PRODUCTID LIMESTONE ROCK TYPE
13. SANDY FOSSILIFEROUS DOLOMICRITE ROCK TYPE

X - CHERT

Y - SANDY INTRACLASTIC MICRITE

BROKEN BEDDING — ② SECTION NUMBER — (2A) AUXILIARY SECTION

VERTICAL SCALE: 1" = 5 FEET
HORIZONTAL SCALE: 8" = 1 MILE

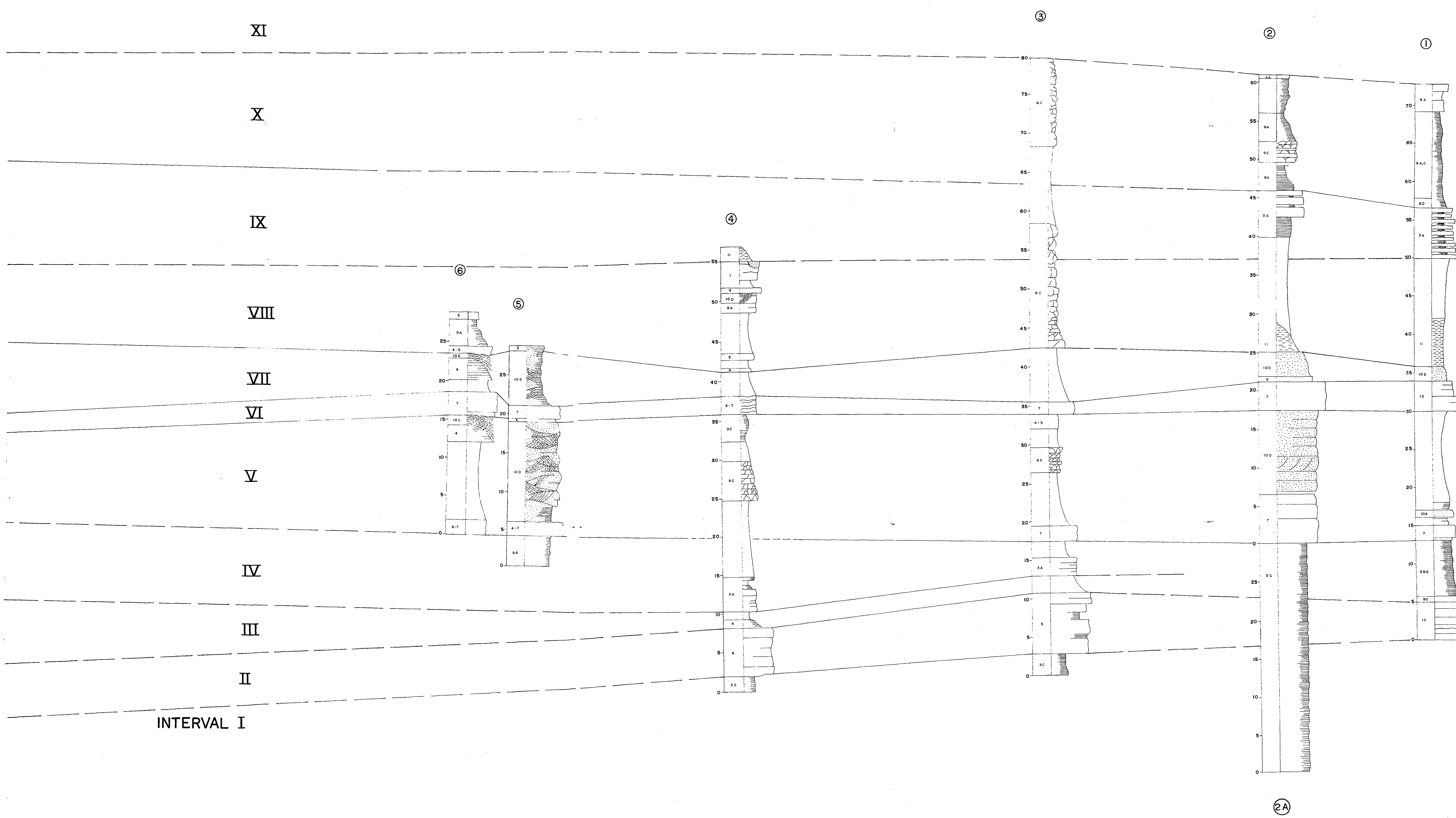


PLATE 3

Section 1A

LOWER MEMBER, AMSDEN FORMATION

Approximate Center of SE¼ of SW¼, section 36

T-13-S, R-10-W, MPM

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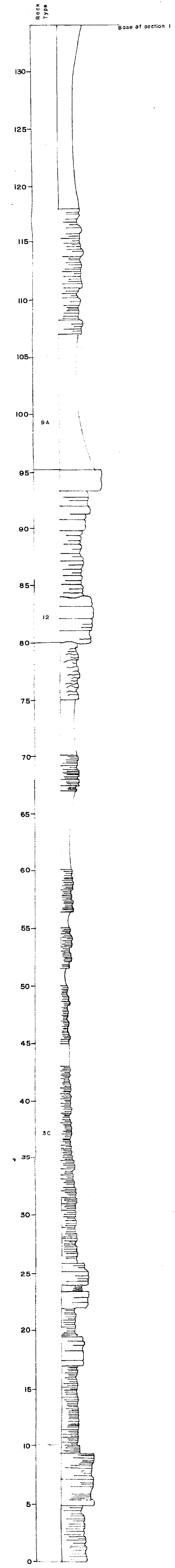
1972



107-118 See 95-103.

95-103 Silty Limestone; Dolomitic(10%), laminated light tan and dark gray, burrowed (⅛" diameter, parallel to bedding), quartz silty(15%), micrite.

84-95 Limestone; Crinoid, echinoid, and bryozoan fragment, encrusting blue-green algal, millerellid and/or endothyrid, brachiopod and brachiopod fragment, churned to burrowed, biomicrite. Channel Carbonate.

80-84 Limestone; Crinoid fragment, composite and productid brachiopod, millerellid and/or endothrid, echinoid fragment, bryozoan fragment, churned and burrowed, biomicrite.

75-80 Limestone; Burrowed, sparry, gastropod, fine fragmented fossil hash, biomicrite.

67.5-70 Limestone; Gastropod, fragmented fossil hash, burrowed, spiculitic, biomicrite.

67-67.5 Limestone; Burrowed (sinuous, 1/8" diameter), micrite.

57-60 Limestone; Spiculitic micrite.

51.5-55 Limestone; Spiculitic micrite.

48.5-50 Limestone; Spiculitic micrite.

47-48.5 Limestone; Unidentifiable fine fossil fragments (trace), spiculitic micrite.

45-47 Limestone; Spiculitic micrite.

40-43 Limestone; Spiculitic micrite.

35-40 Limestone; Crinoid fragment (trace), spiculitic micrite.

19.5-35 Limestone; Spiculitic, discontinuously laminated, micrite. Rock has dark specks - may be plant spores.

17-19.5 Limestone; Spiculitic, crinoid and spine fragment (trace), micrite.

12.5-17 Limestone; Laminated tan and black fenestrate bryozoan (trace), spiculitic micrite.

3-12.5 Limestone; Laminated tan and black, spiculitic micrite.

0-3 Limestone; Spiculitic, dense micrite.

PLATE 4

Section 15A

LOWER MEMBER, AMSDEN FORMATION

Center of NE¼ of SE¼, section 36

T-14-S, R-9-W, MPM

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245	Base of section #15
241.5-245	Brachiopod (composite, orthid, and strophomenid) and brachiopod fragment, crinoid and echinoid fragment, spine bearing, biomicrite.
239-239.5	Brachiopod, crinoid and echinoid fragment, biomicrite.
236.5-238.5	Limestone; Brachiopod and brachiopod frag., crinoid and echinoid frag., spine bearing, biomicrite.
236-236.5	Dolomitic Limestone; Brachiopod frag., dense, dolomicrite
233.5-235	Sandy Limestone; Fine encrusted and coated fossil frag., apterinellid, fragmental biomicrite.
233-233.5	Limestone; Composite brachiopod and brachiopod fragment, crinoid and echinoid fragment, spine bearing, biomicrite.
227-227.5	Limestone; Sparry, burrowed, dense, micrite.
222-225	Limestone; Brachiopod fragment, sparry, burrowed, dense micrite; tops of beds coated with mat algal biolithite.
171-222	Covered interval.
169-171	Limestone; Brachiopod and crinoid fragment, echinoid fragment, spine bearing, churned, fragmental biomicrite.
158-160	Limestone; Brachiopod and crinoid fragment, echinoid fragment, spine bearing, churned, fragmental biomicrite.
149-153.5	Limestone; Encrusted algal (?) plate, fine encrusted brachiopod and crinoid fragment, fine unidentified fragments, encrusting apterinellid and blue green algae, packed, fragmental biomicrite.
145-148	Limestone; See 142-144.
142-144	Limestone; Brachiopod fragment, crinoid and echinoid fragment, bryozoan fragment, biomicrite.
124-132	Limestone; Sparry, micrite intraclast, dense, micrite.
108-110	Limestone; Laminated, sparry, mat algal biolithite.
106-106.5	Pisolitic Limestone.
103.5-106	Limestone; Laminated, sparry, mat algal biolithite.
102.5-103.5	See 101-102.
101-102	Limestone; Brachiopod, crinoid fragment, spine bearing, churned, biomicrite.
96-97	Limestone; Fine, encrusted brachiopod, algal (?)plate, spine bearing, quartz fine sandy, encrusting apterinellid and blue green algae biomicrite.
95.2-96	Limestone; Fine fossil frag.(2%),hematitic dense micrit
94.5-95.2	Limestone; Laminated, sparry, mat algal biolithite.
93-94.5	Limestone; Rounded micrite Intraclast (5%), sparry(5%) interlaminated pelmicrite and mat algal biolithite.
86-87.5	Limestone; Brachiopod (20%), crinoid fragment (5%), spine bearing (1%), churned, biomicrite.
81.2-86	Limestone; Encrusted algal (?) plate (25%), brachiopod and crinoid fragment (10%), spine bearing (1%), encrusting apterinellid and blue green algae, coated fine sandy quartz grain, sparry, fragmental biomicrite.
77-81.2	Limestone; Micrite intraclast (10%), fine fossil fragment (3%), ostracod fragment (1%), pelmicrite.
69-70	Limestone; Brachiopod frag., crinoid frag., spine bearing churned biomicrite.
64-66	Limestone; Brachiopod fragment, crinoid fragment, spine bearing, biomicrite.
62.5-64	Limestone; Laminated, sparry, fine fossil fragment(5%), mat algal biolithite.
58.5-60.2	Limestone; Brachiopod fragment, crinoid fragment, echinoid frag., bryozoan frag., churned, biomicrite.
56.5-57.5	Limestone; Dense, sparry (5%), pelmicrite.
55.5-56.5	Silty Limestone; Small unidentified shells (2%),(brachiopod ?), quartz silty (5%), micrite.
53-55.5	Limestone; Sparry (5%), interlaminated pelmicrite and mat algal biolithite.
47-47.6	Silty Limestone; Spine bearing, fine fossil fragment (3%), quartz silty (1%), micrite.
41.5-42.5	Limestone; Brachiopod and crinoid frag.(1%), interlaminated mat algal biolithite and pelmicrite.
41-41.5	See 39-40.
39-40	Dolomite; Brachiopod (3%), quartz fine sandy (5%), dolomicrite.
36.5-38	Limestone; Encrusted algal(?) plate (5%), brachiopod fragment (1%), spine bearing, encrusting apterinellid and blue green algal (5%), fragmental biomicrite.
33-33.5	Limestone; Fine fossil fragment (1%), pelmicrite.
29-32	Limestone; Brachiopod fragment (2%), ostracod (5%), pelmicrite.
25.5-29	Limestone; Ostracod, laminated, sparry, mat algal biolithite.
24-25.5	Limestone; Sparry (10%), pelmicrite.
18-19.5	Limestone; Brachiopod fragment (1%), dense, pelmicrite.
13.5-15.5	Limestone; Laminated, sparry, mat algal biolithite.
9-10	Limestone; Laminated, sparry (5%), ostracod (1%), mat algal biolithite.
5-7	Limestone; Brachiopod fragment (1%), crinoid fragment (2%), spine bearing, burrowed, sparry(5%), pelmicrite.
3.5-3.9	Limestone; Encrusted algal plate(30%), brachiopod and crinoid fragment(1%), encrusting blue green algal and apterinellid(10%), biosparite.
0-3	Limestone; Brachiopod fragment(1%), crinoid fragment (1%), apterinellid, sparry(10%), pelmicrite.

PLATE 5

SECTION 15

CENTER OF NE 1/4 SE 1/4, SECTION 36

T-14-S R-9-W, M.P.M.

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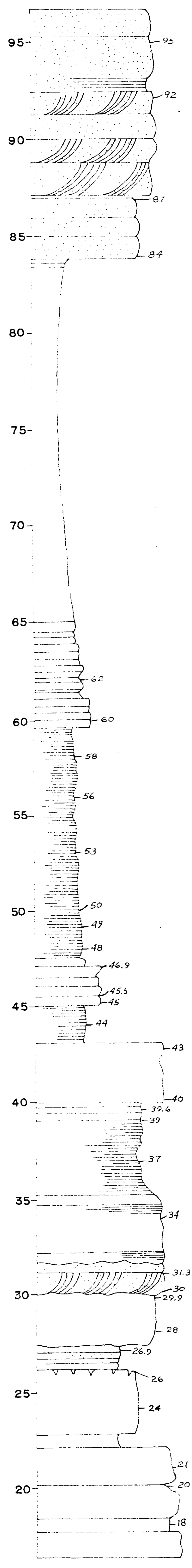
1972



Sample	Type of Sample	Fresh Color	Chert	Rock Type	Description
95	SB	10YR7/4		10C	See 92.
92	SB	10YR7/4		10C	Sandstone; Micrite and silica cemented (20%), fine to medium grained, subround to subangular, bimodally sorted, Quartz Sandstone.
87	SB	10YR7/4		10C	See 92.
84	SB	10YR7/4		10C	See 92.
					Samples from soil indicate silty, dolomitic micrite.
62	SB	10YR4/2		5	See 60.
60	SB	10YR4/2		5	Dolomitic Limestone; Laminated, sparry (15%), dolomitic (20%), mat algal biolithite. (Locally mudcracked.)
58	SB	10YR4/2	BRN	9A	See 53.
56	SB	10YR4/2	BRN	9A	See 53.
53	SB	10YR4/2	BRN	9A	Silty Limestone; Unidentified dwarfed shell fragments (5%), encrusting apterinellid (10%), quartz silty (5%), sparse micrite.
50	SB	"	BRN	9A	See 53.
49	SB	"	BRN	9A	See 53.
48	SB	"	BRN	9A	See 53.
46.9	TS	10YR4/2	BRN	9A	Silty Limestone; Brachiopod fragment (3%), crinoid fragment (3%), encrusting apterinellid and blue green algae (15%), fine fragments (10%), quartz silty (5%), fragmental biomicrite.
45.5	SB	"		9A	See 46.9
45	SB	"		9A	See 46.9
44	SB	10YR4/2		9A	Silty Limestone; Brachiopod fragment (1%), apterinellid (10%), fine fragments (10%), quartz silty (5%), fragmental micrite.
43	SB	10YR4/2		4	Limestone; Burrowed quartz fine sandy (3%), badly silicified pelsparite.
40	SB	10YR4/2		4	See 43.
39	SB	10YR7/4			See 37.
37	SB	10YR7/4	BRN	9C	Silty Dolomite, Quartz fine silty (5%), dolomicrite.
34	SB	10YR4/2	BRN	9A	Silty Limestone; Brachiopod fragment (10%), crinoid fragment (3%), echinoid fragment (1%), encrusting apterinellid and blue green algae (3%), pelmicrite intraclast (3%), quartz silty (5%), sparry (25%), burrowed, biomicrite.
31.3	SB	10YR6/6		10A-C	Sandstone; Micrite cemented (20%), fine to medium grained, subround to subangular, Quartz Sandstone.
30	SB	"		10A-C	See 31.3
29.9	SB	N6			See 28.
28	SB	N6	BRN	1-2	Limestone; Strophomenid brachiopod (35%), crinoid fragment, echinoid fragment (1%), packed biomicrite.
26.9	TS	10YR4/2		2	Sandy Limestone; Brachiopod fragment (20%), ostracod fragment (1%), crinoid fragment (20%), encrusting apterinellid and blue green algal (15%), millerellid (T), quartz fine sandy (10%), packed, encrusted, fragmental biomicrite.
26	TS	10YR4/2		4	Limestone; Ostracod (15%), bored and burrowed, pelsparite.
24	SB	"		4	See 26.
21	SB	10YR6/2	BRN	2	See 20.
20	TS	10YR6/2	BRN	2	Limestone; Strophomenid brachiopod (40%), crinoid fragment (10%), echinoid fragment (2%), millerellid (1%), endothyrid (1%), packed biomicrite.
18	SB	10YR6/2	BRN	2	See 20.

PLATE 6

SECTION 14

APPROXIMATE NW 1/4 NW 1/4 NE 1/4, SECTION 2

T-15-S R-9-W, M.P.M.

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1972

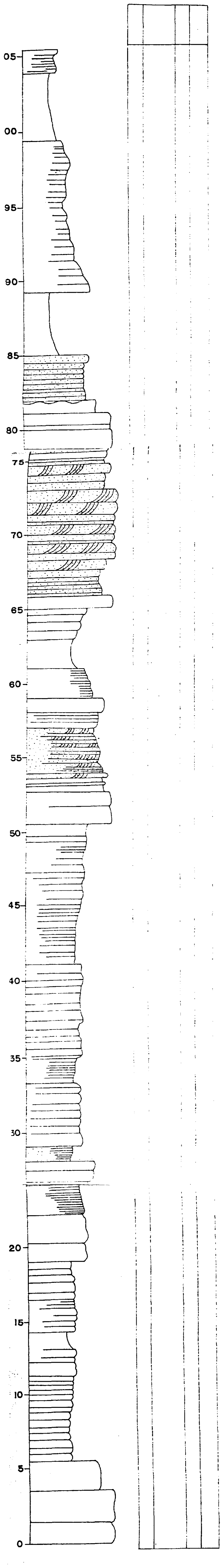

PLATE 7
SECTION 13

APPROXIMATE CENTER OF SE 1/4 SW 1/4, SECTION 35

T-14-S R-9-W, M.P.M.

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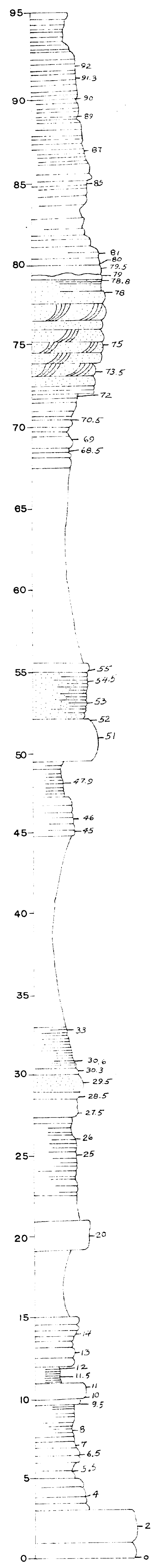
1972



Type of Sample	Fresh Color	Chert	Rock Type	
TS	N1	BLK	3B	Limestone; Brachiopod fragment(2%), encrusting apterinellid (10%), algal plate (5%), micrite intraclast(2%), quartz fine sandy (2%), micrite.
TS	"	BLK	3B	See 92
TS	"	BLK	3B	See 92
TS	"	BLK	3B	See 92
TS	"	BLK	3B	See 92.
TS	"	BLK	3B	See 92.
TS	10YR7/4		10A	Dolomitic Sandstone; Micrite (dolomite)(10%), and silica cemented(40%), mat algal and pelletal intraclast(10%), fine to medium grained(.03 - 24mm), subround to subangular, bimodally sorted, hematite, chert, Quartz Sandstone.
TS	10YR4/2		5	Limestone; ostracod(5%), laminated, sparry (5%), birds eye texture, mat algal biolithite.
TS	10YR7/4		10A	Sandstone; Micrite cemented(25%), infraclast(10%), fine grained(.08-.18mm), subrd. to subang., Quartz Sandstone.
TS	10YR6/2		5	Limestone; Ostracod(10%), laminated, birds-eye texture, sparry (5%), mat algal biolithite.
TS	10YR7/4		10C	See 75.
SB	"		10C	See 75.
TS	10YR7/4		10C	Sandstone, Dolomicrite, micrite and silica cemented(relict overgrowths)(25%), fine to medium grained(.08-.24mm), subround to subangular, hematite, chert, bimodally sorted, Quartz Sandstone.
SB	"		10C	See 75.
SB	10YR5/4	BRN	13	Dolomite; Brachiopod fragment (2%), phosphatic fragment (2%), dolomicrite.
SB	10YR4/2	BRN	13	See 69.
TS	10YR4/2	BRN	13	Sandy Limestone, Brachiopod fragment(5%), recrystallized plant fragment? (5%), ostracod fragment(1%), crinoid fragment, quartz fine sandy (3%), micrite.
SB	"	BRN	13	See 69.
SB	10YR2/2		4	Limestone, Ostracod (10%), burrowed pelmicrite.
SB	10YR7/4		10B	Sandstone; Micrite cemented(40%), brachiopod fragment (2%), ostracod fragment (2%), algal plate (5%), micrite coated, subangular to subround, fine to medium grained, black micrite intraclast (2%), Quartz Sandstone.
SB	"		10B	See 54.5
TS	10YR4/2	BRN	7	Limestone; Coated algal plates(25%), encrusting apterinellid and blue green algae(20%), rounded, micrite coated intraclast and "lumps"(30%), micrite coated quartz fine sand(3%), pseudo - oosparite.
SB	"	BRN	7	See 52.
SB	10YR4/2		13	Limestone; Brachiopod (15%), encrusting apterinellid (10%), clayey?, biomicrite.
SB	10YR6/2		13	See 45.
TS	10YR6/2		13	Dolomite; Brachiopod (5%), quartz silty (5%), dolomicrite.
TS	N1	BLK	3B	Limestone; Brachiopod fragment (10%), ostracod(5%), crinoid fragment(10%), echinoid fragment (2%), algal plates (1%), encrusting apterinellids and blue-green algae (5%), spine bearing, quartz silty (1%), churned fragmental micrite.
TS	N1	BLK	3B	Clayey Limestone; Brachiopod fragment(2%), apterinellid(2%), ostracod(1%), plant fragment(?), phosphatic fragments (2%), "worm tubes"?(1%), clay (40%), micrite.
TS	N1		5	Limestone; Ostracod (10%), laminated, mat algal biolithite.
TS	5YR3/2		10A	Sandstone; Micrite (40%), and silica cemented, subround to subangular, fine to medium grained, hematite, Quartz Sandstone.
SB	5YR3/2		5	Limestone; Ostracod (15%), pelsparite-filled burrows(10%), laminated, quartz fine sandy (30%), mat algal biolithite.
SB	10YR4/2		4	Limestone; Ostracod fragment (2%), blue-green algal fragment(5%), pelmicrite intraclast (25%), sparry (5%), quartz fine silty (1%), burrowed pelmicrite.
SB	5YR3/2		4	Limestone, Ostracod(3%), sparry(5%), burrowed, quartz silty(3%), pelmicrite.
SB	"		4	See 26.
TS	10YR4/2	BRN	1	Limestone, Brachiopod fragment(15%), crinoid fragment(10%), ostracod(2%), apterinellid (5%), endothyrid(2%), spine bearing, quartz silty(1%), churned micrite.
SB	N1		4	Limestone, Ostracod(10%), sparry (10%), laminated, mat algal biolithite.
SB	N1	BLK	3A	Limestone; Brachiopod fragment(15%), crinoid fragment(10%), bryozoan fragment(5%), echinoid frag.(2%), apterinellid (1%), spine bearing, ostracod frag., phosphatic frag., quartz silty(1%), fragmental biomicrite.
SB	N1			See 13.
SB	10YR2/2		5	See 10.
SB	10YR2/2		5	See 10
SB	10YR2/2		5	Limestone; Ostracod(30%), pelmicrite intraclast(15%), laminated, quartz silty (1%), mat algal biolithite.
SB	10YR2/2		7	Limestone; Ostracod fragment (5%), micrite intraclast (10%), superficial oolith (10%), brachiopod and crinoid fragment (5%), pelletal, sparry, biomicrite.
TS	10YR2/2			Limestone, Ostracod(30%), brachiopod fragment (3%), phosphatic fragments (2%), blue green algal fragment (20%), intraclastic, quartz silty (5%), pelsparite.
SB	"			See 8.
SB	10YR6/2		3A	Limestone; Brachiopod frag. (5%), crinoid frag. (10%), echinoid frag. (1%), bryozoan frag., ostracod frag., spine bearing, apterinellid (1%), compacted pelletal (?), sparry (20%), quartz silty (2%), churned, micrite.
TS	10YR4/2		4	Dolomitic limestone; Ostracod (1%), mat algal and pelmicrite intraclast(40%), dolomitic (10%), quartz silty (3%), pelmicrite.
SB	10YR4/2		5	Limestone, Ostracod (10%), phosphatic shell frag. (1%), laminated, sparry, pelletal, quartz silty (3%), mat algal biolithite.
TS	10YR6/2	BRN	4	Dolomitic limestone; Brachiopod fragment(5%), bryozoan frag. (1%), ostracod (3%), crinoid fragment (5%), echinoid frag. (1%), spine bearing, burrowed, dolomitic (20%), compacted pelmicrite.
TS	N1	BLK	3A	Limestone, Productid brachiopod (10%), crinoid fragment(10%), echinoid fragment (1%), bryozoan fragment (1%), spine bearing, fragmental micrite.

PLATE 8

SECTION 12

CENTER OF SE 1/4 NE 1/4, SECTION 34

T-14-S R-9-W, M.P.M.

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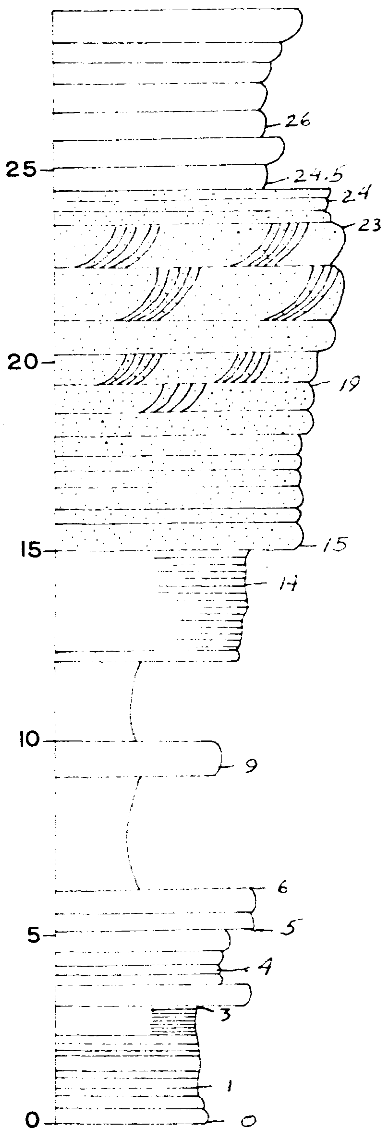

	Type of Sample	Fresh Color	Chert	Rock Type	
26	SB	10YR4/2		4	Limestone; Ostracod (2%), compacted pelmicrite.
24.5	SB	10YR4/2		5	Limestone; Ostracod (10%), laminated, birds-eye texture, mat algal biolithite.
24	SB	10YR7/4		10C	Sandstone; Micrite cemented (20%), pelmicrite intraclast (5%), fine to medium grained, subround to subangular, Quartz Sandstone.
23	SB	10YR7/4		10C	See 19.
19	SB	10YR7/4		10C	Sandstone; Micrite cemented (20%), fine to medium grained, subround to subangular, Quartz Sandstone.
15	SB	10YR7/4			See 19.
14	SB	10YR4/2		13	Sandy Limestone; Silty micrite intraclast (2%), brachiopod fragment (1%), algal plate (1%), encrusting blue green algal, dolomite (10%), quartz fine sandy, micrite.
9	SB	10YR4/2		13	Limestone; Micrite.
6	SB	10YR4/2		7	Limestone; Brachiopod fragment (10%), crinoid fragment (5%), algal plate (15%), ostracod (3%), apterinellid (2%), encrusting blue green algal (5%), spine bearing, burrowed, sparry (10%), micrite.
5	SB	"		7	See 6.
4	SB	10YR4/2		5	Limestone; Ostracod (10%), laminated, sparry (20%), mat algal biolithite.
3	SB	"		5	See 4.
1	SB	10YR4/2		4	See 0.
0	SB	10YR 4/2		4	Limestone; Ostracod (15%), pelmicrite.

PLATE 9

SECTION 11

APPROXIMATE SW 1/4 NW 1/4 SW 1/4, SECTION 27

T-14-S R-9-W, M.P.M.

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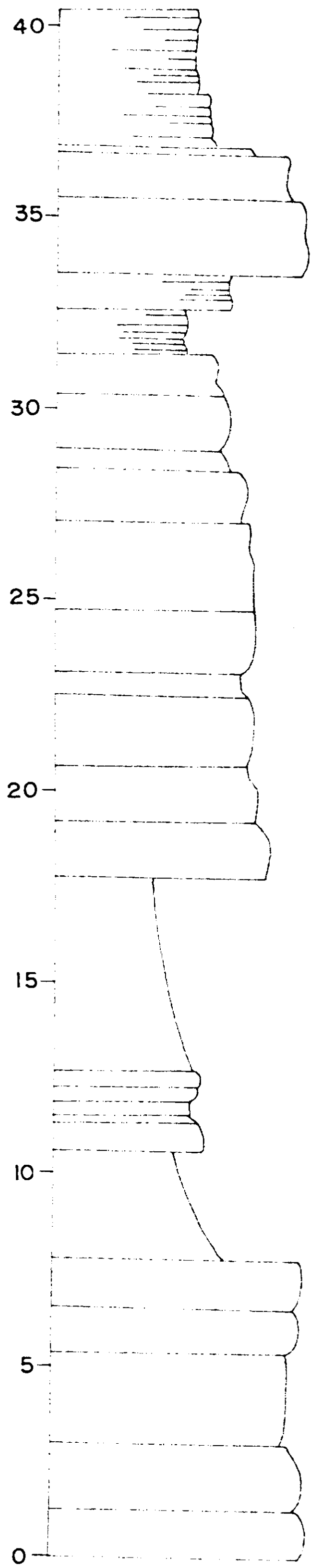

PLATE 10

SECTION 10 AND 10A

APPROXIMATE CENTER OF NE 1/4, SECTION 28
T-14-S R-9-W, M.P.M.

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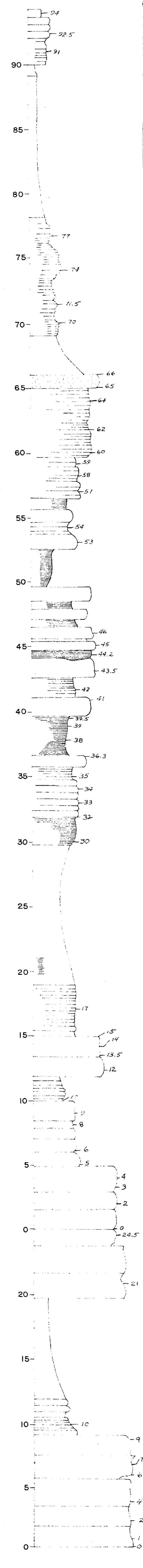

Type of Sample	Fresh Color	Chert	Rock Type	
SB	10YR4/2	BRN	4	Limestone; Ostracod (5%).
SB	10YR7/4	BRN	7	Limestone; Algal plate (10%), pelletol, superficial oolith (75%), sparite.
SB	10YR7/4	BRN	9A	Silty Limestone; Brachiopod fragment (1%), crinoid fragment (1%), apterinellid, quartz silty (5%), fragmental biomicrite.
SB	N1-3		3B-9A	Silty Limestone, Brachiopod fragment (5%), crinoid fragment (3%), apterinellid (2%), echinoid fragment (1%), quartz silty (10%), fragmental biomicrite.
SB	"	BRN	9A	See 77
SB	"	BRN	9A	See 77.
SB	"	BRN	9A	See 77.
SB	10YR6/6		10A	Sandstone, Micrite cemented (20%), hematitic, fine to medium grained, well sorted, burrowed, Quartz Sandstone
SB	10YR8/2		10A	Sandstone, Micrite cemented (15%), fine to medium grained, angular to subangular, well sorted, Quartz Sandstone.
SB	10YR6/2		4A	Sandy Limestone; Pelletal (10%), apterinellid (1%), ostracod fragment, pelmicrite intraclost (1%), burrowed, discontinuously laminated, quartz fine sandy (30%), micrite.
SB	10YR7/4		4A	Sandy Limestone; sparry (5%), burrowed, pelmicrite intraclast (1%), quartz fine sandy (5%), pelmicrite.
SB	10YR4/2		4	See 59.
SB	10YR4/2		4	Sandy Limestone; Ostracod (15%), sparry (15%), quartz fine sandy (10%), burrowed, partly compacted pelmicrite.
TS	10YR4/2		4A	Sandy Limestone; Ostracod fragment (30%), quartz fine sandy (30%), rounded pelmicrite intraclast (20%), pelmicrite.
SB	10YR4/2		4	Limestone; Ostracod (2%), brachiopod fragment (1%), partly compacted pelsparite.
SB	10YR4/2		5	Limestone; Ostracod (20%), sparry, laminated, mat algal biolithite.
SB	"		5	See 54.
SB	N1	BLK	3B	See 43.5
SB	"	BLK	3B	See 43.5
SB	"	BLK	3B	See 43.5
TS	N1	BLK	3B	Limestone; Brachiopod (20%), encrusting apterinellid (15%), crinoid fragment (3%), spine bearing, gastropods, phosphatic fragments (2%), laminated tan and black micrite, locally burrowed, quartz fine sandy (3%), biomicrite.
SB	"	BLK	3B	See 43.5
TS	N1	BLK	3B	Limestone; Brachiopod (5%), encrusting apterinellid (5%), gastropod (3%), crinoid fragment (2%), fragmented fossil hasn (10%), burrowed, mottled, quartz fine sandy (3%), fragmental biomicrite.
SB	10YR4/2	BRN	3B	See 39.
TS	10YR4/2	BRN	3B	Limestone; Brachiopod (5%), encrusting apterinellid (5%), crinoid fragments, ostracod fragment (1%), mottled and laminated mat algae (?), brown and black, quartz fine sandy (3%), biomicrite.
SB	"	BRN	3B	See 39.
SB	N1	BRN	3B	See 39.
TS	N1	BLK	3B	Limestone; Brachiopod fragment (10%), bryozoan fragment (2%), phosphatic fragment (5%), crinoid fragment (5%), echinoid fragment (2%), encrusting blue green algae (5%), apterinellid (2%), quartz fine silty (1%), biomicrite.
SB	N1	BLK	3B	See 33.
TS	N1	BLK	3B	Limestone, Brachiopod (20%), encrusting apterinellid (35%), unidentified horizontal algal mass (30%), crinoid fragment (10%), packed foraminiferal - algal consortium.
TS	N1	BLK	3B	Limestone; Apterinellid (15%), brachiopod fragment (2%), micrite.
SB	N1	BLK	3B	Limestone; Apterinellid (20%), chewed fragment (15%), micrite.
				Samples in soil indicate 3B.
SB	5YR2/1		5	Limestone; Ostracod (30%), algal plate (2%), in situ mat algal intraclast (10%), sparry, mat algal biolithite.
SB	10YR4/2		4	See 14.
TS	10YR4/2		4	Limestone; Ostracod (10%), blue green algal fragment (15%), pelmicrite intraclast (5%), sparry, quartz fine sandy (3%), pelmicrite.
SB	10YR4/2		5	Limestone; Ostracod (20%), laminated, sparry (30%), mat algal biolithite.
TS	10YR6/2	BRN	6	Limestone; Phylloid algal (60%), brachiopod fragment (1%), encrusting apterinellid and blue green algae (10%), endothyrid (T), millerellid (?), biosparite.
TS	10YR4/2		5	Limestone; Ostracod (25%), laminated, sparry, mat algal biolithite.
SB	10YR4/2		4	Limestone, Ostracod (10%), sparry (3%), fine quartz sandy (3%), pelmicrite.
TS	10YR4/2		5	Limestone; Ostracod (15%), laminated, birds-eye texture, sparry (20%), mat algal biolithite.
SB	10YR4/2		4	See 3.
SB	"		4	See 3.
SB	"	BRN	4	See 3.
SB	10YR4/2	BRN	4	Limestone; Brachiopod fragment (5%), crinoid fragment (5%), echinoid fragment (2%), spine bearing, pelmicrite.
TS	N1	BLK	3A	Limestone; Productid brachiopod (15%), crinoid fragment (15%), bryozoan fragment (5%), echinoid fragment (3%), encrusting apterinellid (3%), phosphatic fragments (1%), spine bearing, packed biomicrite.
SB	"	BLK	3A	See 2.
SB	"	BLK	3A	See 2.
SB	"	BLK	3A	See 2.
SB	5Y4/1	BRN	2	Sandy limestone; Brachiopod fragment (5%), ostracod fragment (1%), black micrite and pelmicrite intraclast (20%), micrite coated fine sand (30%), micrite.
SB	10YR6/2	BRN	2	See 7.
TS	10YR6/2	BRN	2	Limestone; Brachiopod (15%), crinoid fragment (15%), echinoid fragment (5%), millerellid (3%), endothyrid (3%), ostracod (3%), bryozoan fragment (3%), boring and encrusting blue green algal (1%), spine bearing, churned, packed micrite.
SB	"	BRN	2	See 7.
SB	"	BRN	2	See 7.
SB	"	BRN	2	See 7.
TS	"	BRN	2	See 7.
SB	10YR6/2	BRN	2	See 7.

PLATE II

SECTION 9

APPROXIMATE NW 1/4 NW 1/4 NE 1/4, SECTION 28
T-14-S R-9-W, M.P.M.

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1972

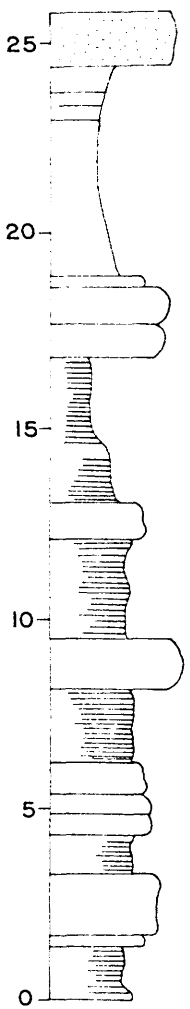

PLATE 12

SECTION 8 AND 8A

APPROXIMATE CENTER OF SW 1/4 SW 1/4, SECTION 21
T-14-S R-9-W, M.P.M.

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Type of Sample	Fresh Color	Chert	Rock Type	
TS	10 YR6/6		10A	Dolomitic Sandstone; Dolomicrite and silica cemented (10%), fine to medium grained (.15-.25mm), well sorted, round to subround, hematite, chert, Quartz Sandstone.
SB	10YR4/2		4-5	Limestone; Brachiopod fragment (1%), burrowed, sparry (10%), mat algal (25%), partly compacted pelmicrite.
SB	10YR2/2	BRN	9A	Silty Limestone; encrusting Calcitornellid (10%), ostracod (3%), brachiopod fragment (1%), crinoid (1%) and echinoid (1%) fragment, algal plate (3%), blue green algal fragment (60%), discontinuously laminated, quartz silty (6%), burrowed, fragmental micrite.
SB	"	BRN	9A	Silty Limestone; see 131.4
TS	5Y 7/2		5	Limestone; Silty micrite intraclast (1%), laminated, quartz fine sandy (1%), Mat algal biolithite.
SB	10YR2/2	BRN	9A	Silty Limestone; Apterinellid (15%), brachiopod fragment (1%), ostracod (1%), echinoid spine bearing, quartz silty (5%), micrite. 127 - same as 127.5
SB	"			
SB	10YR 4/2		5	Limestone; laminated, sparry, mat algal biolithite.
SB	"		5	Limestone; see 126.5
TS	5YR3/2		4	Limestone; Brachiopod fragment (3%), Apterinellid (2%), mat algal frag. (25%), sparry pelmicrite.
TS	10YR6/2	BRN	9A	Silty Limestone; Brachiopod fragment (5%), ostracod (1%), apterinellid (3%), crinoid fragment, echinoid fragment, churned, sparry (20%), quartz silty (5%), micrite. 124.5 - see 125.
TS	"			
TS	10YR5/4			Sandstone; Micrite and silica cemented (20%), apterinellid (10%), ostracod frag. (3%), algal plate (1%), micrite intraclast (3%), fine to medium grained (.08-.24mm), subround to subang. Quartz Sandstone.
TS	10YR 4/2		5	Limestone; Ostracod (40%), sparry, laminated, quartz sandy (3%), mat algal biolithite.
SB	10YR8/2			See 117.
TS	10YR8/2		10C	Sandstone; Micrite and silica cemented (15%), fine to medium grained, subround to subangular, bimodally sorted, chert, Quartz Sandstone.
TS	10YR 8/2		10C	Sandstone; Micrite cemented (25%), apterinellid (3%), silty micrite intraclast (5%), fine to medium grained (.05-.24mm), bimodally sorted, subround to subangular, chert (2%), leucoxene, Quartz sandstone.
TS	10 YR 6/2		5	Limestone; Ostracod (10%), sparry, laminated, quartz silty (3%), mat algal biolithite.
SB	10 YR 6/2		4	Limestone; Ostracod (10%), quartz silty (3%), sparry (10%), partly compacted pelmicrite.
TS	5YR 5/2		5	Limestone; Ostracod (3%), laminated, sparry, birds-eye texture, mat algal biolithite.
TS	"		5	See 111.8
TS	10YR 7/4		10B	Dolomitic sandstone; dolomicrite cemented, silty micrite intraclast (5%), coarse silt-fine sand grained (.03-.15mm), angular to subangular, bimodally sorted, chert (2%), hematite, leucoxene, quartz sandstone.
SB	"		10B	See 110.3
SB	"		10B	See 110.3
TS	N1		13	Dolomitic Limestone; Ostracod (1%), apterinellid (1%), brachiopod fragment (2%), crinoid fragment (1%), discontinuously laminated, quartz silty (1%), dolomitic (5%), clayey micrite.
TS	10YR4/2		13	Dolomitic Limestone; Quartz silty (1%), burrowed, dolomitic (40%), micrite.
TS	5Y 4/1		13	Silty dolomite; brachiopod fragment (5%), calcitic (5%), quartz fine silty (5%), dolomicrite.
TS	5Y 4/1		13	Sandy dolomitic Limestone; Quartz silty to fine sandy (10%), dolomitic (20%), micrite.
TS	10YR4/2		4-7	Sandy dolomitic Limestone; Ostracod fragment (1%), rounded intraclast, pelletal, dolomitic (10%), quartz silty to fine sandy, intrapelsparite.
TS	10YR8/2		10B	Sandstone; Micrite and silica (relict overgrowths) cemented, silty micrite intraclast (2%), trimodally sorted, fine to medium grained (.02-.30mm), angular to subround, chert, plagioclase, magnetite, quartz sandstone.
TS	5Y 7/2		10B	Sandstone; Micrite cemented (30%), silty and pelletal micrite intraclast (20%), trimodally sorted (.26mm - .18mm - .078mm), fine to medium grained, subround to angular, chert, plagioclase, tourmaline, leucoxene, Quartz (70%) Sandstone. 92 - see 93.
				See 93.
TS	5Y 6/1		7	Sandy Limestone; apterinellid (5%), ostracod (3%), crinoid and echinoid frag. (5%), phylloid algal (40%), quartz fine sandy (5%), biomicrite.
TS	N1		3B-9A	Limestone; Brachiopod (60%), encrusting apterinellid (3%), crinoid fragment (5%), echinoid fragment (3%), phylloid algal plate (40%), quartz fine sandy (5%), sparry, biomicrite.
SB	10 YR4/2	BRN	9A	Sandy dolomitic limestone, Brachiopod fragment (5%), ostracod fragment (10%), crinoid fragment (5%), echinoid fragment (2%), algal plate (10%), intraclastic (5%), quartz fine sandy (5%), dolomitic (15%), biomicrite.
SB	10YR4/2	BRN	9A	Dolomitic Limestone; Brachiopod fragment (5%), ostracod (2%), dolomitic (20%), laminated, sparry (10%), micrite.
SB	10YR4/2	BRN	9A	Sandy dolomitic Limestone; Ostracod fragment (2%), blue green algal fragment (10%), dolomitic (20%), quartz fine sandy, sparry (15%), micrite.
TS	10YR4/2	BRN	9A	Dolomitic silty Limestone; Brachiopod fragment (5%), ostracod fragment (5%), crinoid fragment (5%), unidentified shell fragments (5%), quartz silty (5%), dolomitic (10%), laminated, micritic biosparite.
SB	10YR4/2	BRN	9A	Dolomitic silty Limestone; Unidentified shell fragments (1%), crinoid fragment, dolomitic (20%), quartz silty (30%), micrite.
SB	10 YR2/2	BRN	9A	Dolomitic Silty Limestone; Ostracod frag. (1%), shell frag. (2%), dolomitic (30%), quartz silty (10%), micrite.
SB	10YR2/2	BRN	9B	Siltstone; micrite cemented (40%), angular, quartz siltstone.
SB	10YR5/4	BRN	9A	Silty Limestone; quartz silty (10%), micrite.
SB	10YR4/2	BRN	9A	Silty Limestone; quartz silty (3%), micrite.
SB	10YR4/2	BRN	4	Brecciated Limestone; unfossiliferous, structureless, micrite.
SB	10YR 5/2	BRN	5	Limestone; Laminated, sparry, birds-eye textured, mat algal biolithite.
SB	10YR4/2	BRN	9A	Limestone; Brachiopod fragment (10%), encrusting apterinellid (2%), algal plate (5%), crinoid fragment (3%), spine bearing, quartz silty (5%), churned, fragmented biomicrite.
SB	"	BRN	9A	See 60.
SB	"	BRN	9A	See 60.
SB	10YR4/2	BRN	8	See 50.
SB	10YR4/2	BRN	8	See 50.
TS	10YR4/2	BRN	8	Limestone; Algal plate (25%), crinoid fragment (10%), echinoid fragment (5%), apterinellid (3%), brachiopod fragment (5%), spine bearing, encrusting algae and foraminifers (5%), intraclastic (8%), quartz fine sandy (1%), micritic, packed biosparite.
SB	"	BRN	8	See 50
SB	10YR4/2	BRN	8	See 43.8
SB	"	BRN	8	See 43.8
SB	"	BRN	8	See 43.8
SB	10YR4/2	BRN	8	Limestone; Brachiopod fragment (10%), phylloid algal plate (20%), apterinellid (10%), bryozoan fragment (5%), echinoid and crinoid frag. (5%), gastropod (2%), ostracod, spine bearing, carbonaceous fragment (5%), encrusting blue green algal (5%), silty micrite intraclast (10%), quartz fine sandy (2%), biomicrite.
SB	"	BRN	8	
TS	10YR4/2	BRN	8	
TS	10 YR7/4	BRN	10A	Sandstone; micrite cemented (20%), burrowed and sandy pelmicrite intraclast (15%), fine grained (.08-.18mm), bimodally sorted, rounded to subangular, cherty (20%), quartz sandstone.
SB	10YR4/2		4	Limestone; Quartz fine sandy (5%), ostracod frag. (3%), sparry (2%), partly compacted pelmicrite.
SB	10YR4/2	BRN	4	Brecciated Limestone; Ostracod (2%), compacted pelmicrite.
SB	10YR6/2	BRN	10A	See 38.
SB	10YR6/2	BRN	10A	Sandstone; micrite cemented (25%), pelmicrite intraclast (5%), subround to subangular, fine grained, quartz sandstone.
SB	10YR5/4		4	Brecciated Limestone; quartz fine sandy (10%), compacted pelmicrite.
SB	F5YR3/2		4	Limestone; Ostracod (5%), quartz fine sandy (2%), sparry (10%), compacted pelmicrite.
TS	10YR4/2		4	Limestone; brachiopod fragment (3%), apterinellid (2%), crinoid fragment, spine bearing, encrusting blue-green algae, sparry (2%), compacted pelmicrite.
TS	N5	BRN	1	Dolomite; brachiopod fragment (15%), bryozoan fragment (2%), crinoid fragment (3%), echinoid fragment (1%), spine bearing (1%), churned, dolomicrite.
SB	10YR4/2		5	Limestone; laminated, ostracod (2%), sparry, birds-eye textured, mat algal biolithite.
SB	10YR4/2		5	See 29.5
SB	10YR4/2		4	Limestone; Ostracod (15%), mat algal fragment (15%), pelmicrite.
SB	10YR6/2		4	Limestone; brachiopod fragment (1%), crinoid fragment (1%), apterinellid (1%), spine bearing, burrowed, mottled, compacted pelmicrite.
SB	10YR4/2		5	Limestone; Ostracod (5%), laminated, pelletal, sparry (10%), mat algal biolithite.
SB	10YR4/2		4	Limestone; Ostracod (10%), blue green algal fragment (10%), pelmicrite.
SB	10YR4/2		4	Limestone; Ostracod (15%), sparry (10%), partly compacted pelmicrite.
SB	10YR6/2	BRN	7	Limestone; Brachiopod fragment (3%), crinoid fragment (5%), algal plate (30%), encrusting apterinellid and blue green algal (10%), intraclast (1%), sparry (10%), superficial oomicrite.
SB	10YR4/2		4	Limestone; Ostracod (10%), sparry (5%), partly compacted pelmicrite.
SB	10YR4/2		4	Limestone; Ostracod (5%), burrowed, compacted pelmicrite.
SB	10YR6/2	BRN	4	Limestone; Brachiopod fragment (3%), crinoid fragment (5%), ostracod fragment, pelletal (?) micrite.
SB	N1	BLK	3A	See 4.
SB	N1	BLK	3A	Limestone; Productid brachiopod (10%), crinoid fragment (15%), bryozoan fragment (5%), echinoid fragment, phosphatic fragment, apterinellid (1%), spine bearing (3%), churned, packed biomicrite.
SB	10YR6/2	BRN	2	See 3.
SB	10YR6/2	BRN	2	Limestone; Brachiopod (10%), crinoid fragment (15%), echinoid fragment (3%), millerellid (1%), bryozoan fragment (1%), encrusting blue green algal (1%), spine bearing (5%), churned biomicrite.

PLATE 13

SECTION 7

APPROXIMATE SE 1/4 SE 1/4 NE 1/4, SECTION 20
T-14-S R-9-W, M.P.M.

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1972

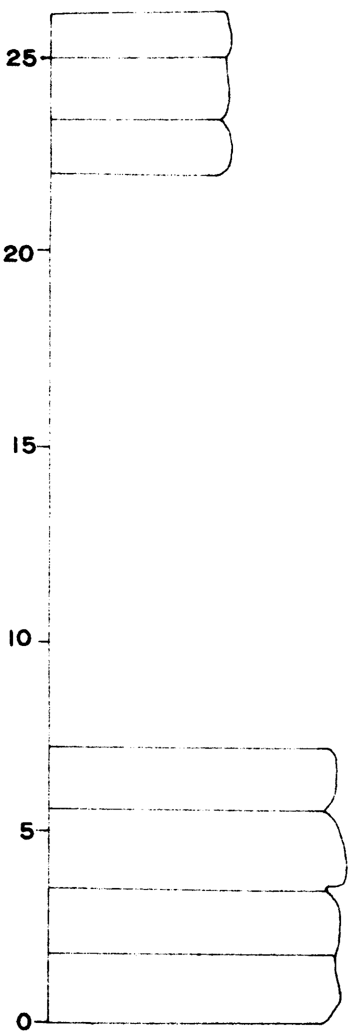

PLATE 14

SECTION 6

APPROXIMATE SW1/4 SW1/4 NW1/4, SECTION 17
T-14-S R-9-W, M.P.M.

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1972

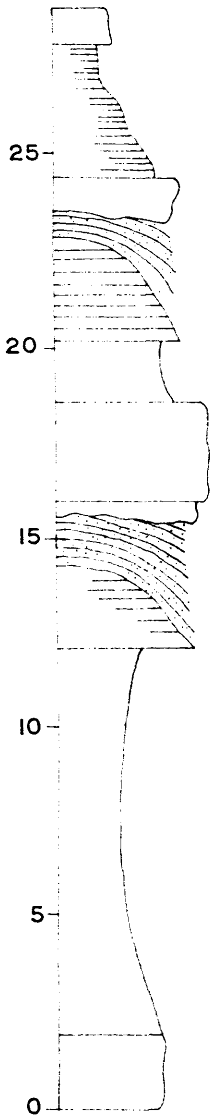

PLATE 15

SECTION 5

APPROXIMATE SW 1/4 SW 1/4 NW 1/4, SECTION 17
T-14-S R-9-W, M.P.M.

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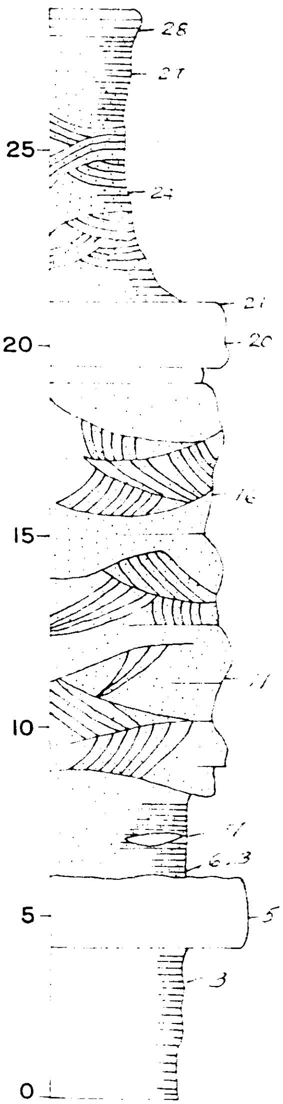

Type of Sample	Fresh Color	Chert	Rock Type	
SB	10YR4/2		5	Limestone; Ostracod (2%), laminated, mat algal biolithite.
SB	10YR7/4		10D	Sandstone; Micrite cemented (20%), fine grained, subround to angular, well sorted, Quartz Sandstone.
SB	10YR7/4		10D	See 27.
SB	10YR6/2		4	Limestone; Sparry (3%), pelmicrite.
SB	10YR4/2 BRN		7	Limestone; Algal fragment (30%), brachiopod and spine fragment (5%), rounded micrite intraclast (5%), pelletal, encrusting apterinellid, quartz fine sandy, superficial oolith (5%), sparry (5%), packed biomicrite.
SB	10YR7/4		10D	Sandstone; Dolomicrite and silica cemented (10%), fine grained, well sorted, subround to angular, Quartz Sandstone.
SB	10YR7/4		10D	See 16.
SB	10YR7/4		10D	Sandstone; Micrite cemented (15%), fine grained, subangular to angular, well sorted, Quartz Sandstone.
SB	5Y6/1		10D	Sandy Limestone; Micrite intraclast (15%), quartz medium-coarse sandy (2%), micrite.
SB	10YR6/2		4-7	Limestone; Sparry (10%), ostracod (1%), pelmicrite intraclast (5%), superficial oolite (1%), burrowed, quartz fine and medium sandy (5%), partly compacted pelsparite.
SB	5Y 7/2		9A	Silty Limestone; Laminated 5Y7/2 and N4, quartz silty (1%), micrite.

PLATE 16
SECTION 4

APPROXIMATE CENTER OF NE 1/4 NW 1/4, SECTION 7
T-14-S R-9-W, M.P.M.

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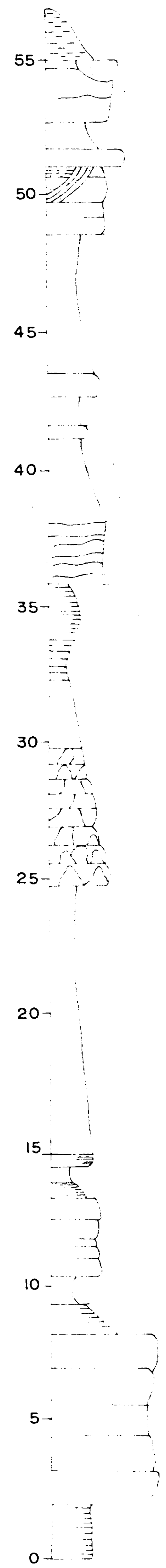
1972



Type of Sample	Fresh Color	Chert	Rock Type	Interval	Description
FD	N1			55 - 57	Shale; Calcareous, fissile, shale.
FD	N1		7 10D	52.7 - 55	Sandy Limestone; Brachiopod fragment (15%), crinoid fragment (5%), encrusted algal plate (30%), superficial oolith (20%), micrite intraclast (1%), encrusting apterinellid and blue green algae (3%), quartz fine sandy (10%), biosparite. Channeled by Sandstone (5YR6/1); Micrite cemented (30%), fine grained, subangular to angular, Quartz Sandstone.
FD	10YR6/2 BRN		4	51 - 51.8	Limestone; Ostracod (5%), sparry (5%), quartz fine sandy (10%), partly compacted pelsparite.
FD	5Y 6/1 BRN		9A 10D	48.5 - 51	Dolomitic silty Limestone; Brachiopod fragment (2%), crinoid fragment (2%), algal fragment (1%), mottled light olive gray (5Y6/1) and black (N1), quartz silty (5%), dolomitic (10%), sparse fragmental micrite. Locally channeled by Sandstone (10YR7/4); Micrite cemented (45%), fine to medium grained, subangular, Quartz Sandstone.
FD	10YR4/2		5	42.5-43.5	Limestone; Ostracod (5%), laminated, sparry, quartz fine sandy (5%), mat algal biolithite.
FD	5YR3/2		4	41.3 - 41.8	Limestone; Ostracod (10%), sparry, burrowed, partly compacted pelsparite.
FD	5YR3/2		4	36 - 38	Limestone; Ostracod (5%), sparry (5%), burrowed, partly compacted pelsparite.
FD	5Y 7/2 BRN		9C	32.5 - 36	Dolomite; Quartz silty, dolomicrite.
FD	5Y 7/2 WH		9C	24.7 - 29.7	Dolomite; Brachiopod fragment (1%), quartz silty, dolomicrite. (Bedding badly broken with vertical fractures.)
FD	N1	BLK	3A	13.2 - 15	Limestone; Brachiopod fragment (2%), crinoid fragment (1%), bryozoan fragment (1%), spine bearing, mottled black (N1) and light olive gray (5Y 6/1), sparse fragmental biomicrite.
FD	N1	BLK	3A	10.5 - 13.2	Limestone; Brachiopod fragment (10%), crinoid fragment (5%), echinoid fragment (1%), bryozoan fragment (3%), apterinellid (1%), phosphatic fragment (1%), spine bearing, biomicrite.
FD	10YR4/2 BRN		4	2 - 9.5	Limestone; Ostracod (5%), sparry (10%), partly compacted pelsparite.
FD	5YR6/1 BRN		9A	0 - 2	Limestone; Quartz silty (3%), unfossiliferous micrite.

PLATE 17

SECTION 3

CENTER OF SE 1/4 NE 1/4, SECTION 1
T-14-S R-10-W, M.P.M.

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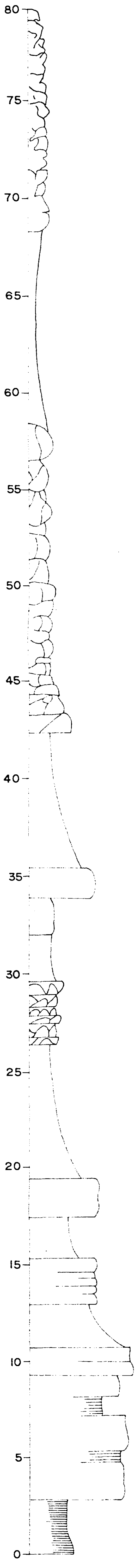
1972



Type of Sample	Fresh Color	Chert	Rock Type		
FD	10YR7/4	WH	9C	68.5 - 80	Dolomite; Rare brachiopod and crinoid fragment, sparry (2%), dolomicrite. (Bedding badly broken with vertical fractures.)
FD	10YR7/4	WH	9C	42.5-58.5	Dolomite; Brachiopod fragment (3%), crinoid fragment (2%), sparry (1%), dolomicrite. (Bedding badly broken with vertical fractures.)
FD	N5		7	34-35.5	Limestone; Brachiopod fragment (2%), crinoid fragment (3%), algal plate (10%), intraclastic, micrite.
FD	N5		5	32-34	Limestone; Laminated, birds-eye textured, sparry (10%), mat algal biolithite.
FD	10YR6/2	WH	9C	26.5-29.5	Dolomite; Unfossiliferous, hematitic, dolomicrite. (Bedding badly broken with vertical fractures.
FD	N5	BRN	7	17.5-19.5	Limestone; Brachiopod fragment (5%), crinoid fragment (5%), encrusted algal plate (30%), encrusting apterinellid (10%), intraclastic (10%), burrowed, sparry (5%), superficial oomicrite.
FD	N3	BLK	3A	13-15.5	Limestone; Brachiopod (10%), crinoid fragment (15%), echinoid and bryozoan fragment, burrowed, biomicrite.
FD	10YR6/2	BRN	5	3-11	Limestone; Ostracod (10%), laminated, birds-eye textured, sparry(15%), mat algal biolithite.
FD	10YR6/2	BRN	9A	0-3	Limestone; Laminated, silty (10%), micrite.

PLATE 18

SECTION 2 AND 2A

APPROXIMATE CENTER OF SE 1/4 SW 1/4, SECTION 36
T-13-S R-10-W, M.P.M.

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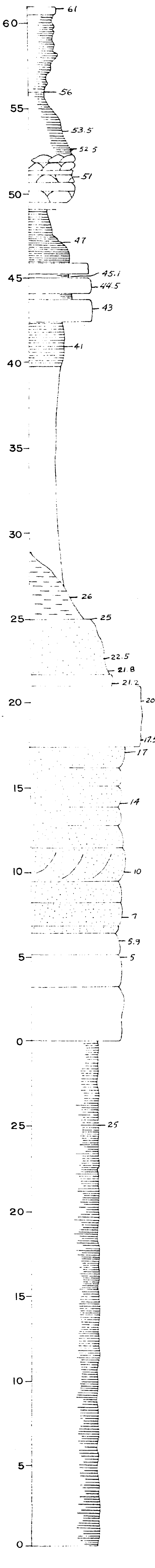
1972



Sample height	Type of Sample	Fresh Color	Chert	Rock Type	Description
61	SB	10YR4/2		4A	Limestone; Ostracod fragment (15%), fine fassil fragment (20%), pelletal (10%), superficial aolith (5%), algal (?) plate (3%), biomicrite.
56	SB	10YR4/2	BRN	9A	Limestone; Gastropod (10%), spine bearing (10%), echinaid fragment (3%), brachiapod fragment, quartz silty to fine sandy (2%), biomicrite.
53.5	SB	10YR4/2	BRN	9A	Silty Limestone; Brachiapad fragment (1%), fine fassil frag. (1%), quartz silty (2%), micrite.
52.5	SB	N1	BLK	9A	Limestone; Brachiopod fragment (1%), crinoid fragment (1%), bryazoan fragment, apterinellid, spine bearing, sparse biomicrite.
51	SB	10YR6/2	WH	9C	Dolomite; Brachiopod fragment (1%), bryozoan fragment (1%), dense dolomicrite. (Bedding braken with vertical fractures.)
47	SB	10YR4/2	BRN	9A	Silty Limestone; Crinoid fragment (1%), bryozaan fragment (1%), brachiapad fragment (1%), quartz silty (3%), sparse biamicrite.
45.1	FD	N1	BLK	3A	Shaly Limestane; Brachiopad (3%), bryozaan (1%), neotremate brachiapad (1%), biamicrite.
44.5	SB	N1	BLK	3A	Limestane; Brachiapod (10%), crinoid fragment (5%), bryozaan (3%), apterinellid (1%), neatremate fragment (1%), biomicrite.
43	SB	N1	BLK	3A	Limestane; Unfassiliferaus, micrite.
41	FD	N1	BLK	3A	Limestane; Brachiapod fragment, crinoid fragment, bryozoan fragment, micrite.
26	FD	N1		11	Shale; Fissile, calcareaus, shale.
25	FD	10YR8/2		10D	Dolomitic Sandstone; Dalomicrite and clay cemented (20%), fine grained, well sorted, subangular to angular, Quartz Sandstone.
22.5	FD	"		10D	See 25.
21.8	SB	10YR8/2			Sandstone; Dolomicrite (10%) and micrite (20%) cemented, astracod frag. (3%), algal plate, crinoid fragment, micrite intraclast (1%), fine to medium grained, subangular, poorly sorted, Quartz Sandstone.
21.2	SB	10YR6/2		Y	Sandy Limestone; Ostracod and ostracod fragment (10%), bracniopod fragment (1%), spine bearing, apterinellid, laminated quartz fine sandy (30%), micrite.
20	SB	10YR6/2	BRN	7	Dolomite; Brachiopod fragment (3%), crinoid fragment (1%), bryozoan fragment, algal plate (5%), micrite intraclast (10%), burrowed, quartz fine sandy (10%), sparse dolomicrite.
17.5	SB	"	BRN	7	See 20.
17	SB	10YR7/4		10D	Sandstone; Micrite and clay cemented (20%), medium and fine grained, subround to subangular, bimodally sorted, limonitic (pyrite), Quartz Sandstone.
14	SB	5Y8/1		10D	Sandstane; Micrite and clay cemented, fine to medium grained, subround to subangular, well sorted, manganiferaus (15%), Quartz Sandstone.
10	SB	10YR7/4		10D	Sandstone; Micrite and clay cemented (15%), fine to medium grained, subround to subangular, well sarted, Quartz Sandstone.
7	SB	5YR6/1		10D	Sandstone; Micrite and silica cemented (30%), fine grained, angular ta subangular, well sorted, brachiopod fragment, algal plate fragment, Quartz Sandstone.
5.9	SB	N5		7	Limestane; Brachiopod fragment (3%), coated algal plate (25%), superficial oolith (35%), encrusting opterinellid and blue green algae (5%), mat algal intraclast (3%), quartz fine sandy (10%), packed biosparite.
5	SB	"	BRN	7	See 5.9
25	FD	N1	BLK	3C	Limestone; Spiculitic (1%), laminated, asphaltic, micrite.

PLATE 19

SECTION I

APPROXIMATE CENTER OF SE 1/4 NW 1/4, SECTION 36
T-13-S R-10-W, M.P.M.

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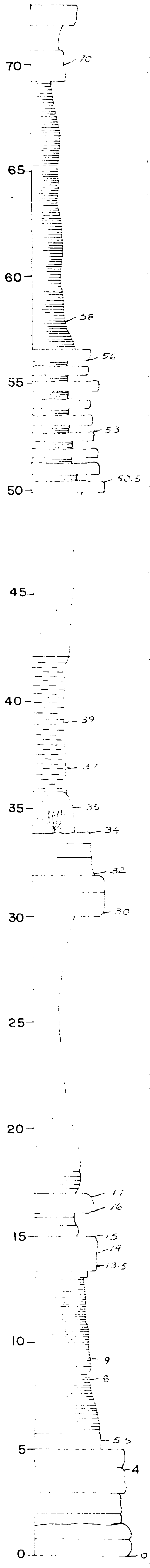
1972



Sample	Type of Sample	Fresh Color	Chert	Rock Type	Description
70	TS	10YR6/2		4A	Limestone, Ostracod fragment (25%), algal fragment.
58	TS	10YR6/2		9D	Limestone; Plant leaf and stem, recrystallized (40%), micrite filled gastropod (25%), packed biomicrite.
56	SB	N1	BLK	3A	See 50.5
53	TS	N1		3A	See 50.5
50.5	SB	N1		3A	Limestone, Productid brachiopod (25%), fenestrate bryozoan (15%), crinoid fragment (15%), spine bearing (5%), echinoid fragment (5%), Neotremate brachiopod (2%), encrusting apterinellid (2%), packed biomicrite.
39	FD	10Y 6/2		11	Shale, See 37.
37	FD	N1		11	Shale; Bryozoan (3%), ostracod (5%), fissile, calcareous shale.
35	SB	10YR7/4		10D	Sandstone; Micrite, clay, and silica cemented (25%), algal blade biolithite (10%), medium to fine grained, subround to subangular, Quartz Sandstone.
34	TS	10YR4/2		12	Limestone; Productid brachiopod (20%), crinoid fragment (15%), echinoid fragment (3%), bryozoan fragment (3%), encrusting apterinellid and blue green algal (3%), millerellid (3%), mat algal intraclast (20%), packed biomicrite.
32	TS	10YR4/2		12	Limestone, Productid brachiopod (25%), crinoid fragment (15%), bryozoan fragment (3%), echinoid fragment (3% encrusting apterinellid (5%), encrusting blue-green algal (3%), mat algal intraclast (1%), spine bearing packed biomicrite.
30	TS	10YR4/2		12	Limestone, Productid brachiopod (15%), crinoid fragment (15%), echinoid fragment (5%), bryozoan fragment (3%), encrusting apterinellid (3%), endothyrid (1%), millerellid (1%), packed biomicrite.
17				10A	See 16
16	TS			10A	Intraclastic Sandstone, Brachiopod fragment (1%), pelmicrite intraclast (15%), dolomicrite and silica cemented (30%), fine grained (.06-.24mm), well rounded to angular, bimodally sorted, laminated, Quartz Sandstone
15	TS	10YR6/2		7	Sandy Limestone; Bracniopod fragment (15%), crinoid fragment (15%), echinoid fragment (3%), phosphatic fragment (2%), encrusting mat algal (3%), encrusting apterinellid (5%), pelmicrite intraclast (5%), quartz fine sandy (35%), fragmental micrite.
14		"		7	14 - See 15
13.5		"		7	See 15.
9	SB	5Y6/1		9B	Siltstone; Micrite cemented (25%), Quartz Siltstone.
8	SB	5Y6/1		9C	Dolomite; Laminated unfossiliferous dolomicrite.
5.5	SB	10Y 7/4		9C	Dolomitic Limestone; Brachiopod fragment (10%), bryozoan fragment (10%), crinoid fragment (5%), burrowed, dolomitic (75%), fragmental micrite
4	TS	N6		12	Limestone; Brachiopod (15%), echinoid fragment (5%), crinoid fragment (10%), bryozoan fragment (3%), apterinellid (3%), millerellid (2%), spine bearing (2%), fragmental, sparry (30%), quartz silty (1%), packed biomicrite.
0	TS	N6		12	See 4.