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The geology and hydrocarbon potential of the Dawson Bay Formation carbonate unit (Middle Devonian), Williston Basin, North Dakota

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THE GEOLOGY AND HYDROCARBON POTENTIAL OF THE DAWSON BAY FORMATION CARBONATE UNIT (MIDDLE DEVONIAN), WILLISTON BASIN, NORTH DAKOTA

by

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This thesis meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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ABSTRACT

The Middle Devonian Dawson Bay Formation carbonate unit is present in the subsurface of North Dakota except where truncated by post-depositional erosion. The carbonate unit thickens from the erosional limit to a maximum thickness of 47.5 m (156 ft.) in Renville County and reaches a maximum depth of 3798 m (12,432 ft.) below the surface in McKenzie County. In North Dakota, a submarine hardground separates the carbonate unit from the underlying "Second Red Bed member" of the Dawson Bay Formation. The upper contact with the Souris River Formation is conformable except in those areas where the Dawson Bay Formation was exposed to subaerial erosion prior to deposition of the Souris River sediments.

The Dawson Bay carbonate unit is predominantly dolomitic and fossiliferous limestone or fossiliferous dolostone. The carbonate unit can be subdivided into five lithofacies on the basis of characteristic fossil fauna, flora, and other lithologic features. In ascending order, the carbonate lithofacies are: lithofacies B (brachiopod-echinoderm wackestones and mudstones), lithofacies C (stromatoporoid boundstones, wackestones, and mudstones), lithofacies D (gastropod-ostracod-brachiopod-echinoderm wackestones and mudstones), lihofacies E (gastropod-ostracod mudstones), and lithofacies F (cryptalgal boundstones and mudstones).

Lithofacies analysis of the Dawson Bay carbonates suggests a shallowing-upward succession of depositional environments and associated energy zones as follows: shallow epieric sea (very low energy), stromatoporoid biostrome/bioherm (low energy), very shallow

epeiric sea (very low energy), restricted shallow epeiric sea (extremely low energy), and shallow epeiric sea shoreline (variable energy).

Eogenetic diagenesis includes: color-mottling, dolomitization of micrite to microcrystalline dolomite with penecontemporaneous anhydrite replacement of cryptalgal mudstones and boundstones, cementation by sparry calcite, and vuggy porosity development. Mesogenetic diagenesis includes: formation of mosaic dolomites; cementation by blocky equant calcite; neomorphism; pressure-solution; fracturing; halite cementation; and hydrocarbon emplacement.

Late mesogenetic hydrocarbon generation occurred within basal Dawson Bay carbonates and/or was the result of migration into the formation. Middle to late mesogenetic anhydrite, halite, and calcite cementation partly limits reservoir potential. Hydrocarbon occurrence in the Dawson Bay carbonates is primarily associated with porosity within the stromatoporoid buildups, multiple fracturing events over topographic and structural highs, and multiple dolomitization events.

INTRODUCTION

General

The Dawson Bay Formation is late Middle Devonian in age. It is found within the 15,600 square mile area of the Williston Basin and is a subsurface formation in North Dakota (Figure 1)(Gerhard and others, 1982). The Dawson Bay Formation is the lowermost carbonate cycle of the Manitoba Group and is composed of a basal argillaceous member and an upper carbonate member (Figure 2). The argillaceous Souris River Formation caps the group (Bluemle and others, 1980). The Dawson Bay Formation reaches a maximum thickness of approximately 56 m (185 ft.) in Saskatchewan (Dunn, 1982). A.D. Baillie (1953) first studied the Dawson Bay Formation where it crops out in northern Manitoba in the vacinity of the Dawson Bay on the shores and islands of Lake Winnipegosis. Baillie named it and correlated it into the subsurface of the Williston Basin (Figure 2) (Baillie, 1953, 1955).

In the study area, the Dawson Bay Formation reaches a maximum thickness of about 47 m (155 ft.) along the northern border of North Dakota, in Towner, Bottineau, Renville, and Burke Counties, thinning to an erosional edge in the eastern, southern, and southwestern portions of the state.

Regionally in the Williston Basin, the Dawson Bay Formation is composed largely of fossiliferous limestone or dolomitized limestone. Anhydrite and halite are occasionally present in appreciable amounts. Bioclasts are a major allochemical constituent. In ascending order,

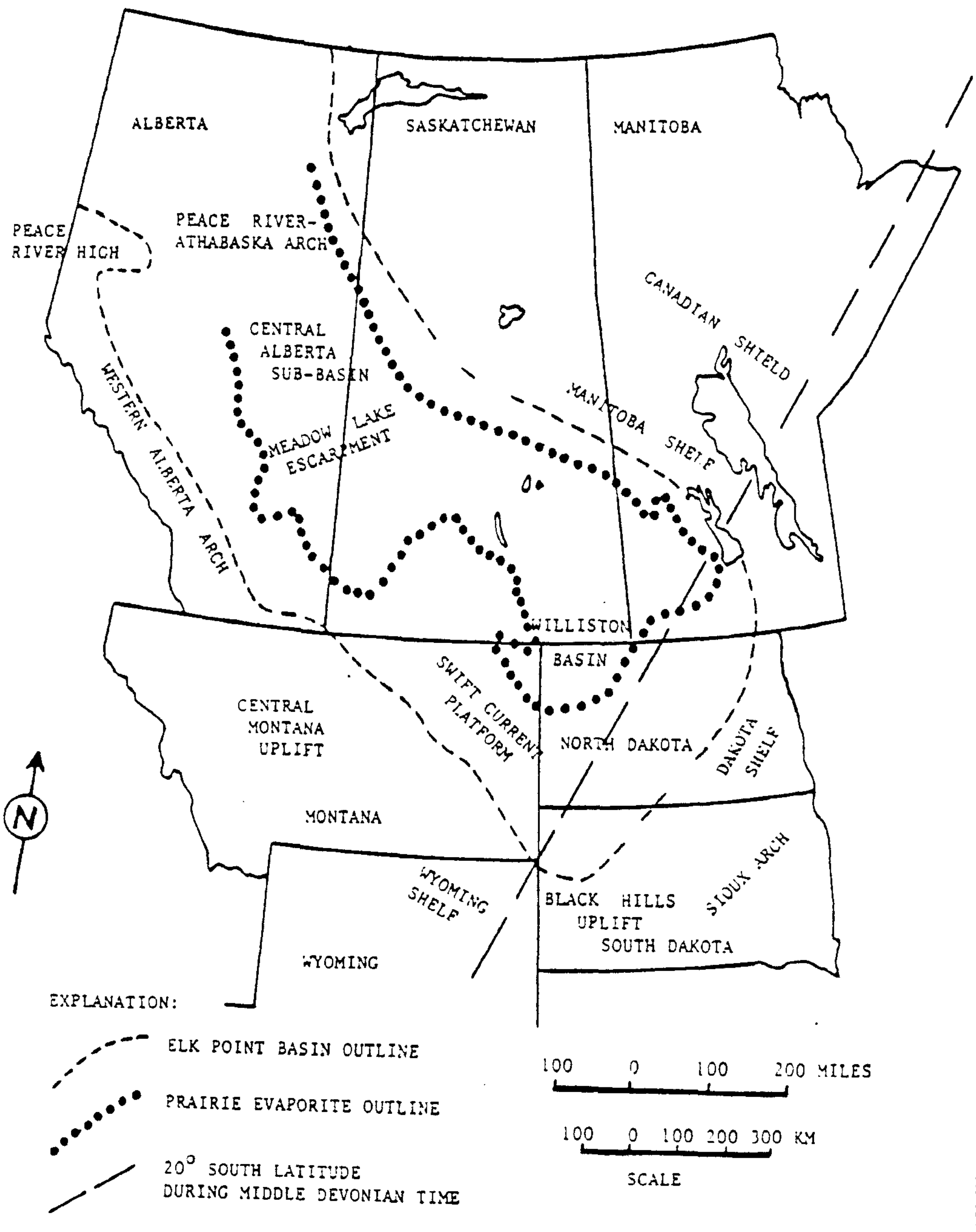


Figure 1: Regional map showing the relationship of the Williston Basin to adjacent features, modified from Worsley and Fuzesy (1978) and the location of the 20° South latitude line during Middle Devonian time, modified from Heckel and Witzke (1979).

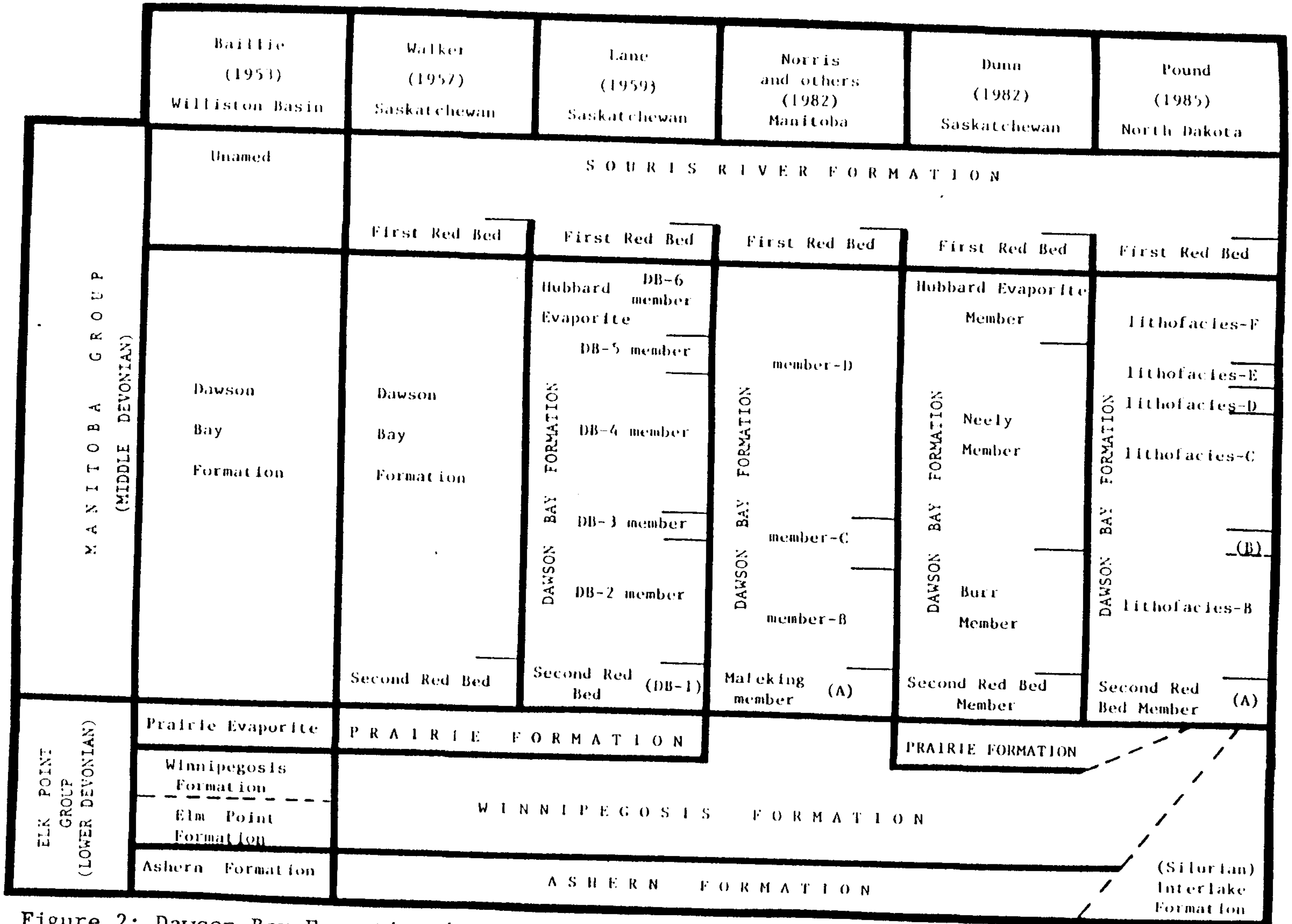


Figure 2: Dawson Bay Formation (Middle Devonian) Correlation Chart for North Dakota, Manitoba, and Saskatchewan.

major bioclastic components include: echinoderms and brachiopods (commonly fragmental), stromatoporoids, gastropods-ostracods-brachiopods-echinoderms, gastropods and ostracods; and cryptalgal laminations (locally anhydritic).

Diagenetic features are dominated by secondary dolomite rhombs, pressure-solution structures, calcite cement, neomorphic calcite crystals, secondary pores, and color-mottling. Secondary halite, anhydrite, and hydrocarbons are diagenetic features due to their post depositional origin.

The Dawson Bay Formation produces oil from sucrosic dolomites associated with structural traps in McCone County, Montana (Edie, 1959) and Williams County, North Dakota (Dean, 1982). Dawson Bay production occurs above the Cedar Creek Anticline in Montana (Sandberg and Mapel, 1967) and on a structural nose flanking the Nesson Anticline in North Dakota (Dean, 1982). Edie (1959) stated that hydrocarbons have been reported over the entire area of the Williston Basin. This observation is reinforced by the results of the present study.

Purpose of Study

The purpose of this study is to:

(1) Determine the petrography of the carbonate unit of the Dawson Bay Formation.

(2) Determine the major diagenetic features of the carbonate unit in the Dawson Bay Formation.

(3) Construct a depositional model that summarizes and interprets the history of the formation.

(4) Indicate possible relationships between lithologic character and petroleum occurrence in the Dawson Bay Formation.

Method of Study

This study of the carbonate unit of the Dawson Bay Formation is confined to the North Dakota portion of the Williston Basin. A data base density of at least two wells per township was used when available (Plates 1, 2, and 3). Legal descriptions for wells cited are listed in Appendix A using the North Dakota Geological Survey (NDGS) well number (e.g. Blanche Thompson No. 1,NDGS #38).

North Dakota Geological Survey wire-line logs were utilized in the selection of top and bottom footages of the carbonate unit (Appendix A). A total of 634 wire-line logs, primarily using dual laterologs with gamma ray, were studied and supplemented by core study. Compensated sonic logs with gamma ray were used secondarily. It was often necessary to use spontaneous-potential logs with resistivity in studying older wells.

An isopach map (Plate 1) and two structure countour maps (Plates 2 and 3) were constructed. The isopach map includes the carbonate member of the Dawson Bay Formation, but excludes the basal argillaceous Second Red Bed member. The structure contour maps were constructed on the top of the Dawson Bay Formation and the top of the Second Red Bed member. Cross-sectons of the Dawson Bay Formation (Plate 4) were constructed from wire-line logs along north-south and east-west transects.

Twelve cores provided by the Wilson M. Laird Core and Sample Library of the North Dakota Geological Survey in Grand Forks, were studied. A total of 195 m (639.1 ft.) of core was studied. The distribution of cores used in this study is shown on Plates 1, 2, and 3. Core analysis included hand-lens and reflected light microscope inspection. Macroscopic descriptions are included in Appendix B.

Chlorothene saturated samples were inspected with ultraviolet light at approximately 1.2 m (4 ft.) intervals to detect the presence of hydrocarbons (Appendix B). Care was taken to avoid contamination and uniform sample sizes were used in this assessment. Dilute (10%) hydrochloric acid was used to distinguish dolomite from calcite. Color designations were made utilizing the Revised Standard Soil Color Charts which are an expansion of the Munsell notations (Oyama and Takehara, 1967).

Samples were taken for thin-section study at approximately 1.2 m (4 ft.) intervals throughout the core. Microscopic analysis of 200 polished thin-sections was conducted utilizing reflected and polarized light (Appendix B). One half of each thin-section was stained in a solution of warm Alizarin Red S as described by Friedman (1959,1971) to distinguish calcite from dolomite.

Thin-sections and cores were described using the nomenclatures of both Folk (1959) and Dunham (1962). Lithologic descriptions generally utilize the terminologies of Choquette and Pray (1970), Folk (1974), Maiklem and others (1969), Mattes and Mountjoy (1980), Schreiber (1981), and Wanless (1979).

The facilities of the Natural Materials Analytical Laboratory of the University of North Dakota were utilized for X-ray analysis, scanning electron microscopy, and microprobe assessment of selected thin-sections and core samples.

Geologic and Tectonic Setting

The Williston Basin is a sedimentary and structural, intracratonic basin located on the western periphery of the North American Craton (Figure 1) (Gerhard and others, 1982). The basin underlies parts of North Dakota, South Dakota, Montana, Wyoming, Manitoba, and Saskatchewan. Precambrian crystalline basement occurs at a maximum depth of approximately 4880 m (16,000 ft.) beneath east-central McKenzie County, North Dakota (Gerhard and others, 1982). Phanerozoic sedimentary rocks of every cratonic succession exist in the Williston Basin (Sloss, 1963) and all Paleozoic systems are present (Carlson and Anderson, 1965). The southern, eastern, and northern limits of the Williston Basin are delineated by the onlap of Paleozoic and Mesozoic rocks onto Precambrian basement rocks. The western margin is less distinct due to depositional and erosional variability (Sandberg and Hammond, 1958).

The Williston Basin is one of several structural basins located upon the North American Craton. The tectonic outline is defined by the Sioux Arch and Dakota Shelf on the southeast, Black Hills Uplift on the south, Wyoming Shelf on the southwest, Central Montana Uplift and Swift Current Platform to the west, Meadow Lake Escarpment to the northwest, Manitiba Shelf to the north, and the edge of the Canadian Shield to the northeast and east (Figure 3) (Norris and others, 1982) (Gerhard and others, 1982). Structural elements which influenced deposition within the North Dakota portion of the basin, include several anticlines, lineaments, and highs, which have permitted development of structural and diagenetic hydrocarbon traps in many of the basin formations.

Early Paleozoic History

The Williston Basin was not present in earliest Paleozoic time. Fault-block highs were initially present on the Precambrian Shield and remained there to influence deposition when subsidence of the Williston Basin commenced (Carlson, 1960). Earliest Phanerozoic sedimentation occured with deposition of the Cambrian to Early Ordovician Deadwood Formation. The Deadwood is characterized by eastward transgressive and westward regressive sandstones, shales, and carbonates (Thompson, 1984). The Deadwood is separated from the Middle Ordovician, Winnipeg Group, by a regional disconformity (Bluemle and others, 1980) (Thompson, 1984).

Poorly defined subsidence of the Williston Basin is thought to have originated with initial Winnipeg Group deposition (Gerhard and others, 1982). Contemporaneous renewed transgressions from the southwest (Foster, 1972), and across the Sioux arch from the eastern interior (Fuller, 1961), deposited basal Winnipeg Group clastics (Bluemle and others, 1980). Subsequently, shelf, lagoonal, and supratidal carbonates, as well as sabkha evaporites were deposited continually from Red River (Middle Ordovician) through Interlake

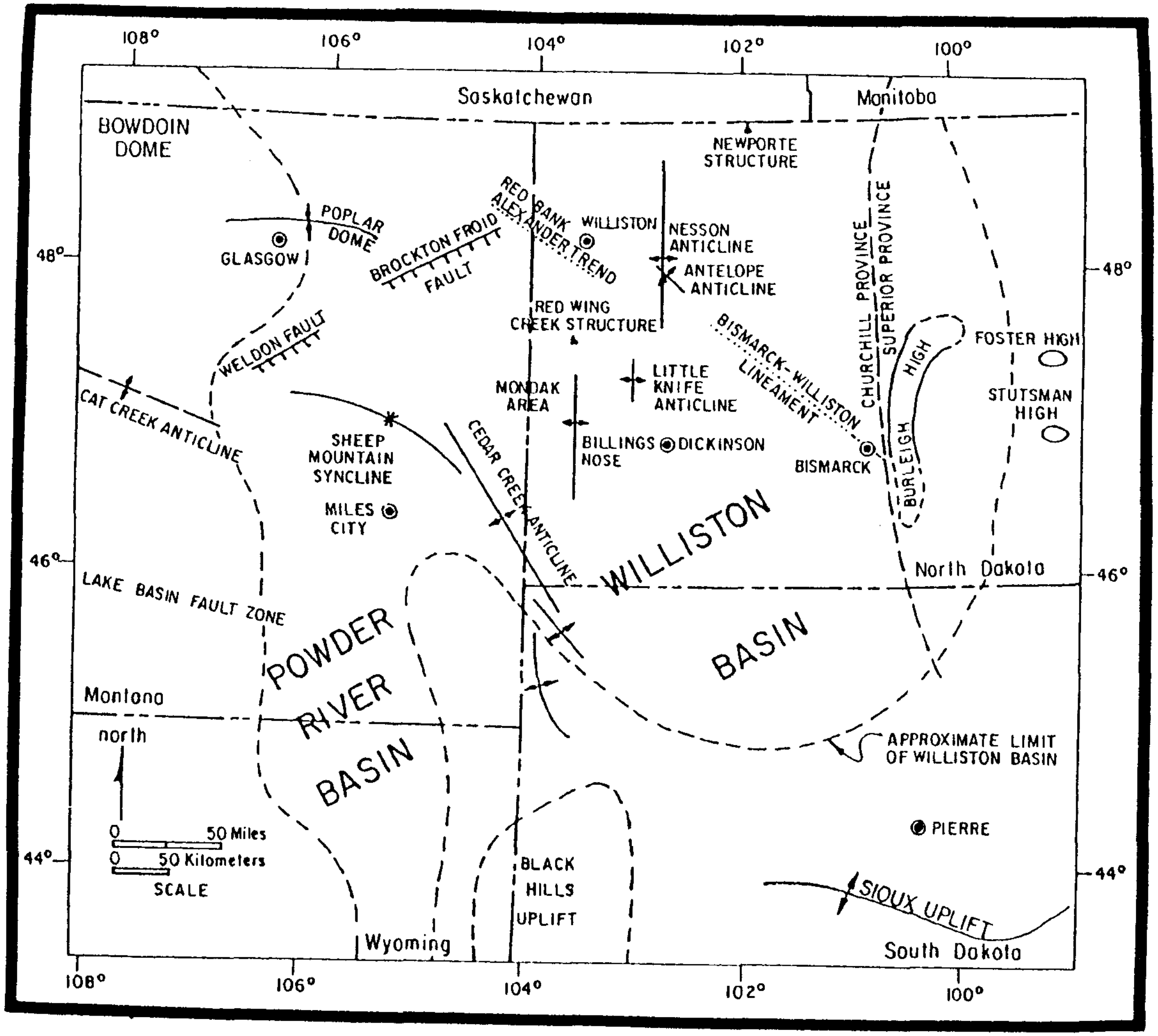


Figure 3: Major structures of the Williston Basin. Reproduced from Anderson and Bluemle (1984) with permission of the authors.

(Silurian) time in the Williston Basin (Carroll, 1979).

Epeirogenetic uplift ended Lower Paleozoic sedimentation in latest Silurian time and a low land mass occupied most of the region throughout the Early Devonian (Heckel and Witzke, 1979). Renewed subsidance commenced in early Middle Devonian time as the transgressing Ashern Sea broached the Meadow Lake Escarpment in Alberta. The Meadow Lake Escarpment separated the slowly-subsiding Elk Point Basin from the Williston Basin in North Dakota (Kent, 1964) (Figure 1). In the early Middle Devonian, red carbonates with anhydrite nodules were deposited on a coastal sabkha proximal to the Nesson Anticline in the Williston Basin. Gray argillaceous carbonates were simultaneously deposited in a restricted marine environment adjacent to the Nesson Anticline. These sediments are those of the Ashern Formation. Gray argillaceous Ashern carbonates spread over the Nesson Anticline as the transgression continued (Lobdell, 1984).

The Middle Devonian Winnipegosis Formation consists of carbonates deposited during the maximum transgression of the Ashern-Winnipegosis-Prairie Sea (Perrin, 1982). Winnipegosis carbonate sedimentation is characterized by a shallowing-upward succession that included large stromatoporoid banks and pinnacle reefs. Eventually these build-ups caused restriction of the basin in late Early Devonian time and allowed the Prairie Formation to accumulate (Kent, 1964). The Prairie Formation contains basal anhydrites and dolomites, locally interbedded with shale and halite, and an upper evaporite member that is predominantly halite (Sandberg and Mapel, 1967). Erosion of Winnipegosis carbonates and Lower Prairie evaporites occurred penecontemporaneously with Upper Prairie Formation evaporite deposition.

In the latest Middle Devonian, the Meadow Lake escarpment in Alberta was again breached, permitting marine transgression southward and westward, with minor fluctuations from the Central Alberta Sub-Basin (Norris and others, 1982) of the Elk Point Basin (Figure 1) (Sandberg and Mapel, 1967). This was the Dawson Bay Sea which in succession progressively inundated the Upper Prairie evaporites, then the eroded Prairie, Winnipegosis and Interlake Formation carbonates. These weathered carbonates are included in the basal Second Red Bed. Carbonate deposition ensued as the Dawson Bay Sea transgressed and regressed.

Previous Work and Stratigraphy

Devonian stratigraphy has been of particular interest to Williston Basin geologists since the 1947 discovery of the Le duc oil field near Edmondton, Alberta (Layer and others, 1949). McGehee (1952) first extended the correlations of the Elk Point Formation (Group) of the Alberta Basin into the subsurface of the Williston Basin.

Mitchell (1951) recognized three Middle Devonian red-bed zones directly below the Beaverhill Lake Formation in Saskatchewan. These red beds were recognized to be laterally persistent within the Williston Basin by Andrichuk (1952) who called the interval between the First Red Bed and the top of the Second Red Bed the "Lower Manitoban". Subsequently, Baillie (1953) named the interval between the base of the First Red Bed and the base of the Second Red Bed the Dawson Bay

Formation (Figure 2).

Argillaceous carbonates of the Dawson Bay Formation were locally deposited on erosional surfaces of the Interlake, Winnipegosis, and Prairie Formations. These weathered surfaces form the base of the Second Red Bed of the basal Dawson Bay Formation (Baillie, 1953). Anderson (1974) indicated that the Dawson Bay Formation, including the Second Red Bed, overlies the Interlake Formation in northeastern North Dakota. The inclusion of the erosional surface within the Dawson Bay does not seem appropriate in view of the general understanding among geologists that the Dawson Bay Formation represents one complete transgressive-regressive cycle during the late Middle Devonian (Sandberg and Hammond, 1958). Baillie stated that the inclusion was made due to the difficulty of separating the red-colored erosional surfaces from the red depositional sediments of the initial Dawson Bay transgression in outcrop exposure (Anderson, 1984). Ballard (1963) considered excluding the erosional surface on which the Dawson Bay sediments rest, but chose not to out of consideration for uniformity and the precedence of past usage.

Wildcat drilling, which followed the initial oil discovery in the United States portion of the Williston Basin on the Nesson Anticline, permitted Baillie (1953, 1955) to standardize and introduce new Devonian nomenclature to encompass the Alberta Basin, western Montana, and the entire Williston Basin. These clarifications were the result of his study of Devonian outcrops in northern Manitoba and new core from the Williston Basin. He divided the Williston Basin Devonian strata into four major units of group rank. The name Manitoba Group was proposed by Baillie (1953) for a series of shallowing-upward carbonate and argillaceous strata overlying the basal Devonian Elk Point Group. According to Baillie (1953) the Dawson Bay Formation is the lowest transgressive-regressive cycle of the Middle Devonian, Manitoba Group, in the Williston Basin (Figure 2).

Baillie (1953, 1955) described the Dawson Bay lithologies in ascending order as: an argillaceous red and green shale (Second Red Bed); a yellowish gray, thin-bedded, fossiliferous limestone with localized ripple-marked surfaces and cemented fossil fragments; yellowish brown, commonly fragmental coral and stromatoporoid reefoid dolomite; and occasional capping-anhydrite beds. Baillie (1955) reported that the basal contact was disconformable over the Winnipegosis Formation and transitional over the Prairie Formation. Subsequent Dawson Bay lithologic descriptions have been similar, and provide evidence of the great lateral continuity of Dawson Bay lithofacies.

Walker (1957) correlated Middle Devonian rocks in western Saskatchewan and indicated a strong lithologic similarity between the Dawson Bay and the Winnipegosis-Prairie Evaporite depositional succession. Walker described the Second Red Bed as residual red clay capping the Winnipegosis-Prairie cycle in Saskatchewan (Figure 2).

Sandberg and Hammond (1958) recognized two unnamed members of the Dawson Bay Formation in the North Dakota-Montana subsurface which conformably overlie the Elk Point Group. They informally described the lower member as the argillaceous member, and indicated that the upper member consists of thick-bedded crystalline limestone/dolomite and anhydrite, or anhydritic limestone/dolomite. They also report a conformable contact with the overlying Souris River Formation in the central part of the basin and a disconformable-erosional contact in parts of northeastern Montana.

A subsurface study of the Dawson Bay Formation was conducted by Lane (1959) in the Regina area of Saskatchewan. He was able to discern six members based on distinct lithologic and faunal content. Lane's (1959) major contribution to the understanding of the Dawson Bay Formation was the recognition of bituminous, peloidal, gastropod containing limestones above the stromatoporoid limestones, but below the anhydrite. In addition, Lane described the Hubbard Evaporite as capping the Dawson Bay in Saskatchewan.

Edie (1959) studied Baillie's data (Baillie, 1953, 1955), and new core from central Saskatchewan. He delineated three regional depositional environments in the upper 15 m (50 ft.) of the Dawson Bay carbonates: lagoon, open marine shelf, and basin margin. The open marine shelf deposits contain stromatoporoid patch reefs, or shoals, with associated crinoids, brachiopods, and rare gastropods. Sucrosic dolomites and dense limestones interfinger with the patch reefs. The basin margin deposits have increased argillaceous content, dark-shale partings, brachiopods, and crinoid ossicles. The crinoids were interpreted to have been swept in and are not indigenous (Edie, 1959).

In 1961 the North Dakota Geological Society convened a meeting of the Williston Basin Devonian System Committee. The depth below the Kelly bushing interval, of 3368 m to 3405 m (11,052 feet to 11,173 ft.), in the Mobil Producing Company's Birdbear No. 1 well (NDGS #793) was designated the reference section for the Dawson Bay Formation in North Dakota (NDGS, 1961) (Figure 4).

Ballard (1963) mapped the Dawson Bay Formation in the eastern half

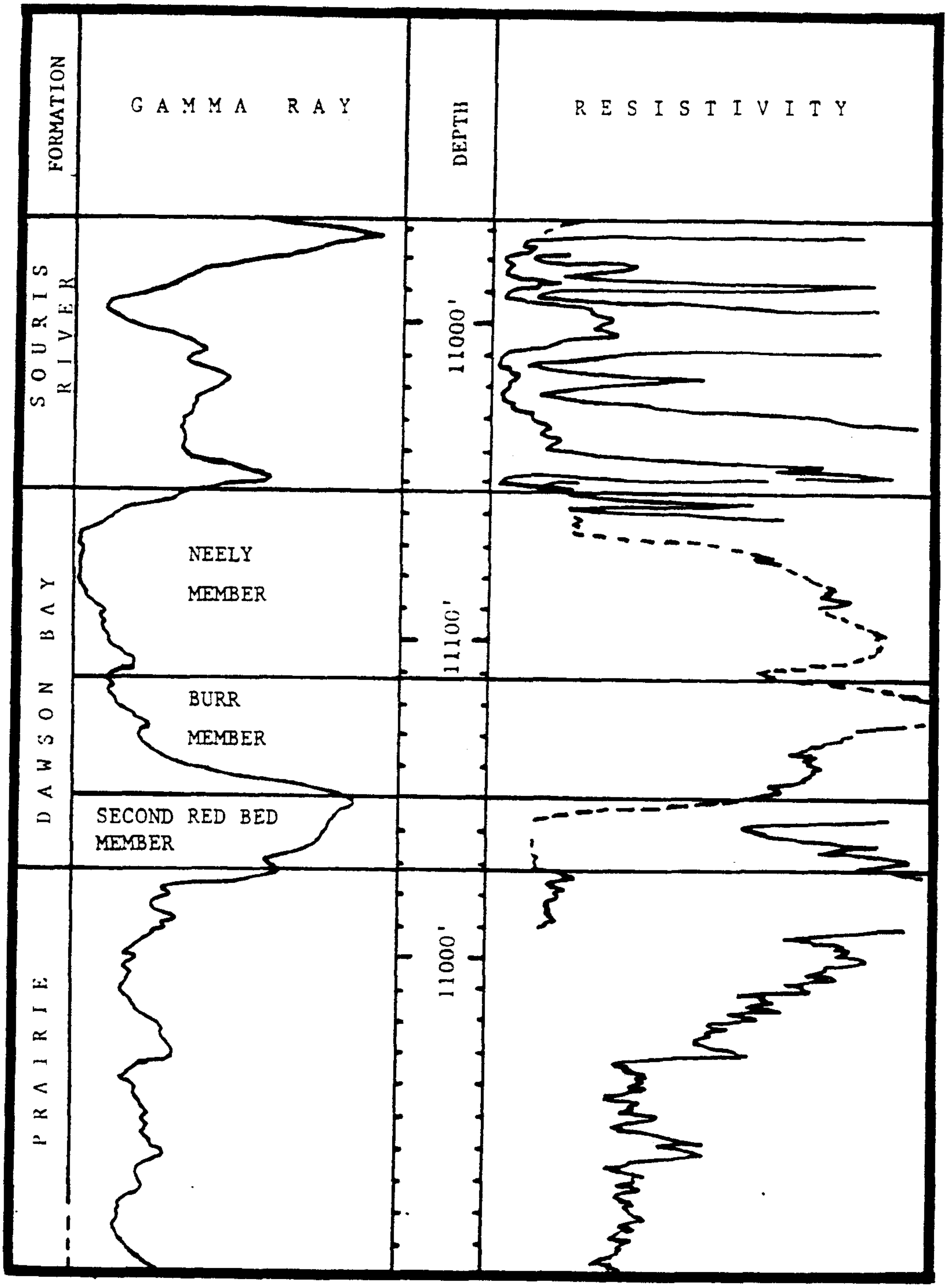


Figure. 4 Illustration of North Dakota Dawson Bay Formation reference section wire-line log from North Dakota Geological Survey well #793, Mobil Producing Company, No. 1 Birdbear, SE1/4 NW1/4, S.22, T.149N., R.91W., Dunn County (NDGS, 1961).

of North Dakota. He recognized a lower argillaceous member and an upper carbonate member consisting of finely crystalline to microcrystalline, porous, dolostone or limestone. Ballard described the uppermost beds as either anhydritic dolostone/limestone or bedded anhydrite. He noted that the Souris River Formation conformably overlies the Dawson Bay Formation except near the eastern limits of the Dawson Bay Formation in North Dakota where the contact is unconformable. He measured a maximum Dawson Bay Formation thickness of 52 m (170 ft.) in the study area. His isopach of the Dawson Bay Formation reveals thinning over the Cavalier High in Cavalier County, several other isolated areas of thinning and thickening, and a few contour irregularities that he attributed to Precambrian basement topography.

Anderson and Hunt (1964) constructed Devonian formation isopach maps for north-central to eastern North Dakota including a Dawson Bay Formation isopach. In several formations above the Prairie Formation they recognized areas of variable thickness along the zero-thickness edge of the Prairie salt isopach, which they interpreted to be indicative of occasional basement movements with subsequent salt-solution due to fluids moving along the resultant fractures.

Dawson Bay Formation core was studied by Dunn (1975) from the Saskatoon area of Saskatchewan. He found that, in his area of study, the Dawson Bay rests disconformably on the Winnipegosis in the absence of Prairie evaporites, whereas the contact with the overlying Souris River Formation is transitional and conformable.

Devonian rocks of the Lake Winnipegosis-Lake Manitoba outcrop belt in Manitoba were studied by Norris and others (1982). They identified four Dawson Bay Formation rock units. In ascending order they are the Mafeking member (A), and members B, C, and D (Figure 2). The Mafeking member is the equivalent of the argillaceous Second Red Bed. The term "Mafeking" was first used by Crickmay (1954). The recognition of the calcareous shale and argillaceous limestone beds of member C are significant, in that, they correspond to a high resistivity deflection on wire-line logs in the Williston Basin (Figure 4).

Dunn (1982) formally defined three members of the Dawson Bay Formation in type wells in Saskatchewan. In ascending order they are the Second Red Bed, Burr, and Neely members (Figure 2). Locally the Dawson Bay is capped by a fourth member, the Hubbard Evaporite. Dunn (1982) reports that the Second Red Bed member is a dolomitic mudstone which is disconformably overlain by the Burr member. Lithologically the Burr member consists of thin, laminated bituminous limestones; overlain by thin, unfossiliferous calcareous dolomites; followed by thick limestones with abundant hardgrounds, crinoid ossicles, corals, and small brachiopods. Dunn (1982) describes the Neely member as a thin unfossiliferous and argillaceous limestone overlain by a thick bituminous limestone containing gastropods, stromatoporoids, corals, and large shelled brachiopods. The Neely member is reefoid, capped by algal-mat dolomite and anhydrite, and has a disconformable lower contact. Dunn (1982) reports that the Neely member is locally capped by the Hubbard Evaporite member.

In summary, acceptance of the stratigraphic position of the Dawson Bay Formation within the Devonian of the Williston Basin has remained unchanged since Baillie (1953) first named it. The name "Second Red Bed" has been widely accepted by subsequent researchers for the basal argillaceous unit of the Dawson Bay. Crickmay (1954) did propose that the basal Dawson Bay argillaceous unit be named the "Mafeking member", but only Norris and others (1982) have since used the name (Figure 2). Walker (1957) described the Dawson Bay carbonates but did not propose formal subdivisions.

Since the work of Walker (1957), Dawson Bay studies have attempted to subdivide the carbonate unit into members on the basis of lithologic character and faunal evidence. Lane (1959) proposed informal member names for the carbonate portion of the Dawson Bay as did Norris and others (1982). However, in both studies the subdivisions used are based upon local formation character and may not be entirely applicable basin wide.

Dunn's (1982) contribution of formal member subdivisions and names for the Dawson Bay is largely functional throughout the Williston Basin (Figure 2). Adequate local characterization of the carbonate unit of the Dawson Bay Formation may require the use of smaller subdivisions such as lithofacies.

The Burr member as described by Dunn (1982) is similar to the locally argillaceous, bituminous, echinoderm and brachiopod carbonates in Lane's (1959) DB-2 member, Norris and other's (1982) member B, and lithofacies B of this study (Figure 2).

The DB-3 member in Lane (1959), member C in Norris and other's (1982), and upper lithofacies B in this study are all similar in lithologic and faunal character to Dunn's (1982) basal Neely member argillaceous carbonates (Figure 2). This argillaceous zone appears as a distinctive resistivity deflection throughout the Williston Basin (Figure 3).

A stromatoporoid carbonate interval, which occurs immediately above the argillaceous carbonate unit throughout the Williston Basin is equivalent to the DB-4 member in Lane (1959), member D in Norris and others (1982), the middle Neely member in Dunn (1982), and lithofacies C in this study (Figure 2). This stromatoporoid zone is present throughout the Williston Basin. Norris and other's (1982) state that the stromatoporoid carbonate zone caps the Dawson Bay Formation in the northern Manitoba outcrop area. They do not, however, suggest loss of the stratigraphically higher lithofacies by erosion.

Locally recognized in this study is a gastropod-ostracod-brachiopod-echinoderm lithofacies D above the stromatoporoid zone (Figure 2). This lithofacies has not been delineated by previous workers and may represent a transition from the stromatoporoid zone to the DB-5 member in Lane (1959) and peloidal, carboniferous, gastropod and ostracod limestone/dolomite Lithofacies E of this study (Figure 2). Dunn (1982) does, however, describe the occurrence of a zone of fossils above the stromatoporoids in his Neely member which may be equivalent Lithofacies D in this study.

According to Dunn (1982), the top of the Neely member consists of anhydritic cryptalgal laminations in Saskatchewan. In contrast, lithofacies F, composed of dolomitic cryptalgal laminations with local replacive massive anhydrite at the top, in this study locally caps the Dawson Bay Formation in North Dakota (Figure 2).

Based on available core, the contact between the Dawson Bay Formation and the overlying Souris River Formation is conformable in North Dakota except in Cavalier and Bottineau Counties. The basal Dawson Bay Formation in North Dakota rests disconformably on the

Interlake, Winnipegosis, and Lower Prairie Formations according to Anderson (1974). Anderson and Hunt (1964) reported the Dawson Bay Formation in North Dakota to rest conformably on the upper evaporite portion of the Prairie Formation where dissolution has not removed the evaporites (Figure 1).

According to both Lane (1959) and Dunn (1982) the Hubbard Evaporite caps the Dawson Bay Formation in their Saskatchewan study area (Figure 2).

Previous Paleontological Studies

Baillie (1953) placed the then unnamed Dawson Bay Formation in the *Stringocephalus* brachiopod zone which is accepted as Middle Devonian in age. Baillie (1953) also identified *Renalycis* algae in his North Dakota core descriptions.

The fauna of the Dawson Bay Formation were studied in Manitoba by McCammon (1960). Collecting was done on the shores and islands of Dawson Bay on Lake Winnipegosis in northern Manitoba. McCammon subdivided the Dawson Bay on the basis of brachiopod zones. The lowermost *Spinatrypa* Zone contains numerous dwarfed species. Fauna include: *Spinatrypa*, *Atrypa*, *Productella*, *Pelecypoda*, trilobites, and fish fragments. Upsection in the *Schizophoria iowensis* Zone fauna include *Schizophoria iowensis*, dendritic corals, *Atrypa*, *Pelecypoda*, and crinoid stems. The *Atrypa bremerensis* Zone, further upsection, is aerially the most extensive brachiopod zone. *Atrypa bremerensis* Zone fauna include: *Atrypa*, *Pelecypoda*, *Gastropoda*, *Spinatrypa*, corals, cephalopods, and fish fragments. The uppermost brachiopod zone is the large shelled Atrypa snakensis Zone in which fauna include: Atrypa, pelecypods, and corals. McCammon notes that the reefoid zone and the stromatoporoid zone reported at the top of the Dawson Bay Formation in the subsurface cores by Baillie (1953, 1955) were not definitely identified in her outcrop study although stromatoporoids were identified.

McCammon (1960) concluded, based on faunal evidence, that the Dawson Bay Formation is Middle Devonian in age and faunally unrelated to the earlier Winnipegosis Formation. This conclusion is contradictory to that of Sandberg and Hammond (1958) who had considered the Dawson Bay fauna to be related to the Winnipegosis fauna. McCammon found that Dawson Bay fossils are closely related to those in the Cedar Valley Formation in Iowa, Illinois, and Minnesota, possibly those in the Milwaukee dolomite of Wisconsin, and those in the William Island Formation of James Bay, Canada. Norris and others (1982) expanded on the faunal identifications and suggested correlations of the fauna in northern Manitoba, done by McCammon (1960), to additional locations outside of their study area.

Kent (1967) cites the Givetian age (upper Middle Devonian) Stringocephalus, Geranocephalus, and Atrypa brachiopods found within the Dawson Bay Formation on his "Biostratigraphic Correlation Chart" for Manitoba and Saskatchewan outcrops and subsurface cores.

The Dawson Bay was also dated as being of Givetian Age by Dunn (1975) on the basis of Stringocephalid brachiopods and conodonts associated with stromatoporoids. Dunn (1982) found that crinoid ossicles, corals, and small brachiopods characterize the Burr member, whereas gastropods, occasionally reefoid stromatoporoids, corals, and large shelled brachiopods typify the upper Neely member.

Hydrocarbons

The porous nature of the "Lower Manitoba" (Dawson Bay Formation) dolomite with occasional capping evaporites was reported by Andrichuk (1952). Bitumens were reported present in the Dawson Bay by Baillie (1953). Sandberg and Hammond (1958) reported that the shelf facies of the carbonate member of the Dawson Bay Formation produced oil in Shell Oil Company's No. 22-25-B-NP and No. 21-33-B-NP wells (Sec. 25 and 33, Twn.22N., Rnge.48E.) in the Richey Field of McCone County, Montana, along the Cedar Creek Anticline. They suggested the occurrence of additional petroleum along the Cedar Creek Anticline (Figure 3) and proximal to other anticlines in the Williston Basin. Sandberg and Hammond (1958) also noted the erosional dissipation and remigration of most Devonian petroleum accumulations due to post-Devonian uplift and tilting. In particular, they consider the more disturbed Central Montana uplift area (Figure 3) to have less productivity potential and suggest that the marginal facies of the Dawson Bay Formation have excellent reservoir characteristics and bitumen content that would provide a faunal source for indigenous oil. Sandberg and Hammond (1958) state that the basinal facies might serve as a source for hydrocarbons, but it has poor reservoir porosity.

Attenuation of the Dawson Bay Formation in southwestern Saskatchewan may offer the prospect of stratigraphic traps according to

Walker (1957). He also suggested that localized selective diagenesis may have resulted in porosity and permeability barriers.

Edie (1959) studied Dawson Bay core in central Saskatchewan and found that the originally extremely porous and permeable upper Dawson Bay carbonates were mostly filled with secondary halite and occasionally anhydrite, but was uncertain of the time of halite and anydrite emplacement. Edie, however, considers the dark-gray shaley beds of the lower Dawson Bay to be the possible source rocks for oil accumulation in the carbonates of the upper Dawson Bay. In addition, he reported the occurrence of minor tarry (black and brown oil) staining in a number of wells in central Saskatchewan. He believed that if oil is present in the Dawson Bay Formation in his study area it would be in the patch reef and sucrosic dolomite facies associated with structural highs.

According to Lane (1959) the porosity and permeability of the Dawson Bay Formation in southeastern Saskatchewan is controlled by these four main factors: (1) lithologic character, (2) dolomitization, (3) infilling of primary and secondary porosities by secondary halite or anhydrite, and (4) fractures resulting from solution removal of underlying Prairie evaporites. Lane precludes petroleum reservoirs from areas underlain by Prairie evaporites. He suggests that in areas not underlain by the Prairie evaporites, cryptocrystalline limestone occurs in the upper portion of the lower half of the carbonate section which could act as a seal. Lane (1959) states that the bituminous shales and partings present in the upper carbonate rocks may constitute source rocks, but the updip surface exposure of the Dawson Bay Formation in northern Manitoba and the fracturing of impermeable beds, especially along the Manitoba Shelf margin (Figure 1) where there is a marked decrease in regional dip, probably has allowed the escape of any hydrocarbons.

Petroleum possibilities within the Devonian of North Dakota were suggested by Anderson (1963). He predicted the migration of hydrocarbons away from the Nesson Anticline in an updip direction toward the edges of the basin. Anderson cited cross-sectional evidence for a reversal in dip across areas affected by solution removal of the evaporite portion of the upper Prairie Formation with subsequent collapse of the overlying lithologies. He suggested that these reversals in dip may form traps.

Ballard (1963) reported excellent porosity in the Dawson Bay Formation in the subsurface of North Dakota. He suggested that good porosity coupled with Dawson Bay production elsewhere in the Williston Basin may suggest the potential for hydrocarbon production in North Dakota. Ballard suggested that pinchouts such as occur proximal to the Foster High in Foster County may result in stratigraphic traps.

The entire edge of the Prairie Evaporite (Figure 1) immediately below the Dawson Bay Formation in North Dakota may have undergone solution creating reverse-dip structural traps as a result of collapse of overlying lithologies (Anderson and Hunt, 1964). Isopachs of the Prairie Evaporite and upsection formations indicate that the salt edge is locally crenulated. Anderson and Hunt also stated that hydrocarbon residue within fractures indicate that migration occurred after or continued following collapse-fracturing.

According to Bannatyne (1981), core studies in the Dawson Bay area of northern Manitoba indicate that halite dissolution occurred in post-

Souris River time and that the solution removal of Prairie Evaporites resulted in the draping of overlying beds over Winnipegosis reefs and subsidence in the inter-reef basins.

Dunn (1975) described severe collapse brecciation in the Dawson Bay due to salt dissolution resulting in the formation of kilometer-sized depressions and vertical fracturing with subsequent anhydrite or halite annealing associated with smaller cavities. He also stated that twenty "meters" of oil and salt water cut mud were recovered from a drillstem test in the reefoid upper Neeley member in Neumann No. 12 well in southeastern Saskatchewan, 15 kilometers (9.5 miles) north of Renville County, North Dakota. According to Dunn (1982) stratigraphic traps are unlikely in Saskatchewan because of the lateral continuity of the Dawson Bay Formation. However, he suggested that cryptocrystalline dolomites associated with evaporites throughout the Williston Basin may in places form a seal to upward migrating hydrocarbons. He believes structural traps are more likely within the Dawson Bay and cites structural contour evidence for synclinal features in the Cononach, Hummingbird, and Estevan areas of the northern Williston Basin in Canada. Dunn states that hydrocarbon entrapment within the upper Neely member took place before halite plugged the porosity. Petrographic evidence that the halite is locally bituminous is interpreted by Dunn (1982) to mean that the halite had to have precipitated around hydrocarbons that were already present.

Dean (1982) reported on the hydrocarbon potential of the Dawson Bay Formation in northwestern North Dakota. She stated that the first commercial oil and gas production from the Dawson Bay in North Dakota was from the Northwest Exploration #1 Rye well in the Temple Field of

Williams County. This discovery well was followed by the location of another pool in the Long Creek Field of Williams County.

According to Dean's isopach map, the thickness of the Dawson Bay Formation decreases in the vicinity of Temple Field along a northwest-southeast trend which cuts diagonally across the north-south oriented Nesson Anticline. Dean's structure map of the top of the Dawson Bay places the Temple Field on an anticlinal nose paralleling the Nesson Anticline and her net-porosity map places the Temple Field within one of several northwest-southeast trending net-porosity highs. Dean (1982) stated that production is controlled by an updip porosity pinchout on an anticlinal nose paralleling the Nesson Anticline. She cautioned that halite infill of porosity can be discerned on logs, but the same technique is unreliable for partial infilling by halite. Dean suggested that drillstem or production testing provided the most reliable evaluation tools in the area of her study.

PETROGRAPHY

Core of the Dawson Bay Formation from twelve North Dakota wells was studied megascopically and microscopically. Investigative techniques included inspection by hand-lens, reflected light microscope, polarizing light microscope, and scanning electron microscope. X-ray and microprobe analysis were also utilized. The following petrographic categories of primary lithologic components were recognized: mineralogy, lithology, orthochemical components, allochemical components, and structures.

Mineralogy

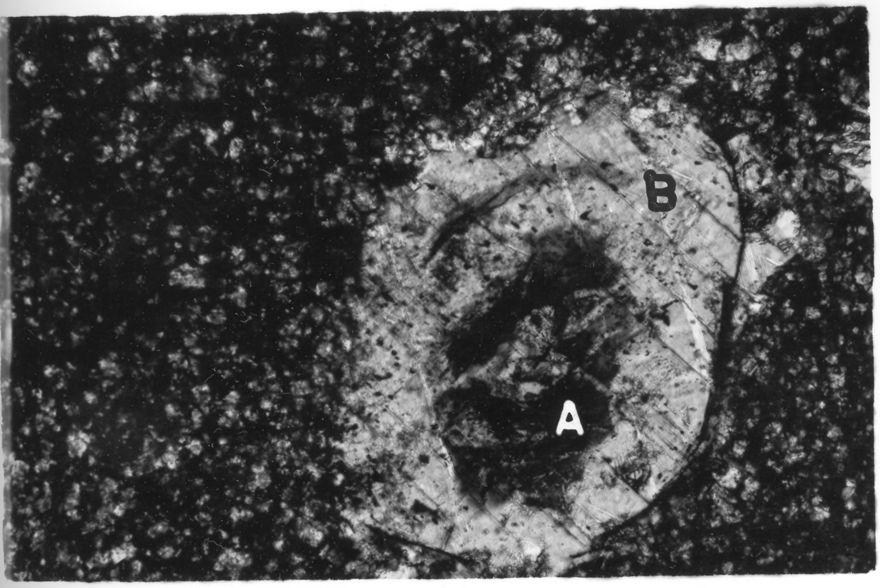
Calcite: Total calcite abundance in the entire core was visually estimated to be 40-60%. An average range of abundance of 60-100% was estimated for calcite when it was present. Most commonly calcite occurs as micrite (Figures 5 and 6). Bioclasts are commonly comprised of calcite (Figures 6 and 7), however, intraclasts very rarely contain primary calcite. Secondary calcite cement generally comprises less than 5 % of the core. Sparry calcite cement locally fills moldic pores in the upper Dawson Bay carbonates (Figure 8). In one location, blocky calcite cement approaches 15% of the composition and 0.5 cm crystals line 3 cm moldic pores near the base of cryptalgal boundstones. Blocky calcite cement locally rims or fills intraparticle pores in stromatoporoids, as well as moldic, vuggy, fracture, microfracture, and fenestral pores (Figure 9). Micrite, calcite bioclasts, and calcite

Figure 5

Photomicrograph of calcite cement and hydrocarbon (A) rimmed ostracod mold with subsequent recrystallization to pseudospar (B). Microcrystalline, euhedral to anhedral, dolomite rhombs disseminated in micrite matrix. (lithofacies E, NDGS well #1403, T.S. 10,653', crossed-polars, long field of view equals 4 mm)

Figure 6

Core photograph of articulated brachiopod forming shelter porosity (A). Microspar replaced micrite forms geopetal structure (B). Fractures (C) and vugs (D) are present in micrite matrix. (lithofacies C, NDGS well #36, 1642.8')


B
A

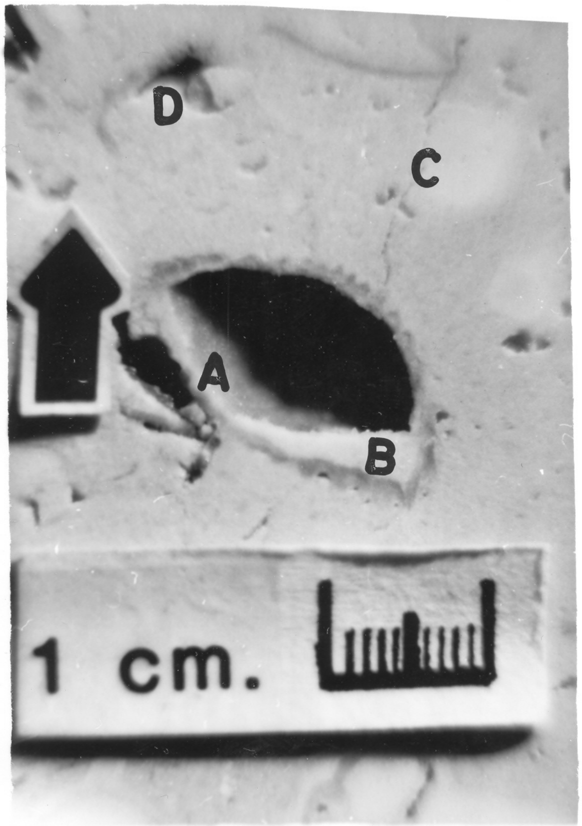
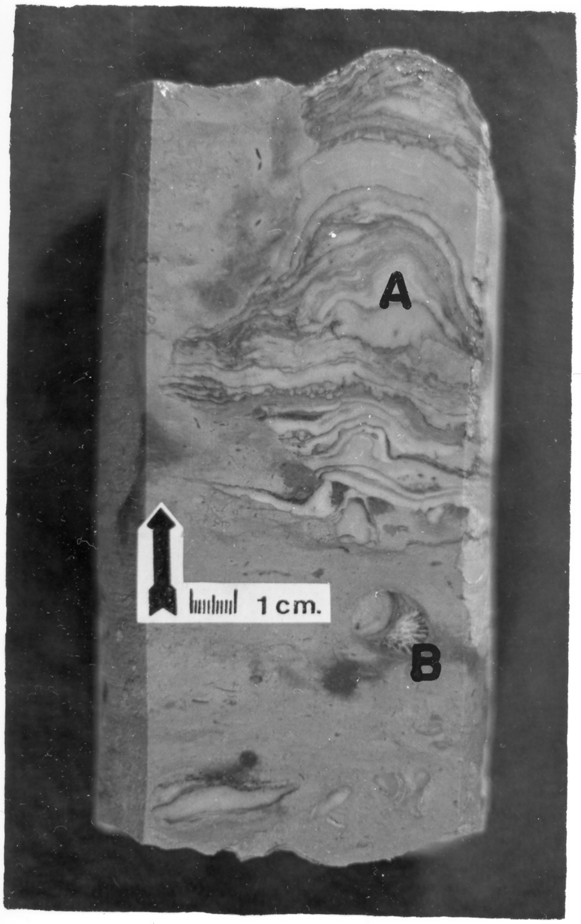

D
C
A
B
1 cm.

Figure 7

Core photograph of stacked tabular stromatoporoids (A) of calcite composition. Tabular stromatoporoid encrustation of coral (B) to the right of the scale. (lithofacies C, NDGS well #37, 2343.5')

Figure 8

Photomicrograph of mold filled by sparry calcite cement (A). Opaque radial bleb (B) is pyrite. (lithofacies C, NDGS well #207, T.S. 4591', crossed-polars, long field of view equals 0.2 mm)


A
1 cm.
B

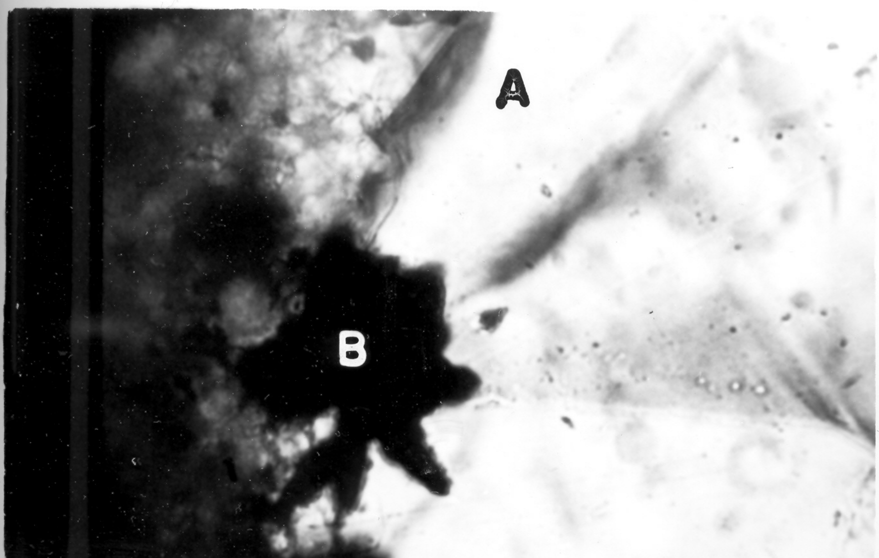
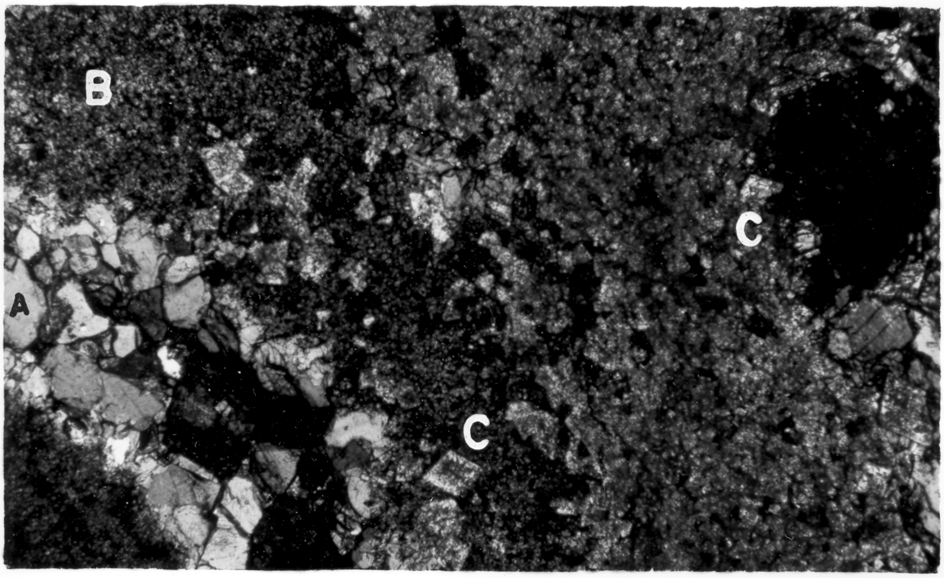

A
B

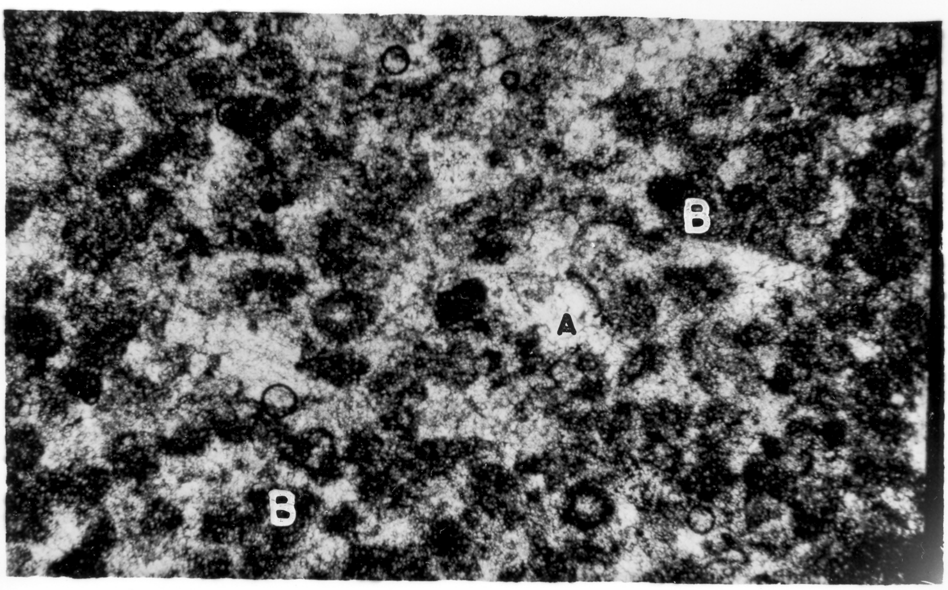
Figure 9

Photomicrograph of blocky-calcite cement (A) rimming pore. Microcrystalline (B) and medium-crystalline (C) dolomite matrix. (lithofacies C, NDGS well #7877, T.S. 10,649', crossed-polars, long field of view equals 3 mm)

Figure 10

Photomicrograph of microspar (A) replacing peloidal (B) micrite. (lithofacies C, NDGS well #2153', crossed-polars, long field of view equals 3 mm)


B
C
A
C


B
A
B

cement may recrystallize to neomorphic microspar and/or pseudospar. Neomorphic calcite usually comprises less than 5% of the Dawson Bay core (Figures 10 and 11).

Dolomite: Total dolomite abundance in the entire core was visually estimated to be 40-60%. An average range of abundance of 40-100% was estimated for dolomite when it was present. Dolomitization occurs throughout the core, but is most abundant where associated with cryptalgal boundstones, or extensive brecciation. Euhedral rhombic crystals occur frequently within the study area, although locally, anhedral dolomite rhombs are common. Microcrystalline to finely-crystalline rhombs are common throughout the study area (Figures 9 and 11). Medium to coarsely-crystalline dolomite rhombs are locally present associated with vuggy, fracture, moldic (Figure 9), and microfracture pores, as well as microstyolites. Dolomitation adjacent to fractures and microfractures is often pervasive and extensive (Figures 12). Dolomite rhombs very-commonly occur disseminated in primary micrite matrix and within bioclasts (Figures 13). Bioclast embayment by dolomite rhombs is common. With rare exception cryptalgal boundstones are completely dolomitized, although nodular and bedded massive anhydrite have locally replaced the early microcrystalline dolomite. The extent of dolomitization is quite variable in the Dawson Bay core.

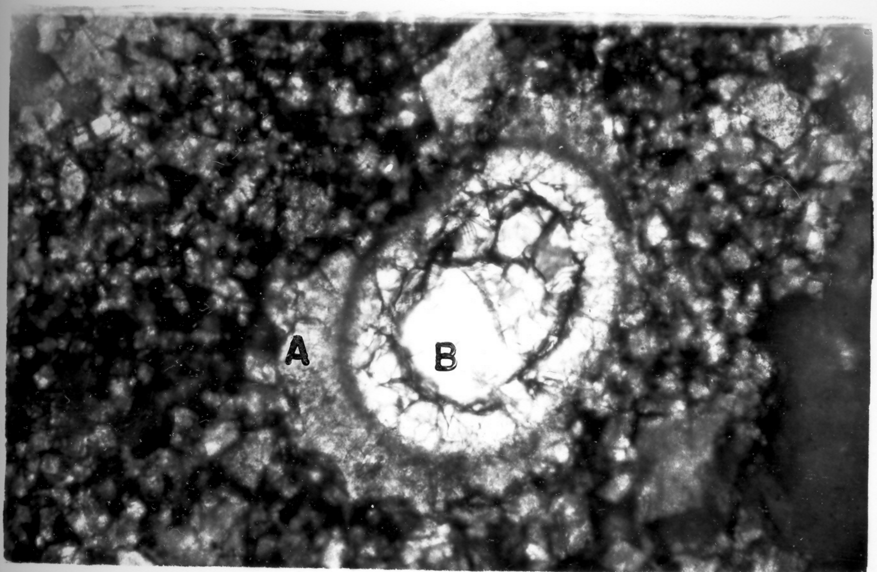
Anhydrite: Total anhydrite abundance in the entire core was visually estimated as less than 5%. A range of abundance of 2-100% was estimated for anhydrite when it was present. Anhydrite is most commonly found associated with cryptalgal laminations, or associated with fracturing in areas underlain by Prairie evaporites. The most

Figure 11

Photomicrograph of radial-axial fibrous pseudospar (A) rimming calcisphere (?) within a finely-crystalline, moasic dolomite, matrix. Blocky pseudospar (B) replaces the bioclast internally and dolomite rhombs embay the bioclast. (lithofacies D, NDGS well #1403, T.S. 10,657', crossed-polars, long field of view equals 1.2 mm)

Figure 12

Core photograph. Subvertical fractures (A) in microcrystalline dolomite (mudstone)(B) are healed by very-finely-crystalline dolomite rhombs (C). Subhorizontal to irregularly oriented Type II microstyolites (D) throughout core. (lithofacies C, NDGS well #7877, 10,655')


A
B

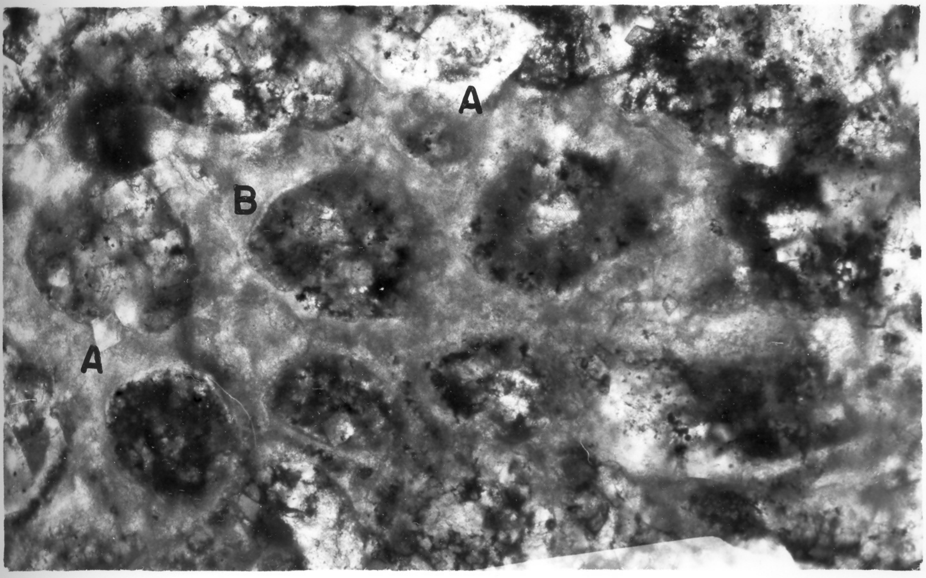

A
B
C
D
1 cm.

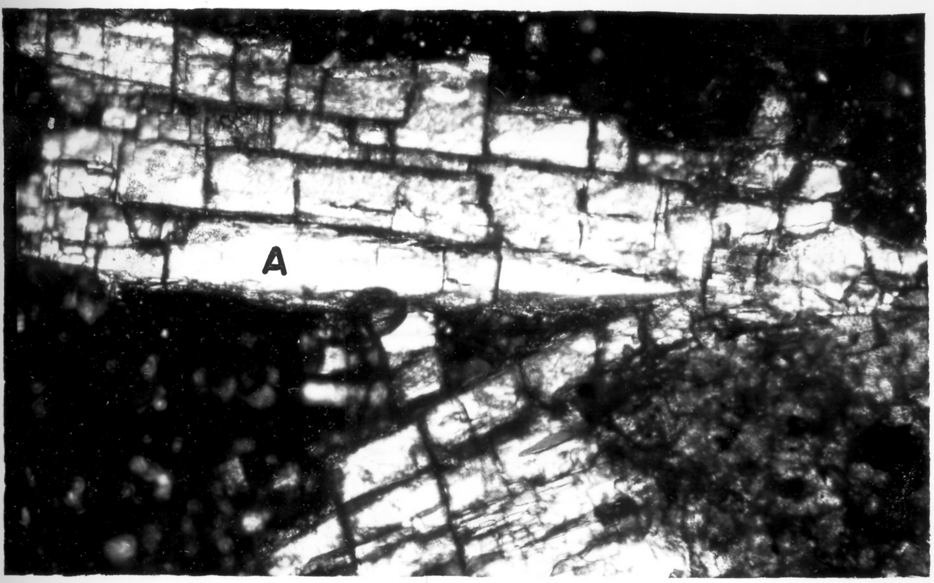
Figure 13

Photomicrograph of microcrystalline dolomite rhomb (A) embayment of bryozoan (B) in dolomitic matrix. (lithofacies B, NDGS well #207, T.S. 4623', crossed-polars, long field of view equals 1.2 mm)

Figure 14

Photomicrograph of bladed anhydrite (A) filling fracture and replacing finely-crystalline dolomite matrix. (lithofacies B, NDGS well #38, T.S. 6264', crossed-polars, long field of view equals 1.2 mm)


A
B
A


A

common form of anhydrite in the core is that of 0.5 mm-1.0 cm bladed laths. Matrix dissemination of individual laths is common, although locally they are tightly felted in fractures, microfractures, and nodular vugs (Figures 14 and 15). Locally in Bottineau County, fractures associated with the solution edge of the Prairie evaporites are filled with felted bladed anhydrite and comprise 80% of the core (Figure 15). In this occurrence the presence of anhydrite was verified by X-ray diffraction. Anhydrite occasionally replaces dolomite adjacent to felted, bladed anhydrite and commonly results in "floating" dolomite clasts (Figures 14 and 15). Bladed anhydrite laths occasionally coalesce to form 1 mm to 3 cm felted nodules.

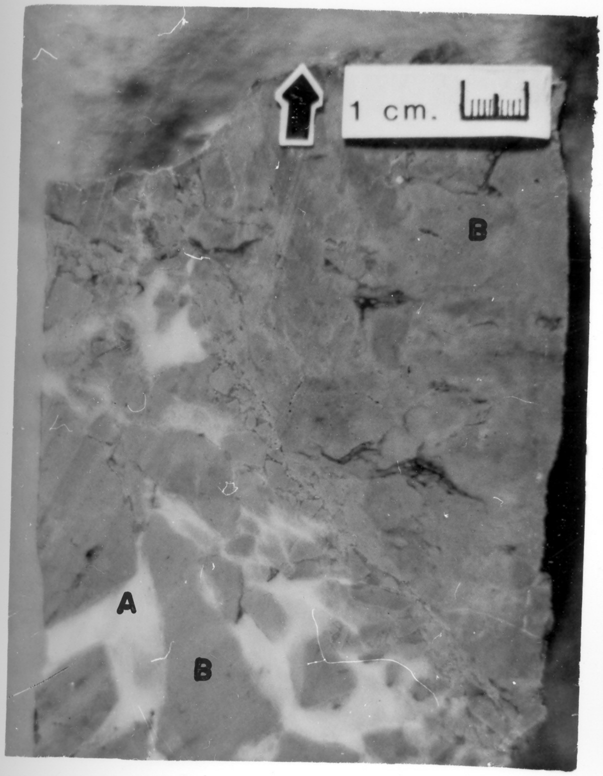
Locally, along the margins of the Dawson Bay Formation, and in one location in north-central Bottineau County, anhydrite replaces carbonates and displaces non-carbonate materials in cryptalgal boundstones. A 9.6 m (31.6 ft.) interval of replaced and displaced boundstone layers is present in west-central Cavalier County; a 1.8 m (6 ft.) interval in north-central Bottineau County; and a 15 cm (0.5 ft.) interval in southeastern Williams County. Several types of anhydrite occur in these replacive anhydrite intervals. One occurrence is that of argillaceous cryptalgal laminations in a dolomitic matrix which are displaced and replaced by anhydrite lath growth. This form of anhydrite is termed "streaky laminated anhydrite" by Maiklem and others (1969)(Figure 16). Another type of anhydrite present is "bedded mosaic anhydrite" (Maiklem and others, 1969), which consists of 1-3 cm subhorizontal layers of irregular masses of microcrystalline anhydrite (Figure 17). Each mass is separated by relict argillaceous dolomite. Occasionally, identifiable anhydritic cryptalgal laminations are

Figure 15

Core photograph. Felted anhydrite (A) filling fractures in collapse breccia and replacing microcrystalline dolomitic matrix (B). (lithofacies B, NDGS well #38, 6230.5')

Figure 16

Core photograph. Entire core composed of "streaky laminated anhydrite" replacing cryptalgal boundstone. (lithofacies F, NDGS well #37, 2310')


1 cm.
B
A
B

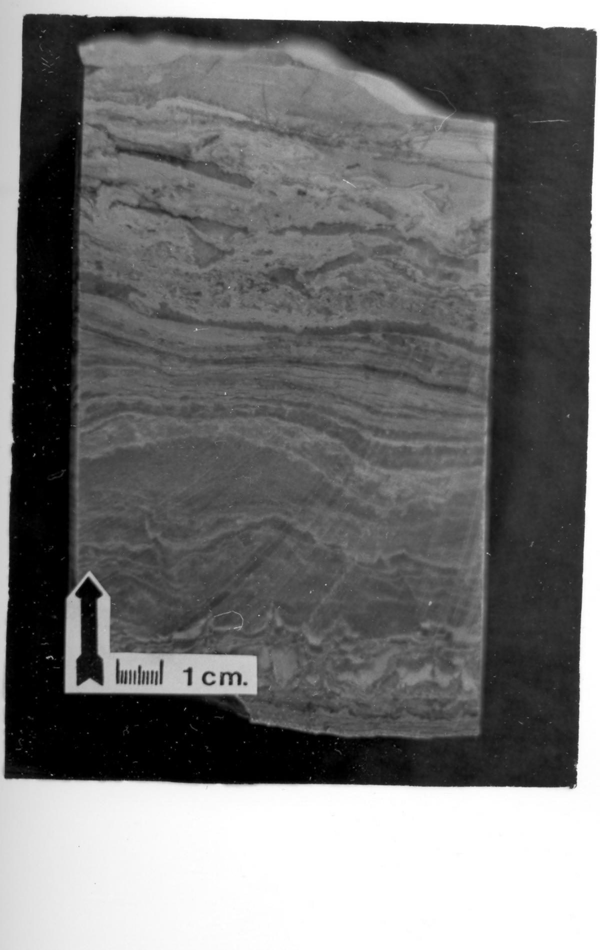
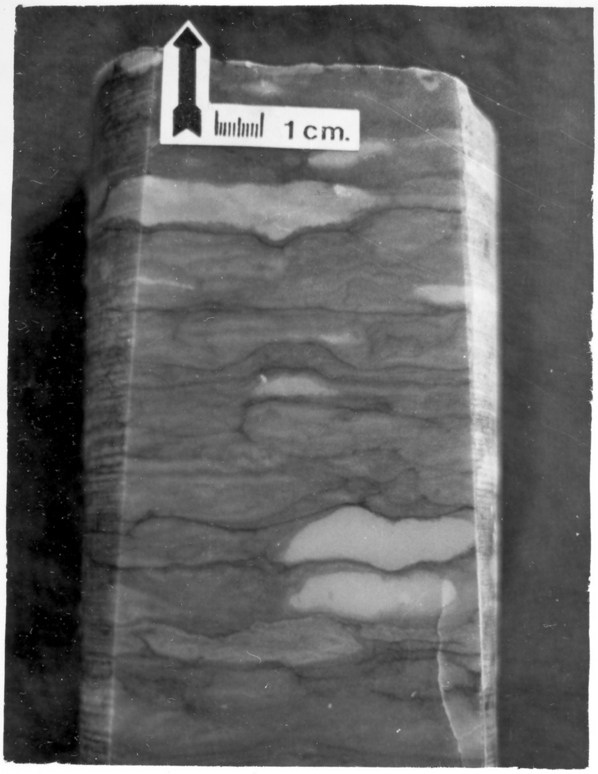

1 cm.

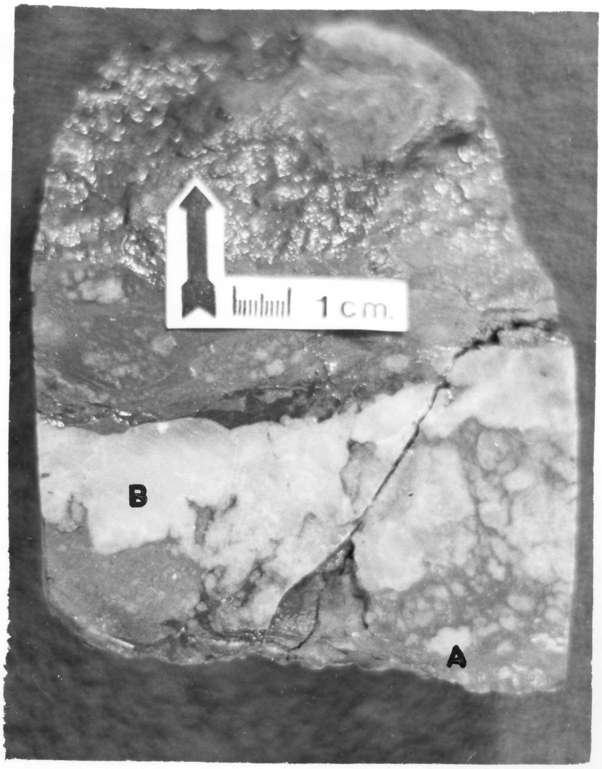
Figure 17

Core photograph. Entire core composed of "bedded mosaic anhydrite" replacing cryptalgal boundstone and microcrystalline dolomite. (lithofacies F, NDGS well# 37, 2307.6')

Figure 18

Core photograph of "nodular anhydrite" (A) and "distorted bedded-nodular anhydrite" (B) replacing cryptalgal boundstone and microcrystalline dolomite. (lithofacies F, NDGS well #37, 2299')


1 cm.


1 cm.
B
A

present in these replacive sections. Replacive anhydrite is sometimes capped by subhorizontally oriented and irregularly shaped nodular anhydrite. Coalesced nodular anhydrite occasionally forms "distorted bedded nodular anhydrite" according to Maiklem and others (1969) (Figure 18).

Sparry bladed anhydrite fills, or partially fills, subvertical fractures in areas underlain by Prairie evaporites (Figure 14). These anhydrite-filled fractures are the youngest present in these localized areas of multiple-fracturing.

Clay (insolubles): Siliciclastic clays are visually estimated to make up less than 3% of the minerals present in thin-sections studied and less than 4% of the entire core. Clay minerals are abundantly disseminated throughout the carbonate matrix, but are locally concentrated by pressure-solution into subhorizontal, wispy laminae (Figure 19). In the uppermost carbonates, oxidized red clay is associated with cryptalgal laminations, and comprises up to 10% of the core (Figure 20). In west-central Cavalier County, an anomalous 0.5 m thick trilobite-bearing, black shale is present within a cryptalgal boundstone and mudstone interval. Local concentrations of light-green (10Y8/1) clay are also present along oxidized dolomudstone surfaces in Cavalier County. X-ray analysis and color suggests that it is the iron-rich smectite, nontronite.

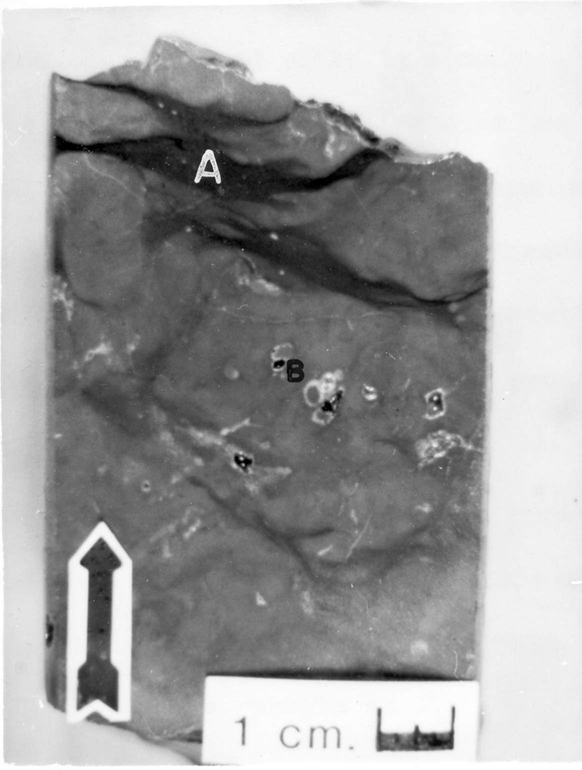
Hematite: The hematite abundance in the entire core is visually estimated to be less than 1%. A less than 30% abundance was estimated for hematite when it is present in the core. The greatest concentrations (10-30%) were associated with cryptalgal laminations in Cavalier County (Figure 20). Most commonly hematite is disseminated in

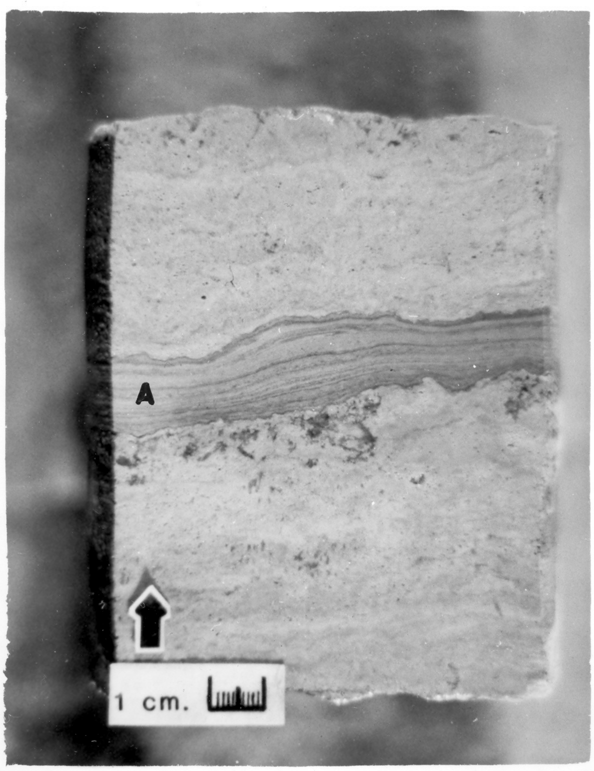
Figure 19

Core photograph of argillaceous and bituminous subhorizontal Type II microstyolites (A) with gastropods (B) in mudstone. (lithofacies D, NDGS well #793, 11,056.8')

Figure 20

Core photograph of color-mottled, argillaceous, hematitic cryptalgal boundstone (A) in diffusely color-mottled and laminated microcrystalline dolomite (mudstone). (lithofacies F, NDGS well #37, 2322.2')


A
B
1 cm.


A
1 cm.

the matrix or concentrated proximal to pores. Although oxidized hematite predominates, the reduced state is common.

Pyrite: Pyrite abundance in the entire core was visually estimated to be less than 1%. A less than 3% abundance was estimated for pyrite when it was present. It is commonly disseminated in dolomitic gastropod-bearing mudstones. Local concentrations occur proximal to pores (Figure 8), or associated with pressure-solution features, bitumens, or anhydrite laths.

Halite: The halite abundance in the entire core was visually estimated to be less than 1%. An average abundance of (1-4%) was estimated for halite when it was present in the core. However, the high solubility of halite often results in its dissolution during the well-drilling process and subsequent sample preparation. Halite loss during slabbing was minimized through the use of antifreeze (ethylene glycol base) as a coolant, although water was used in making thin-sections. Consequently, the visual estimates given for halite may be inaccurate. Halite was observed to fill fractures, microfractures, moldic-vuggy pores, and pores in dolomite mosaics (Figure 21). In areas underlain by Prairie evaporites, the quantity of halite diminished upwards away from the underlying evaporites, and was not observed in Dawson Bay carbonates not underlain by Prairie evaporites (Figure 1).

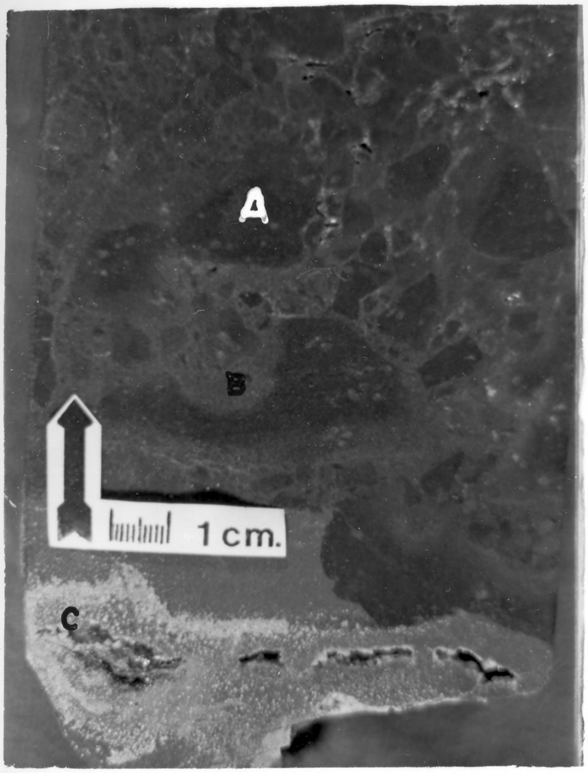
Quartz: Quartz abundance in the entire core was considerably less than 1%. Subangular to rounded silt, and rare, medium sand-sized grains are present in amounts less than 1% in association with cryptalgal laminations (Figure 22). Quartz silt very rarely occurs disseminated in the carbonate matrix, or associated with

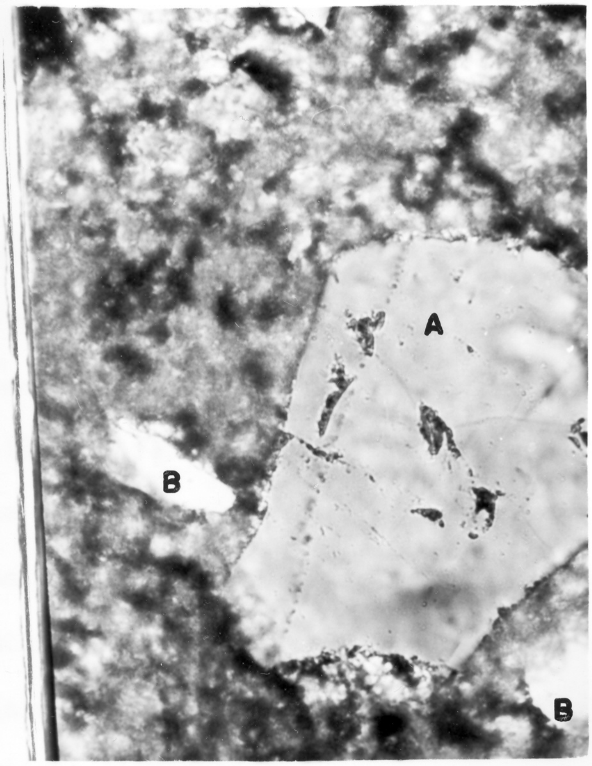
Figure 21

Core photograph of breccia fractures in microcrystalline dolomite (A) which are partially healed by very-finely-crystalline dolomite (B) and producing a pseudointraclastic texture. Halite common in all pores and encrusts core slab upon drying (C). (lithofacies C, NDGS well #7877, 10649.6')

Figure 22

Photomicrograph of angular, medium-sized, quartz sand grain (A) and two, subrounded, quartz silt grains (B) in microcrystalline to very-finely-crystalline dolomite matrix. Quartz grains associated with cryptalgal laminations. (lithofacies F, NDGS well #37, T.S. 2300.8', crossed-polars, long field of view equals 3 mm)


A
B
1 cm.
C


A
B
B

microstyolites. A few medium sand-size, quartz particles, and examples of microspar replacement of grains was observed in thin-section.

Bitumens: Bitumen abundance in the entire core was visually estimated to be less than 3%. A range of 2-20% abundance was estimated for bitumens when present. Bitumens occur as disseminated, brown-black colored, organic particulate material and are locally concentrated by microstyolites (Figure 19). Sizes range from microgranular to very-fine-grained and irregularly shaped masses.

Hydrocarbons are included with bitumens in the text, but occur within pores (Figure 5), or are indiscernable except by ultraviolet light/chlorothene testing. Pore associated hydrocarbons are black and adhere to pore walls. Residual hydrocarbons were observed in Bottineau and Williams Counties, and detected by ultraviolet light/chlorothene testing throughout the study area (Appendix B).

Lithology

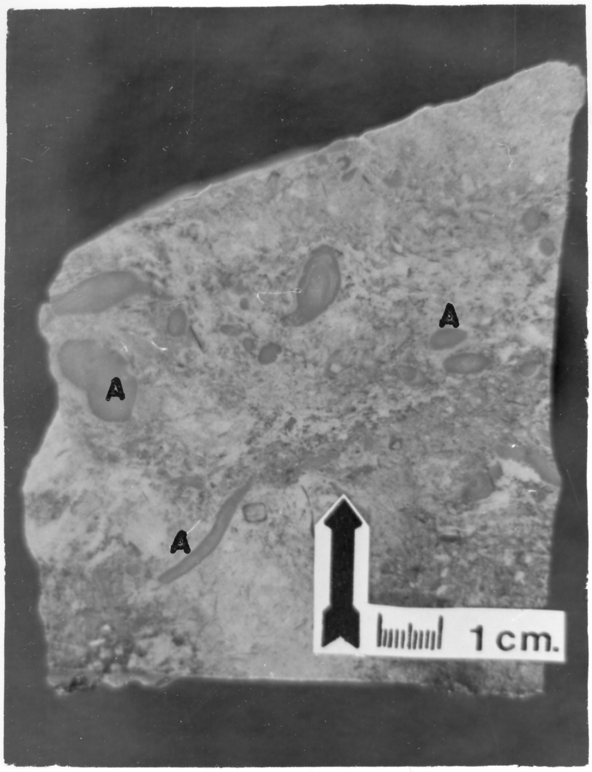
The carbonates of the Dawson Bay Formation in North Dakota are primarily composed of very-fine-crystalline to microcrystalline, dolomitized mudstone and dolomitized wackestone. The occurrence of mudstone (Figures 12 and 19), wackestone (Figure 23), packstone (Figure 24), and boundstone (Figures 25) is variable vertically, whereas the rock types are usually less variable laterally. Grainstones are rare to absent in the studied Dawson Bay core. Some bioclast and rock-type associations are laterally and vertically persistent allowing recognition of distinct lithofacies.

Figure 23

Core photograph of Stachoydes stromatoporoids (A) in microcrystalline dolomite wackestone. (lithofacies C, NDGS well #27, 2143.5')

Figure 24

Core photograph of Stachyodes (A) in finely-crystalline dolomite packstone. (lithofacies C, NDGS well #1231, 10,743.5')


A
A
A
1 cm.

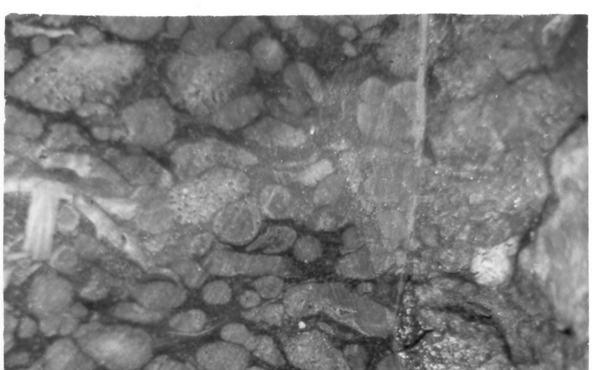

A
A
1 cm.

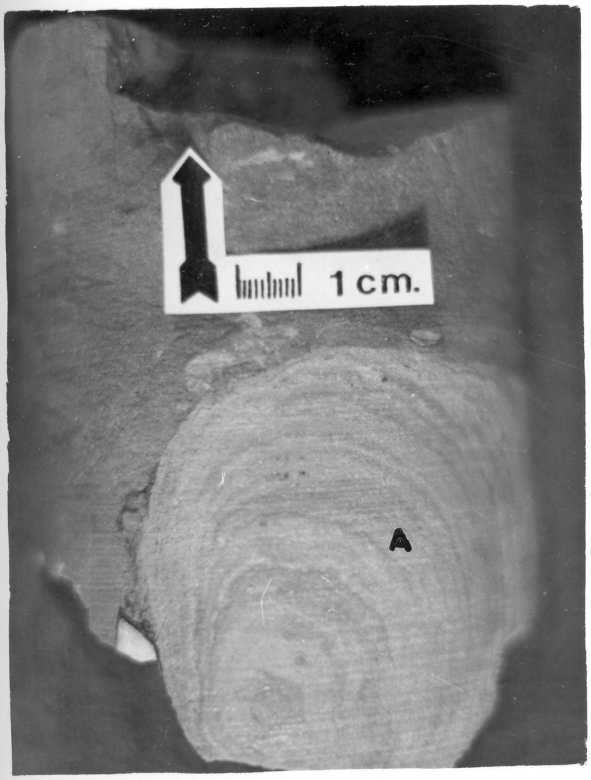
Figure 25

Core photograph of tabular stromatoporoid boundstone with subhorizontal Type I "Sutured-Seam Styolites" (A). (lithofacies C, NDGS well #31, 1747.5', scale: arrow length = 2.5 cm.)

Figure 26

Core photograph of subspherical stromatoporoid (A) in very-finely-crystalline dolomite matrix. (lithofacies C, NDGS well #38, 6194')


A
A
A


1 cm.
A

Orthochems

Micrite is comprised of microcrystalline calcite and dominates the orthochemical constituents of the available core (Figure 6). Micrite comprises 60-100% of the core and is present as the matrix between and within allochems. Micrite also occurs in amounts less than 1% as the product of the recrystallization of bioclasts (diagenesis), and as the result of dedolomitization proximal to pores (diagenesis).

Microcrystalline to medium-crystalline dolomitized micrite, nearly as common as micrite in the study area (Figures 5, 9, 11, 12 and 13), composes 2-100% of the core locally and commonly occurs as euhedral rhombs floating within or coalescing within micrite matrix. Medium-crystalline dolomite rhombs normally range from 2-40% of the core, and predominantly heal fractures or occur in association with microstyolites or pores (Figure 9). Medium-crystalline subhedral rhombs are occasionally present in Williams and Bottineau Counties. Total replacement of the matrix is not uncommon. Microcrystalline dolomite is present throughout the study area, but predominates in mudstones associated with cryptalgal laminations (Figure 20).

Other orthochems locally compose between 0-5% of the total core. Sparry calcite cement ranges from 0-3% of the core and commonly fills pores (Figure 8). Calcite cement is often associated with calcareous stromatoporoids. Pseudospar (Figures 5 and 11) and microspar (Figure 10) usually occur together and replace micrite adjacent to, and within, bioclasts. Pseudospar averages 0-5% of the core when present, and microspar averages 0-3%. Pseudospar predominantly occurs as blocky crystals, but also as a radial-axial fibrous and syntaxial replacement

(Figure 11).

Allochems

Fossils

Bioclasts in the stromatoporoid buildups locally comprise 100% of the core, but more commonly 0-40%. Sparry bioclast ghosts, micritization of bioclasts, molds, and vuggy-molds (to 3 cm in longest dimension) are locally abundant. Faunal descriptions of McCammon (1960) and Norris and others (1982) provide useful references, particularly for genus and species identification.

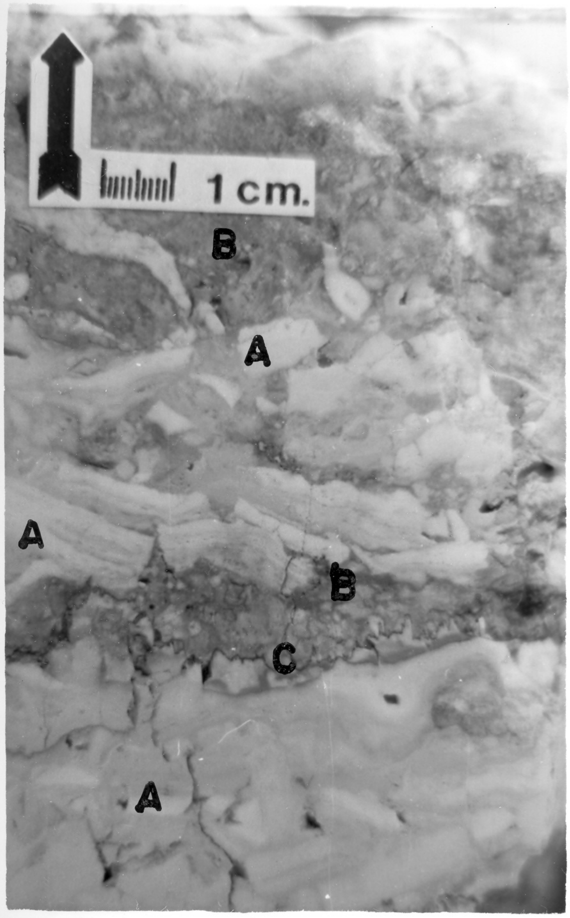
Stromatoporoids: All stromatoporoids studied occur in the middle of the Dawson Bay carbonate section and are laterally persistent. Dawson Bay stromatoporoids include cylindrical (Figures 23 and 24), subspherical (Figure 26), and tabular (Figures 7, 25 and 27) growth-forms (Read, 1973). Cylindrical stromatoporoids occur throughout the study area. Stromatoporoids make up less than 5% of the entire Dawson Bay core. They were visually estimated to represent less than 80% of the bioclasts, and comprise less than 16% of the core when present. Cylindrical stromatoporoids include 0.25-3 mm Amphipora genera (Figure 28) and 6-11 mm Stachoydes genera (Figures 23 and 24). Straight, and branching, cylindrical stromatoporoid forms were observed, and include the "dendroid" forms of Klovan (1964), Murray (1966) and Fischbuch (1968). Subspherical stromatoporoids were visually estimated to comprise less than 90% of the fossils in the Dawson Bay Formation core

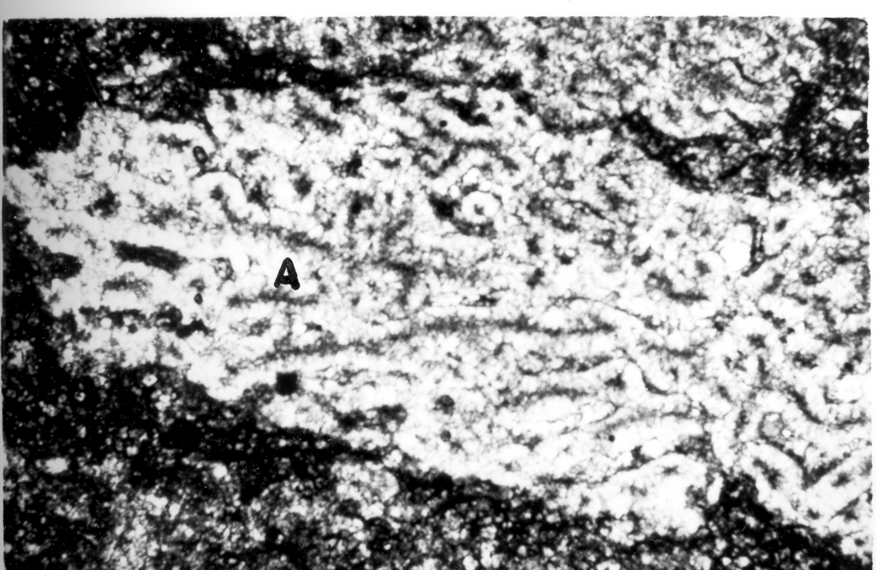
Figure 27

Core photograph of fragmented tabular stromatoporoid boundstone layers (A) which grade upward into oxidized Stachoydes packstones (B). Type I "Sutured-Seam Styolites" (C) separate the fragmented boundstone from the wackestone. (lithofacies C, NDGS well #31, 1770')

Figure 28

Photomicrograph of an Amphipora stromatoporoid (A) in a bituminous and argillaceous Type II microstyolite swarm. (lithofacies C, NDGS well #1231, 10738', crossed-polars, long field of view equals 4 mm)


1 cm.
B
A
A
B
C
A


A

(Figure 26), and represent less than 18% of the core when present. Measured long-axis lengths range from 2-8 cm. Subspherical forms display arcuate laminae. Fischbuch (1968) describes subspherical stromatoporoids as "dome-like", "subspherical", and "hemispherical". The terms, "massive" and "bulbous", have been used by Murray (1966) to describe subspherical forms. Tabular stromatoporoids locally comprise 100%, although more frequently, they comprise less than 30% of the core (Figures 25 and 27). The occurrence of tabular forms in the study area is more restricted than that of other stromatoporoid forms. Tabular stromatoporoids often occur in bioclastic wackestones, but locally occur in boundstones. Tabular stromatoporoids, which grew on underlying strata, locally appear as 1-10 cm thick, flat laminae. A single example of vertically-stacked growth predominating over that of lateral growth was observed (Figure 7). Embrey and Klovan (1971) termed the tabular growth-form of Read (1973), "massive", and defined it as laterally extensive colonies thicker than 5 cm.

Brachiopods: Brachiopods are a common Dawson Bay Formation constituent in North Dakota (Figure 6). They are absent only in the uppermost carbonates. Brachiopods make up less than 1% of the entire core. Their presence in the carbonates locally ranges from 2-100% of the fossils, and 0-30% of the core. Brachiopod form is primarily fragmental, but articulated and disarticulated forms are occasionally present with valves intact. Brachiopod spines are sometimes abundant where brachiopods occur. Numerous whole brachiopods with spiral brachidium (Figure 29) were observed in the middle of the carbonate section.

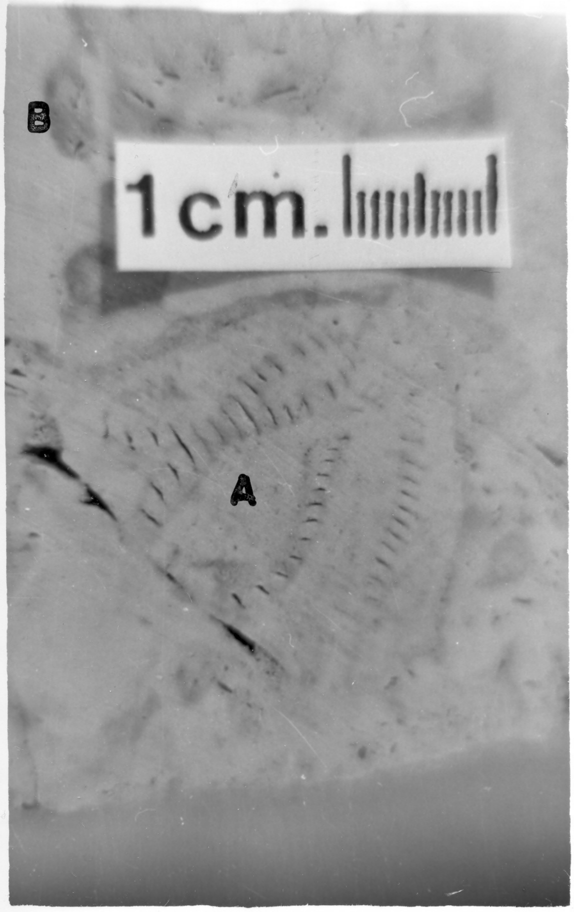
Echinoderm: Echinoderm fragments make up less than 1% of the

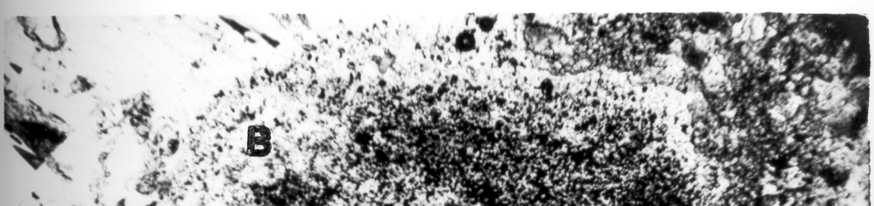
Figure 29

Core photograph of brachiopod with spiral brachidium (A) in biomicrite. Gray areas are oxidized hematite (B). (lithofacies C, NDGS well #36, 1649')

Figure 30

Photomicrograph of syntaxial pseudospar (A) overgrowth of echinoderm plate (B) in dolomitic micrite matrix. (lithofacies C, NDGS well #36, 1652', crossed-polars, long field of view equals 3 mm)


B
1 cm.
A


B
A

entire core. Echinoderms comprise 0-25% of the bioclasts, and 0-20% of the core, when present. Disarticulated (fragmental) echinoderm plates locally comprise 100% of all Dawson Bay Formation fauna in the study area (Figure 30). Articulated echinoderm plates are very rarely present. Echinoderm fragments range in size from 0.5-5 mm in longest dimension and are usually absent in the uppermost carbonate section. The fragments are occasionally concentrated in subhorizontal layers by pressure-solution. Microscopic inspection revealed occasional micritization of the optically continuous echinoderm plates.

Ostracods: Ostracod abundance in the entire core is less than 1% (Figure 5, 31 and 32). Ostracods locally comprise 100% of the bioclasts, although they more commonly make up less than 40% of the bioclasts. The percentage of ostracods in the core increases upward from the base of the carbonate section although a complete absence usually occurs at the top of the section throughout the study area. Maximum ostracod long-axis lengths average less than 1 mm, with most Dawson Bay ostracods in North Dakota ranging from 0.25-0.75 mm. Articulated and disarticulated molds are common.

Gastropods: Univalved and coiled whole-gastropods comprise less than 1% of the entire core, but locally 0-18% of the core. Gastropods comprise 20-100% of the Dawson Bay fauna in the study area (Figure 19 and 32). In general, their percentage increases upward after an initial localized abundance near the base of the carbonate section. Gastropod fragments were generally unidentifiable. Whole gastropod valves were measured along their long-dimension and an apparent size bimodality was observed with either 0.1 cm or 0.5 cm average sizes.

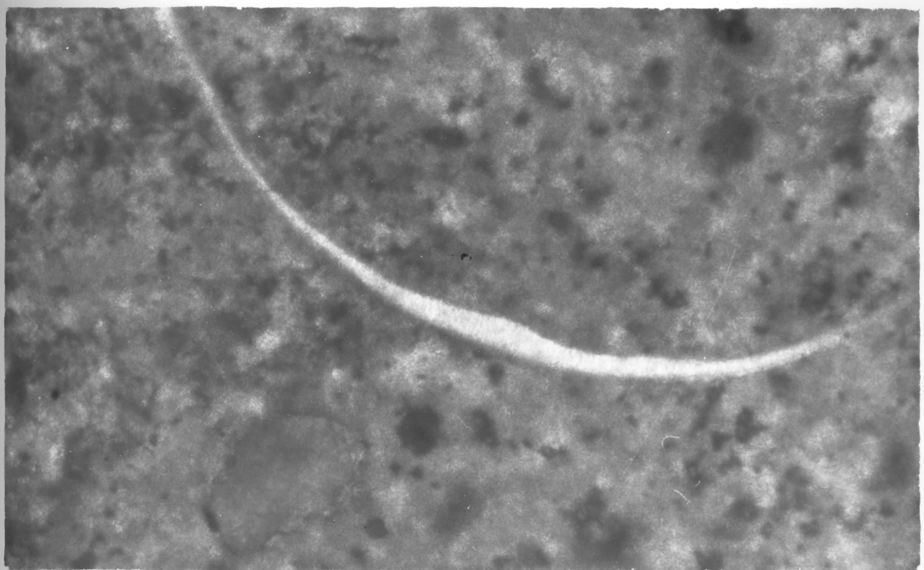
Blue-green algae: In the uppermost Dawson Bay, cryptalgal

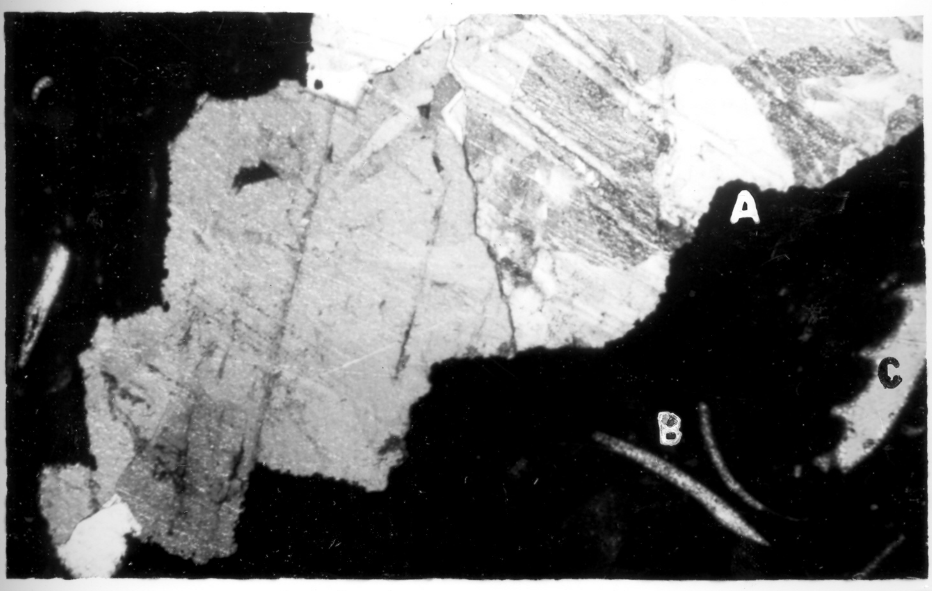
Figure 31

Photomicrograph of ostracod in micritic matrix. (lithofacies B, NDGS well#37, T.S. 2363', crossed-polars, long field of view equals 0.5 mm)

Figure 32

Photomicrograph of pyrite (A) replaced gastropod shell with ostracod (B) and brachiopod (C) fragments in micrite matrix. (lithofacies D, NDGS well #793, T.S. 11,060.5', crossed-polars, long field of view equals 4 mm)




A
B
C

laminations of relict blue-green algae comprise 100% of the fossil record and 0-30% of the core (Figure 20). In the study area blue-green algae comprise less than 2% of the entire core and less than 5% of the bioclasts in the core. Clay, quartz silt, and oxidized hematite are closely associated in subhorizontal laminations (Figure 22). Individual laminations average 0.5 mm in thickness with multiple lamination groupings reaching a maximum thickness of 7 cm within a dolomite matrix. Cryptalgal laminations display subhorizontal crenulations with millimeter-to-centimeter scale angular unconformities, subhorizontal ("laminoid" of Grover and Read, 1978) fenestral fabric, dessication cracks, and intraclasts of cryptalgal composition.

Anthozoans: Tabulate (Figure 33) and rugosan (Figure 34) coral abundances in the entire core are less than 1%. Corals comprise 0-50% of the fauna in the middle of the carbonate section and comprise 0-10% of the core when present. Solitary forms have 1.0 cm average diameters. The average zooecium diameter for both branching colonial and solitary corals is 1.0 mm.

Bryozoans: Lacy, encrusting forms of bryozoans with less than 0.5 mm zooecia are very local occurrences which are usually associated with stromatoporoids (Figure 13). Bryozoans make up less than 1% of the entire Dawson Bay core. When they are present bryozoans comprise less than 90% of the bioclasts. They are most commonly absent, but comprise 0-17% of the core when present.

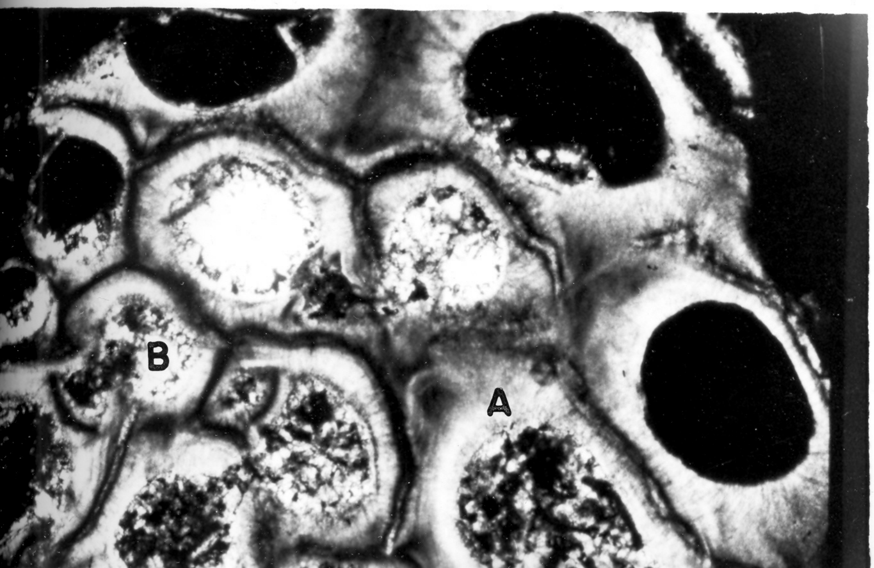
Trilobites: Whole and fragmental trilobites are present throughout the carbonate unit (Figure 35). Trilobites are found in less than 1% of the entire core. They comprise less than 15% of the

Figure 33

Photomicrograph of tabulate coral displaying neomorphic recrystallization of corallite walls to radial-axial pseudospar (A). Micrite within zooecia have similarly been recrystallized to microspar (B). (lithofacies C, NDGS well #207, T.S. 4615', crossed-polars, long field of view equals 4 mm)

Figure 34

Photomicrograph of rugosan coral displaying microcrystalline to finely-crystalline, euhedral, dolomite rhombs (A) rimming intraparticle pores. (lithofacies C, NDGS well #27, 2177', crossed-polars, long field of view equals 4 mm)


B
A

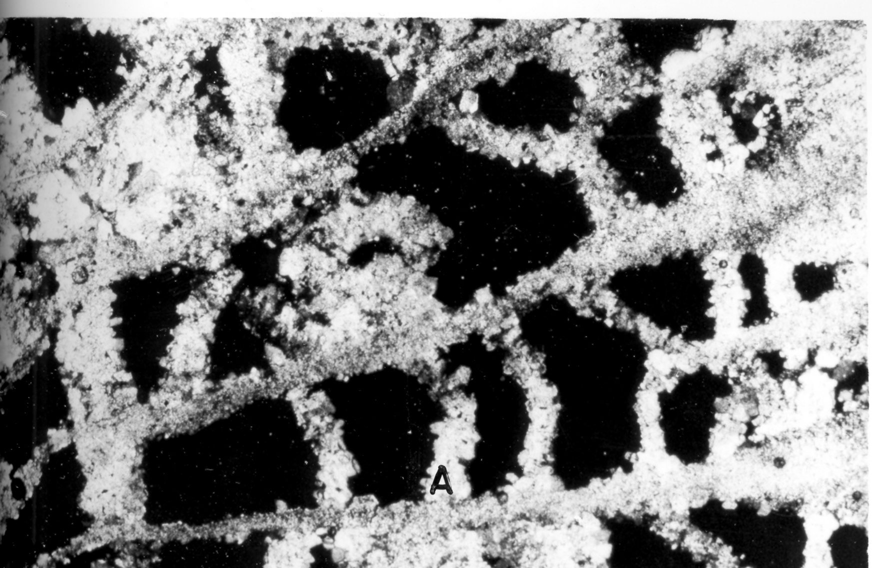
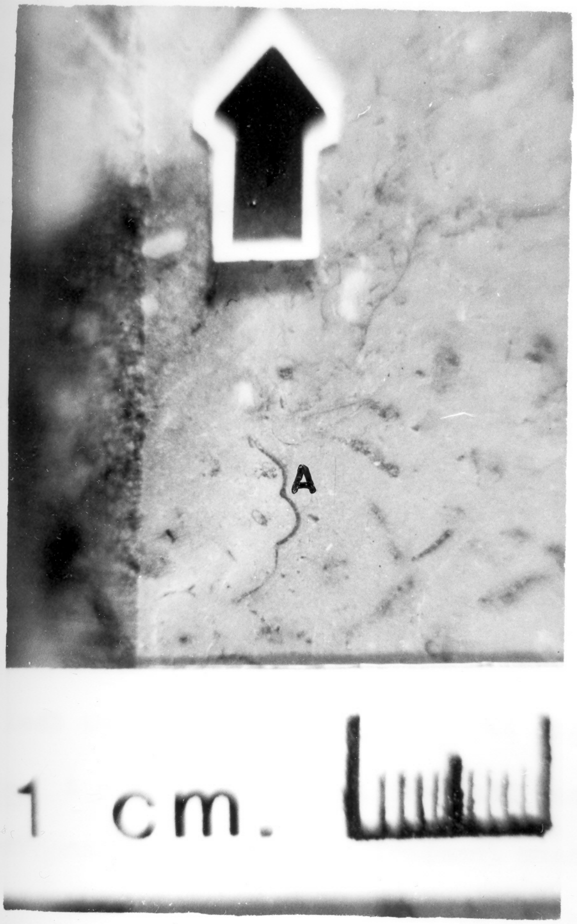

A

Figure 35

Core photograph of trilobite (A) in wackestone. (lithofacies C, NDGS well #207, T.S. 4594')

Figure 36

Photomicrograph of rounded intraclasts (A) of fragmental brachiopod, peloid, and micrite composition. Microspar (B) has preferentially recrystallized bioclasts within intraclasts and micritic matrix. (lithofacies D, NDGS well #27, T.S. 2137', crossed-polars, long field of view equals 3 mm)


A
1 cm.


A
B
B

bioclasts and 0-2% of the core when present. The maximum transverse dimension of whole trilobites averages 0.5 cm. Characteristic "shepard's crooks" are seen in thin-section.

Calcispheres: The presence of calcispheres is limited to the lower and middle carbonate section where they make up less than 10% of the bioclasts and less than 1% of the core (Figure 11). Their average diameter is 0.2 mm, and a maximum calcisphere diameter of 0.5 mm was observed in thin-section.

Red algae: Red algae comprise less than 1% of the entire core. Very localized occurrences comprise 100% of the fossils present, although a 0-1% range is more typical. The diameter of their cellular structures are less than 1.0 mm. *Renalysis* red algae may be present.

Cephalopods: A single cephalopod fragment was observed in the middle of the carbonate section. The fragment measures approximately 1 cm x 2 cm. Cephalopods comprise less than 1% of the Dawson Bay bioclasts and core.

Unidentified fossil fragments: Fragmental bioclasts are present throughout the entire Dawson Bay core in amounts less than 5%. They occasionally constitute 100% of the fossils, but more typically range from 0-40%. Their sizes range from sub-millimeter to centimeter scale.

Intraclasts

Intraclasts of 1.0 mm to 10 mm maximum dimension comprise less than 1% of the entire Dawson Bay core. They generally comprise less than 10% of the core where present (Figure 36). Locally intraclasts make up 80% of the allochems present. Subhorizontal orientation of intraclasts is common with occasional irregular orientation. Shapes range from subangular to rounded. Intraclast composition usually reflects surrounding lithologies and usually consist of bioclastic, dolomitized, micrite. One local group of intraclasts contain cryptalgal laminations, ripple laminations, soft-sediment deformation structures, centimeter-scale angular unconformities, and ostracod bioclasts.

Peloids

Rounded to subrounded peloids occasionally occur within micritic mudstone matrix, or in association with cryptalgal laminations. Peloids comprise 0-10% of the entire core and locally less than 35%. Peloids in the Dawson Bay range in size from 0.03-0.15 mm, are of micritic composition, and are without internal structure (Figure 10).

Structures

Local sedimentary structures within available Dawson Bay core include: burrow-mottling, burrows, laminations, angular unconformities, fenestral fabric, dessication cracks, borings, and pseudostructures.

Burrow-mottling is only recognizable where dolomitization has not obscured the original structures. Though micrite ranges from 60-100% of the total Dawson Bay lithology, burrow-mottling disrupts 90-100% of the micrite (Figure 37). Only one distinctive burrow was recognized in the available core. It was observed within mudstone associated with cryptalgal laminations in the uppermost Dawson Bay. The burrow's long dimension was 12 cm and its width was 2 cm (Figure 37).

Several varieties of laminae are present in the core. Millimeter-scale argillaceous laminae occur in less than 1% of the core in association with cryptalgal mudstones (Figure 20). Millimeter to centimeter-scale laminae of micron-scale pyrite clusters also occur locally in the basal carbonate section. These rare laminae (less than 1%) were observed only in eastern Bottineau County. They occur proximal to the edge of the Prairie Evaporite and are extensively fractured and offset. Bioclastic laminae of millimeter to centimeter-scale comprise less than 1% of the middle and lower Dawson Bay carbonates. Echinoderm and brachiopod fragments are most abundant. These bioclast laminae were the only grainstone occurrences observed in the available core. Rare (less than 1%) centimeter-scale ripple laminae are present in Cavalier County in association with cryptalgal mudstones. The most abundant laminations in the Dawson Bay carbonates are those of cryptalgal lamination composition comprising up to 30% of the lithology when present. They occur as millimeter-scale oxidized argillaceous laminations which alternate vertically with mudstones. Quartz silt (less than 1%) is often associated with these laminations. The cryptalgal laminations are typically crenulated and occasionally display micro to macro angular unconformities (Figure 20).

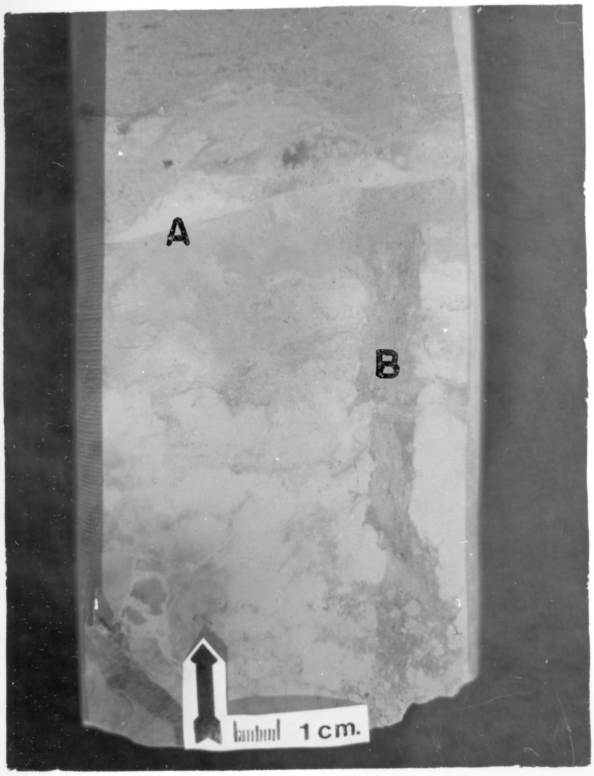
Subvertical, subhorizontal, and irregularly oriented fenestral fabrics occur occasionally in the study area (Figure 38). In each case the fenestral fabric occurs high in the carbonate section and is

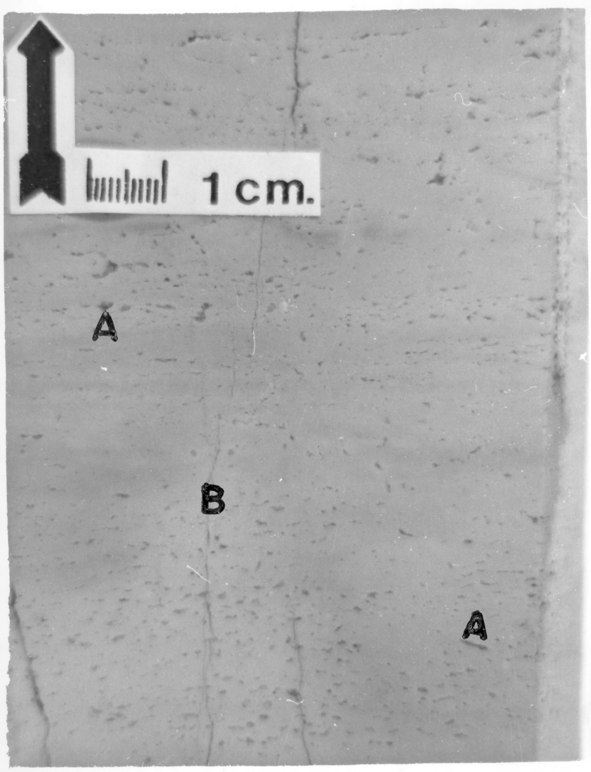
Figure 37

Core photograph of burrow-mottled microcrystalline dolomite with subhorizontal scour surface (A) and subvertical burrow (B). The darker burrow color is due to increased argillaceous content. (lithofacies F, NDGS well #37, 2298')

Figure 38

Core photograph of subhorizontal fenestral pores (A) in microcrystalline dolomicrite. Subvertical and subparallel fractures (B) cut the lithology. (lithofacies E, NDGS well #31, 1739')


A
B
1 cm.


1 cm.
A
B
A

associated with mudstones. Subvertical and irregularly oriented fenestral fabric is a rare (less than 1%) occurrence limited to northern Dunn County. Subhorizontal fenestral fabrics locally comprise up to 10% of the cryptalgal associated mudstone core in Cavalier County. Remaining porosity is minimal, but does exist as indicated by iron oxide solution-mottling, which occasionally rims the remaining pores.

Dessication cracks are very rare occurrences (less than 1%) which are commonly associated with red clays (Figure 39). Light-green clays are occasionally present with these dessication features in Cavalier County associated with oxidized surfaces. They range upward from the middle of the stromatoporoid-buildup section and were observed to reach a maximum subvertical long-dimension length of approximately 10 cm, although a 2-3 cm depth is most common.

The depth of borings have a range of 0.25 mm-1.5 mm and were observed in brachiopods, trilobites, stromatoporoids, and unidentifiable bioclasts (Figures 40 and 41). They were not commonly observed (less than 1%) in the Dawson Bay core. They were at times difficult to distinguish from punctuate structures which transect the entire bioclast and are always linear.

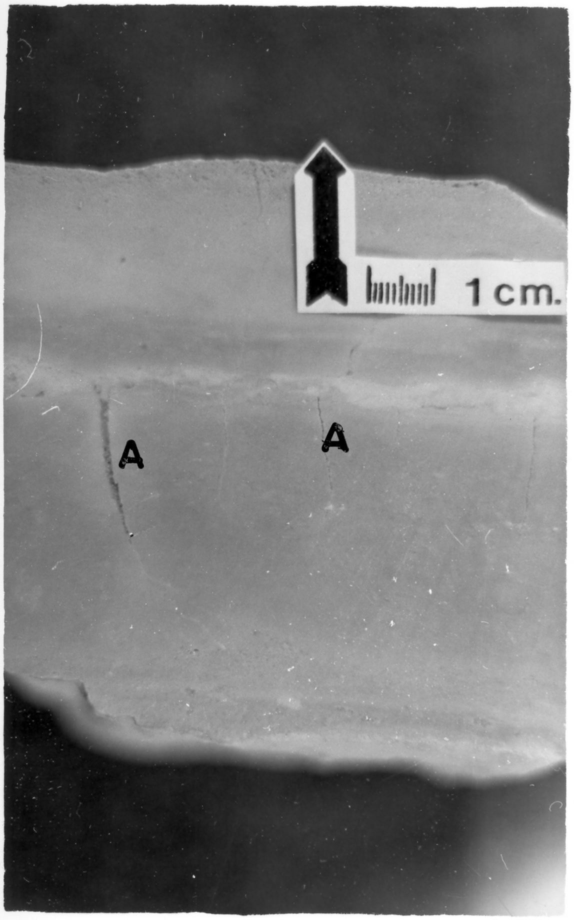
Pseudostructures include pseudointraclasts and "pseudoburrows". A pseudointraclastic texture is present in portions of Williams County and locally comprises 20-80% of the lithology. It has the appearance of brownish gray (10YR4/1) microcrystalline dolomite intraclasts floating in a matrix of dark-brown (10YR3/3) very-finely-crystalline dolomite (Figure 21). This appearance is the result of diagenetic subvertical and subhorizontal fracturing of the microcrystalline

Figure 39

Core photograph of dessication cracks (A) in microcrystalline to finely-crystalline dolomitic matrix. (lithofacies F, NDGS well #31, 1737.9')

Figure 40

Photomicrograph of microborings (A) in brachiopod fragment. (lithofacies C, NDGS well #37, T.S. 2343', crossed-polars, long field of view equals 0.5 mm)


1 cm.
A
A

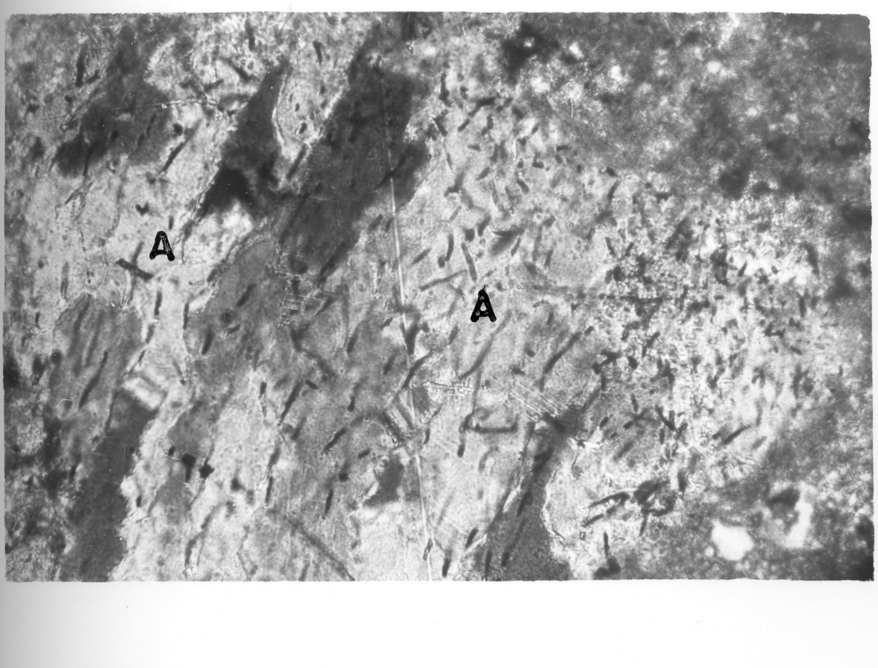
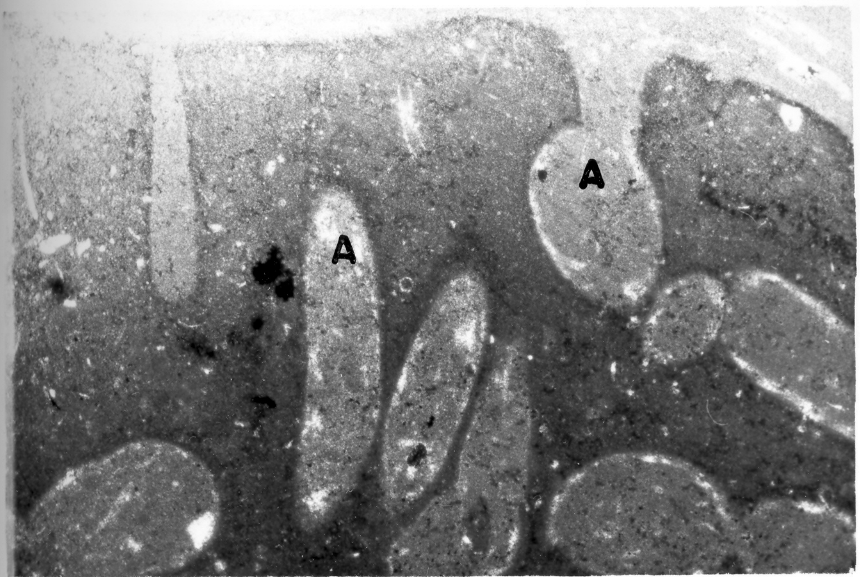

A
A

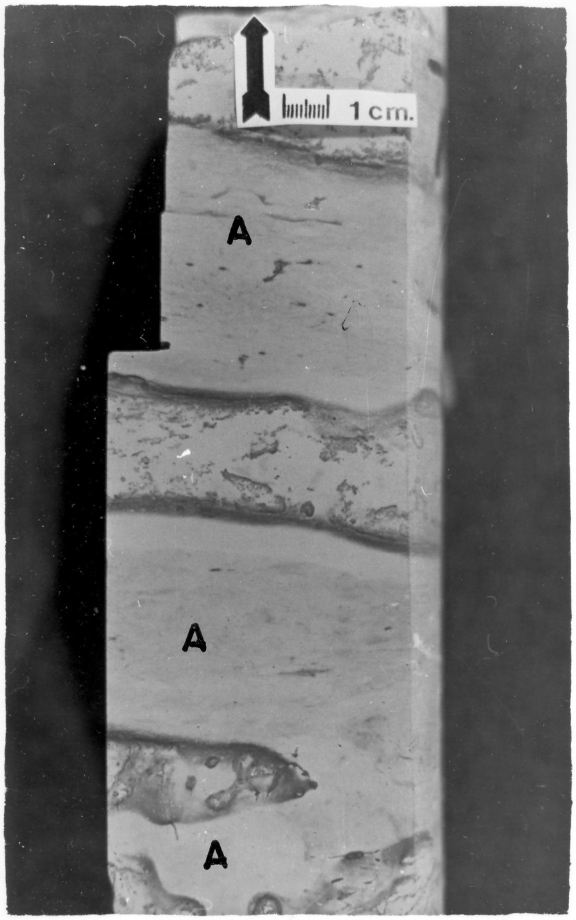
Figure 41

Photomicrograph of bored (A), micritic, intraclast. (lithofacies D, NDGS well #793, T.S. 11060.5', crossed-polars, long field of view equals 4 mm)

Figure 42

Core photograph of subhorizontal "pseudoburrow" (A) resulting from cryptalgal lamination control of color-mottling by paleogroundwater flow in microcrystalline dolomite. (lithofacies F, NDGS well #34, 1728.5')


A
A


1 cm.
A
A
A

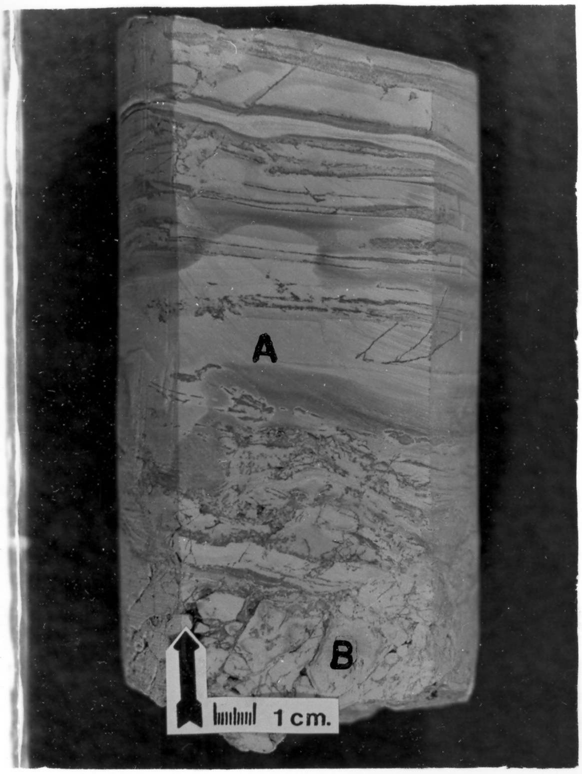
dolomite with subsequent coarser recrystallization of dolomite proximal to the fractures. "Pseudoburrows" are a particular form of solution-mottling which are found proximal to cryptalgal laminations (Figures 42 and 43), or bioclasts (Figure 44), in Cavalier County. "Pseudoburrows" have the appearance of filled burrows with widths ranging from 0.5-8 cm. They are usually oriented subhorizontally in association with cryptalgal laminations, and oriented irregularly in association with brachiopod wackestones.

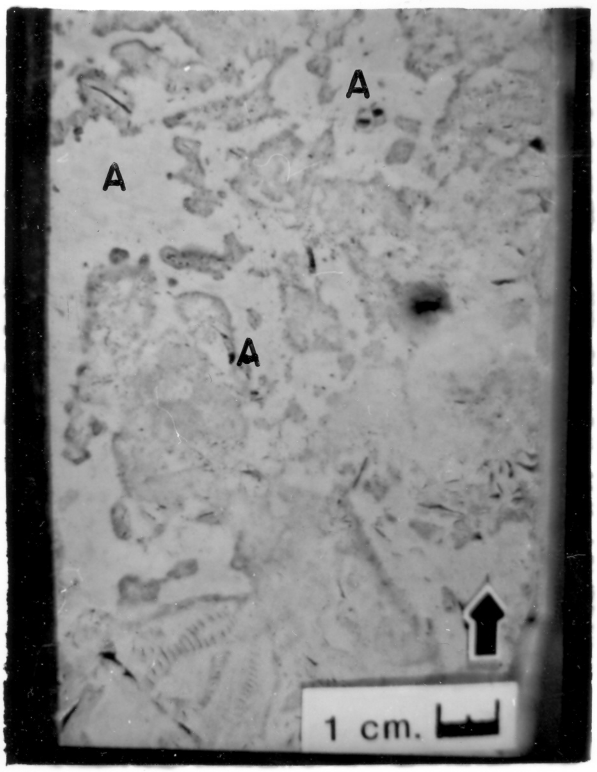
Figure 43

Core photograph of incompletely developed, subhorizontal, "pseudoburrow" (A). Solution-mottled intraclasts (B) of cryptalgal, microcrystalline, dolomudstone composition in lower half of photograph. (lithofacies F, NDGS well #34, 1726')

Figure 44

Core photograph of irregularly oriented "pseudoburrows" (A) in brachiopod wackestone. (lithofacies B, NDGS well #27, 2233')


A
B
1 cm.


A
A
A
1 cm.

DIAGENETIC FEATURES

Diagenetic features often mask the original character of the lithologies making depositional environment interpretations less certain. Hydrocarbon exploration is also influenced by post depositional alteration of potential reservoir rocks. In particular, porosity and permeability may be enhanced or reduced by diagenesis. Diagenetic features identified include: secondary dolomite, pressure-solution structures, calcite cement, neomorphic calcite, secondary pores, color-mottling, halite, anhydrite, and hydrocarbons.

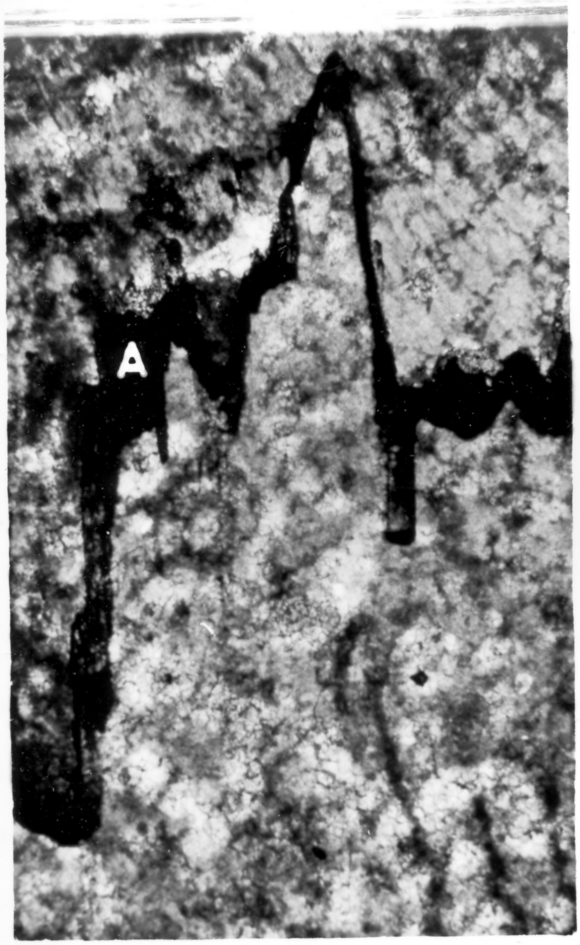
Pressure-Solution Responses

Carbonates undergo deformation, neomorphism, and/or dissolution when subjected to the stresses from overburden or tectonics (Wanless, 1979). Three major types of pressure-solution responses are described by Wanless (1979). Type I is "Sutured-Seam Solution" and includes styolites and grain contact solution features (Figures 25 and 45), which are typical of clean limestones with structurally resistant elements (Wanless, 1979). Type II is "Non-Sutured Seam Solution" which includes microstyolites, swarms, and seams in clayey limestones (Figure 19). Type III is "Non-Seam Solution" which is characterized by pervasive solution dolomitization occurring in clean limestones without resistant elements.

Although Type I pressure-solution responses are most common within the Dawson Bay stromatoporoid boundstones, packstones, and wackestones,

Figure 45

Photomicrograph of a Type I, "Sutured-Seam Styolite" (A) between resistant tabular stromatoporoids. (lithofacies C, NDGS well #31, T.S. 1748', crossed-polars, long field of view equals 4 mm)


A

occasional to very abundant Type II pressure-solution responses are present in all samples. In northeastern Williams and southwestern Bottineau Counties, recrystallization of dolomite to larger sizes is often associated with Type II microstyolites as well as fractures. Microstyolites often cut earlier healed fractures and are themselves cut by later fractures. In general, dolomitization associated with microstyolites commonly results in the healing of early fractures and the enhancement of porosity (Figure 12). Bioclasts are occasionally subhorizontal in orientation association with Type II microstyolites. Occasionally, Type III pressure-solution structures were observed within the carbonate members of the Dawson Bay in North Dakota.

Neomorphic Calcite

Calcite occurs in the Dawson Bay Formation as microspar, pseudospar, and as the product of dedolomization. Microspar usually consists of 5-6 micron, uniformly sized grains, as described by Folk (1965, 1974)(Figures 6 and 10), and locally ranges from 0-3 % of the core. Most often microspar replaces micritic matrix adjacent to pores and adjacent to, or within, bioclasts. Occasionally, microspar replaces micritic matrix and bioclasts, fills coral zooecia, fills borings in stromatoporoids, and fills the interiors of whole bioclasts. When the quantity of microspar reaches 3%, and very locally as high as 15%, it occurs as patchy micritic matrix replacement.

Neomorphic calcite, which is clearer and coarser then microspar, is termed "pseudospar" by Folk (1965, 1974)(Figures 5, 11 and 30).

Several forms of pseudospar occur in the study area in amounts normally ranging up to 5%. Very localized occurrences range from 10-20%. Blocky crystals replacing bioclasts are the most common type of pseudospar occurrence, although micrite replacement adjacent to pores and bioclasts, both internally and externally, is also common. Syntaxial overgrowths on echinoderm fragments are another commonly observed form of pseudospar. Radial-axial fibrous growth into micritic matrix from syntaxial echinoderm overgrowths, or blocky-equant pseudospar bioclast replacement, occurs occasionally.

Dedolomitization adjacent to pores occurs very locally in amounts less than 1 % of the studied core. Dedolomitization usually occurs within a few millimeters of pores.

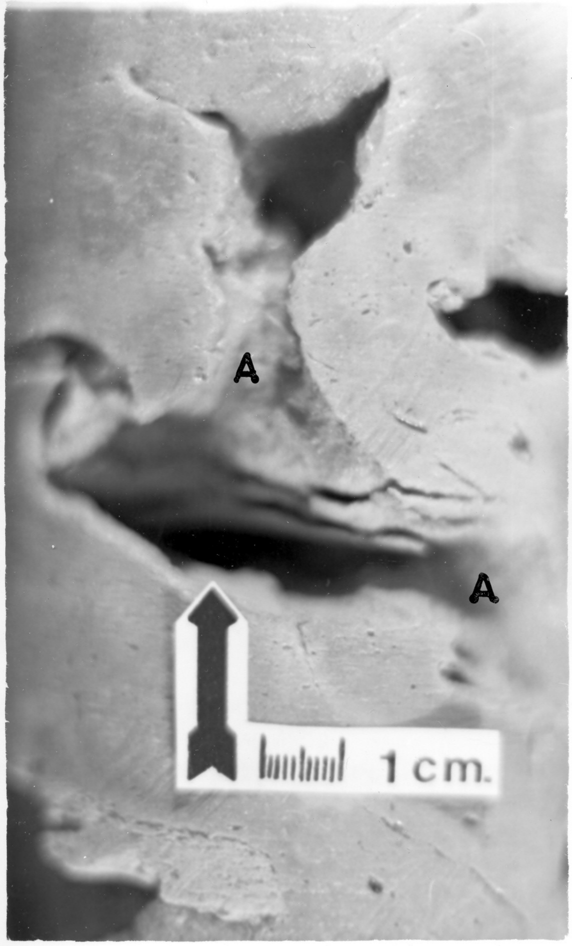
Porosity

Eight porosity types were recognized within the carbonate members of the Dawson Bay Formation in the study area. The nomenclature of Choquette and Pray (1970) was used in core and thin-section descriptions. The following porosity types are present in order of decreasing occurrence: intercrystalline, fracture, moldic, vuggy, microfracture, intraparticle, fenestral, and shelter porosity. Occasionally, specific pore types can not be distinguished and must be described, as for example, "moldic-vuggy" (Figure 46).

Intercrystalline porosity falls within the micropore to mesopore size range of Choquette and Pray (1970)(Figures 9 and 12). Size variability is associated with multiple event dolomitization adjacent

Figure 46

Core photograph. Vuggy-mold of stromatoporoid (A) in very-finely-crystalline dolomite. (lithofacies C, NDGS well #27, 2216')


A
A
1 cm.

to multiple event fracturing and microstyolites. Fracturé porosity ranges from mesopore to megapore size (Figures 15, 21 and 27). Most microfracture porosity is in the mesopore range and associated with multiple-fractured dolomites (Figure 12). Brecciation with occasional slickensides are present in areas underlain by the Prairie Evaporite. Moldic porosity (Figures 6 and 19) ranges from mesopore to megapore size, with a 2 cm maximum long-dimension brachiopod size, and a 8 cm maximum moldic stromatoporoid size. Vuggy porosity ranges between mesopore and megapore sizes. The largest vug sizes are associated with moldic-vuggy stromatoporoids (Figure 46). Intraparticle porosity is in the mesopore-size range and most commonly associated with stromatoporoids, corals, and bryozoans (Figures 24, 26, 27, 33, and 34). Fenestral porosities are in the micropore to mesopore size range and are limited to Cavalier County (Figure 38). Shelter porosity is of mesopore to megapore size and primarily associated with articulated brachiopods and whole gastropods.

In areas of North Dakota where the Dawson Bay Formation is underlain by the Prairie Evaporite (Figure 1) visual inspection of core can not accurately determine porosities and permeabilities. Drilling processes may have removed halite from pores. Wire-line log evaluation of permeabilities, or drill-stem tests, may be necessary.

Color-Mottling

Diagenetic color-mottling is very common within the study area. Lateral color changes are significant, whereas vertical changes are minimal within each cored well. In Cavalier County, the Dawson Bay carbonate is light gray (7.5YR8/2) with yellow (2.5Y8/6) to dark-red (7.5R3/4) mottling. The colors change to light brownish-gray (5YR7/2) with yellow-brown (10YR6/2) mottling occurring southward into Wells County and westward into Bottineau County. Throughout Bottineau County these colors persist with only slight variation, but shift to brownish gray (5YR6/1) with black (7.5YR2/1) or yellow-brown (10YR6/2) mottling in Dunn and Williams Counties. Rare color-streaming, consistently to one side of relict structures within "pseudoburrows", was observed.

"Pseudoburrows" are frequently observed in oxidized Dawson Bay carbonates in eastern Cavalier County. Megascopically, these distinctive forms of color-mottling have the appearance of filled burrows (Figure 33). Internally, these features are gray (5YR8/2) in color, while externally, the colors are those of the matrix country rock. In thin-section, "pseudoburrows" are difficult to distinguish because their boundaries are defined by diffuse dark red (7.5R3/4) mottled walls. In-place relict cryptalgal laminations, or bioclasts, occur within and cross-cut "pseudoburrows".

Two types of "pseudoburrows" were recognized. The most common is the subhorizontal variety which has a maximum width of 8 cm and appears to be controlled by associated subhorizontal cryptalgal laminations (Figures 42 and 43). The second type of pseudoburrow discerned has either an irregular orientation or vertical components (Figure 44). "Pseudoburrows" of this type have widths in the range of 0.5-2.0 cm. These are associated with fenestral fabrics in cryptalgal boundstones and occasionally with bioclastic wackestones-packstones.

Hydrocarbons

At intervals of approximately four feet, uniform-sized samples of core were taken for hydrocarbon testing. Additional samples were taken to verify prior test results. The samples were immersed in chlorothene which dissolves the hydrocarbons. Care was taken to avoid contamination during preparation and during testing. The chlorothene used in each test batch was checked for contamination by ultraviolet light. After immersion, the samples were immediately viewed under ultraviolet light. In several instances, light hydrocarbons were observed to stream away from the sample. Because of the 1950's drilling dates for several of the cored Dawson Bay intervals, it is probable that some light hydrocarbons have been lost. In an attempt to standardize the hydrocarbon testing, the samples were simply evaluated as "show" or "absent" after evaporation of chlorothene. "Shows" were observed throughout the study area. The results are presented in Table 1.

Several thin-sections and core revealed the presence of residual hydrocarbons in Williams and Bottineau Counties. These hydrocarbons are associated with multiple, and commonly healed, fractured dolomites and with vuggy, moldic, and intraparticle porosity. Hydrocarbons are also present in the most recent subvertical fractures which are commonly partially filled by anhydrite, halite, and calcite cement.

TABLE 1

ULTRAVIOLET LIGHT / CHLOROTHENE HYDROCARBON TEST RESULTS

KEY:

Lith.: Lithofacies
S: Show
A: Absent
-: Not Present or Not Tested

WELL # 27 CAVALIER CO.

Lith.	S	A
F	0	3
E	-	-
D	0	2
C	1	9
B	3	11

WELL # 31 CAVALIER CO.

Lith.	S	A
F	2	7
E	0	1
D	0	1
C	13	13
B	0	0

WELL # 36 CAVALIER CO.

Lith.	S	A
F	0	3
E	-	-
D	-	-
C	4	9
B	5	2

WELL # 37 CAVALIER CO.

Lith.	S	A
F	0	7
E	-	-
D	0	1
C	0	3
B	0	3

WELL # 38 BOTTINEAU CO.

Lith.	S	A
F	3	2
E	3	0
D	4	0
C	15	0
B	31	0

WELL # 207 WELLS CO.

Lith.	S	A
F	-	-
E	-	-
D	0	2
C	5	0
B	2	0

WELL # 286 BOTTINEAU CO.

Lith.	S	A
F	1	4
E	1	0
D	-	-
C	4	7
B	0	1

WELL # 793 DUNN CO.

Lith.	S	A
F	-	-
E	-	-
D	9	0
C	11	2
B	36	3

WELL # 1231 WILLIAMS CO.

Lith.	S	A
F	1	0
E	2	0
D	9	0
C	8	0
B	8	0

WELL # 1403 WILLIAMS CO.

Lith.	S	A
F	-	-
E	1	0
D	7	0
C	1	0
B	-	-

WELL # 7877 WILLIAMS CO.

Lith.	S	A
F	-	-
E	-	-
D	-	-
C	31	2
B	-	-

LITHOFACIES

Introduction

Core and thin-section study resulted in the delineation of five lithofacies within the Dawson Bay Formation in North Dakota. Descriptions of the carbonate lithofacies of the Dawson Bay are given in Appendix B. The following cored North Dakota wells penetrate the entire Dawson Bay Formation: #27, #38, #207, and #793. Partial penetrations occur in wells: #31, #36, #37, #286, #1231, #1403, #5277, and #7877. Table 2 is a summary of the general lithologic and faunal characteristics for each identified lithofacies. The stratigraphic relations of North Dakota Dawson Bay Formation lithofacies occurrences and their thicknesses are given in Figure 47.

In addition to the five lithofacies identified and used in this study, two additional lithofacies have been identified within the Dawson Bay Formation by earlier workers. One is the Second Red Bed which comprises the basal, argillaceous, Dawson Bay member (Dunn, 1982). Even though the Second Red Bed is not included in the present study, it is desiginated lithofacies A because of its presence in the study area (Table 2)(Figure 2). The Hubbard Evaporite member, another lithofacies recognized by previous researchers (Lane, 1959)(Dunn, 1982), caps the Dawson Bay in Saskatchewan, but is not present in the North Dakota portion of the Williston Basin (Figure 2). Consequently, it is not designated as a lithofacies in this study.

The lithofacies identified in the present study were defined on

TABLE 2: LITHOFACIES CHARACTERISTICS AND DEPOSITIONAL ENVIRONMENTS OF THE DAWSON BAY FORMATION IN NORTH DAKOTA

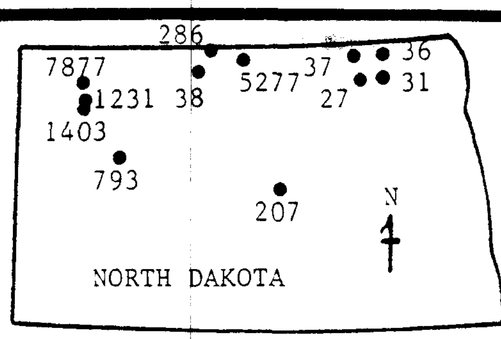
DAWSON BAY FORMATION MEMBERS (DUNN, 1982)	NORTH DAKOTA DAWSON BAY FORMATION LITHOFACIES	ROCK NAME	DEPOSITIONAL STRUCTURES, ALLOCHEMS, AND PHYSICAL CHARACTER	FAUNA AND FLORA	ENVIRONMENT OF DEPOSITION
NEELY MEMBER	C	INTERBEDDED WACKESTONE, PACKSTONE, MUDSTONE, AND BOUNDSTONE	INTRACLASTS; RARE PELOIDS; LOCAL OXIDIZED SURFACES; TYPE I, SUTURE SEAM STYOLITES. HARDGROUNDS AND ARGILLACEOUS NEAR BASE	CYLINDRICAL, SUBSPHERICAL, AND TABULAR STROMATOPOROIDS; CORALS; BRACHIOPODS; BLUE-GREEN ALGAE; BRYOZOANS; ECHINODERMS; GASTROPODS; OSTRACODS; CEPHALOPODS; TRILOBITES; AND CALCISPHERES.	STROMATOPOROID BIOSTROMES AND LOCAL BIOHERMS
	B		(VERY ARGILLACEOUS)		
BURR MEMBER	B	WACKESTONE AND MUDSTONE OCCASIONAL GRAINSTONE	HARDGROUNDS, ARGILLACEOUS. OCCASIONAL LAG DEPOSIT. RARE, LOCAL, QUARTZ SILT AND LAMINATIONS NEAR BASE.	BRACHIOPODS; ECHINODERMS; CORALS; BRYOZOANS; OSTRACODS; RED ALGAE (?); TRILOBITES; AND CALCISPHERES.	SHALLOW EPEIRIC SEA
SECOND RED BED MEMBER	A		UNSTUDIED THIS REPORT		

TABLE 2, CONTINUED: LITHOFACIES CHARACTERISTICS AND DEPOSITIONAL ENVIRONMENTS OF THE DAWSON BAY FORMATION IN NORTH DAKOTA

DAWSON BAY FORMATION MEMBERS (DUNN, 1982)	NORTH DAKOTA DAWSON BAY FORMATION LITHOFACIES	ROCK NAME	DEPOSITIONAL STRUCTURES, ALLOCHEMS, AND PHYSICAL CHARACTER	FAUNA AND FLORA	ENVIRONMENT OF DEPOSITION
NEELY MEMBER	F	MUDSTONE (TOP) CRYPTALGAL BOUNDSTONE (LOCALLY ANHYDRITIC)	OXIDIZED AND CRENULATED LAMINAE; FENESTRAE; DESSICATION CRACKS; RIPPLE LAMINAE; SCOUR SURFACES; FRAGMENTAL FOSSILIFEROUS LAMINAE; BURROWS; PELOIDS; INTRACLASTS; ARGILLACEOUS; TRACE QUARTZ SILT; COLOR-MOTTLING INCLUDING LOCAL PSEUDOBURROWS.	CRYPTALGAL LAMINATIONS (BLUE-GREEN ALGAE)	SHALLOW EPEIRIC SEA SHORELINE
		LOCAL INTRACLAST WACKESTONE NEAR BASE.		LOCALLY, POORLY FOSSILIFEROUS NEAR TOP AND BASE	
	E	MUDSTONE (TOP) RARE, LOCAL, INTRACLAST WACKESTONE AND PACKSTONE	FENESTRAE; BURROW-MOTTLING; BITUMENS; PELOIDS; INTRACLASTS; PYRITE; ARGILLACEOUS; TRACE QUARTZ SILT; COLOR-MOTTLING.	POORLY FOSSILIFEROUS (TOP) GASTROPODS; OSTRACODS; AND LOCAL BLUE-GREEN ALGAE	RESTRICTED SHALLOW EPEIRIC SEA
	D	MUDSTONE AND WACKESTONE LOCAL PELOIDAL PACKSTONE	FENESTRAE; BURROW-MOTTLING; BORINGS; COLOR-MOTTLING; PELOIDS; INTRACLASTS; RIPPLE LAMINAE; LOCAL DESSICATION CRACKS; ARGILLACEOUS.	GASTROPODS; OSTRACODS; BRACHIOPODS; ECHINODERMS; CORALS; BLUE-GREEN ALGAE; CALCISPHERES; TRILOBITES; and AMPHIPORA	VERY SHALLOW EPEIRIC SEA

LITHOFACIES KEY:

- F: Epeiric Sea Shoreline
- E: Restricted Shallow Epeiric Sea
- D: Very Shallow Epeiric Sea
- C: Stromatoporoid Biostromes and Bioherms
- B: Shallow Epeiric Sea
- A: Second Red Bed Member
- MC: Missing Core
- * : End of Available Core



WELL # 27 CAVALIER CO.	WELL # 31 CAVALIER CO.	WELL # 36 CAVALIER CO.	WELL # 37 CAVALIER CO.
D 13'	F 1'	F 16'	F 87.5'
F 2'	D 1'	C 20'	D 10'
D 1'	F 12'	B* 5'	C 8'
F 7'	E 2'	MC 97'	B* 19'
C 81'	F 1'		MC 30'
B 38'	E 1'		
A	C* 45'		
MC 0'	MC 47'		

WELL # 38 BOTTINEAU CO.	WELL # 207 WELLS CO.	WELL # 286 BOTTINEAU CO.	WELL # 793 DUNN CO.
F .5'	D 14.2'	F 5.6'	D 16.2'
E .6'	C 30.4'	E .4'	C 23.3'
F 3.2'	B 9.1'	C 35.8'	B 58.5'
E .6'	A	B* 5.2'	A
D 6.4'			
C 24.2'			
B 64.8'			
A			

WELL # 1231 WILLIAMS CO.	WELL # 1403 WILLIAMS CO.	WELL # 5277 BOTTINEAU CO.	WELL # 7877 WILLIAMS CO.
E 1.7'	D 9.6'	B 4.3'	C* 24.8'
D 9.6'	C* .8'	A	MC 111'
C 21'	MC 114'		
B* 19'			
MC 75'			

Figure 47: Lithofacies Occurrence in Cored Wells of the Dawson Bay Formation in North Dakota.

the basis of rock types, characteristic fauna and flora, depositional structures, and allochems (Table 2). Due to extensive secondary dolomitization within all carbonate lithofacies of the Dawson Bay Formation, many allochems and other depositional features may have been destroyed or obscured. Lithofacies contacts are normally transitional. The succession of lithofacies occurrence is nearly uniform throughout the study area, although instances of lithofacies interfingering do occur. The capping lithofacies in North Dakota vary locally.

The only distinctly unconformable contact observed between lithofacies in this study occurs between lithofacies A and lithofacies B. The Dawson Bay/Souris River contact at the top of the Dawson Bay Formation is disconformable only in core from Cavalier County.

Lithofacies A

(Second Red Bed Member)

Lithofacies A comprises the basal, argillaceous member of the Dawson Bay Formation in the Williston Basin of North Dakota (Table 2). The Second Red Bed was excluded from the present study to narrow the scope of this regional investigation. Holter (1969) reported that the highly dolomitic Second Red Bed shales are typically red, change upward to green or grey shales in the lower section, and are capped by light brown, very calcareous beds at the top. According to Holter the Second Red Bed shales are commonly slickensided and cut by vertical halite stringers. Dunn (1982) adds that a veneer of green-red carbonates generally caps the Second Red Bed, and the contact between Pound's

(1985) lithofacies A and lithofacies B is disconformable (Figure 48).

Lithofacies B

Lithofacies B is characterized as dolomitized brachiopod-echinoderm wackestone to mudstone with occasional subhorizontal grainstone layers (Figures 13, 15 and 44)(Table 2), and ranges in thickness from 9-64 feet in the available core (Figure 47). Mudstone dominates in Bottineau and Cavalier Counties, particularly in the lower section. Distinct subhorizontal packstone layers are present in Bottineau, Wells, and Dunn Counties.

Micrite is abundant (60-90%) and associated with bioclasts in Cavalier, Wells and Dunn Counties. Quartz grains which are present in amounts less than 1% in Cavalier, Wells, and Bottineau Counties, are entirely subrounded in Wells County, subrounded to subangular in Bottineau County, and rounded to subangular in Cavalier County.

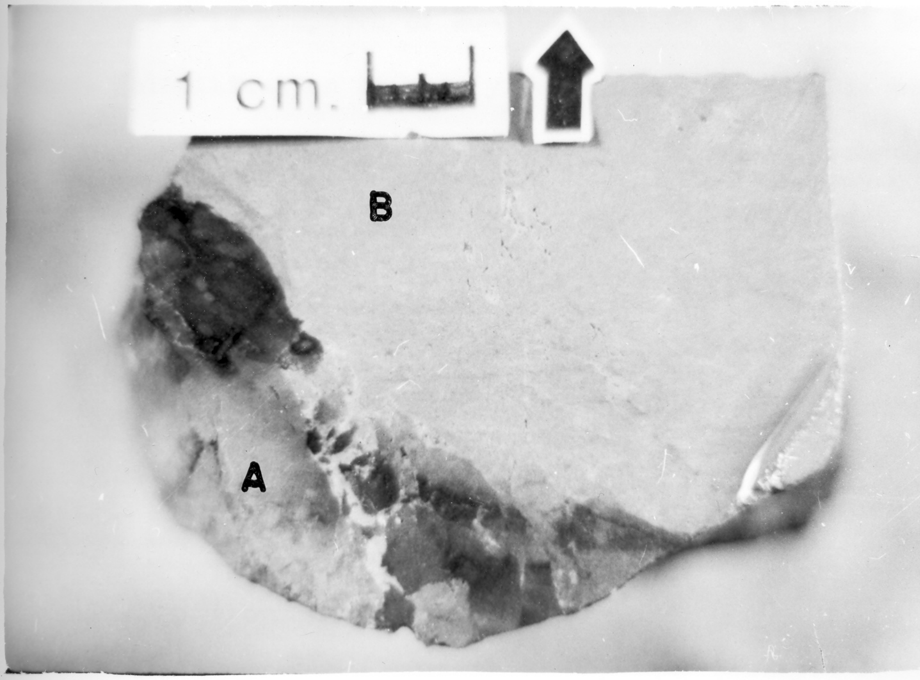
Brachiopods (2-100%) and echinoderms (25-100%) dominate the lithofacies B fauna. The fossils present and their percent occurrence are: gastropods (less than 30%), corals (less than 1%), ostracods (1-10%), bryozoans (1%), trilobites (less than 1%), algae (10%), and calcispheres (5-10%).

Lithofacies C

Lithofacies C consists of three interbedded biofacies:

Figure 48

Core photograph of submarine hardground contact between the basal Dawson Bay lithofacies A (Second Red Bed member) (A) and lithofacies B (B). A red and bluish-black clay is found along the contact. (lithofacies A/B, NDGS well #38, 6279')


1 cm.
B
A

(1) interbedded stromatoporoid boundstone and fossiliferous wackestones/packstones in southern Cavalier County (Figures 25 and 27); (2) interbedded subspherical and cylindrical stromatoporoid wackestones/packstones throughout North Dakota (Figures 23 and 24); (3) and fossiliferous mudstones to wackestones throughout the study area (Figures 7 and 26)(Table 2).

Lithofacies C is composed of 20-100% calcite in all but Bottineau County where dolomitization is nearly pervasive. Micrite is commonly associated with calcite bioclasts. Rare (less than 1%), subrounded, quartz silt is found along subhorizontal layers of oxidized fossiliferous wackestones/packstones in southwestern Cavalier County. Minor (1%) bitumens, present in southwestern Bottineau, Dunn, and Williams Counties are associated with pressure-solution features or disseminated in the matrix.

Allochems include intraclasts, peloids, and fossils. Minor (less than 1%) occurrences of interclasts are found in Wells County, and abundant (10%) occurences are present in Williams County. Peloids are occasionally abundant (less than 40%) constituents of lithofacies C.

Calcareous, cylindrical (less than 80%), subspherical (60-90%), and tabular (40-100%) stromatoporoids occur in lithofacies C. Additional lithofacies C fauna include: corals (less than 40%), brachiopods (less than 80%), blue-green algae (less than 5%), bryozoans (20-90%), echinoderms (40-100%), trilobites (less than 15%), gastropods (less than 20%), ostracods (1-40%), calcispheres (less than 10%), and cephalopods (less than 15%).

Lithofacies D

Lithofacies D consists of gastropod-ostracod-brachiopod-echinoderm mudstones and wackestones with very localized peloidal and intraclastic packstones (Figures 19, 31 and 36)(Table 2). The occurrence of mudstones and wackestones is variable with a general decrease in the percentage of mudstone moving westward across the study area toward Williams County. In southwestern Cavalier County, western Wells County, and northern Dunn County, lithofacies D caps the Dawson Bay Formation (Figure 47). This lithofacies is entirely absent along the eastern margin of the Dawson Bay depositional area in Cavalier County and locally in Bottineau County. A thin (1 foot) unit of lithofacies D is found near the top of lithofacies F in southeastern Cavalier County. Dolomitization predominates in Cavalier and Bottineau Counties. Residual hydrocarbons (0-2%) locally rim lithofacies D pores in Williams County. Minor (0-3%) amounts of siliciclastic clays are present within lithofacies D throughout the study area.

Allochems observed include peloids, intraclasts, and fossils. Peloids are locally minor (less than 10%) constituents of lithofacies D throughout North Dakota and in Wells and Bottineau Counties peloids locally form packstones. Intraclasts are common (20-70%) in Dunn County and are minor (less than 20%) constituents in Wells and Cavalier Counties (Figure 36).

The most abundant faunal constituents of lithofacies D are gastropods (60-85%), ostracods (40-85%), articulate and disarticulate brachiopods (60-100%), and echinoderms (5-80%). Individual abundances for all lithofacies D fauna vary locally. Calcispheres (less than

1%)(Figure 11), corals (less than 50%), trilobites (less than 15%), algae (less than 30%), and Amphipora (cylindrical stromatoporoids) (less than 1%) comprise the less abundant fauna and flora.

Ripple laminations and possible dessication fractures with associated iron oxide are occasionally present in southwestern Cavalier County. Fenestral fabric is common in northern Dunn County and immediately underlies the anomalus cryptalgal boundstone lithofacies F occurrence. Rare burrow-mottling is present in southwestern Bottineau and in northern Dunn County.

Lithofacies E

Lithofacies E can be characterized as a dolomitized gastropod and ostracod mudstone in the study area (Figures 5 and 38)(Table 2), and ranges from 0.4-2 feet in thickness (Figure 47). Very locally, intraclasts of possible algal composition compose wackstones and packstones. Algal bearing intraclasts in Williams County contain the only diagenetically unaltered algae (?) observed in the study area. Lithofacies E interfingers with lithofacies F in southeastern Cavalier County and in southwestern Bottineau County (Figure 47), and is locally missing in Cavalier County.

Statewide, the depositional structures of lithofacies E include fenestral fabrics, thinly laminated dolomicrites, borings, ripple laminations, and rare dessication cracks. Burrow-mottling is present only in Williams County where it is common to abundant.

lithofacies E allochems include peloids, intraclasts, and fossils.

Peloids vary from (1-10%) in north-central Bottineau County and in southeastern Williams County. Intraclasts occur (less than 3%) in lithofacies E in the uppermost interfingering of lithofacies E and F in southeastern Cavalier County. Gastropod-ostracod intraclasts are abundant near the base of the lithofacies E section in southwestern Bottineau County. Subrounded to subangular mudstone intraclasts are locally present near the center of lithofacies E in Williams County.

Gastropods (40-60%) and ostracods (40-60%) dominate the fossil fauna throughout the study area (Figure 5). In east-central Williams County blue-green algae are abundant (60-100%) and occur interlaminated with mudstones.

Lithofacies F

Lithofacies F consists primarily of dolomitized cryptalgal boundstone which is locally replaced by anhydrite (Figures 16, 17, 18, 20, 37, 42 and 43)(Table 2), and ranges in thickness from 0.5-87.5 feet in the studied core (Figure 47). Minor intraclastic wackestone is present near the base of the lithofacies in southwestern Bottineau County and north-central Cavalier County. Interfingering of laterally adjacent lithofacies is common in southeastern Cavalier County and in southwestern Bottineau County (Figure 47).

Cryptalgal boundstones predominate in the study area (Figures 20 and 43), and mudstone is a minor constituent except in west-central Cavalier County where it is very abundant (less than 60%) in the lower lithofacies F section (Figure 37). Bedded streaky-laminated massive anhydrite and bedded massive anhydrite are extensively (60-100%) replacive of cryptalgal boundstone in west-central Cavalier County and in north-central Bottineau County (Figures 16, 17, and 18).

Siliciclastic clays include a green-colored clay which is present in minor (less than 3%) amounts along oxidized surfaces in southeastern Cavalier County. Insolubles are abundant in Cavalier County and occur as minor constituents throughout the study area. Siliciclastic clays occur in association with cryptalgal laminations or disseminated in the dolomicrite matrix.

On rare occasions, calcite cement rims or fills pores in lithofacies F. In southeastern Cavalier County near the base of lithofacies F, moldic pores are lined with calcite crystals.

Trace (less than 1%) quantities of subrounded to subangular quartz silt associated with cryptalgal laminations are present throughout Cavalier County (Figure 22).

Bitumens are locally present in minor amounts, and occur as very-thin horizontal laminae or disseminated throughout the matrix.

Color-mottling is distinctive along the eastern third of the study area. lithofacies F is usually light grey (7.5YR8/2) to pale orange (5YR8/4) due to iron-oxide mottling, and occasionally mottled purplish-gray (5RP3/1) associated with diagenetic "pseudoburrows" (Figures 42 and 43).

Crenulated cryptalgal laminations are very common, and subhorizontal fenestral fabrics are commonly associated with cryptalgal laminations, as are ripple laminae and dessication cracks (Figure 39). In western Cavalier County, a single subvertical scour-truncated burrow was observed near the top of the lithofacies F section (Figure 37).

Allochems include peloids, intraclasts, and fossils. Peloids compose less than 15% of the core in Cavalier and Bottineau Counties. Intraclasts of cryptalgal composition make up less than 5% locally in Cavalier and Bottineau Counties. In west-central Cavalier County, micritic intraclasts with ripple laminations and dessication cracks range from 20-80% in the upper section of lithofacies F.

Blue-green algae (?) (90-100%) dominate the lithofacies F flora (Figure 20). Thin anomalous layers of subhorizontal fragmental brachiopods (3-5%), echinoderms (1%), ostracods (less than 1%), calcispheres (less than 1%), blue-green algae (less than 80%), cylindrical stromatoporoids (less than 1%), and unidentified fossil fragments (less than 5%) occur locally in eastern Cavalier County. Occasionally, lithofacies F is poorly fossiliferous near its base and its top.

LITHOFACIES INTERPRETATIONS

Introduction

During the late Middle Devonian, the Williston Basin is interpreted to have been located at approximately 20 degrees south latitude on the basis of paleoclimate and tectonic indicators (Heckel and Witzke, 1979). This would place the Dawson Bay Sea in a warm tropical climate as is suggested by the thick carbonate successions (Heckel and Witzke, 1979).

Carbonates are primarily of organic, but also of physico-chemical origin (Wilson, 1975). Increasing temperatures promote organic growth and physico-chemical precipitation of carbonates by hastening evaporation in dry climates and lowering carbon dioxide solubility under marine conditions. Benthonic carbonate production is greatest today in the lower latitudes between 30 degrees North and 30 degrees South (Wilson, 1975) In these latitudes, shallow warm water is present on shallow shelves today and in epeiric seas in the geologic past (Heckel and Witzke, 1979).

Anhydrite replacement of cryptalgal mats provides evidence of proximity to a marine shoreline in an arid, warm, high evaporation, and high salinity environment according to Schreiber (1981). Lithofacies F of the Dawson Bay Formation in North Dakota provides evidence of similar climatic conditions.

Prolific, biogenic production of carbonate sediment also requires clear water conditions. Terrigenous clastics are transported to the sea under humid conditions and the resultant turbidity minimizes carbonate sedimentation near-shore. Thick carbonate intervals can form further off-shore in humid climates, but the evaporites which typify arid environments are absent (Heckel and Witzke, 1979). Dawson Bay Formation carbonate core contain trace amounts of quartz silt and very-fine sand which is interpreted to be of terrigenous eolian origin due to competency requirements suggested by Pettijohn and others (1973). Heckel and Witzke (1979) suggest that the source of eolian quartz silt in Devonian carbonates is likely the emergent craton, although another possibility is derivation from older formations.

Consequently, the climate during Dawson Bay deposition is considered to have been hot and arid. The regional depositional environment was that of a shallow marine epeiric sea. Lithologic evidence from Dawson Bay Formation core, in comparison with modern environments of deposition, suggests the following, generalized shallowing-upward, succession of depositional environments: shallow epeiric sea (lithofacies B), stromatoporoid biostrome/bioherm (lithofacies C), very shallow epeiric sea (lithofacies D), restricted shallow epeiric sea (lithofacies E) and shallow epeiric sea shoreline (lithofacies F)(Figure 49).

Lithofacies A

(Second Red Bed Member)

Lithofacies A was not included in this study. Previous workers have interpreted the predominantly dolomitic shales of the Second Red

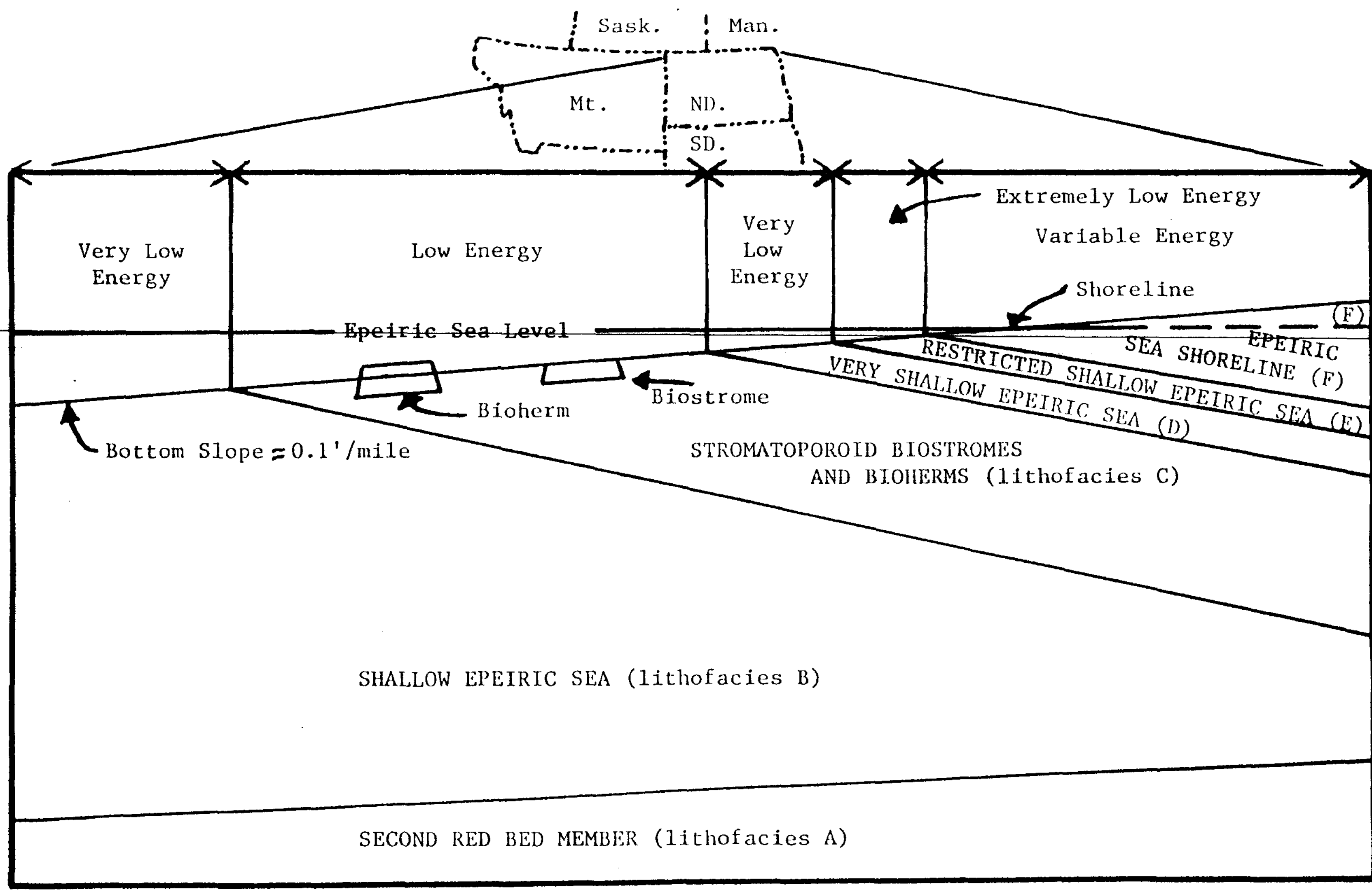


Figure 49: Generalized Diagramatic Cross-section of the Dawson Bay Formation Lithofacies and Depositional Environments in North Dakota (no scale).

Bed to have been deposited during the initial transgression of the Dawson Bay Sea (Figure 49)(Dunn, 1982). In this study, the contact between the Second Red Bed (lithofacies A) and lithofacies B was observed in some North Dakota core and interpreted to be a submarine hardground (Figure 48). Bathurst (1981) stated that corroded, or abrasion eroded, upper surfaces of marine carbonates are hardgrounds of submarine origin.

Lithofacies B

Burrow-mottled wackestones and mudstones characterize lithofacies B rocks and are interpreted to have originated as shallow marine sediments below wave base (Figures 48 and 49). According to Wilson (1975), homogenization of sediments by burrowing organisms is characteristic of shelf-facies sediments. However, thinly laminated, unfossiliferous mudstone is present at the base of lithofacies B in eastern Bottineau County. The presence of laminations suggests the absence of burrowing organisms. Elevated salinity levels could be expected in the basal carbonates. The hot and dry climate would have concentrated halite in the very shallow marine sea until sufficient depth was reached to dilute the evaporative concentration effect. The elevated salinity would have inhibited plant and animal life.

Lithofacies B biota consists predominantly of brachiopods and echinoderms with trace to minor amounts of corals, bryozoans, trilobites, gastropods, ostracods, red algae (?), and calcispheres. According to Laporte (1967), diverse fauna in carbonate skeletal mudstones and wackestones is characteristic of the subtidal marine environment. Wilson (1975) reviewed the literature describing Middle and Late Devonian lithofacies and identified thirteen general facies types. He found that shelf and platform facies with open circulation contain a varied faunal assemblage dominated by crinoids, brachiopods, and scattered rugose corals and bryozoans. Heckel and Witzke (1979) state that modern shelf and platform facies are similar to the epeiric seas of the Devonian. Heckel (1972) charted the modern distribution of major fossilizable nonvertebrate groups relative to salinity. All lithofacies B fauna, with the exception of the excluded extinct trilobites, fall within Heckel's "normal marine" environment. Trilobites lived in a wide range of habitats including normal marine habitats (Clarkson, 1979).

Mudstones, such as characterize lithofacies B, predominate below wave base because sufficient energy does not exist to remove the accumulating muds. However, the presence of articulated and fragmental bioclastic wackestone within lithofacies B suggests that deposition occurred near wave base (Wilson, 1975). Other structures that might delineate the depositional environment of lithofacies B have largely been obliterated by dolomitization.

Occasionally, thin (1-3 cm) grainstone layers are present in the fossiliferous wackestones and mudstones. These layers of skeletal material are interpreted to be lag deposits resulting from near-cessation of lime mud deposition for a long period of time as is suggested for the Devonian Tully Limestone of New York (Heckel, 1972). Enos (1983), James (1979), and Wilson (1975) all suggest that the near-cessation of lime mud deposition postulated for lag deposits can result from slower mud sedimentation with continued (normal) bioclast deposition due to simple dilution during renewed transgression. The influx of water is thought to permit the continued suspension of fine carbonate sediments, whereas the larger bioclasts accumulate at their normal rates. The periodic presence of lag deposits suggests occasional renewed transgression. Consequently, the Dawson Bay Sea is interpreted to have not reached its maximum transgression before the end of lithofacies B deposition.

Lithofacies C

Lithofacies C is dominated by stromatoporoid bioherms and biostromes which suggest shallower marine conditions relative to lithofacies B (Figure 49)(Heckel, 1972). James (1983) reports that, in modern and ancient environments, tabular (lamellar) and cylindrical (branching) growth forms occur during the colonization stage of early reef development. Cylindrical and subspherical (domal or massive) forms occur in the subsequent diversification stage. Tabular growth forms are associated with moderate wave energy environments related to moderate sedimentation rates according to James (1983).

Bioherms are present in southern Cavalier County, whereas biostromes are present in all other areas of the state. Bioherms are defined by having a greater height to length ratio than biostromes (James, 1983). He adds that bioherms are identifiable as lithologically distinct masses within adjacent lithologies and protrude above surrounding sediments. Lithofacies C bioherms consist of alternating, tabular, stromatoporoid boundstone with subspherical and/or, cylindrical, stromatoporoid wackestone or packstone. The succession averages 10 cm in thickness, though 10-20 cm tabular stromatoporoid layers are present which suggest that these buildups are in fact bioherms with vertically significant dimensions.

Corals, brachiopods, echinoderms, bryozoans, trilobites, blue-green algae (?), gastropods, ostracods, calcispheres, and cephalopods are commonly associated with the tabular stromatoporoid bioherms of lithofacies C. According to Wilson (1975) normal-marine bank fauna associated with tabular stromatoporoids are varied, with brachiopods, echinoderms, and corals commonly present.

Biostromes occur as successions of alternating subspherical stromatoporoid mudstones and cylindrical stromatoporoid wackestones and packstones. The dominating stromatoporoid genera in lithofacies C biostromes is that of cylindrical Stachoydes. Amphipora, cylindrical stromatoporoids, are occasionally present. Fragmental tabular stromatoporoids are minor constituents of these wackestones and packstones. Corals, brachiopods, echinoderms, bryozoans, gastropods, ostracods, trilobites, calcispheres, blue-green algae (?), and cephalopods occur in the studied biostromes and suggest normal marine conditions (Heckel, 1972). According to Irwin (1965) the presence of algae indicates that water depths were less than 15 m (50 ft.) due to the light requirements of algae.

Tabular stromatoporoids probably did not play a significant role in North Dakota because of their deeper depth of occurrence. Embrey and Klovan (1971), from their study of exposed stromatoporoid banks on Arctic Island, Northwest Territories, Canada, estimate a 10-20 m (30-60 ft.) marine depth for tabular stromatoporoid growth, a depth of a few meters for the subspherical stromatoporoids, and less than 10 m (30 ft.) for the larger cylindrical stromatoporoid, Stachoydes. Wilson (1975) states that the smaller cylindrical stromatoporoid, Amphipora forms biostromes in the bank interior (back-reef) facies, suggesting very shallow marine conditions.

A third stromatoporoid occurrence within lithofacies C is that of fossiliferous stromatoporoid mudstones and wackestones. All previously mentioned lithofacies C fauna are present in varied quantity in this third type of stromatoporoid occurrence. The mudstones and wackestones are found below, within, and above the biostromes and bioherms suggesting deposition in low energy environments between the build-ups.

The alternation of tabular and cylindrical stromatoporoid growth in Cavalier County suggests fluctuating water depths. Local oxidation of the uppermost portion of each succession also suggests subaerial exposure prior to each increase in water depth. Local or regional changes in epeiric sea level probably resulted in the repetitive successions observed. Fluctuations in the sea level may have been relatively rapid and numerous as suggested by the 10 cm average thickness of each stromatoporoid succession and their quantity. However, the fluctuations of water depth may have been greater than 10 cm because Type I "Sutured-Seam Styolites" indicate the loss of carbonate section (Wanless, 1979).

It is possible that the repetitive successions resulted from vertical reef growth, followed by basin subsidence, and renewed stromatoporoid growth toward the surface. Alternatively, Maiklem (1971) has suggested an evaporative regression mechanism for hot arid environments which could have produced the shallowing upward successions present in the southern Cavalier County bioherms. Maiklem suggests that the Peace River-Athabaska Arch was either periodically breached by eustatic fluctuations in sea level or very-high salinity conditions in the evaporative Dawson Bay Sea, resulted in the flow of lower-salinity water from the deeper Devonian Sea through the Peace River-Athabaska Arch into the Elk Point Basin. It is similarly possible that less-saline waters offshore in the Dawson Bay Sea periodically flowed through local stromatoporoid buildups into shallow, very saline, interbioherm or shoreward environments. Maiklems's (1971) mechanism of periodic freshening could have provided the increased water depth required to explain localized repetition of, shallowing-upward, stromatoporoid successions.

The biostromes in the study area are interpreted to have formed at shallower water depths than the more localized bioherms. A shallow epeiric sea environment within wave base is suggested on the basis of the higher energy requirements of cylindrical and subspherical stromatoporoids (James, 1983). The fluctuations in sea level also probably disrupted biostrome growth and resulted in the alternation of the shallower and deeper water fauna observed. According to Shaw (1964) the slopes of epeiric seas were very low (on the order of 0.1 ft./mile) and topographic irregularities such as bioherms, although of small size, would have a disproportionately large barrier effect. This barrier effect could be expected to affect interbioherm and interbiostrome sedimentation as well as shoreward lithofacies D. Fossiliferous stromatoporoid mudstones and wackestones are interpreted to have been deposited primarily in interbiostrome areas.

Lithofacies D

Mudstones predominate in lithofacies D throughout the study area. Wackestones are common, but occur most frequently in eastern Williams County. The preponderance of mudstone suggests shallow, calm waters (Figure 49). According to Dunham (1962), calm water is characterized by carbonate mud sedimentation.

The bioherms of lithofacies C may have acted as barriers, minimizing turbulance and preventing higher energy sands and ooids from forming shoreward of the barriers. According to Shaw (1964), even very low barriers, such as the seaward bioherms of lithofacies C, would have disproportionately large damping effects in relatively shallow sloped and smooth bottomed epeiric seas resulting in mud deposition.

Very-shallow marine environments are typified by somewhat random facies transitions due to minor changes in sea level or depositional topography (Laporte, 1967). Consequently, the presence of thin, interfingering marine, shoreline cryptalgal boundstone (lithofacies F) with lithofacies D in southeastern Cavalier County, probably indicates fluctuating water depths and lateral changes in depositional conditions.

The occasional occurrence of burrow-mottling, intraclasts, ripple laminations, fenestral fabrics, dessication fractures, and color-mottling lend support to an interpretation of changing depositional conditions. Burrow-mottles are associated with very-shallow marine environments (Enos, 1983). Intraclasts and ripple laminations indicate high energy environments (Wilson, 1975). Fenestral textures can occur in either submarine pelletal and oolitic grainstones (5-6 meter depths) or on tidal flats (Shinn, 1983). Periodically flooded mud flats may be the epeiric sea equivalent of modern tidal flats according to Shinn. The vertical orientation of fenestral fabrics (such as occur in northern Dunn County) is probably the result of upward degasing from the decomposition of organic materials in muds (Shinn, 1983). Dessication fractures and color-mottling are evidence of subaerial exposure (Shinn and others, 1969).

The local absence of lithofacies D in northeastern Cavalier County and in north-central Bottineau County suggests regressive, shallowing-upward, marine conditions during accumulation. During a marine regression, shallowing conditions vary locally depending upon differences in sea floor topography, with a relatively low slope resulting in rapidly changing depositional environments. Consequently, the biota or sediments, which characterize a particular lithofacies, may not be present, or may be too thin in the rock record to be recognizable.

Wackestones are abundant in lithofacies D in eastern Williams County and suggest higher energy conditions in that area. This occurrence of wackestones provides additional evidence that the stromatoporoid buildups of lithofacies C in eastern Williams County were indeed biostromes rather than energy damping protrusive bioherms.

Peloidal packstones are abundant in southwestern Bottineau County. If pellets were originally present in the study area, they were obscured due to micritization. Modern and ancient very-shallow (depth restricted) marine environments such as lagoons, shelves, and bays, are characterized by peloidal intraclastic mudstone and wackestones according to Enos (1983). Fecal pellets are associated with increased salinity (Heckel, 1972) and in epeiric seas such conditions may develop many miles from the shoreline (Shaw, 1964). Heckel (1972) adds that in the harsh, nearshore, shallow marine environment, both salinities, and temperatures are higher. Consequently, biota are less diverse, but fecal depositing fauna are common (Heckel, 1972).

The most abundant fauna in lithofacies D are gastropods, ostracods, brachiopods, and echinoderms. Trilobites, corals, blue-green algae (?), Amphipora (cylindrical stromatoporoids), and calcispheres are minor to rare occurrences. Ostracods, gastropods, and brachiopods are the most characteristic skeletal components of modern and ancient very-shallow marine environments (Enos, 1983). Heckel (1972) indicates that a typical hypersaline faunal assemblage includes some types of smaller brachiopods, blue-green algae, ostracods, and gastropods. He adds that the presence of corals and echinoderms indicate clear water environments. According to Heckel (1972) coral and echinoderm diversity drops abruptly away from the normal marine environment suggesting that these biota in the Dawson Bay may be washed in rather then indigenous.

Trilobites are known to have lived in very shallow, mud-bottomed and hypersaline environments (Clarkson, 1979). However, trilobites lived in habitats ranging from normal marine to brackish environments and were infaunal to epiplanktonic. Consequently, they may be washed in and their environmental significance may be limited (Clarkson, 1979) (Bergstrom, 1972).

It should be noted that Amphipora, the 3 mm cylindrical stromatoporoid, was generally common in very-shallow marine environments during the Devonian (Read, 1973). Their rarity in lithofacies D may reflect fluctuating salinities or their destruction during diagenetic dolomitization.

The evidence suggests that lithofacies D was deposited in a shallow, somewhat saline, and occasionally protected marine environment. Shallowness could be attributed to proximity to the shoreline, however, this is not a necessary requirement in an epeiric sea with its very-shallow bottom profile (Irwin, 1965).

Minor to abundant amounts of bitumens and minor insolubles are present throughout lithofacies D. Environmental conditions during deposition in the late Middle Devonian Dawson Bay Sea may have been similar to the shallow marine conditions in parts of the modern Persian Gulf (Heckel, 1972). Heckel reports that Persian Gulf muds contain fine terrigenous clays and the organic content is high in the finer sediments since organisms can settle out in the quiet envirionment without complete removal by the less-diverse burrowing fauna.

Lithofacies D is interpreted to have been deposited in a very-restricted shallow epeiric sea (Figure 49). The Dawson Bay Sea was receding, but possibly with occasional minor readvances indicated by the interfingering of lithofacies D with adjacent lithofacies. The depositional environment of lithofacies D and subsequent lithofacies of shallower origin were probably greatly influenced by the energy dampening effects of emergent shoals and islands in Bottineau and adjacent counties (Plate 1).

Lithofacies E

Mudstone characterizes lithofacies E in the study area. Restricted environments in which carbonate muds have the opportunity to settle out produce mudstones (Dunham, 1962)(Figure 49).

Intraclastic wackestones and packstones, present in southwestern Bottineau County, may provide evidence of subaerial exposure according to Walker and Laporte (1970). Walker and Laporte indicate that intraclast formation is the result of carbonate sedimentation with subsequent exposure to air, induration, dessication cracking, and weathering. They then call upon flooding, from whatever cause, to redistribute the intraclasts into the subaerial-shallow marine environments. Alternatively, Folk (1962) considers intraclasts to more commonly result from erosion of weakly consolidated carbonate sediments on the sea floor. Shinn (1983) adds that intraclasts can also form in subaqueous environments such as modern tidal channels proximal to tidal flats.

Peloids are common constituents of lithofacies E, but are obscured by diagenetic processes in Cavalier and northern Bottineau Counties. In southeastern Williams County intraclasts are composed of peloids and blue-green algae (?). It is important to note that these fragmental peloidal and algal (?) accumulations are not in-place as indicated by varying degrees of rounding and size. The presence of peloids and intraclasts suggests lateral proximity to shallow-marine-shoreline conditions (Shinn, 1983) and blue-green algae are abundant in modern shallow seas according to Walker and Laporte (1970).

Crenulated and thinly laminated micrite in association with high salinity, tolerant ostracods and gastropods typifies lithofacies E. These features suggest very-restricted subtidal conditions, too severe for most laminae disrupting, burrowing organisms (Walker and Laporte, 1970). According to Shinn (1983), all varieties of horizontal laminations are restricted to supratidal and upper intertidal conditions in modern tidal flats.

Slightly lower salinities are suggested in southeastern Williams County by the rare occurrence of burrow-mottling in lithofacies E. Slightly greater water depth, or the frequent influct of lower salinity water from proximal deeper water, could explain the presence of burrowing organisms. Evidence for the proximity of deeper epeiric sea conditions is the capping of the Dawson Bay Formation in northeastern Williams County by lithofacies C biostromes (Figure 49). The fact that lithofacies C caps the Dawson Bay Formation in a marine regressive environment suggests that lithofacies E was depositing penecontemporaneously shoreward of lithofacies C.

Lithofacies E is therefore interpreted to have been deposited in extremely shallow, very restricted, epeiric sea conditions (Figure 49). However, slightly deeper depositional conditions were possible in southeastern Williams County, where a pre-Dawson Bay erosional low existed. A thicker carbonate section is present in that area according to the Dawson Bay, carbonate unit, isopach map (Plate 1).

Lithofacies F

Cryptalgal boundstones typify lithofacies F and are present in all

Cavalier and Bottineau County core. Stratigraphic alternation with adjacent lithofacies, suggests occasional marine transgressions (Figure 47).

Ancient, and even modern tidal-flat laminations, can be difficult to interpret because some layers are purely of sedimentary origin and others are algae induced (Shinn, 1983). Modern algal stromatolites are the result of the trapping and binding of fine sediment grains by successive generations of mucilaginous blue-green algal mats in intertidal environments (Laporte, 1967). Shinn (1983) extends the environment of algal-laminated sediment from the upper intertidal zone to the overlying supratidal zone.

Conclusive evidence of an algal origin of the crenulated, generally oxidized laminations characteristic of lithofacies F is missing. Certain identification would require antigravity structures such as sediments adhearing to vertical sides of originally adhesive algal surfaces or algal tubules (preserved original algal fillaments) (Shinn ,1983). Consequently, the term "cryptalgal" as proposed by Aitken (1967) has been used in this report to denote the uncertain origin of these diagenetically altered, non-calcareous blue-green and green algal laminations.

Abundant oxidized argillaceous material and trace amounts of quartz silt to very-fine-grained sand occasionally comprise thin laminations within finely-crystalline dolomicrite. An experiment conducted by Shinn (1983), along the arid Persian Gulf coast, may explain these occurrences. Vaseline-coated glass microscope slides, emulating the adhesive surfaces of living algal stromatolites, were exposed to the wind with the adhered eolian sediments studied petrographically. Shinn reports that the eolian dust typically contained approximately 60% detrital dolomite and unspecified percentages of quartz silt and clay. The color of the collected sediments was rusty-tan. Shinn (1983) concluded that algal laminations in arid areas can result from algal growth alternating with either marine flooding with deposition, or from eolian deposition.

Uniformly microcrystalline dolomicrites associated with the cryptalgal boundstones may form as a result of secondary replacement of calcium carbonates by dolomite (McKenzie and others, 1980). A secondary replacement origin is supported by the occasional preservation of fine textural detail.

Nodular, streaky laminated, and bedded mosaic anhydrite commonly replace and displace cryptalgal laminations near the top of lithofacies F. Evaporative dolomitization in modern supratidal flats, such as the Persian Gulf, commonly involves gypsum and anhydrite precipitation (Schreiber, 1981)(Schreiber and others, 1982) and suggests an explanation for the occurrence of the replacive anhydrite observed. Shinn (1983) cautions that it is impossible in ancient anhydrite and gypsum deposits to determine how much of the anhydrite has formed from the replacement of gypsum, and how much was primary.

Crenulated cryptalgal laminae, dessication cracks, soft sediment deformation, ripple laminae, scour surfaces, burrows, rare fragmental fossil laminae, peloids, and intraclasts are locally present in lithofacies F. All of these features are associated with the lower shallow-marine-shoreline environment (Shinn, 1983).

The horizontally-oriented fenestral fabrics associated with cryptalgal laminations in the study area are considered reliable supratidal indicators by Fischer (1964) in his descriptions of "loferites". Shinn (1983) suggests that fenestral fabrics can occur in either subaqueous or supratidal environments. Subhorizontal fenestral vugs may result from shrinkage and expansion, or wrinkles in algal mats according to Shinn. He adds that subvertical fenestral fabric, such as occurs in Williams County, is the result of organic decomposition with subsequent degasing, or air escape during flooding.

Lithofacies F, the uppermost lithofacies, is interpreted to have been deposited along the shoreline of the Dawson Bay (epeiric) Sea within the zone of marine water influence (Figure 49). The maximum Dawson Bay Sea regession is interpreted to have reached a basinward position between Cavalier and Bottineau Counties; between Cavalier County and western Foster County where lithofacies D caps the Dawson Bay; and between western Bottineau and eastern Williams Counties. Color-mottling provides evidence for this interpretation. Lithofacies F is present in southwestern and north-central Bottineau County on structural highs (Plate 1), suggesting that shoals or islands were emergent from the Dawson Bay Sea in the Bottineau area at this stage of the recession. Lithofacies F is not present in Williams County indicating an area of continued submergence. The stromatolitic shoreline of the modern Persian Gulf (Shinn, 1983) offers a close analogy to the epeiric sea shoreline along which Devonian algal mats grew.

DIAGENETIC INTERPRETATIONS

Introduction

Diagenesis is a term that describes physical and chemical changes in sediments and rocks after deposition until the onset of metamorphism (Wilson, 1975). According to Wilson, carbonate rocks are very sensitive to diagenesis. The most common carbonate diagenetic processes are compaction, cementation, pressure-solution, and neomorphism (Shinn and Robbin, 1983). Earliest diagenesis begins with compaction immediately after sediment deposition on the sea floor. Considering the estimated five million year period of Dawson Bay Sea deposition (Bluemle and others, 1980), diagenesis had been underway in the deeper sediments for millions of years before the shallowest sediments were even deposited.

Choquette and Pray (1970) proposed three terms which have proved to be useful in the description of diagenesis. Their terms, "eogenetic", "mesogenetic", and "telogenetic" each denote the time of diagenesis, the post-depositional burial environment or zone of diagenesis, and the associated diagenetic processes. Eogenetic refers to early and shallow burial processes, including both subaerial and subaqueous shallow-subsurface environments. Mesogenetic involves those processes taking place after deeper burial below the major influences of processes operating at the surface. The water table is a practical upper limit of the mesogenetic diagenetic environment. Telogenetic includes late stage processes in the near-surface or subaerial environments associated with erosion of long-buried carbonates.

According to Folk (1974), low-magnesium sparry calcite cements occur in low Mg/Ca ratio environments. These include shallow-depth, vadose, meteoric cements of 5 micron euhedral rhombs; intermediate depth (below the water table), phreatic, meteoric cements of coarse crystal size; deep meteoric-derived, complex anhedral, sparry calcite crystals; and deep origin coarse, complex, sparry calcite cements which form in conate waters associated with dolomite crystallization or chloritic/montmorillonitic clay development.

Progressive pressure-solution features occur in carbonates that have been subjected to overburdon or tectonic stress (Wanless, 1979). Wanless recognizes three styles of pressure-solution responses that reflect primary sedimentary structures, compositions, textures, and fabrics. These are his Type I styolites and Type II and III microstyolites.

Neomorphism includes the processes of: (1) inversion (conversion of aragonite to calcite), (2) recrystallization (conversion of micrite to microspar, to pseudospar), and (3) strain-recrystallization (the alteration of strained calcite to unstrained calcite) (Folk,1965).

The following diagenetic features were recognized within Dawson Bay Formation core in North Dakota: color-mottling, anhydrite, dolomite, pressure-solution responses, calcite cement, neomorphic calcite, secondary porosity, halite, and hydrocarbons.

Color-Mottling

According to Coogan (1967), marine regression can be interpreted from evidence of subaerial exposure. Diagenetic color-mottling provides evidence of subaerial exposure and basinward movement of the Dawson Bay Sea shoreline. The lighter colors indicate leaching and the red colors reflect oxidation of iron minerals (Esteban and Klappa, 1983).

Local subaerial exposure, perhaps on islands or shoals in the Dawson Bay Sea, is suggested by localized color-mottling in Bottineau County core. More widespread subaerial exposure due to marine evaporative regression occurred along the edges of the Dawson Bay Sea. Highly oxidized core from Cavalier County suggests widespread subaerial exposure in that area of the state.

"Pseudoburrows" are distinctive forms of color-mottling that were only observed in Cavalier County core. They are similar in appearance to relict filled-burrows, but occasional cross-cutting structures provide evidence of their non-burrowed origin. They are interpreted to be the result of paleogroundwater flow along paths controlled by depositional structures such as cryptalgal laminations. Irregularly oriented "pseudoburrows" are associated with fenestral fabrics or bioclast ghosts, probably brachiopods. Groundwater flow through fenestral porosity or bioclasts appears to disrupt the direction of flow resulting in both vertical and horizontal components. Groundwater appears to have oxidized and leached iron minerals from the center of groundwater pathways and to have concentrated them along the outer perimeter of the pathways. Their presence provides evidence of paleogroundwater movement in the eogenetic environment proximal to the Dawson Bay Sea and suggests that lithologic textures influenced groundwater flow.

McKenzie and others (1980) measured the movement of groundwater beneath modern coastal sabkhas in the Persian Gulf. They found that subhorizontal groundwater flow occurs throughout the year in the regional direction of the sea. In addition, McKenzie and others (1980) found that downward directed vertical flow toward the water table occurs during winter or spring storm recharge. They explained that vertical groundwater movement upward toward the ground surface occurs during dry periods due to evaporative pumping (McKenzie and others, 1980).

Vadose waters contain oxygen which is transported into the subsurface by groundwater. Iron minerals such as hematite and pyrite are oxidized to various shades of red by exposure to oxygenated water. Groundwater could be expected to selectively, or more pervasively, oxidize iron minerals if the path of groundwater flow were controlled by sediment or rock textures.

Subhorizontal color-streaming of iron oxides to one side of relict structures also suggests the groundwater origin of "pseudoburrows". The direction of paleogroundwater flow could be determined only if cores were recovered in their original orientation.

Anhydrite

In isolated areas cryptalgal dolostones in lithofacies F are replaced by bedded nodular, streaky laminated, and bedded mosaic anhydrite. Lithofacies F anhydrites are interpreted to be of eogenetic origin and to have formed along the regressive shoreline of the Middle Devonian Dawson Bay Sea in hot arid climatic conditions.

Modern algal mats in hot arid intertidal zones commonly contain large numbers of displacive gypsum crystals (Schreiber, 1981). Schreiber reports that the mechanism for gypsum/anhydrite crystal growth is that of evaporative concentration of minerals from sea water. In marine regressive conditions, the supratidal lithofacies migrate shoreward, and within a few meters of the shore, displacive lenticular gypsum converts to anhydrite in the supratidal environment. These pseudomorphs of gypsum gradually grow into nodular masses (Schreiber, 1981). Progressive replacement of carbonates and displacement of non-calcareous materials associated with algal mats sequentially produce the bedded nodular, streaky laminated, and bedded mosaic anhydrite. Schreiber adds that algal mats and associated carbonates are commonly preserved within these sulfate layers.

Anhydrite also occurs in other Dawson Bay lithofacies underlain by Prairie evaporites (Figure 1). The modes of occurrence include disseminated, individual, bladed laths; nodules composed of compact, matted laths; and fractures filled by either matted, bladed laths or sparry anhydrite. All of these anhydrite occurrences are interpreted to be of late mesogenetic origin based on the location of the anhydrites within, or replacing deep-burial dolomites.

The Dawson Bay Formation in northern Williams County is capped by lithofacies C. This suggests that the regressive Dawson Bay Sea was not so restrictive as to have exceeded the salinity tolerances of the normal marine fauna living in the bioherms. This environmental interpretation is important when postulating the source of late mesogenetic fracture filling anhydrite and halite. The source of the mesogenetic Dawson Bay evaporite minerals is interpreted to have been the underlying Prairie Evaporite, because the relatively normal salinities at the end of Dawson Bay time suggest that the Dawson Bay Carbonates did not self-generate saline/sulfate brines. Thomas and Powell (1980) report that late fracture filling anhydrite and halite in Northwest Exploration's No. 1 Pederson (NDGS #7877) in Temple Field, Williams County, North Dakota, is the result of dissolution of underlying Prairie evaporites, migration upsection, and subsequent reprecipitation. They cited the increased concentrations of anhydrite and halite proximal to the Prairie Salt as evidence. This same observation was also made in this study.

Dolomite

The earliest dolomitization event within the Dawson Bay Formation is interpreted to have been very-early, eogenetic, microcrystalline dolomite replacement in association with cryptalgal replacive anhydrite along the receeding Dawson Bay Sea shoreline.

Dolomite replacement in hot arid climates occurs a few centimeters above normal high tide on modern supratidal flats (McKenzie and others, (1980). This nearly penecontemporaneous process involves bringing underlying seawater to the surface by storm flooding, capillary action, and/or evaporative pumping. Through evaporative concentration, gypsum and aragonite precipitation remove calcium. This increases the magnesium to calcium ratio and dolomitization occurs.

Davies (1979) suggests that primary, or very-early diagenetic dolomite often may be recognized by its fine crystal size and the preservation of fine textural detail. Preservation of textural detail is occasionally observed in the laminated mudstones associated with the cryptalgal laminations of lithofacies F. This evaporite associated dolomitization along the Dawson Bay Sea shoreline shifted basinward as the sea retreated.

The remaining dolomites of the Dawson Bay Formation are exceedingly variable in crystal size and distribution. Deep-burial mosaic type dolomite (Mattes and Mountjoy, 1980) is the most common occurrence of dolomite. Considering the approximately 3798 m (12,432 ft.) maximum burial depth of the Dawson Bay carbonate section in the Williston Basin, deep burial mosaic dolomitization could be expected. According to Mattes and Mountjoy, mosaic dolomite in the Miette Buildup in Alberta is characterized by very-fine to coarse rhombohedra which float within host micrite, or coalesce to form dense mosaics. They postulate an intermediate, deep-burial mesogenetic environment, for the mosaic type dolomite.

Dolomites associated with fractures and microstyolites commonly cross-cut mosaic type dolomite in the study area. It can be inferred that most fractures, and all microstyolites, are older than the mosaic type dolomite. Mattes and Mountjoy (1980) interpret pressure-solution associated dolomitization in the Miette Buildup to have occurred in the late mesogenetic environment, the same environment interpreted for the dolomites associated with fractures and pressure-solution features in the Dawson Bay carbonates.

Calcite Cement

Calcite cement is most common throughout lithofacies C, but is present in all lithofacies. Fibrous-radial and syntaxial overgrowth cements are occasionally present in lithofacies C. Folk (1974) suggests a submarine, or marine phreatic, eogenetic origin for these forms of calcite cement.

The Dawson Bay carbonates very commonly contain blocky-equant calcite cements. This is particularly true in the deeper portions of the Williston Basin. Mattes and Mountjoy (1980) recognized similar occurrences in the Miette buildup in Alberta and suggest a shallow eogenetic to deep mesogenetic environment of precipitation. The Dawson Bay blocky-equant-calcite cements are interpreted to have formed in the late mesogenetic because they commonly fill fractures which cut very late mesogenetic microstyolites.

Pressure-Solution Responses

Pressure-solution responses have been shown to be the result of stress-induced solution (Wanless, 1979). Wanless states that subhorizontally oriented Type I and Type II pressure-solution features, such as those present in the Dawson Bay carbonates, are the result of vertically-oriented overburden stress. This supports Dean's (1982) interpretation that the Dawson Bay Formation was deposited in a tectonically stable period of time. It also suggests that the Williston Basin has remained relatively free of lateral stress of a compressional nature since Dawson Bay time.

Type I "Sutured-Seam Styolites" occur only at the boundaries of carbonates which have structural resistance to stress according to (Wanless, 1979). In the Dawson Bay Formation, Type I styolites are present in declining order of occurrence within boundstones, packstones, wackestones, and mudstones.

Type I pressure-solution features, when associated with mudstones, always involve either allochems or prior variable cementation. Type I styolites most commonly are present in the stromatoporoid boundstones of lithofacies C.

Type II "Non-Sutured Seam" pressure-solution responses, are common throughout the Dawson Bay Formation. They are most common in lithofacies B in association with high argillaceous content. The structurally resistant stromatoporoid boundstones of lithofacies C contain the least number of microstyolites, swarms, and seams.

Diagenetically, both Type I and Type II pressure-solution features are significant in that they provide a source of carbonate cement at great burial depths (Bathurst, 1981). Type I styolites reduce porosity and permeability by cementation in their immediate vacinity (Wanless, 1979). Type II pressure-solution features have been shown to be conducive to the growth of 30-120 micron size dolomite rhombs in areas between nodules, and along microstyolites (Wanless, 1979). Pressure-solution dolomitization is very common in the Dawson Bay carbonates and is important to porosity development in the hydrocarbon producing NDGS well #7877 in Williams County. Kissling (1984) suggests that Type II pressure-solution carbonate volume reduction may induce tension fractures which enhance porosity.

Neomorphic Calcite

Microspar is most common in the micritic areas of lithofacies D and lithofacies E. The patchy distribution of microspar in micrite, and the fact that microspar cuts allochems, indicates that microspar is the product of recrystallizaton (Folk, 1965). According to Folk, microspar is most common in "normal marine" to brackish limestones, rare in dolostones and highly saline or fresh-water limestones.

Pseudospar is associated with non-dolomitized micrite, or calcite bioclasts, which are most common in stromatoporoid biostrome/bioherm lithofacies C. Folk (1965) indicates that pseudospar forms by inversion of organic skeletons, such as aragonite skeletons to a mosaic of coarsely-crystalline sparry calcite. He adds that pseudospar may also form by recrystallization of micrite to coarser crystals of different morphology than microspar. Bathurst (1981) reports that pseudospar shapes include equant grains that are uniformly greater than micron size, irregular shapes and sizes with "wiggly" boundaries, or random mosaics. The morphology differences within pseudospar are due to differences in the mode of nucleation (Folk, 1965). Folk adds that nucleation within micrite results in mosaic pseudospar, whereas radial and syntaxial overgrowths commonly reflect bioclast surface nucleation. Mosaic, radial-axial, and syntaxial pseudospar forms all occur within the carbonates of the Dawson Bay Formation.

Pseudospar occurs in the same environments as microspar (Folk, 1965). Bathurst (1981) adds that not only do the forms of neomorphic calcite occur together, but an evolutionary diagenetic process exists between micrite, microspar, and pseudospar. Folk (1974) states that neomorphic calcite, such as occurs in the Dawson Bay carbonates of North Dakota, forms in the eogenetic to late mesogenetic environments. Mattes and Mountjoy (1980) concur with Folk (1974) on the basis of their work in the Miette buildup in Alberta. Neomorphic recrystallization is found in Dawson Bay limestones, dolomitic limestones, and in dolomites. Consequently, the time of recrystallization is uncertain, but is believed to have occurred within the eogenetic to late mesogenetic range suggested by Folk (1974).

Porosity

Porosity development throughout the Dawson Bay lithofacies is greatest in Bottineau County along the dissolution edge of the underlying Prairie Evaporite and in Williams County associated with the Nesson Anticline. In both areas, porosity has been enhanced by extensive, late mesogenetic fracturing. The late mesogenetic interpretation is based upon the cross-cutting relationship that these fractures have with deep-burial and pressure-solution dolomites. In Bottineau County the fracturing is related to dissolution of the Prairie Evaporite in post-Souris River time (Dunn, 1982) (Anderson and Hunt, 1964). The isopach map of the Dawson Bay carbonate section indicates that local extensive fracturing in Bottineau County is related to the presence of topographic highs (Plate 1). In Williams County, the fracturing is associated with the underlying Nesson Anticline (Plates 2 and 3) and may also reflect limited Prairie evaporite dissolution. Similar fracture porosity could be expected along the Prairie evaporite dissolution edge, but may not be as well developed in areas where Dawson Bay topographic highs are absent (Plate 1).

The widespread stromatoporoid biostromes and local bioherms of lithofacies C laterally display the greatest Dawson Bay porosity, particularly in Cavalier County where it is enhanced by vuggy porosity development in the eogenetic environment under subaerial conditions. Additionally, multiple-fracturing has significantly improved lithofacies C porosity locally in Williams and Bottineau Counties.

Dean (1982) indicated that maximum porosity development in Northwest Exploration's #1 Pederson well in northeastern Williams County (Appendix A) is at the top of the Dawson Bay Formation in rocks that correspond to lithofacies C of this study (Table 2). According to Dean, several factors contributed to the high porosity in the producing #1 Pederson well: (1) the original depositional fabric consisted of coarse-grained fragmental carbonate and bioclasts with micrite winnowed by current patterns, (2) the heightened entrapment of magnesium carbonate waters, and longer reaction period due to shallower water depths and slower rates of deposition, and (3) decreased halite and anhydrite filling of pores.

Eogenetic vuggy-porosity development in all lithofacies, but particularly in lithofacies C, is greatest in areas where subaerial exposure occurred. Intercrystalline porosities were initially enhanced in the eogenetic environment by evaporative dolomitization in lithofacies F. Subsequent mesogenetic burial and pressure-solution dolomitization substantially increased Dawson Bay intercrystalline porosity. This late dolomitization was both localized and selective.

Eogenetic calcite cementation principally reduced moldic, vuggy, and fracture porosity throughout the Dawson Bay carbonates. Anhydrite and halite further reduced Dawson Bay porosity in late mesogenetic environments. Anhydrite partially fills fractures in late burial dolomites and replaces adjacent dolomite. Subsequent halite precipitation filled vuggy and intercrystalline dolomite porosity. Vuggy porosity reduction by halite locally remains high throughout the Dawson Bay Formation underlain by the Prairie Evaporite. However, intercrystalline porosity reduction appears to diminish upsection away from the Prairie Evaporite. Subsequent to halite emplacement, the fractures formerly filled by anhydrite were again reopened by structural movement. Late mesogenetic, sparry calcite cementation, locally filled fractures.

The problem of Dawson Bay Formation porosity reduction by late anhydrite and halite is common regionally in the Williston Basin (Dunn, 1982). This porosity loss is most serious wherever carbonates are underlain by evaporites (Shearman and Fuller, 1969). Porosity and permeability variability characterises the Dawson Bay carbonates in North Dakota.

Halite

Halite commonly fills vugs and intercrystalline pores in dolomite in areas underlain by Prairie evaporites. The source of the halite is interpreted to be the Prairie evaporite deposits, based on the decrease in halite quantity away from the evaporites and the absence of halite in the Dawson Bay core in areas of the state not underlain by Prairie evaporites. The Dawson Bay Formation as a source for the halite is considered to be unlikely because relatively normal marine conditions existed at the end of Dawson Bay time in large portions of the study area. The time of halite emplacement is interpreted to have been late mesogenetic because halite fills late mesogenetic mosaic dolomites and fractures.

Multiple-stage fracturing of Dawson Bay carbonates suggests multiple dissolution events in the Prairie evaporites. Structural subsidence, supplimented by deep-burial, in the Williston Basin may have resulted in halite dissolution and migration (Plates 2 and 3)(Anderson and Hunt, 1964).

Hydrocarbons

The main source of petroleum is organic matter buried with fine-grained sediments. Usually this fine-grained sediment is clay, but carbonates frequently contain high concentrations of organic matter with or without clay. Diagenesis of organic matter before, or during migration, involves increasing temperatures during burial (Chapman, 1973).

Dark, organic rich shales are commonly associated with geologic formations that contain oil (Dickey, 1979). Consequently, the oxidized red clays of the basal Second Red Bed member of the Dawson Bay Formation are not a likely hydrocarbon source. According to Sherman and Fuller (1969) evaporites often form effective barriers to the migration of hydrocarbons from lower source beds. The Prairie evaporites probably blocked upward migration by hydrocarbons.

Hydrocarbons migrated into Dawson Bay reservoirs during late mesogenic diagenesis since the hydrocarbons fill mesogenetic pores in mosaic dolomites. Under deep-burial conditions, hydrocarbon migration into grain supported lithofacies C rocks from overlying formations, such as the Souris River, is possible due to over-pressuring. Lateral migration is also possible from younger, or older, formations that are stratigraphically lower then the Dawson Bay. Structural draping, such as occurs over the Nesson Anticline due to basin subsidence, can produce the stratigraphic conditions conducive to hydrocarbon migration and/or entrapment.

In-situ evolution of Dawson Bay hydrocarbons is considered to be a possible source for Dawson Bay oil. Baillie (1953) recognized the abundance of bitumens in the Dawson Bay Formation. The carbonates of lithofacies B are rich in bitumens. This abundance of bitumens prompted Sandberg and Hammond (1958) to suggest the basinal facies as a potential hydrocarbon source.

Late mesogenetic anhydrite, halite and calcite porosity reduction limits the reservoir potential of all Dawson Bay lithofacies. The diminishing amount of halite and anhydrite upsection away from the

Prairie Evaporite suggests improved reservoir potential higher in the Dawson Bay carbonate section. The medium crystalline dolomites of lithofacies C in the study area have the greatest reservoir potential.

The results of ultraviolet light/chlorothene testing indicate the presence of hydrocarbons in ten of the eleven cored Dawson Bay carbonate sections in North Dakota (Table 1). Hydrocarbons were most frequently detected in lithofacies B, C, and D throughout the study area.

The only Dawson Bay hydrocarbon production is from Northwest Exploration's Rye #1 well, Pederson #1 well, and Pederson #3 well (Appendix C). These wells all produce from a structural trap (Dean, 1982) in Temple Field, Williams County, North Dakota associated with the Nesson Anticline. Core from the most productive, Pederson #1, suggests that extensive and recurrent fracturing is common in Temple Field. The anticlinal, structural, trapping mechanism in Williams County may be supplemented by halite filled porosity and argillaceous lithologies present in the basal Souris River Formation. In southwestern Bottineau County, ultraviolet light/chlorothene testing revealed hydrocarbons throughout the Dawson Bay core in the Blanche Thompson #1 (Table 1). Late fracturing over a topographic high (Plate 1) is associated with this well and suggests hydrocarbon migration control. Migration of hydrocarbons in the vacinity of the #1 Pederson and Blanche Thompson #1 wells may have been toward their associated late fractures as a consequence of fracture-induced pressure reduction. It is possible that hydrocarbons are trapped beneath the replacive anhydrites in lithofacies F associated with the depositionally-thin isopach anomalies in Bottineau and adjacent Counties.

If Dawson Bay hydrocarbons were generated in-situ, it is possible that generation occurred in the very carbonaceous lithofacies B. A similar occurrence in the Green River-Upper Wasatch Formations in the Duchesne field in Wyoming produce crude oil that is thought to have been generated in-situ from carbonaceous sediments at depths of 3050 m (10,000 ft.) or more (Hunt, 1979).

Hydrocarbon migration in the Dawson Bay is a late mesogenetic event. Figure 5 shows hydrocarbons rimming a lithofacies E pore within a late-mesogenetic mosaic dolomite matrix. The pore contains a calcite cement rim which has subsequently been neomorphically recrystallized to eogenenetic-late mesogenetic (Folk, 1974) optically continuous pseudospar. Hydrocarbon presence was also indicated by microprobe analysis.

Dunn's (1982) statement that the Dawson Bay Formation is capped basinwide by cryptocrystalline dolomite mixed with anhydrite (lithofacies F) is not the case in the North Dakota portion of the Williston Basin (Figure 47). However, localized stratigraphic trapping by anhydrite is possible. Areas of thin Dawson Bay sediment accumulation occur on the Dawson Bay carbonate isopach map (Plate 1). These thinner intervals suggest locations of possible topographic highs which locally are capped by replacive bedded-anhydrite in Bottineau, Rolette, McHenry, and Foster Counties.

Production statistics for Northwest Exploration's three producing Dawson Bay wells are presented in Appendix D. More than 281,000 barrels of oil have been produced from the Dawson Bay Formation since 1980 (Petroleum Information Corporation, 1980-1984)(NDGS, 1984). Initial oil production statistics have ranged from 340-895 BOPD.

Production in each well is from stromatoporoid biostrome/bioherm lithofacies F in Williams County, North Dakota, associated with the Nesson Anticline.

The sources of Dawson Bay hydrocarbons are in-situ generation from lithofacies B of the Dawson Bay, or lateral migration from an uncertain source. Hydrocarbon entrapment postdates late-mesogenetic mosaic dolomite formation. The stromatoporoid biostromes of lithofacies C have the greatest reservoir potential. Deep-burial dolomitization and late multiple-fracturing have locally enhanced porosity and permeability, but occurs locally throughout the study area. Multiple-fracturing has resulted from periodic dissolution of the Prairie evaporites with resultant collapse of the Dawson Bay. Core studies reveal that Prairie evaporite dissolution is most extensive in areas associated with anomalous depositional thinning in Bottineau County (Plate 1). Similar anomalies are present in adjacent counties on the Dawson Bay carbonate unit isopach map and may suggest areas conducive to hydrocarbon movement or entrapment. Anhydrites locally replace lithofacies F on these depositionally higher areas and may inhibit upward migration of hydrocarbons. Halite filling of porosity decreases upsection within the Dawson Bay carbonates underlain by the Prairie evaporites and is absent in other areas of the state.

Multiple-fracturing is also present over the structural Nesson Anticline (Plates 2 and 3). This fracturing may be the result of basin subsidence with consequent draping of the Dawson Bay over the structural high. It is also possible that dissolution of Prairie evaporites has occurred above the Nesson Anticline as a result of structural draping. Fracturing due to a combination of evaporite dissolution and structural draping could enhance hydrocarbon movement or entrapment over the Nesson Anticline.

DEPOSITIONAL MODEL AND HISTORY

A generalized schematic cross-section of the Dawson Bay Formation lithofacies and depositional environments in North Dakota is illustrated in Figure 49. Energy levels are indicated for each lithofacies.

Approximately 375 million years B.P., the Dawson Bay (epeiric) Sea began its transgression of the North American Craton (Bluemle and others, 1980)(Figure 1). The transgression from the deep Devonian Sea is marked by initial deposition of predominantly red-colored dolomitic shales on top of a basal weathered surface. The red shales are probably reworked materials of the transgressed weathered surface. This basal erosion surface and the overlying argillaceous sediments are collectively called the Second Red Bed member of the Dawson Bay Formation (Lithofacies A, Figure 49, Table 2). These sediments overlie evaporites of the Prairie Formation in the northwest corner of the study area (Figure 1) corresponding to the deeper portion of the Dawson Bay Sea basin. In the shallower portions of the basin, the Second Red Bed overlies subaerially exposed carbonates of the Prairie, Winnipegosis, and Interlake Formations.

Marine life was limited in the initial Dawson Bay Sea because of hypersaline conditions in the arid environment. The high salinity resulted from evaporative concentration of minerals in the shallow sea. Fauna tolerant of hypersaline conditions, such as gastropods and brachiopods, predominate in the most basal Dawson Bay carbonates (Lithofacies B, Figure 49, Table 2).

Warm-hot prevailing winds approached the study area from the present northeast across the Precambrian craton (Figure 1). A low elevation carbonate sebkha environment formed on the adjacent subaerial landmass. The landscape to the east of the study area was probably composed of hills with low, rounded, profiles similar to areas along the modern Persian Gulf. The topographic highs were composed of subaerially exposed older carbonate formations. The only evidence of low-lying igneous and metamorphic Precambrian Shield rocks to the northeast are trace amounts of eolian transported quartz silt and fine-sand grains in the lower carbonates of the Dawson Bay Formation.

Normal shallow epeiric sea conditions prevailed after the Dawson Bay Sea reached a depth sufficient to dilute the initial hypersalinity. Low topographic highs present in Bottineau and McHenry Counties may have remained as low islands until they too were submerged by the transgressing Dawson Bay Sea (Plate 1).

Brachiopods and echinoderms were most common in this very low energy , relatively normal marine environment (Lithofacies B, Figure 49, Table 2). A few anthozoans, bryozoans, ostracods, red algae, and trilobites also lived in this lime mud-bottomed epeiric sea.

The sea did not transgress the entire Williston Basin area to its maximum depth all at once. Instead, transgression occurred in pulses as marine water flooded across the Meadow Lake Escarpment in southern Alberta and east-central Saskatchewan into the Williston Basin. Each new influx of water was marked by a relative clearing of the diluted Dawson Bay Sea and was marked by a period of reduction of lime mud sedimentation while deposition of marine fauna continued on the sea floor. Occasionally, the grainstones formed in these conditions were cemented by marine cements and formed hardgrounds (Dunn, 1982).

Fine organic material was produced in abundance in the Dawson Bay Sea. These bitumens and eolian derived clays were disseminated throughout the low-energy basal carbonate unit. Occasional, laterally extensive, argillaceous and bitumenous intervals reflect periods of diminished carbonate sedimentation.

Nearer to shore, stromatoporoids began to flourish (Lithofacies C, Figure 49, Table 2). Associated algae require sufficient light to grow, indicating normal clear water conditions, and depths less than approximately 15 m (50 ft.)(Irwin, 1965). However, the actual depth was probably somewhat less due to the diffusion of light by the abundant bitumenous and argillaceous material. Several stromatoporoid growth forms (James, 1983) are present and reflect variable water depth, sedimentation rates, and wave energy

In Cavalier County local areas of deeper water existed as indicated by the presence of slightly higher energy tabular stromatoporoid bioherms which protruded slightly above the sea floor. The carbonate unit isopach (Plate 1) also provides evidence of deeper water locally in eastern Cavalier County. Post-Dawson Bay erosion probably accounts for the local topographic irregularity. In this area of topographic variability, tabular stromatoporoids grew upward, alternating with shallower and higher energy subspherical stromatoporoids and cylindrical stromatoporoids of shallow, low energy, environments.

The Dawson Bay Sea is interpreted to have reached it greatest depth during the Lithofacies C stromatoporoid buildup. According to Heckel (1972), maximum transgression is usually reached at the time when stromatoporoids establish themselves across the sea floor.

The alternation of deeper-water tabular stromatoporoids with the shallowing-upward succession of subspherical and, finally, cylindrical stromatoporoids was terminated each time by oxidation of the bioherm wackestones and packstones. This is interpreted to mean that the Dawson Bay Sea level or the sea floor was fluctuating during the initial regressive phase. The shallowing of the sea may have resulted from regional evaporation in hot arid conditions that existed behind the stromatoporoid buildups along the Meadow Lake Escarpment northwest of the study area. The rising salinity of the Dawson Bay Sea may have permitted periodic deepening by diffusive influx of relatively normal marine water from the open Devonian Sea through the stromatoporoid barriers (Maiklem, 1971). However, the fact that relatively-normal epieric sea conditions continued through the end of Dawson Bay time in Williams County suggests that salinity did not rise regionally, but was a localized occurrence behind and between the shallower stromatoporoid buildups.

Area-wide shallowing conditions permitted stromatoporoid biostromes to spread across the sea floor. During lithofacies C accumulation, brachiopod and echinoderm faunas appear to have diminished in most of the study area. Relatively-normal marine conditions persisted seaward of the stromatoporoid buildups during stromatoporoid biostrome and localized bioherm dominance. The stromatoporoid community also included anthozoans, brachiopods, blue-green algae, bryozoans, echinoderms, gastropods, ostracods, cephalopods, trilobites, and calcispheres.

Occasionally, when the stromatoporoid buildups approached the surface of the sea, the higher energy conditions produced biostrome/bioherm rip-up intraclasts. Locally, carbonate muds and bioclasts accumulated in the low energy, deeper water environments between stromatoporoid buildups. They were also commonly deposited within the biostrome buildups at the end of shallowing-upward successions resulting from the evaporative shallowing of the sea followed by renewed influx of less-saline marine water.

In the nearshore areas adjacent to the stromatoporoid buildups, very-shallow epeiric sea conditions developed (Lithofacies D, Figure 49, Table 2), dominated by carbonate mud accumulation. environment. In the higher temperature waters with lower energy conditions and higher salinities, the wide diversity of normal marine fauna could not exist, thus gastropods, ostracods, brachiopods, and echinoderms predominated. Normal-marine echinoderms and occasional anthozoans may have washed in from the stromatoporoid buildups. Other less common fauna that could tolerate the slightly increased salinity include blue-green algae, trilobites, Amphipora stromatoporoids, and calcispheres.

The muddy, although not exceedingly saline conditions, permitted burrowing and boring organisms to flourish. Peloids, probably of fecal origin, and carbonaceous material accumulated, testifying to the abundance of marine fauna and vegetation in the very-shallow epeiric sea environment. Degasing of decaying organic material is evident in the occurrence of fenestral fabrics.

Rip-up intraclasts were carried into the very-shallow epeiric sea environment from both the higher-energy stromatoporoid buildups and the proximal, stromatolitic, subaerial shoreline.

In present western Wells, northern Dunn, and locally in eastern

Williams Counties, very-shallow marine conditions prevailed until deepening conditions returned with the Souris River Sea transgression.

It should be noted that the geologic record not only records shallowing epeiric-sea-conditions as shorelines are approached laterally in a single horizon, but also vertically in a regressive succession (Heckel, 1972). The shallowing-upward succession of Dawson Bay lithology indicates that, as regression continued, shallower environments of deposition also moved basinward. Fluctuations, with occasional minor transgressions, are indicated by the random stacking of sediments from laterally-adjacent depositional environments. These randomly-stacked sedimentary successions may also reflect localized re-entrant channels which permitted storm drainage of the backshore sabkhas (Hardie and Garrett, 1977).

Even closer to the Dawson Bay Sea shoreline, environmental conditions were very restrictive (Lithofacies E, Figure 49, Table 2). In the extremely low energy and highly saline conditions, only gastropods, ostracods, and localized blue-green algae lived. Fecal pellet deposition and burrowing organism diversity was lower in this environment, but those flora and fauna present were abundant due to limited competition. Bitumenous material was generated abundantly in these restricted shallow-water conditions, and fenestral textures commonly resulted from the decay of accumulated organic matter.

Trace amounts of quartz silt accumulated as the result of eolian transportation from the tectonically stable and low-lying Precambrian craton to the northeast. Some quartz silt may have weathered out of subaerially exposed older formations in the low backshore area. Locally in eastern Williams County (Figure 47), restricted shallow-marine conditions continued through the remaining Dawson Bay period of deposition.

Algal stromatolites, interspersed with accumulating carbonate muds, grew along the Dawson Bay Sea shoreline on the mainland and on emergent offshore islands (Lithofacies F, Figure 49, Plate 1). Tides may or may not have been present in the Dawson Bay (epeiric) Sea due to its shallow water depth.

Subhorizontal fenestral textures associated with blue-green algae stromatolites were common in these shoreline sediments. A few hypersaline fauna, such as gastropods, were also present in association with peloids of probable fecal origin. Burrows are very rarely present locally near the base of the section, since most burrowers can not tolerate hypersaline conditions (Walker and Laporte, 1970).

Storms occasionally deposited thin laminae of fragmental bioclasts that originated in deeper water. Variable energy levels (Figure 49) are suggested by these storm deposits. Occasional scour surfaces and ripple laminae also indicate local high-energy conditions.

Evidence of subaerial exposure is provided by dessication cracks with associated oxidized surfaces, and by color-mottling. Argillaceous clay, and quartz silt to fine sand, is associated with algal stromatolites and are probably of terrigenous eolian origin. The larger sand sizes could have moved into the shoreline environment by means of eolian saltation.

Shoreline sediments cap the Dawson Bay Formation on the present Cavalier County mainland and on offshore Bottineau County islands (Plate 1). These areas were exposed to subaerial diagenesis prior to the invasion of the Souris River Sea. The subaerial exposure resulted in evaporative dolomitization and penecontemperaneous replacement by anhydrite. Nodular and bedded-nodular anhydrite formed diagenetically very close to the shorelines. As evaporative regression of the Dawson Bay Sea continued, oxygenated waters moved downward and laterally basinward through the sediments, resulting in pervasive color-mottling. Lithologically controlled "pseudoburrows" were formed at this time. Diagenesis continued after the Souris River Sea transgressed unconformable Dawson Bay weathered surfaces. Conformable Dawson Bay/Souris River contacts are present in areas that were not emergent during late Dawson Bay time.

CONCLUSIONS

1. The Middle Devonian Dawson Bay Formation carbonate unit is present in the subsurface of North Dakota except where truncated by post-depositional erosion. It is composed of dolomitic, fossiliferous limestone, or dolostone. The carbonates have a maximum thickness of 47.5 m (156 ft.) and reach a maximum depth below the surface of 3798 m (12,432 ft.) in the study area.

2. Five laterally persistant lithofacies can be recognized in the Dawson Bay carbonates in North Dakota. Characteristic fossil fauna, flora, and other lithologic features distinguish each lithofacies. Proceeding upsection the carbonate lithofacies are: Lithofacies B (brachiopod-echinoderm wackestones and mudstones); Lithofacies C (stromatoporoid boundstones, wackestones, and mudstones); Lithofacies D (gastropod-ostracod-brachiopod-echinoderm wackestones and mudstones); Lithofacies E (gastropod-ostracod mudstones); and Lithofacies F (cryptalgal boundstones and mudstones).

3. The depositional history of the Dawson Bay Formation carbonate unit is relatively simple and reflects the interaction between a changing strandline position, topographic highs, and sedimentation in a hot arid climate. After initial transgressive deposition of the basal argillaceous Second Red Bed, lithofacies analysis of the carbonate unit suggests the following shallowing-upward succession of depositional environments and associated energy zones: shallow epieric sea (very low energy); stromatoporoid biostrome/bioherm (low energy); very shallow epeiric sea (very low energy); restricted shallow epeiric sea (extremely low energy); and shallow epeiric sea shoreline (variable

energy). Subaerial exposure of stromatoporoid shoals, stromatolitic island shorelines, and mainland stromatolite flats occurred. Stromatoporoid biostromes persisted in relatively-normal epeiric sea conditions in northwestern North Dakota until the sea again deepened at the beginning of Souris River time.

4. Gypsum and anhydrite replaced mudstones and displaced stromatolitic boundstones locally along subaerially exposed shorelines in the early eogenetic stage of diagenesis. Dolomitization of these same lithologies occurred penecontemporaneously.

5. Color-mottling and development of vuggy porosity were important early to late eogenetic events. "Pseudoburrows" are a distinctive form of diagenetic color-mottling which reflect lithologic control of paleogroundwater flow.

6. Several Prairie Evaporite dissolution events are indicated by multiple collapse-fracturing and dolomite-healing events in the overlying Dawson Bay Formation. Collapse-fracturing associated with anomalous isopach thins in Bottineau and possibly adjacent counties is common. Fracturing due to structural-draping is pronounced over the Nesson Anticline.

7. Middle to late mesogenetic, deep-burial mosaic dolomite is the most common form of dolomite in the study area. It is extremely variable in crystal size and distribution.

8. Type II microstyolites are the major late-mesogenetic pressure-solution response in the Dawson Bay carbonates. Dolomitization is very commonly associated with microstyolites. Pressure-solution responses may have strongly influenced late mesogenetic in-situ hydrocarbon generation and mobilization of carbonates in solution.

9. Stromatoporoid buildups show the greatest porosity development in the study area. Sucrossic dolomitization along fractures has greatly improved local porosity.

10. Hydrocarbons were either generated within the basal carbonate lithofacies or migrated laterally into the formation. Evidence is present for at least one late mesogenetic migration event. Middle to late mesogenetic anhydrite, halite, and calcite cementation restricts the reservoir potential of the Dawson Bay Formation but does not eliminate it. The stromatoporoid buildup lithofacies has the greatest reservoir potential in the study area. Possible trapping mechanisms for Dawson Bay hydrocarbons include structural, facies change, and diagenetic types.

FUTURE STUDIES

1.) A palaeontological study of the Dawson Bay carbonates in North Dakota is needed to add additional detail to the interpretation of depositional environments.

2.) The wire-line picks along the erosional edge of the Dawson Bay Formation in Cavalier County are tenuous and should be reconsidered as part of a detailed stratigraphic study which would include all core from the Precambrian through the Cenozoic.

3.) The relationship between "pseudoburrows" and paleogroundwater flow should be given additional consideration.

4.) A detailed geochemical study of the late Dawson Bay dolomites and calcite cements would refine the diagenetic history of the Dawson Bay. Cathodoluminescence would probably add considerable detail to the diagenetic history. A detailed diagenetic study within the limitations presented by the uncertain halite presence in the Dawson Bay core may identify diagenetic reservoirs and traps.

5.) The proposed in-situ generation of hydrocarbons from lithofacies B should be investigated futher, particularly, the relations between depth of burial, pressure-response features, and hydrocarbon maturation.

6.) Hydrocarbon exploration in the study area should consider the presence of the topographic highs on the Dawson Bay Formation, carbonate unit, isopach map. Their relation to salt dissolution and collapse, dolomitization, and the presence of possible capping anhydrite may provide both the required hydrocarbon reservoir conditions and trapping mechanism.

APPENDICES

APPENDIX A

WELL LOCATIONS, LEGAL DESCRIPTIONS, AND DAWSON BAY FORMATION (CARBONATE UNIT) PICKS

Well data is arranged alphabetically by county and numerically by North Dakota Geological Survey well numbers within counties. The standard Land Office Grid System is used to desiginate well locations. The appendix heading uses the abreviations T., R., S., and QTRS. for Township, range, section, and quarters respectively. Townships and ranges are respectively north and west of the principle baseline and meridian. The two quarters given define well locations in the first and second quarters of a section. The Kelly bushing units are in feet above sea level. The top of the Dawson Bay Formation and the top of the Second Red Bed Member are given in feet below the Kelly bushing. The thickness of the Dawson Bay carbonate interval is given in feet and was obtained by calculating the difference between the top of the Dawson Bay Formation and the top of the Second Red Bed. Dashes (-) are used to indicate that the Dawson Bay Formation is not present. Asterisks (*) indicate wells with Dawson Bay core that are described in Appendix B.

DAWSON BAY FORMATION (CARBONATE UNIT)
WELL LOCATIONS, LEGAL DESCRIPTIONS, AND PICKS

NDGS WELL#	T.R.S.	QTRS.	COMPANY NAME WELL NAME	KELLY BUSHING (FEET)	TOP D. BAY (FEET)	TOP SRBM (FEET)
ADAMS COUNTY						
6050	129-98-30	SWSW	AMERADA HESS CORP HOLMQUIST #1	2695	-	-
6322	130-91-7	NESW	ENERGETICS INC SOELBERG #23-7	2453	7594	7606
7642	130-95-28	NWSE	AMOCO PROD. CO. JACOB CHRISTMAN #1	2804	8384	8396
7939	131-98-33	SESW	AMOCO PROD. CO. HIRSCH #1	2805	8960	8980
BENSON COUNTY						
632	154-70-31	NWSE	CALVERT DRILLING CO AUTHUR J &IDA J &GINA STADUM#1	1637	3705	3810
BILLINGS COUNTY						
291	139-100-9	NWNE	AMERADA PETROLEUM CORP HERMAN MAY U #1	2774	11150	11187
859	144-100-31	SWNE	TEXACO INC GOVT M S PACE #1	2463	11490	11554
2853	143-101-5	NENE	SHELL OIL CO -NORTHERN PACIFIC RAILR GOVT 41X-5-1	2572	11501	11560
3746	138-100-10	SWSW	DAVIS OIL CO KEVIN FEDERAL #1	2814	10993	11023
3927	139-101-21	NWNE	AMERADA PETROLEUM CORP USA HODGE #1	2548	10863	10890
4254	137-100-28	SENW	PAN AMERICAN PET CORP USA ADAH G MACAULEY "B" #1	2864	10733	10760
4833	141-100-34	NENW	R M WATKINS & MESA PET FEDERAL #1-34	2593	11202	11247

5195	137-100-2	SENE	LONE STAR PRODUCING ALFRED SCHWARTZ "B"	2800	10756	10785
6140	142-98-36	NWSW	GULF OIL CORP STATE SCHL LAND #2-36	2676	11577	11629
6169	143-101-25	NWNW	TENNECO OIL CO BURLINGTON NORTHERN #1	2555	11459	11517
6228	144-98-3	NWSW	GULF OIL CORP ZABOLOTNY #1-3-4-A	2532	11900	11968
6470	142-98-15	SWSW	GULF OIL CORP SCHMIDT #1	2708	11717	11769
6512	141-98-8	NENE	GULF OIL CORP KORDONOWY #1	2581	11500	11547
6667	143-98-36	NENW	MOSBACHER PRUET OIL CO. STATE GRESZ #1-13-1B	2690	11840	11897
6689	141-101-23	SENE	JERRY CHAMBERS STATE OF ND #2-23	2501	11125	11171
6744	142-99-22	NENW	W.H. HUNT TRUST HLEBECHUK FLB #1	2712	11823	11874
6921	142-100-7	NWNE	TENNECO OIL CO. STUART #1-7	2764	11557	11604
7065	142-100-35	NESW	SUPRON ENERGY CORP. F-35-142-100 #1	2759	11575	11626
7086	141-101-1	NESW	GETTY OIL CO. MYSTERY CREEK #1-11	2518	11183	11230
7307	143-99-22	SENE	AMOCO PROD. CO. KNUDTSON STATE #1	2771	12031	12094
7348	143-99-2	SWSW	AMOCO PROD. CO. HECKER #1	2722	12060	12124
7508	140-100-2	NWNW	CONOCO INC. FEDERAL SADDLE #2	2767	11638	11681
7527	141-102-9	NESW	AL-AQUITAINE EXPLOR. 9-141-102 US #1-9	2467	10967	11008
7591	142-102-9	NENW	DIAMOND SHAMROCK CORP. RAUCH SHAPIRO #21-9	2529	11233	11278
7600	144-101-11	SENW	KOCH EXPLOR. CO. FEDERAL #6-11	2325	11433	11500

7618	142-99-3	NWNE	W.H. HUNT TRUST BARANKO #1	2728	11907	11966
7996	141-98-33	NESE	MOSBACHER-PRUET OIL CO. F.F. VOLESKY #33-1	2618	11340	11387
8075	142-101-8	NESE	CONOCO, INC. FEDERAL HANSON 8 #1	2430	11181	11227
8337	141-102-30	NESE	PATRICK PETROLEUM COMPANY HARRIS-FEDERAL #1-30	2603	10972	11012
8391	141-100-26	NWSW	SUPRON ENERGY CORPORATION F-26-141-100 #2	2589	11294	11339
8558	144-99-29	NWSE	AMOCO PRODUCTION COMPANY A. W. THOMPSON "B" #1-A	2675	12014	12079
8907	143-102-13	SENE	CONOCO INC. BLACKTAIL #13-2	2344	11188	11245
9087	141-99-28	SENW	ADOBE OIL & GAS CORP. STATE PEDELISKI #22-28	2720	11533	11578
9134	144-100-4	SWNE	PATRICK PETROLEUM CO. BLACKTAIL FEDERAL #1-4	2594	11862	11935
9340	143-102-15	NESE	COASTAL OIL & GAS CORP. COGC/ALAQ 15-143-102 BN #1	2275	11137	11193
BOTTINEAU	COUNTY					
38*	160-81-31	SWSE	CALIFORNIA OIL CO BLANCHE THOMPSON #1	1526	6172	6279
64	163-77-18	SWNW	HUNT OIL OLIVER OLSON #1	1520	4727	4868
110	163-75-23	NWNW	LION OIL HUSS #1	2205	4816	4951
170	163-77-2	SESW	LION OIL MAGNUSON #1	1669	4672	4813
286*	164-78-32	NWNE	LION OIL ERICKSON #1	1539	4831	4963
359	164-74-36	SWSE	WARD-WILLISTON DRILLING CO N DAK STATE #1	2256	4565	4693
524	161-81-19	SENW	DAKOTA OIL OLE ANDERSON #1	1522	5890	6040

1069	159-82-1	NWNW	CARDINAL, KAUFMAN, GREAT PLAINS ET A BEATRICE M KEELER #1	1536	6124	6260
1102	161-74-2	SWNE	CARDINAL PET CO J ANDRIEUX #1	1664	4198	4330
1968	163-78-30	SWNW	CALVERT DRILLING CO L T HANSON #1	1513	4905	5048
2596	160-80-19	SENW	PHILLIPS PETROLEUM CO GLENN BRANDT #1	1511	5838	5965
2638	162-78-12	SWSE	PHILLIPS PETROLEUM CO BRANDVOLD #1	1495	4823	4966
3827	162-78-20	SESE	AMERADA PETROLEUM CORP LILA STARK #1	1502	5026	5170
4192	160-81-5	NESW	CONTINENTAL THOMPSON ET AL #1	1516	5908	6052
4347	163-78-9	NESW	CARDINAL PET CO EKREHAGEN ESTATE #1-A	1532	4846	4986
4655	162-78-31	SESW	AMERADA PETROLEUM CORP H D LILLESTRAND #1	1486	5115	5247
4670	161-80-1	NESE	GENERAL AMERICAN OIL CO OF TEXAS U-HENRY#1-1(161-80)	1488	5411	5558
4790	159-81-20	SESE	UNION OIL CO OF CALIF ABRA STEEN #1	1517	6243	6370
4844	161-81-15	NESW	GENERAL AMERICAN OIL CO OF TEXAS WALTER R SAUSKER #1-15	1511	5796	5947
4846	163-81-8	NENW	LAMAR HUNT W CRANSTON #1	1518	5415	5572
4918	161-82-33	NWSW	MARATHON OIL CO GEORGE C ADAMS #1	1561	6220	6372
4924	161-81-2	NENE	UNION OIL CO OF CALIF C M HUBER #1-A-2	1514	5705	5852
5071	160-81-34	NWSW	ESTATE OF WM G HETIS E VAN HORN ET AL #1	1503	6076	6199
5141	164-77-33	SWNE	GEMINI CORP CARL #1-X	1598	4600	4760
5184	162-77-14	SENE	CHAMPLIN PET CO DUNBAR #1 42-14	1552	4690	4825

5277*	162-77-11	SWSW	MCMORON EXPLORATION CO TONNESON #1	1543	4702	4840
5280	161-76-24	SWSW	MCMORON EXPLORATION CO DERAAS #1	1527	4540	4674
5692	159-82-32	NENW	KIRBY EXPLORATION BROOKS #1	1587	6484	6608
6021	161-82-27	SWNW	CITIES SERVICE OIL CO RICE A #1	1553	6055	6208
6535	161-83-2	NENE	SHELL OIL COMPANY GREEK #41-2	1589	6200	6350
BOWMAN COUNTY						
516	132-102-13	NWSW	WESTERN NATURAL GAS TRUAX-TRAER COAL #1	3074	-	-
4922	130-100-5	SESW	PEL-TEX, INC INGOLF & NORA LANDA #1	2944	-	-
4952	130-100-32	SWSW	PEL-TEX, INC G R BOOR ET AL #1	2958	-	-
5772	131-100-5	NWNW	TURE OIL CO FISHER #11-5	2892	-	-
5888	132-104-15	NWSW	KENNETH LUFF, INC O GUNVALDSEN #1-15	3167	-	-
6370	129-100-21	SWNE	C F BRAUN & CO PALOZWESKI #1	2787	-	-
6465	130-104-10	NESE	TERRA RESOURCES INC WICK #1-10	3157	-	-
BURKE COUNTY						
5161	161-94-31	NENW	PHILLIPS PETROLEUM CO. HOLTE - BND #1	2439	10072	10210
5919	161-94-30	SESW	HOME PETROLEUM CORP SONFLOT HEIRS UNIT #1	2459	10084	10220
6607	161-94-5	NENE	NO. CENTRAL OIL CORP. PRIEBE-STATE #1	2404	9816	9950
6802	160-93-24	SWNW	B. W. A. & B. WESTERN INVEST. CO. #24-12	2394	10087	10232

BURLEIGH COUNTY						
19	140-77-6	SWSW	CONTINENTAL-PURE, DAVIDSON STRATIGRAPHIC TEST	1909	5359	5425
151	140-80-18	SWSW	HUNT OIL EMMA KLEVEN	1922	6262	6340
155	140-75-9	NENE	CONTINENTAL DRONEN #1	1912	4518	4565
174	140-77-3	NWNW	CONTINENTAL DUENELAND #1	1981	5293	5347
701	144-75-36	NENE	CAROLINE HUNT TRUST ESTATE BOARD OF UNIV &SCHOOL LANDS #1	2023	4940	4998
723	139-76-36	NENE	CAROLINE HUNT TRUST ESTATE R P SCHLABACH #1	1880	4657	4690
763	144-77-14	SESE	CAROLINE HUNT TRUST ESTATE ANTON NOVY # 1	1947	5485	5560
765	142-76-31	SWSW	CAROLINE HUNT TRUST ESTATE SODER INVESTMENT CO #1	2027	5392	5455
772	140-79-23	NWNW	CAROLINE HUNT TRUST ESTATE PAUL RYBERG #1	2007	5807	5874
1409	140-77-11	NWSE	LEACH OIL & CALVERT PATTERSON LAND CO #1	2019	5248	5303
4389	141-80-33	SWNE	TOM VESSELS HELEN BOURGOIS #1	2126	6501	6583
7010	138-78-31	NENE	ASAMERA OIL (U.S.) INC. WELCH #1	1752	5221	5268
8674	141-76-17	SWSW	SUN OIL COMPANY T. D. THORSON #1	1874	5294	5350
CAVALIER COUNTY						
1ST	161-59-26	-	THE CARTER OIL COMPANY SYMONS B-1	1649	1533	1635
3ST	162-57-7	-	THE CARTER OIL COMPANY CHAPUT #B-3	1504	1177	1246
5ST	161-57-5	-	THE CARTER OIL COMPANY ADELARD BENOIT B-5	1549	-	-
6ST	163-59-16	-	THE CARTER OIL COMPANY HELL #B-6	1575	1498	1601

7ST	163-58-27	-	THE CARTER OIL COMPANY OLE ROMFO #B-7	1326	1236	1368
8ST	163-58-18	-	THE CARTER OIL COMPANY EMIL AMUNDSON #B-8	1539	1350	1445
9A-ST	162-59-13	-	THE CARTER OIL COMPANY MCDOWALL #B-9A	1577	1388	1533
10ST	163-60-31	-	THE CARTER OIL COMPANY ANTHONY HILTNER #B-10	1562	1644	1763
11ST	162-59-32	-	THE CARTER OIL COMPANY JOHN ZARN #B-11	1634	1529	1659
12ST	162-59-30	-	THE CARTER OIL COMPANY RUEBEN RUEGER #B-12	1618	1594	1720
27*	159-63-28	NWNW	UNION OIL CO OF CALIF CHRIS SKJERVHEIM #1	1562	2129	2270
31*	160-60-32	NWSW	UNION OIL CO LILLIAN WOHLETZ #1	1612	1721	1832
36*	161-60-12	NWNE	UNION OIL CO OF CALIF -LOS NIETOS ELLIS #1	1646	1629	1763
37*	162-64-26	SWNW	UNION OIL CO OF CALIF -LOS NIETOS RESTAO #1	1630	2245	2395
1694	162-63-10	NWNW	JOHNSON OIL EARL MOORE #1	1586	2045	2180
2342	160-57-3	NWSW	FRED TRAUGNOTT GOODMAN ESTATE #1	1559	-	-
2521	161-62-35	NESE	AMERADA PETROLEUM CORP ABE LOEWEN T-1 #1	1581	1930	2050
DIVIDE COUNTY						
548	160-98-11	SWNW	PURE OIL OLE GUNDERSON #1	2241	10166	10290
1443	162-96-6	SWNE	DAHAMONT EXPLORATION CORP HAROLD E JACOBSON #1	1949	9070	9200
2010	163-102-7	NWNE	CARTER OIL CO DALLAS D MOORE #1	2206	8968	9093
4837	160-100-12	SWNE	MIAMI OIL PROD INC ROY HAGEN #1	2112	10011	10133

5009	160-96-35	NESE	CONSOLIDATED OIL & GAS CO INC CHARLEY MYER ETAL #1	2290	10300	10430
5135	161-95-29	SENW	ASHLAND OIL INC F FENSTER #1-29	2291	9884	10023
5192	160-95-3	NENE	H L HUNT A B ERICSON #1	2373	10045	10185
5246	161-95-5	NENE	SHELL OIL CO VERNON TANBERG #1	2364	9660	9794
5248	160-98-10	NENE	OIL DEV CO OF TEXAS ROGERS #1	2243	10136	10260
5404	163-99-23	NWSE	TIGER OIL CO MATHEWS #1-23	2209	9250	9384
5535	160-96-24	NWSW	TREND EXPL CO VATNE ETAL #1	2299	10220	10350
5989	164-95-31	NESE	W.A. MONCRIEF & WESTHOMA KEBA OIL & GAS #31-1	1903	8612	8752
6429	162-103-26	SWSE	W H HUNT TRUST EST SKABO #1	2145	9350	9468
6541	162-100-13	SENE	TIPPERARY OIL & GAS CORP. OLSEN #1	2349	9595	9723
6603	160-96-36	SWSW	CHAPMAN EXPL:, INC. STATE OF ND #1-A	2295	10327	10455
6751	161-101-3	NWNW	PATRICK PETR. CORP. JOHNSON #1	2244	9628	9753
6798	162-96-16	NESE	SHELL OIL CO. RINDEL #43-16	2141	9342	9475
6864	161-102-30	SWNW	MOSBACHER PRUET OIL CO. ANDERSON-STATE #30-1	2104	9590	9703
7087	163-95-18	SESW	SHELL OIL CO. SVANGSTU #24-18	1918	8713	8853
7116	160-99-24	NESW	TERRA RESOURCES, INC. FEDERAL #1-24	2236	10319	10443
7395	161-95-12	SENW	KELDON OIL CO. ZIMMERMAN #1	2403	9918	10054
7863	161-95-25	NESE	HOME PETROLEUM CORP. KJELSHUS #1	2472	10095	10235

7942	160-97-19	NWSE	W.H. HUNT TRUST ESTATE LEONARD ROSTEN #1	2349	10443	10564
8461	160-102-31	SENE	W. H. HUNT TRUST ESTATE GERALD FISCHER #1	2101	10077	10183
8495	163-99-14	SWSE	TEXAS INTERNATIONAL PETR. CORP. BAKKE #1	2259	9176	9312
8498	162-101-22	NWNW	SOUTHLAND ROYALTY COMPANY GERALD RAAUM #1-22	2167	9340	9466
9083	161-99-11	SWNW	LEAR PETROLEUM EXPLORATION, INC. KVIGNE #1	2131	9705	9833
9274	161-98-10	NENE	LEAR PETROLEUM EXPL. INC. REUBEN HALL #1	2104	9805	9932
9398	163-101-16	SESE	CONOCO, INC. STATE 16 #1	2260	9237	9363
9446	162-102-1	SESE	TENNECO OIL CO. REISTAD #1-1	2190	9261	9388
DUNN COUNTY						
505	141-94-6	SENE	SOCONY-VACUUM OIL C DVORAK #1	2296	10912	10970
793*	149-91-22	SENW	MOBIL PROD CO PEGASUS DIV SOLOMON BIRD BEAR	2102	11052	11150
2400	148-96-10	SWSE	AMERADA PETROLEUM CORP SIGNALNESS UNIT #1	2396	11967	12060
3044	143-92-27	NENE	AMERADA PETROLEUM CORP MARIE SELLE T-1 #1	2200	10553	10626
4611	146-96-36	SWSW	HELMERICH & PAYNE INC STATE OF NORTH DAKOTA #1	2435	12043	12124
4725	148-97-24	SWSE	KATHOL PETR INC TIDDENS PETR CO LITTLE MO #1-24	2373	12245	12337
4957	147-93-8	NWNW	MIAMI OIL PROD INC ESTATE OF HAIRY ROBE #1	2212	11474	11570
5621	142-97-23	NENW	MESA PETROLEUM ROSHAU #1	2583	11445	11500
6034	145-97-32	NWNW	GULF OIL CORP P MARIENKO #1-32-1A	2518	11905	11975

6086	145-94-7	NENE	AMOCO PROD CO BERENT SELLE #1	2325	11599	11680
6148	141-96-2	SWSW	AMOCO PROD CO ANDREW M HEISER #1	2615	11292	11347
6182	146-94-21	NENW	TRUE OIL CO BENZ #21-21	2186	11710	11799
6348	145-95-1	NENE	AMOCO PROD CO MUGGLI #1	2359	11669	11750
6448	146-94-24	NWNW	SMOKEY OIL CO O'NEIL #11-24	2256	11595	11680
6464	147-95-19	NWSE	GAS PROD ENTERPR & AL AQUITAINE BN #1	2526	12116	12205
6489	144-96-30	NENE	AMOCO PROD CO ROY KAREY #1	2310	11677	11746
6492	145-91-35	NWNE	ANADARKO PROD CO GUSTAFSON "A" #1	2133	10566	10646
6530	141-95-18	SENE	AMOCO PROD. CO. WOLBERG #1	2595	11133	11187
6582	148-95-8	NESW	AL-AQUITAINE OIL & GAS DEEP CREEK	2378	12126	12219
6591	143-94-35	NWNW	AMOCO PROD. CO. ODIN ANDERSON #1	2130	10887	10950
6605	146-96-11	NESE	AMOCO PROD. CO. KELLING #1	2515	12075	12163
6887	146-95-35	SWNE	AMOCO PROD. CO. RICHARDSON #1	2324	11697	11783
6967	147-96-34	NENE	ELF AQUITAINE OIL & GAS NELS E. BENSON #1-34	2915	12512	12598
7346	144-92-7	SENE	ALPAR RESOURCES, INC. MCNAMARA #1-7	2261	10958	11035
7412	145-93-18	SWNW	CITIES SERVICE CO. STATE OF ND #A-1	2218	11314	11397
7584	145-95-8	NENW	AMOCO PROD. CO. ROSHAU #1	2322	11796	11876
7707	145-93-35	NESW	TERRA RESOURCES, INC. BORTH #1-35	2257	11226	11302

7745	147-92-10	NENE	SANTA FE ENERGY CO. YOUNG BEAR #1	2048	11102	11198
7760	146-93-24	SESW	MOSBACHER PRUET OIL CO. THOMAS COOK #24-1	2318	11390	11480
7978	145-91-17	NWSE	TERRA RESOURCES, INC. TOZIER #1-17	2223	10815	10896
8107	147-96-23	SWNE	AMOCO PROD. CO. ENGVOLD #1-A	2538	12151	12240
8115	142-92-24	NESW	KELDON OIL COMPANY DRESSLER #1	2277	10393	10465
8235	144-92-36	SESE	SANTA FE ENERGY COMPANY STATE #1-36	2258	10650	10723
8243	142-92-36	SESE	HOUSTON OIL & MINERALS CORPORATION UNION STATE #44-36	2147	10177	10247
8374	144-96-4	NENE	ADOBE OIL & GAS CORPORATION FEDERAL KILLDEER #41-4	2435	11917	11990
8396	141-97-15	SENE	PUMA PETROLEUM COMPANY HECKER #1-15	2546	11350	11399
8491	142-96-30	NESW	VANDERBILT RESOURCES CORPORATION BULLINGER #1-30	2635	11452	11507
8536	144-93-7	SWSE	TERRA RESOURCES, INC. KLING #1-7	2247	11176	11252
8925	147-95-29	NWSE	COASTAL OIL & GAS CORP. COGC/AlAq 29-147-95 BN #2	3256	12006	12093
9027	144-92-31	SESW	LUFF EXPLORATION CO. GELLER N-31	2204	10836	10908
9040	149-93-21	SWNW	APACHE CORP. HARMON #1	2235	11356	11447
9044	146-93-11	SENW	ANR PRODUCTION CO. HANSEN #1-11A	2270	11355	11446
9065	145-94-30	NWNW	AMOCO PRODUCTION CO. HUTCHINSON AMOCO UNIT "A" #1	2272	11646	11724
9080	144-92-16	SENW	GETTY OIL CO. HALLIDAY #16-6	2224	10890	10966
9103	147-96-10	SESE	MESA PETROLEUM CO. FEDERAL #10-1	2193	11807	11897

9106	143-92-16	NENW	UNION OIL CO. OF CALIF. MYRON #1-N9	2221	10714	10785
9137	141-97-32	SENE	TENNECO OIL CO. ZELINSKY #1-32	2550	11222	11269
9191	147-91-15	NENW	HOME PETROLEUM CORP. C.A.DANKS #1-15	2100	10975	11072
9226	144-94-14	NWSE	BWAB, Inc. OESLER #14-33	2279	11351	11425
9402	146-95-15	SWNW	AMOCO PRODUCTION CO. KUPPER AMOCO "A" #1	2337	11882	11967
9462	148-96-34	SWNW	MESA PETROLEUM CO. KNUTSON-WERRE 34 #1	2182	11772	11863
EDDY COUNTY						
437	150-67-16	NWNW	CALVERT DRILLING CO N DAK STATE #1	1478	2926	2993
768	150-65-8	NENE	CALVERT DRILLING CO #1 STATE #1	1561	2652	2693
1274	148-62-9	SESE	WETCH ZACHMEIER & DISNEY C E BLASKY #1	1584	-	-
7271	148-65-9	NWSW	KISSINGER PETR. CORP. ANDERSON #12-9	1530	2716	2750
EMMONS COUNTY						
16	133-75-35	NWSW	NORTHER ORDINANCE FRANKLIN INVESTMENT CO #1	1909	-	-
23	133-76-35	NESE	ROESSER & PENDELTON J J WEBER #1	2012	-	-
43	132-78-8	NESE	PEAK DRILLING OLHAUSER #1	1820	-	-
7936	136-75-13	NWNW	CHEVRON U.S.A. INC. RASSEN RAMBOUGH #1	1925	-	-
FOSTER COUNTY						
287	146-63-13	NWNW	FRAZIER-CONRAY SARAH DUNBAR #1	1518	-	-
334	145-64-24	NENE	T M EVANS CHRISTIAN ERICKSON #1	1547	-	-

403	146-66-15	NENE	PURE OIL J M CARR #1	1547	-	-
1105	146-65-8	SESW	CARDINAL, KAUFMAN, GREAT PLAINS ET A J S SMITH #1	1533	-	-
1112	146-66-23	NENE	CARDINAL, KAUFMAN, GREAT PLAINS ET A N A GRAVES&FEDERAL LAND BANK#1	1536	2685	2695
1126	146-67-10	NWNW	CARDINAL DRLG. CO ET AL J M ANDERSON #1	1589	2980	2993
1227	147-64-25	NENE	MIKE WETCH H F SPICKLER #1-A	1463	-	-
GOLDEN VALLEY COUNTY						
470	140-105-15	NESE	BLACKWOOD & NICHOLS GILMAN &LANG #1	2867	10841	10857
4130	138-105-9	SWNW	AMERADA PETROLEUM CORP RAMONA WALDRON #1	2867	10284	10294
5438	141-105-27	NENW	TEXAS GAS EXPLORATION CO GUY M BROWN ETAL #1	2710	10682	10714
6272	137-106-22	NWNW	SHELL OIL CO KREMERS #21-22	3034	-	-
6319	136-105-22	NENW	APACHE CORP MARGARET LANGDON #1	2694	9708	9716
6563	139-105-4	NWNE	SHELL OIL CO. SMITH #31-4	2744	10600	10613
6858	144-104-1	SWNW	TERRA RESOURCES, INC. MESSERSMITH #2-1	2446	11336	11397
6947	144-103-18	SENW	TERRA RESOURCES, INC. MOSSER #1-18	2531	11479	11536
7094	144-103-20	NWNW	GULF OIL CORP. BOYCE FEDERAL #1-20-1A	2422	11286	11342
7255	142-103-3	SWSE	SHELL OIL CO. BN #34-3	2595	11243	11286
7753	141-104-7	SENE	MORAN EXPLORATION, INC. KUNICK #1	2759	10915	10954
7784	136-106-23	NWSE	TRUE OIL CO. STARK #33-23	2937	-	-

7842	137-103-28	SWSW	BASS ENTERPRISES PROD. CO. BULLION BUTTE FEDERAL #28-1	2728	10278	10296
7969	142-105-32	NWSE	MORAN EXPLOR., INC. STECKER #1	2692	10697	10734
7983	136-105-6	NESE	READING & BATES PETR. CO. NORTHRUP #6-1	2908	9839	9848
8460	141-103-31	NWNE	JAKE L. HAMON & SAMSON RESOURCES CO. TESCHER #3	2726	10984	11023
8906	144-105-23	NWSW	ANDERSON PETROLEUM, INC. GASHO #2-23	2642	11250	11300
8986	144-104-23	SWNW	EVERETT DRILLING VENTURES, INC. ALVIN TESCHER, ET AL #5-23	2622	11444	11502
8987	141-105-11	NWSE	TERRA RESOURCES, INC. KITTELSON #2-11	2802	10928	10963
9011	140-105-6	NENE	MORAN EXPLORATION, INC. KUKOWSKI #1	2739	10664	10691
9115	142-105-5	NESE	MORAN EXPLORATION, INC. TRESTER #1	2538	10834	10878
9144	143-103-22	SWNE	GRACE PETROLEUM CORP. FEDERAL #32-22	2474	11166	11214
9148	139-105-16	NENE	HUNT OIL COMPANY KIPPLEY-STATE #1-16	2836	10541	10553
9165	141-104-36	NWNE	SAMSON RESOURCES CO. TESCHER #1-36	2724	10959	10997
9211	142-104-35	SENW	BWAB, Inc. KUNICK #35-22	2604	10985	11030
9376	144-105-27	NENE	ANDERSON PETROLEUM, INC. RAYMOND BN #1-27	2496	11084	11136
GRANT COUNTY						
232	133-83-26	SWSW	YOUNGBLOOD & YOUNGBLOOD KELSTROM#1	1997	5904	5939
3636	133-90-1	SWNE	CARDINAL-LONE STAR-NAT'L BANK MARIE BIERWAGEN #1	2350	7975	8018
5097	131-88-27	NENW	HELMERICH & PAYNE INC BURLINGTON NORTHERN"J"#27-1	2531	7085	7112

5118	130-88-23	NWSW	HELMERICH & PAYNE INC BURLINGTON NORTHERN"L"#23-1	2206	-	-
5496	134-90-5	SENW	WAINOCO INC KRAUSE #22-5	2420	8324	8370
5572	132-86-27	NENW	GAS PROD ENT INC BURL NO #1	2172	6579	6609
6420	132-86-7	SWSW	MARSHALL R YOUNG OIL CO 7-132-86-BN #1	2285	6847	6878
7020	137-88-5	SENE	TEXAS PACIFIC OIL CO. WILLIAM STECKLER #1	2342	8142	8210
HETTINGER COUNTY						
511	134-96-24	SWSW	SOCONY-VACUUM OIL CLARENCE &M JACOBS F14-24-P	2616	9376	9405
4984	135-92-12	NWNE	PUBCO PET CORP J HABERSTROH #12-2	2524	8957	9003
5447	136-92-15	SESW	WILLIAM HERBERT HUNT VALENTINE SENN #1	2429	9054	9103
5783	136-93-35	NWNE	FARMERS UNION GROSZ #2-35	2548	9343	9388
6413	133-92-21	SESE	ENERGETICS INC HARSCH-MEHRER #44-21	2508	8504	8542
6795	136-97-19	SENE	WEXPRO COMPANY JIRGES #1	2692	10228	10260
7075	133-93-26	SWSE	AMOCO PROD. CO. ROKUSEK #1	2517	8673	8710
7231	134-93-22	SESW	DIAMOND SHAMROCK CORP. BLICKENDORF #24-22	2367	8866	8906
7819	133-97-23	SESE	AMOCO PROD. CO. REDETZKE #1	2694	9266	9289
7876	136-96-14	NENW	AMOCO PROD. CO. KENNY #1	2738	10045	10079
7965	134-96-31	NENE	GULF OIL CORP. ZENKER #1-31-2B	2829	9617	9643
8010	133-97-25	NWNE	AMOCO PROD. CO. URLACHER STATE UNIT #1	2677	9272	9296

8143	134-92-3	NENW	NORTEX GAS & OIL COMPANY & POGO WOLF #1-3	2442	8814	8859
8206	132-93-16	NESW	SUPRON ENERGY CORPORATION 16-132-93 #1 SND	2556	8494	8524
8312	135-96-35	NWSW	SKYLINE OIL COMPANY FEDERAL HERBERHOLZ 35 #1	2544	9497	9532
KIDDER COUNTY						
24	141-73-36	SENE	MAGNOLIS PET DAK "A"STRAT TEST	1968	4260	4288
230	143-71-16	NESE	CARTER OIL CO NORTH DAKOTA STATE #1	1889	3930	3964
748	142-74-32	NWNE	CAROLINE HUNT TRUST ESTATE E B SAUTER #1	1848	4600	4648
McHENRY COUNTY						
39	157-78-3	NESW	HUNT OIL W B SHOEMAKER #1	1480	5400	5530
61	153-77-17	NWSE	HUNT OIL PETER LENNERTZ #1	1570	5517	5632
769	154-78-14	NWNW	CALVERT DRILLING CO FRED & SIGNA WRIGHT #1	1481	5563	5660
1354	156-77-26	NWNW	MONSANTO CHEMICAL COM ED #1	1489	5114	5238
2675	159-79-34	NWNW	AMERADA PETROLEUM CORP T PFAU #1	1478	5565	5728
5279	157-76-34	NESW	MCMORON EXPLORATION CO STATE #1	1476	4923	5045
5281	158-75-16	SWSW	MCMORON EXPLORATION CO STATE #2	1470	4607	4736
5283	158-77-34	NENE	MCMORON EXPLORATION CO FAIRBROTHER #1	1477	5061	5197
8307	155-77-31	NENW	ASAMERA OIL (U.S.) INC. LARSON #1	1516	5460	5560
McKENZIE COUNTY						
33	149-96-12	SWSE	AMERADA PETROLEUM CORP BENHOMER RISSER #1	2438	11975	12070

545	152-102-13	NESE	PHILLIPS PETROLEUM CO F G HOEHN "A" #1	2278	11889	11990
956	148-104-28	NWSW	GULF OIL CORP BENNIE-PIERRE FED U #1	2339	11540	11618
1765	151-97-35	NWNW	TEXACO INC R KOESER (NCT-1) #1	2430	12060	12156
2373	152-95-1	NESE	AMERADA PETROLEUM CORP ANTELOPE-DEV U #8	2117	11113	11234
2584	145-101-16	SWNE	SHELL OIL CO -NORTHERN PACIFIC RAILR STATE OF N D #32-16-1	2463	11675	11742
3645	145-105-24	SESE	QUINTANA PET CORP U S A #1	2379	11111	11173
3804	153-95-23	NWSW	CALVERT DRILLING CO RALPH SLAATEN #1	2344	11361	11475
4062	148-101-28	SENW	SHELL OIL CO GOV'T #22X-28-1	2214	11877	11965
4594	151-94-10	NWNW	GULFLAND INC DRAGS WOLF #1	1956	11373	11483
5086	146-103-16	NENE	TARGET OIL CO STATE OF N D #1-16	2285	11435	11508
5182	148-101-27	SENW	TURE OIL CO BURLINGTON NORTHERN #22-27	2165	11873	11962
5345	150-103-27	NENE	CHANDLER & ASS INC U S GOV'T #1-27	2248	11756	11846
5655	150-104-25	SWSW	PENNZOIL COMPANY FEDERAL #25-1	2170	11503	11586
5774	150-100-29	NWSE	TURE OIL CO HEGGEN #33-29	2335	12102	12200
5821	149-104-31	SWSE	SHELL OIL CO U S GOV'T #34X-31-1	2128	11196	11274
5824	148-102-22	NENW	KERR MCGEE CORP FEDERAL 22 #1	2422	11900	11986
5836	148-102-16	SWNE	KERR MCGEE CORP N D STATE #1-X	2411	11842	11930
5846	148-102-16	SENW	KERR MCGEE CORP N D STATE #2	2439	11914	12004

5847	148-102-9	SWNW	KERR MCGEE CORP HAUGEN #1	2466	11900	11988
5856	150-104-36	NENW	TIGER OIL CO STATE NO 1-36	2131	11475	11556
5993	147-103-24	NWNW	F.U.C.E., INC. ENSTULEN #4-24	2262	11586	11664
6014	145-103-19	NENE	TERRA RESOURCES INC B N R R	2590	11515	11578
6049	148-102-8	SESE	KERR-MCGEE CORP WEST LAW #1	2446	11920	12008
6109	148-102-17	SENE	KERR MCGEE CORP FEDERAL 17 #1	2463	11940	12024
6129	148-102-8	SWNE	KERR MCGEE CORP HAUGEN-STATE #1	2532	11988	12081
6387	148-104-6	SWSE	SHELL OIL CO USA #34X-6	2321	11530	11608
6414	148-104-8	NENW	SHELL OIL CO US GOVT #21-8	2334	11555	11633
6454	148-104-20	SESE	B W A & B PET INC-FED #20-44	2286	11498	11572
6479	153-95-22	SESW	TEXACO INC SILURIAN UNIT 2 #1	2379	11350	11465
6544	145-103-29	SENE	TERRA RESOURCES, INC. BN RR #1-29	2466	11406	11468
6613	148-105-12	SWSW	SHELL OIL CO. USA #14-12-11	2243	11348	11426
6715	148-104-21	SESW	SHELL OIL CO. USA #24-21-17	2373	11540	11616
6790	152-102-35	SWNW	SUPERIOR OIL CO. DONALD LINK ET AL #1	2276	11850	11950
6826	149-97-19	NENW	SAMEDAN OIL CORP. KELLY #1	2244	12170	12264
6839	150-104-11	NESE	SHELL OIL CO. USA #43-11	2066	11468	11553
6846	146-101-15	SESE	PENNZOIL CO.-DEPCO #15-44 BN	2443	11760	11837

6904	147-104-3	SENW	B. W. A. & B. FEDERAL #3-22	2196	11345	11423
6907	149-102-5	SWNE	SUNBHEM GAS, INC NORMON ROD #1	2313	11817	11908
6946	152-101-5	NENW	GULF OIL CORP. CLARA ECKERT #1-5	2198	11796	11900
6959	145-99-30	SESW	LADD PETR. CORP. FEDERAL #30-24	2493	11813	11880
6966	146-104-36	SESW	SHELL OIL CO. STATE OF ND #24-36	2502	11500	11567
6984	147-101-10	NENE	PENNZOIL CO. & DEPCO FEDERAL #10-41	2244	11744	11830
7001	154-95-34	NWSW	TEXACO INC. & AMERADA RED RIVER UNIT 1 #1	1895	10714	10828
7226	149-99-10	NENW	AMOCO PROD. CO. SONDROL #1	2167	12100	12194
7233	153-97-16	NWSW	GETTY OIL CO. TOBACCO GARDEN #16-12	2052	12130	12239
7306	149-102-35	SESE	SUNBEHM GAS, INC. OKLAND #1	2402	11900	11990
7422	150-103-3	NWSW	SHELL OIL CO. SHAIDE #13-3	2127	11626	11718
7501	145-100-25	NESE	AMOCO PROD. CO. FEDERAL "B" #1	2556	11924	11992
7571	151-95-31	SWNE	TEXACO INC. REITSCH NCT-2 #4	2486	11730	11828
7579	145-104-24	SENE	SHELL OIL CO. USA #42-24A	2664	11632	11695
7611	146-99-21	NENW	PENNZOIL CO. GRASSY BUTTE #21-21	2628	12243	12327
7647	149-104-4	SESW	SHELL OIL CO. USA #44-4	2204	11474	11553
7648	148-103-24	SENW	SHELL OIL CO. USA #22-24	2474	11908	11992
7650	150-102-31	NESW	TENNECO OIL CO. FEDERAL #1-31	2262	11777	11874

7666	146-104-31	SWNW	SHELL OIL CO. USA #12-31-97	2523	11366	11432
7685	147-99-34	SWNW	PENNZOIL CO. SLAWSON #34-12 MC	2581	12326	12412
7700	148-100-31	SENE	TEXAS GAS EXPLOR. CORP. SPERATI FED. #1-31	2402	12038	12127
7704	150-98-23	NESE	GULF OIL CORP. SHAFER STATE #1-23-3B	2022	12005	12100
7845	150-101-23	SENW	PETROLEUM INC. & EXCEL NYGAARD STATE #1	2318	11994	12091
7879	149-100-22	NENE	CHAMPLIN PETROLEUM CO. STATE-ROGNESS 41-22 #1	2209	11990	12083
7886	150-96-15	SWNE	HILLIARD OIL & GAS, INC. LILLIBRIDGE #1	2300	11733	11829
7943	149-99-23	NENW	AMOCO PROD. CO. HAMRE #1	2380	12290	12383
8013	145-100-1	SENE	AMOCO PROD. CO. STORM #1	2442	11960	12037
8020	150-99-34	SWNE	ALPAR RESOURCES, INC. ROGNESS #1-34	2114	12044	12140
8094	149-103-9	SESW	GETTY OIL COMPANY CHARBONNEAU #9-14	2285	11710	11790
8184	149-104-25	SWSW	SHELL OIL COMPANY USA #14-25-111	2445	11754	11832
8215	147-98-25	SESE	GULF OIL CORPORATION MORMAN BUTTE #1-25-3C	2512	12108	12196
8238	146-103-6	NESE	SHELL OIL COMPANY USA #43-6-117	2329	11473	11547
8285	152-102-8	SWNE	GULF OIL CORPORATION REHBERG #1-8-2D	1989	11550	11650
8287	146-104-18	NWSE	SHELL OIL COMPANY USA #33-18-123	2450	11432	11499
8314	147-103-8	SENE	SHELL OIL COMPANY USA #42-8	2221	11506	11584
8322	151-102-34	SWSE	HNG OIL COMPANY LINK #34-1	2267	11810	11906

8400	145-102-27	NWSW	PENNZOIL COMPANY & DEPCO SIX CREEK #27-13BN	2205	11308	11373
8409	149-103-34	SWNE	PATRICK PETROLEUM COMPANY WINTER-FEDERAL #1-34	2375	11800	11880
8471	149-96-22	NENW	APACHE CORPORATION FEDERAL #22-1	2408	12095	12188
8873	151-96-27	NWSE	PETRO-LEWIS CORPORATION GEORGE TANK #2	2373	11726	11822
8882	153-101-35	SESE	TEXAS GAS EXPLORATION CORP. LINDVIG 1-35	2226	11830	11935
8883	148-102-35	SESW	PENNZOIL COMPANY DEPCO-BOWLINE CREEK #35-24BN	2263	11705	11790
8887	148-99-25	NWNW	WILLIAN H. HUNT TRUST ESTATE STUTRUD #1	2515	12399	12489
8905	149-103-25	SWSW	PATRICK PETROLEUM COMPANY HIGHLAND FEDERAL #1-15	2309	11770	11856
8945	150-100-6	NENE	AL-AQUITAINE EXPL. LTD. SE ALEX.,ALAQ 6-150-100 HOVDE #1-6	2242	11973	12069
8961	149-101-35	NENW	HNG OIL COMPANY NYGAARD #35-1	2436	12100	12193
8969	150-99-9	NWNE	TEXACO, INC. ANDREW JOHNSRUD "A" NCT-1 #1	2286	12247	12343
8983	151-100-16	NWSW	GREAT WESTERN DRILLING CO. BRUINS #1	2298	12167	12265
8985	151-104-24	NESE	LADD PETROLEUM CORP. LADD DUNCAN PAULSON #24-43	2105	11526	11620
9024	150-97-20	SWNW	GULF OIL CORPORATION H & M GIERKE #1-20-1D	2123	12105	12200
9066	148-99-12	SENW	WM. H. HUNT TRUST ESTATE KNUTE HAGEN #1	2401	12360	12452
9102	150-102-2	NWNW	GULF OIL CORP. GAJEWSKI #1-2-1A	2152	11702	11800
9132	151-101-23	SENW	SUNBEHM GAS, INC. SKEDSVOLD #23-6	2109	11815	11914
9138	146-98-22	SWSE	WM. H. HUNT TRUST ESTATE HOLLER #1	2378	12060	12146

9180	149-98-3	SESE	POGO PRODUCING CO. JOHNSRUD #1-3	2220	12214	12310
9184	151-95-5	NESW	TEXACO, INC. F. P. KEOGH #6	2421	11635	11732
9185	150-95-17	SWNE	TEXACO, INC. G. V. LEVANG (NCT-1) #1	2360	11718	11816
9252	146-102-25	SWNE	PENNZOIL COMPANY PENNZOIL-DEPCO RIVERSIDE #25-32BN	2293	11570	11643
9263	151-98-20	NESW	PATRICK PETROLEUM COMPANY DAVID ROLFSON #1-20	2059	12135	12234
9276	147-101-33	SENE	PENNZOIL EXPL. & PROD. CO. PENNZOIL-DEPCO BULLMOOSES. #33-42BN	2042	11475	11553
9283	152-100-36	SESE	EXETER EXPLORATION CO. STATE OF N.D. #16-36	2369	12220	12321
9309	153-101-11	SESE	GULF OIL CORPORATION N. ALEXANDER #1-11-3C	2105	11770	11876
9318	153-95-30	SENE	UNIVERSAL RESOURCES CORP. T.K. #1	2287	11222	11332
9344	151-99-29	SWSE	GREAT WESTERN DRILLING CO. WALLA #1	2166	12103	12201
9362	147-102-9	NENW	PENNZOIL EXPLORATION & PRODUCTION CO. BURNING MINE BUTTE #9-21 BN	2287	11716	11800
9377	151-103-21	NENE	EXETER EXPLORATION CO. SKOGEN-FEDERAL #1-21	2163	11652	11745
9388	150-100-35	NWNW	MOBIL OIL CORP. ROY MOEN #1	2364	11450	11544
9403	152-103-27	NWSE	SUN EXPLORATION & PRODUCTION CO. ERICKSON #1-27	2180	11680	11775
9414	150-95-9	SWNW	TEXACO, INC. R. L. OLSON #10	2355	11683	11780
9434	145-99-9	SENW	AMOCO PRODUCTION CO. SIPE AMOCO UNIT "A" #1-A	2513	12047	12122
9464	151-104-1	NENW	AMOCO PRODUCTION CO. CROY AMOCO "A" #1	2123	11551	11645
9501	146-102-6	SWNE	SKYLINE OIL CO. FEDERAL RIVET 6 #1-X	2427	11696	11771

9508	151-102-23	SWSE	EXETER EXPLORATION CO. JIM TAYLOR #15-23	2160	11754	11850
McLEAN COUNTY						
22	146-81-10	SWNE	SAMEDAN OIL CORP VAUGHN HANSON #1	1995	7175	7265
49	150-80-28	SWSW	STANALIND MCCLEAN COUNTY #1	2100	7075	7150
432	146-81-2	SWSE	H HANSON OIL SYNDICATE N E HANSON H-1	1957	7080	7172
7783	150-90-1	SENW	HOME PETR. CORP. TRIBAL #1-1	2212	10610	10740
8060	148-89-7	SWNE	APACHE CORP. SOLCUM #1	2109	10394	10494
MERCER COUNTY						
21	142-89-28	NWNE	KELLY-PLYMOUTH FRITZ LEUTZ #1	2284	9830	9924
6683	143-90-13	NWSW	TRUE OIL CO. HAUCK #13-13	2097	10025	10116
7616	144-90-29	SWNW	CONOCO INC. ENTZE 29 #1	2080	10212	10305
MORTON COUNTY						
26	136-81-29	NENW	PHILLIPS-CARTER DAKOTA #1	2005	5959	6002
1620	139-90-27	NESW	PAN AMERICAN PET CORP RAYMOND YETTER #1	2426	9286	9361
3859	135-83-34	SENE	AMERADA PETROLEUM CORP JAMES MEYER #1	2124	6371	6413
3978	137-83-34	SENW	AUSTRAL OIL CO , INC JOHN J LEINGANG #1	2281	6916	6974
5379	138-83-5	NWNE	CAMPBELL PARTNERS LTD PICHA #1	1980	6969	7044
5979	136-81-18	NWNW	HOUSTON OIL & MINIRAL JOHN J. HAIDER #1	1907	6017	6060
7340	140-88-26	NWSE	AMOCO PROD. CO. RICHTER #1	2230	8830	8920

7691	138-85-19	SENW	AMOCO PROD. CO. OLIN #1	2094	7702	7777
7770	138-85-6	NWSW	AMOCO PROD. CO. KARCH #1	2076	7792	7872
7797	137-87-14	SESE	TEXAS PACIFIC OIL CO. BACHLER #1	2281	8119	8186
7937	138-86-19	NENE	AMOCO PROD. CO. OLSEN #1	1965	7813	7888
8158	138-82-6	SWSE	PENZOIL COMPANY SWEET BRIAR #6-34	1792	6498	6567
8395	137-87-1	SWSE	SUN OIL COMPANY JACOB LARSON #1	2211	8100	8170
8553	140-82-17	SENW	SHELL OIL COMPANY VOGEL #22-27	1994	7004	7086
8630	134-83-2	SESW	PENNZOIL COMPANY RAILROAD BEND #2-24	2146	6328	6368
MOUNTRAIL COUNTY						
355	158-94-18	SWNW	AMERADA PETROLEUM CORP CLIFFORD HANSON #3	2339	10558	10683
474	155-90-24	NWNW	WILLIAM HERBERT HUNT W & U DUNHAM #1	2161	10113	10257
528	157-89-25	NWNE	WILLIAM HERBERT HUNT L C ANDERSON #1	2271	9516	9660
4113	150-93-4	SENW	TEXACO INC FORT BERTHOLD ALLOTTEE 437 #A1	2198	11722	11840
4386	151-90-28	SESE	EMPIRE STATE OIL CO VORWERK #1	2216	10799	10909
5072	158-94-22	NENE	AMERADA PETROLEUM CORP ALBERT ERICKSON #1X	2367	10885	11020
5257	151-90-34	NWSW	MCCULLOCH OIL CORP WAHNER #1-34	2223	10790	10896
5831	157-94-23	SWSW	SMOKEY OIL CO , INC WILL #14-23	2300	11065	11188
6087	157-94-9	SWSE	TOM BROWN INC JORSTAD #9-34	2325	10760	10886

6289	155-91-10	NESW	THOMSON PETR INC HARSTAD ET AL #1	2281	10686	10825
6677	157-90-14	NESE	TRUE OIL CO. HALVERSON #33-14	2305	9838	9980
6764	155-90-2	NENW	DONALD C SLAUSON KVAMME # 2-1	2220	10136	10280
6780	151-89-24	SENE	BASS ENTERPR. PROD. CO. ROBERT ANDES #24-1	2133	10075	10210
6872	153-88-16	NESE	MARATHON OIL CO. MAE OLSON #1	2108	9728	9867
7238	154-88-5	NWNE	UNION OIL CO. OF CALIF. OYNES #1-B5	2132	9610	9744
7362	155-91-13	NESW	MARATHON OIL CO. OGDEN ARMOUR #13-23	2310	10600	10732
7457	150-92-20	NWNE	APACHE CORP. GRACE #1-20	2143	11418	11543
7570	155-94-9	NENE	KISSINGER PETR. CORP. GRONDALE #1-9	2074	11375	11500
7741	156-94-28	SWSW	KISSINGER PETR. CORP. ORTLOFF #13-28	2331	11530	11652
8071	152-90-3	NENW	LEAR PETROLEUM EXPLORATION, INC. PARSHALL S.D. #1	1967	10238	10376
8371	157-91-17	SWSW	TRUE OIL COMPANY KUSTER #14-17	2310	10499	10646
9055	152-90-35	NWSE	MITCHELL ENERGY CORP. ELBERG #1-35	2001	10311	10447
9278	155-91-23	NENE	MARATHON OIL COMPANY HOLTER #23-41	2283	10676	10815
9326	156-92-1	SWNW	GULF OIL CORPORATION JUMA 1-1-1D	2266	10652	10790
9373	156-93-36	NWSE	PENNZOIL EXPLORATION & PRODUCTION CO. ROSS #36-32	2449	11396	11528
NELSON COUNTY						
1934	152-60-5	SESE	REELFOOT DEV CO INC L & A BRYL #1	1521	-	-

4664	151-61-32	NWSW	JACK M JOHNSTON DRILLING CO SYDNEY L HAAS #1	1473	-	-
4714	152-60-36	NESW	JACK M JOHNSTON DRILLING CO C O HVIDSTEN #1	1407	-	-
4750	149-61-23	SWNE	JACK M JOHNSTON DRILLING CO ARVID FLAAGGEN #1	1518	-	-
4785	151-60-6	NENE	JACK M JOHNSTON DRILLING CO GRITZ #1	1496	-	-
5102	149-61-33	NENE	COLORADO OIL & GAS QUAM #1	1543	-	-
OLIVER COUNTY						
15	141-81-18	SESE	CARTER OIL CO E L SEMLING #1	2037	6928	7010
95	141-81-3	SESW	YOUNGBLOOD & YOUNGBLOOD EUGENE WACHTER #1	1924	6688	6770
4940	142-85-24	SESW	GENERAL AMERICAN OIL CO OF TEXAS RAYMOND HENKE #1-24	2252	8332	8422
PIERCE COUNTY						
435	158-69-12	SWNE	MIDWEST OIL CORP HECKMAN #1	1589	3174	3310
538	154-72-17	NESE	CALVERT DRILLING CO CYRUS & JOSEPH RAMBERG #1	1556	4102	4212
706	157-70-23	SESE	SHELL OIL CO GIFFORD MARCHUS #1	1652	3553	3673
3920	152-74-23	SESE	A J HODGES IND INC ALEX MARTIN #1	1605	4472	4577
5576	152-73-34	SWSW	GETTY OIL LUDWIG VETTER #1	1579	4346	4450
RAMSEY COUNTY						
20	158-62-29	NENE	UNION OIL COMPANY OF CALIFORNIA AANSTAD NUMBER ONE	1544	1998	2103
196	154-65-16	NENE	CARTER OIL COMPANY ALLAN MACDIARMID # 1	1487	2487	2573
246	154-63-36	NENE	NORTHERN NATURAL GAS PRODUCING CO. RAYMOND P & BLANCHE T LEE	1517	2100	2160

383	158-62-17	NWNW	S D JOHNSON M D WOLF # 1	1556	2030	2141
407	153-63-13	NESW	CALVERT EXPLORATION COMPANY CARL JACK # 1	1487	2110	2160
408	153-63-1	SWSW	CALVERT EXPLORATION COMPANY W HALEY # 1	1489	2080	2138
411	158-63-11	SWSE	S D JOHNSON EDWIN WERNER # 1	1557	2077	2193
422	158-62-33	NESW	MCLAUGHLIN INC WOLFE # 1	1534	1985	2080
2522	158-61-21	NENE	AMERADA PETR. CORP. R.A. HAMMER #1	1549	1837	1913
4745	156-62-14	NWSW	JOHN R. BLACK ESTATE CECIL J. MILLER #1	1511	1920	1987
4771	155-64-2	NWNW	JACK M. JOHNSTON DRILLING CORP. WILLIAM OVERBO #1	1468	2218	2305
4783	153-62-2	NESE	JOHNSTON PETR. CORP. FRANK HORSTEIN #1	1503	1945	1985
4914	156-61-32	NENE	MILLER & FOX DRILLING CORP. ERWIN LORENZ #1	1514	1837	1875
5177	155-61-3	NENW	TEJAS GAS CORP. ERWIN LORENZ #1	1557	1765	1797
6627	152-62-24	NWNE	JEROME F. WHITESELL JAMES FISK #1	1501	1963	1992
RENVILLE COUNTY						
1689	158-81-7	NENW	ANSCHUTZ OIL COMPANY EINER CHRISTIANSON # 1	1532	6280	6405
6296	163-87-9	NESW	SHELL OIL CO LARSON #23X-9	1807	7140	7296
6349	164-87-34	SWSW	SHELL OIL CO MOTT #14-34	1636	6846	7002
6401	163-87-10	NESW	SHELL OIL CO WISDAHL #23-10	1703	6968	7121
6436	163-87-5	NESE	SHELL OIL CO DUERRE #43-5	1822	7105	7261

6504	162-87-1	SWNE	GREAT YELLOWSTONE ONES #1	1716	7135	7290
6624	161-85-1	SENW	SHELL OIL CO. OSTERBERG #22X-1	1715	6840	6993
6684	161-85-2	NENW	SHELL OIL CO. OSTERBERG #21-2	1713	6840	6994
7577	160-86-15	SWNW	SHELL OIL CO. DEWING #12-15	1842	7534	7685
ROLETTE COUNTY						
83	161-73-23	SENW	LION OIL COMPANY SEBELIUS # 1	1627	4005	4137
316	160-70-23	NWSW	EVANS PRODUCTION CORPORATION ANDY LEROY JOHNSON #1	1691	3483	3619
685	163-73-32	SWSW	BRITISH-AMERICAN OIL PRODUCING CO P WENSTAD # 1	2107	4386	4519
806	163-73-14	NESE	BRITISH AMERICAN OIL PRODUCING CO HENRY DIETRICH # 1	2180	4362	4495
1630	161-72-19	NWSE	GENERAL CRUDE OIL COMPANY AIDA HIGGINS # 1	1632	3945	4080
SHERIDAN COUNTY						
665	148-76-15	NENE	CAROLINE HUNT TRUST ESTATE JOHN WALTZ JR # 1	1792	5308	5396
684	147-75-1	NENE	CAROLINE HUNT TRUST ESTATE J R MATZ # 1	1849	4943	5025
693	146-76-19	SWSW	CAROLINE HUNT TRUST ESTATE WALTER E BAUER # 1	1984	5647	5728
735	146-74-16	SWSW	CAROLINE HUNT TRUST ESTATE C A PFEIFFER # 1	1994	4963	5035
SIOUX COUNTY						
631	131-80-29	NESW	OHIO OIL COMPANY STANDING ROCK SIOUX TRIBE # 1	1731	-	-
SLOPE COUNTY						
4124	136-101-4	NWSE	H.L. HUNT EVA HAYDEN #1	2740	10406	10428
4280	135-103-18	NESW	AMERADA PETR. CORP. IVAN MITCHELL #1	2971	10081	10090

4749	133-101-33	SWNW	STATES OIL CO. SEDEVIE, J.J. #1	2976	9674	9680
5210	133-100-3	NENW	BELCO PETROLEUM CORP. CANNONBALL #3-3	2975	9936	9955
5929	135-101-10	SWSW	JERRY CHAMBERS WILLIAM O. RABE #1	2788	10200	10219
5933	133-102-9	SESW	JERRY CHAMBERS H. J. BURKE #1	2897	-	-
6355	134-105-21	SWSE	TERRA RESOURCES INC FEDERAL #2-21	2907	-	-
6412	136-101-34	NWNE	PATRICK PETR CORP FEDERAL #1	2751	10310	10328
7016	133-100-23	SESW	LADD PETR. ORP. SANDERS #23-24	2876	9565	9584
7132	136-99-22	SWSE	TERRA RESOURCES, INC. WITMAN #1-22	2686	10270	10293
7383	133-103-28	NWSE	GREAT WESTERN DRLING. CO. FEDERAL #1-28	3005	-	-
7548	133-106-22	SENE	TERRA RESOURCES, INC. WANG #1-22	2828	-	-
7890	134-100-23	SENW	GULF OIL CORP. POGO-NAROM #1-23-1C	2955	10040	10060
7987	135-98-17	NWSE	CITIES SERVICE CO. SCHMITT B-1	2870	10225	10255
9209	135-106-14	SESW	ANADARKO PRODUCTION COMPANY CASH CREEK FEDERAL "A" #1	2887	-	-
9237	134-100-4	SESW	TENNECO OIL COMPANY STEGNER #1-4	2916	10131	10154
9244	136-98-2	SWNE	WILLIAM C. KIRKWOOD EHLIS #32-2	2780	10425	10457
STARK COUNTY						
3515	140-93-9	NWNW	CONTINENTAL OIL CO. CHRIST STOXEN #1	2292	10156	10214
5142	137-92-9	SENE	BRIDGER PETROLEUM CORP B. KILZER #1	2326	9243	9293

5143	137-97-9	NENW	LONE STAR PRODUCING CO. K. WANNER #1	2688	10554	10610
5255	137-95-22	NESW	CONTINENTAL OIL CO. FEIMER-ANGER #1	2717	10230	10268
6243	137-92-26	SENW	ENERGETICS INC MARTIN-KILZER #1	2357	9184	9235
6447	139-97-8	SWNW	ANADARKO PROD CO KOSTELECKY #1	2496	10683	10723
6797	139-92-16	SESW	W.H. HUNT TRUST ESTATE RUMMEL-STATE #1	2494	9898	9956
6812	138-93-1	NWNW	W.H. HUNT TRUST ESTATE ELKINS #1	2479	10084	10137
7007	138-98-26	SESE	SUPRON ENERGY CORP. PRIVRATSKY #1	2756	10760	10796
~~7127~~	~~139-96-30~~	~~NWNE~~	~~SHELL OIL CO.~~ KOSTELECKY #31-30	2521	10610	10647
7247	140-95-5	NESW	HUNT ENERGY CORP. BARTA #1	2455	10915	10964
8088	141-93-28	NWNE	MOBIL OIL CORPORATION WILLIAM BERNHARDT #1	2165	10223	10283
8098	139-99-9	SENE	MONSANTO CO. FROELICH #1	2611	11150	11186
8169	138-92-21	NENW	GULF OIL CORP. LEVIATHAN #1-21-1B	2372	9501	9553
8342	140-95-36	NWNW	SUPRON ENERGY CORPORATION LAWRENCE #1	2418	10601	10649
9135	138-91-28	SENE	PIONEER PRODUCTION CORP. DIEDE #1-28	2361	9381	9438
9256	139-93-14	NWSE	GULF OIL CORPORATION HUTCHINSON 1-14-3A	2458	9940	9993
9422	140-98-9	SENE	UNION TEXAS PETROLEUM CORP. KUNTZ #9-1	2647	11179	11224
STUTSMAN COUNTY						
134	142-65-15	SWNE	GENERAL ATLAS CARBON CO. F BORTHEL #1	1552	-	-

644	139-68-5	SESE	GORDON B. BUTTERFIELD RUDOLPH TRAUTMAN #1	1945	-	-
669	139-68-35	SESW	CALVERT EXPL. CO. CHRIST RAV #1	1880	-	-
671	140-67-12	NWSW	CALVERT EXPL. CO. GEORGE GANSER #1	1900	-	-
TOWNER COUNTY						
100	161-68-35	SWSE	UNION OIL COMPANY OF CALIFORNIA ARNE SAARI NUMBER ONE	1717	3130	3246
171	163-65-18	NWNE	F H RHODES HAROLD MURPHY # 1	1597	2514	2670
194	157-65-17	SWSE	F H RHODES R R GIBBENS # 1	1499	2474	2590
227	158-66-31	SESW	EARL F WAKEFIELD EDNA LOUISE HILL # 1	1465	2690	2810
390	160-67-24	SWSE	MIDWEST EXPLORATION CORP H ANANN # 1	1544	2670	2816
434	163-68-27	NWNW	MIDWEST EXPLORATION COMPANY INC HENRY P JUTENEN # 1	1729	3003	3146
3980	162-68-7	SWSE	LA HABANA CORP. & NAT'L ASSOC. PETR. KEITH R. DUNLOP #1	1761	3146	3284
WALSH COUNTY						
2623	156-58-9	NENW	TRAUGOTT DRILLING HATTIE BAKKE #1	1562	-	-
WARD COUNTY						
47	155-81-23	SESW	WILLIAM HERBERT HUNT TRUST ESTATE JOE H & ANNA WALD #1	1596	6551	6683
52	156-85-24	NENE	WANETE M O LEE ET AL #1	1839	7728	7860
105	153-85-2	SWNE	STANALIND WALTER & INGEBERG WASWICK #1	2175	8523	8656
126	156-83-33	SWSE	QUINTANA PET CORP C W LINNERTZ #1	1772	7270	7418
588	152-82-33	SWSE	WILLIAM HERBERT HUNT F C NEUMANN #1	2087	7630	7750

656	155-82-13	NWNE	WILLIAM HERBERT HUNT GUY ALMY #1	1632	6852	6984
4923	156-81-5	NWNE	UNION OIL CO OF CALIF VERNON OLSON #1-B-5	1573	6495	6627
4990	156-84-22	NWSW	THE ANSCHUTZ CORP RICHARD MUSCH #1	1788	7539	7674
4992	156-82-2	NESE	UNION OIL CO OF CALIF HAROLD ANDERSON #1-I-2	1618	6670	6814
5105	152-86-28	NWNW	GENERAL CRUDE OIL CO JEROME JENSEN #1	2120	9083	9212
5158	153-85-13	NENW	UNION OIL CO OF CALIF MYRTLE HANSON #1-C-13	2117	8496	8628
5498	157-82-1	NWSE	MARATHON OIL CO GOWIN #1	1559	6534	6678
7612	155-87-15	SESW	MARATHON OIL CO. BERG #15-24	2219	9142	9274
WELLS COUNTY						
207*	146-73-27	SESE	CONTINENTAL OIL COMPANY JOHN LUETH NUMBER ONE	1933	4552	4606
609	148-71-14	SWSE	CAROLINE HUNT TRUST ESTATE GEORGE LEITNER #1	1612	3764	3844
635	145-68-30	NENE	S D JOHNSON C HAGEL #1	1785	3403	3430
642	150-70-32	NWNE	CAROLINE HUNT TRUST ESTATE OBED LARSON #1	1599	3690	3773
689	147-71-31	NENE	CAROLINE HUNT TRUST ESTATE N THORMODSGARD #1	1702	3955	4021
1211	146-68-8	NENE	CALVERT DRILLING CO FRANCIS ZWINGLER #1	1608	3220	3240
WILLIAMS COUNTY						
25	155-95-6	SWSW	AMERADA PETROLEUM CORP C IVERSON #1	2390	10899	11020
32	157-95-12	SWNW	AMERADA PETROLEUM CORP BAKKEN #1	2458	10763	10894
34	155-95-18	NENW	RUDMAN RESOURCES, INC M IVERSON #1	2326	10871	10994

48	156-96-7	NESE	CHAMPLIN PET CO TANK #1	2311	11175	11300
235	158-95-35	NENE	AMERADA PETROLEUM CORP LALIM #2	2467	10629	10762
254	156-95-19	SWNE	AMERADA HESS LARS KVAN TI # 2	2397	10885	11020
999	154-100-23	SWNE	TEXACO INC J M DONAHUE #1	2253	12000	12108
1231*	155-96-2	SENE	AMERADA PETROLEUM CORP IVERSON + NELSON U #1	2316	10714	10842
1385	156-95-16	SESW	AMERADA PETROLEUM CORP N D "A" U #9	2360	10962	11084
1403*	155-96-15	SWNE	AMERADA PETROLEUM CORP BOE-OLSON #1	2165	10651	10778
1514	156-96-34	SENE	AMERADA PETROLEUM CORP ULVEN UNIT #1	2286	10862	10987
1636	156-95-17	SESW	AMERADA PETROLEUM CORP PETERSON DEVIDSON U #1	2401	10893	11023
1745	157-95-21	SENW	HUNT OIL WILLARD ODEGAARD #1	2361	10740	10860
1856	156-96-24	NESW	AMERADA PETROLEUM CORP P DILLARD + J KNUTSON U #1	2353	10925	11055
1895	155-96-22	NENE	AMERADA PETROLEUM CORP HANSOE BOE #1	2102	10635	10755
2092	156-95-17	SWNE	AMERADA PETROLEUM CORP NELSON BAKKEN U #1	2373	10943	11072
4321	158-95-36	NWSW	AMERADA PETROLEUM CORP N D "C" B#9	2457	10676	10810
4323	158-95-26	NESW	AMERADA PETROLEUM CORP HJALMER IVES #B-1	2460	10636	10763
4379	158-95-25	NWSW	AMERADA PETROLEUM CORP HJALMAR IVES #3	2495	10668	10795
4572	157-103-18	SWNE	MIAMI OIL PROD INC NELLIE MILLER #1	2293	10854	10956
4597	154-103-5	SWNE	LAMAR HUNT DONALD VOLL #1	2338	11530	11640

4618	156-103-17	NENW	AMERADA PETROLEUM CORP NILS TROGSTAD #1	2413	11294	11397
4754	154-103-21	NESE	SAM BOREN ROOKE #1	2223	11565	11676
4916	156-102-29	NESW	LAMAR HUNT PAUL HARSTAD #1	2408	11600	11715
5015	155-96-31	SESE	HOME-STAKE PROD CO WOODROW N SVEEN ET UX #1	1945	10809	10930
5114	158-103-21	SENW	UNIVERSAL RESOURCES AGNES BURNS #1	2192	10590	10694
5373	154-103-7	SWNE	TREND EXPL CO & PATRICK PETROLEUM OYLOE-BANK OF N D #1-A	2254	11444	11550
5425	154-103-7	NWSE	TREND EXPL CO & PATRICK PETROLEUM O HAUGEN #1	2268	11466	11572
5528	157-95-29	SWNE	TIGER OIL CO OLSON #1-29	2313	10701	10811
5656	157-95-3	SWSW	TEXAKOTA, INC H BORSTAD #1	2468	10736	10858
5762	156-103-32	SENW	TURE OIL CO AAFEDT #22-32	2433	11458	11567
5871	157-97-2	NESW	SMOKEY OIL CO , INC FLATEN #23-2	2301	11345	11465
5968	154-95-9	SWSE	AMERADA HESS CORP. MENDENHALL UNIT #1	2266	11039	11160
5992	154-103-4	NESW	CAROLINE H. SCHOELLKOPF LOUISE OYLOE #1	2305	11575	11685
6029	157-95-16	SENE	TIGER OIL CO STATE OF N D #1-16	2427	10772	10892
6098	154-95-3	SENE	TIGER OIL CO HOVE #42-3	2022	11080	11200
6114	156-97-6	NENW	SMOKEY OIL CO WHEELER #21-6	2390	11764	11886
6306	155-101-4	NESW	TENNECO OIL CO JENSEN #1-4	2186	11551	11659
6362	155-95-18	NESW	AMERADA HESS CORP MARVIN IVERSON #23-18	2305	10840	10962

6478	155-100-5	SWSW	LAMAR HUNT SHAIDE-FLB #1	1910	11443	11550
6545	159-95-28	SESW	W. H. HUNT HAUG #1	2348	10523	10650
6604	155-101-4	SWNE	KISSINGER PETR. CORP. SCHWAB #7-4	2191	11603	11715
6687	154-95-16	SWNE	AMERADA HESS CORP. STATE "E" #32-16	2300	11100	11220
6702	157-101-30	NWSW	UNION TEXAS PETR. MELVIN ANDERSON #1	2383	11375	11485
6723	157-96-2	NESW	APACHE CORP. WILLIAMS-DELANEY #1-2	2423	11035	11158
6745	159-97-10	SESW	HUNT ENERGY CORP. HALVORSON-FLB #1	2317	10788	10915
6789	156-103-23	SWSW	ARGONAUT ENERGY CORP. BARKIE #1	2389	11435	11544
6806	155-101-8	NWNE	TENNECO OIL CO. BOOKE #1-8	2192	11564	11677
6847	158-101-10	SWNE	W.H. HUNT TRUST ESTATE TANGEN #1	2033	10585	10697
6896	157-100-22	NESE	W.H. HUNT TRUST ESTATE NJOS #1	2075	11204	11323
6975	155-100-16	SESE	LAMAR HUNT ROLFSTAD STATE #1	1951	11556	11670
7004	155-100-30	NESE	LAMAR HUNT TREFFERY #1	1898	11534	11647
7054	156-102-14	NENW	PATRICK PETR. CO. FEDJE #1	2151	11268	11380
7063	157-97-22	SWNW	HUNT ENERGY CORP. JOHNSON #1	2339	11602	11723
7115	154-95-1	NESE	KISSINGER PETR. CORP. MARMON #9-1	2124	11639	11761
7285	154-100-18	NESE	HARDY SALT CO. HARDY LEE #1	2002	11670	11783
7330	159-100-33	NENE	W.H. HUNT TRUST EST. DRAGSETH #1	2011	10515	10637

7405	155-99-8	SWNE	AL-AQUITAINE EXPLOR. LTD. BROWN #1-8	2116	11802	11920
7470	153-99-1	NESE	NORTHWEST EXPLOR. CO. LONG CREEK #2	2342	12292	12400
7503	153-104-36	SESE	GULF OIL CORP. MARLEY STATE #1-36-3C	2183	11544	11642
7565	158-96-26	SWNE	NORTHWEST EXPLOR. CO. NORMARK #1	2354	10895	11020
7595	158-95-15	SESE	ENERGETICS, INC. HOVE #44-15	2505	10738	10863
7632	153-104-25	SWNW	GULF OIL CORP. NORDELL #1-25-1D	2172	11529	11625
7692	155-102-24	SWSE	DEPCO, INC. MORTENSON #34-24	2192	11632	11743
7712	155-98-21	SWSW	SHELL OIL CO. KIRKPATRICK #14-21	2249	12136	12254
7848	158-100-2	NWSE	DEPCO, INC. SMITH #33-2	2140	10793	10913
7870	158-103-4	SWSE	DONALD SLAWSON ET AL TRIBAL #4-1	2146	10390	10493
7877*	158-95-18	SWSE	NORTHWEST EXPLORATION CO. PEDERSON #1	2388	10640	10776
7884	157-96-32	SWNW	GETTY OIL CO. TEMPLE PROSPECT #32-5	2317	11219	11341
8082	154-99-5	NWNW	TEXAS GAS EXPLORATION CORP. SPRINGBROOK-BIBLER #1-5	2200	11987	12103
8123	157-101-8	SWSW	UNIVERSAL RESOURCES CORP. BREVIK #1	2187	11074	11183
8316	159-102-18	SWSE	DEPCO, INC. FISCHER #34-18	2157	10332	10438
8413	156-97-14	SENW	DEPCO, INC. WITTROCK #22-14	2255	11268	11389
8423	154-102-9	SESW	GULF OIL CORPORATION ALFSON #1-9-4C	2155	11593	11701
8441	153-100-1	NENE	MAPCO PROCUCTION COMPANY TOFTE #1-1	2313	12165	12271

8571	155-102-9	SWNW	AL-AQUITAINE EXPLORATION, LTD. JORGENSON #1-9	2309	11566	11676
8861	156-99-31	SENW	AL-AQUITAINE EXPL. LTD. STONEYCREEK31-156-99HIEPLER1-31	2250	11856	11972
8862	155-100-22	NESE	TEXAS GAS EXPLORATION CORP. BROKAW #1-22	2129	11805	11920
8914	155-103-14	SENW	PUMA PETROLEUM CO. LEE #1-14	2289	11497	11607
8956	156-103-2	SWSW	PUMA PETROLEUM CO. MACMASTER #1-2	2328	11310	11419
9234	156-104-12	NENW	RAYMOND T. DUNCAN SUNDET #2-12	2480	11383	11478
9264	156-100-6	SWNW	NUCORP ENERGY, INC. DANIEL #1	1921	11210	11323
9282	158-102-3	NESW	MAPCO PRODUCTION COMPANY ROSS #11-3	2258	10693	10802
9296	159-96-31	SESW	DIAMOND SHAMROCK CORPORATION SMITH #24-31	2363	11084	11204
9323	159-98-25	NESW	TEXACO, INC. FEDERAL LAND BANK OF ST. PAUL #1	2295	10915	11035
9330	156-100-16	NESW	NUCORP ENERGY, INC. STATE 16 #1	2017	11443	11560
9395	154-103-20	NWNE	VIERSEN & COCHRAN GESSNER #1	2241	11515	11622
9412	159-103-33	NESW	HUNT OIL CO. LUNDBY #1-33	2073	10222	10325
9465	159-101-6	SWNE	NORTHWEST EXPLORATION CO. PHARRIS #1	2248	10369	10482

APPENDIX B

DAWSON BAY FORMATION (CARBONATE UNIT)

CORE AND THIN-SECTION DESCRIPTIONS

Cores and thin-sections are arranged alphabetically by county and numerically by North Dakota Geological Survey (NDGS) well numbers with counties. Core and thin-section depths are recorded from core-box labels as filed with the NDGS Wilson M. Laird Core and Sample Library. Thin-section descriptions are indicated by the designation, T.S., followed by the number of feet below the Kelly bushing from which the rock sample was obtained. NDGS well number, well location, well name, operator name, carbonate unit picks in feet below the Kelly bushing, and Kelly bushing elevation are given in each heading.

Description format is as follows: rock name (Folk's, 1959, classification system is followed by Dunham's, 1962, classification); minerals; color; allochems; orthochems; porosity; structures; ultraviolet light/chlorothene hydrocarbon test results (UV oil tests); and remarks. In each category the characteristics are listed in order of decreasing abundance. Percent abundances were determined by visual inspection and based on each interval described. Fossils are further subdivided into types and the percentages are based on the total fossil assemblage present in the sample.

Terminology used in the descriptions are those proposed by Choquette and Pray (1970); Dunham (1962); Folk (1959, 1965); Maiklem and others (1969); Mattes and Mountjoy (1980); Oyama and Takehara (1967); Schreiber (1981); and Wanless (1979).

CAVALIER COUNTY

NDGS #27
LOCATIONS: T159N-R63W-S28, NW NW
WELL NAME: CHRIS SKJERVHEIM #1
COMPANY: UNION OIL OF CALIFORNIA
DAWSON BAY FORMATION TOP DEPTH: 2128.6'
TOP OF THE SECOND RED BED MEMBER: 2270.4'
CORED INTERVAL: 2128.6'-2270.4'
KELLY BUSHING ELEVATION: 1562'

INTERVAL AND DESCRIPTIONS

2128.6'-2134'
NAME: Microcrystalline, peloidal, ostracod dolomite (wackestone).
MINERALS: Dolomite (95%) matrix; Calcite (4%) adjacent to fractures (dedolomitization?); Anhydrite (1%) fracture fill.
COLOR: Light brownish-gray (7.5YR7/2) with occasional subhorizontal dark red (7.5R3/4) iron oxide mottling.
ALLOCHEMS: Fossils (5-10%) ostracods (80%), gastropods (5%), and unidentified fragments (15%); Peloids (3%) micritic; Intraclasts (less than 1%).
ORTHOCHEMS: Dolomitized micrite (96%); Dedolomitized micrite (4%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic oxide mottling; Occasional subhorizontal Type II microstyolite swarm; Ripple laminations and intraclasts near top of section; Fractures (possible desiccation cracks) at upper contact associated with iron oxides.
UV OIL TESTS: Absent at 2132'.

T.S. 2128.6'
NAME: Dolomitized, calcisphere and brachiopod biomicrudite (wackestone).
MICRITE: (5%) dedolomitized adjacent to fractures.
FOSSILS: (15%) thin-shelled brachiopods (50%), unidentified fragment ghosts (40%), calcispheres (10%).
DOLOMITE: (75%) microcrystalline, euhedral rhombs.
INSOLUBLES: (1%) horizontal orientation.
HEMATITE: (5%) oxidized, associated with fractures and disconformable contact with formation above.
REMARKS: Color-mottling associated with diagenetic oxidation of hematite.

T.S. 2133'
NAME: Dolomitized, intraclastic, peloidal, brachiopod biomicrudite (wackestone)
INTRACLASTS: (2%) bioclastic dolomitized micrite composition.
PELOIDS: (5%) associated with larger brachiopod fragments.
FOSSILS: (5-10%) thin-shelled brachiopods (80%), unidentified fragments (20%).
DOLOMITE: (80-85%) microcrystalline euhedral rhomb matrix.
HEMATITE: (3%) oxidized, associated with bioclasts, fractures, and micro-vuggy porosity.

2134'-2137'

NAME: Microcrystalline, fossiliferous, peloidal dolomite (mudstone-wackestone).
MINERALS: Dolomite (100%)
COLOR: Mottled, light gray (7.5YR8/2) to dark red (7.5R3/4).
ALLOCHEMS: Peloids (5-10%); Fossils (2-5%) ostracods (50%), blue-green algae (30%), gastropods (20%).
ORTHOCHEMS: Dolomitized micrite (85-93%)
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling.

T.S. 2137'
NAME: Dolomitized, peloidal, fossiliferous intramicrudite (wackestone)
INTRACLASTS: (40%) rounded,with bioclasts, and occasional rimming by sparry and radial-axial pseudospar.
PELOIDS: (5%) dolomitized micrite composition.
FOSSILS: (10%) fragmental, thin-shelled brachiopods (100%), ostracods (less than 1%).
DOLOMITE: (42%) microcrystalline, euhedral rhomb matrix, and very finely crystalline, euhedral rhombs, occasionally associated with microstyolites.
INSOLUBLES: (2%) microstyolite associated.
HEMATITE: (1%) oxidized.

2137'-2141'
NAME: Microcrystalline, peloidal and fossiliferous dolomite (wackestone).
MINERALS: Dolomite (100%)
COLOR: Mottled, light gray (7.5YR8/2) to dark red (7.5R3/4).
ALLOCHEMS: Fossils (10%) ostracods (50%), unidentified fossil fragments (30%), gastropods (15%), blue-green algae (5-15%), brachiopods (1%); Peloids (10%).
ORTHOCHEMS: Dolomitized micrite (80%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Occasional subhorizontal Type I suture seam styolites.
UV OIL TESTS: Absent at 2138'.

2141'-2143'
NAME: Microcrystalline cryptalgal dolomite (boundstone).
MINERALS: Dolomite (100%).
COLOR: Mottled, grayish red (7.5R6/2) with dark red (7.5R3/4) and light gray (10YR8/1) along subhorizontal cryptalgal laminations.
ALLOCHEMS: Fossils (65%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (35%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Cryptalgal laminations; Occasionally very abundant Type II microstyolite swarms.
UV OIL TESTS: Absent at 2142'.

T.S. 2141'
NAME: Dolomitized, ostracod, brachiopod, and stromatoporoid biomicrudite (wackestone).
FOSSILS: (20%) unidentified fragments (35%), cylindrical

stromatoporoids (30%), brachiopod fragments (20%), echinoderm fragments (15%), ostracods (10%), calcispheres (1%).
DOLOMITE: (80%) microcrystalline-lower euhedral rhomb matrix; occasionally abundant, microcrystalline-upper, euhedral rhombs disseminated in matrix; and common microcrystalline dolomite euhedral rhombs adjacent to bioclasts.

2143'-2144'
NAME: Microcrystalline fossiliferous dolomite (wackestone).
MINERALS: Dolomite (100%).
COLOR: Mottled, light gray (10YR8/2) to dark red (7.5R3/4).
ALLOCHEMS: Fossils (20%) unidentified fragments (40%), brachiopod fragments (25%), bored cylindrical stromatoporoids (20%), ostracods (10%), echinoderm fragments (5%).
ORTHOCHEMS: Dolomitized micrite (80%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling.

2144'-2151'
NAME: Microcrystalline cryptalgal dolomite (boundstone).
MINERALS: Dolomite (100%).
COLOR: Mottled, grayish red (7.5R6/2) with dark red (7.5R3/4) and light gray (10YR8/1).
ALLOCHEMS: Fossils (50%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (50%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling controlled by subhorizontal cryptalgal laminations, and masking cryptalgal laminations. Occasional subvertical fracturing which controlled adjacent diagenetic color-mottling; Angular unconformity.
UV OIL TESTS: Absent at 2145' and 2150'.

T.S. 2145'
NAME: Dolomitized cryptalgal biolithite (boundstone).
FOSSILS: (40%) blue-green algae (?) (100%).
Dolomite: (59%) microcrystalline, euhedral rhomb matrix, and very-finely-crystalline, euhedral rhombs associated with cryptalgal laminations.
HEMATITE: (1%) oxidized, associated with cryptalgal laminations.
QUARTZ: (less than 1%) subrounded silt associated with cryptalgal laminations.
REMARKS: Fenestral fabric, occasionally well developed associated with cryptalgal laminations; Soft sediment deformation; Micro-angular unconformity.

T.S. 2149'
NAME: Dolomitized cryptalgal biolithite (boundstone).
FOSSILS: (50%) blue-green algae (?) (100%).
DOLOMITE: (49%) microcrystalline, euhedral rhomb matrix; very rare disseminated, very-finely-crystalline, euhedral rhombs.
HEMATITE: (1%) oxidized, associated with cryptalgal laminations and proximal to laminoid fenestral pores.

2151'-2157'

NAME: Fine-medium crystalline, fossiliferous dolomite (wackestone-boundstone).
MINERALS: Dolomite (100%)
COLOR: Light gray (10YR8/1) with light gray (7.5YR8/1) and abundant red (7.5R4/6).
ALLOCHEMS: Fossils (10-30%) cylindrical stromatoporoids (50%), tabular stromatoporoids (20%), disarticulated-fragmented brachiopods (20%), coral (10%).
ORTHOCHEMS: Dolomitized micrite (70-90%).
POROSITY: Intercrystalline, intraparticle, fracture.
STRUCTURES: Abundant subvertical fractures within stromatoporoids; Abundant Type I suture seam styolites near top of section.
UV OIL TESTS: Absent at 2153'.

T.S. 2153'
NAME: Dolomitized, peloidal, stromatoporoid biomicrudite (wackestone).
FOSSILS: (10%) unidentified fragments (40%), tabular stromatoporoids (30%), very-thin fragmental brachiopods (15%), echinoderm fragments (5%), encrusting blue-green algae (?) (5%), gastropods (3%), ostracods (1%),
PELOIDS: (5%) composed of dolomitized micrite.
DOLOMITE: (85%) microcrystalline, euhedral rhombs with dolomite rimming to filling pores.
HEMATITE: (less than 1%) oxidized, associated with fractures and microstyolites.

T.S. 2157'
NAME: Dolomitized, brachiopod and ostracod biomicrudite (wackestone).
FOSSILS: (10-15%) brachiopod spines and fragments (50%), ostracods (25%), unidentified fragments (23%), echinoderm fragments (2%).
DOLOMITE: (85-90%) microcrystalline-lower, euhedral rhomb matrix with abundant, dispersed, microcrystalline-upper euhedral rhombs.
HEMATITE: (less than 1%) proximal to fractures and larger brachiopods.

2157'-2165' Missing.

2165'-2181'
NAME: Very-finely-crystalline, stromatoporoid dolomite (boundstone).
MINERALS: Dolomite (30-80%); Calcite (20-70%) in bioclasts.
COLOR: Light gray (10YR8/1) with light gray (7.5YR8/1) and trace grayish red (7.5R7/1).
ALLOCHEMS: Fossils (20-70%) tabular stromatoporoids (65%), subspherical stromatoporoids (20%), cylindrical stromatoporoids (10%), articulated and disarticulated brachiopods (5%), rugosan coral (less than 1%).
ORTHOCHEMS: Dolomitized micrite (30-80%).
POROSITY: Intercrystalline, intraparticle, fracture.
STRUCTURES: Very abundant diagonal and subvertical fractures.
UV OIL TESTS: Absent at 2176'.

T.S. 2169'

NAME: Stromatoporoid biolithite (boundstone)
FOSSILS: (100%) tabular stromatoporoids (100%).
DOLOMITE: (less than 1%) microcrystalline, euhedral rhombs disseminated within tabular stromatoporoids.

T.S. 2173'
NAME: Dolomitized stromatoporoid biomicrudite (mudstone-wackestone).
MICRITE: (3%) matrix.
FOSSILS: (5-10%) tabular stromatoporoids (45%), cylindrical stromatoporoids (30%), brachiopod fragments (20%), red algae (?) (5%).
DOLOMITE: (87-92%) microcrystalline, euhedral rhomb matrix and abundant, medium crystalline dispersed euhedral rhombs, and minor dolomite filling to rimming pores and fractures.
QUARTZ: (less than 1%) subrounded silt.
REMARKS: Abundant subvertical fractures which are commonly healed to partially healed by dolomite euhedral rhombs.

T.S. 2177'
NAME: Dolomitic, stromatoporoid and anthozoan biomicrudite (packstone).
MICRITE: (10%) matrix.
FOSSILS: (70%) tabular stromatoporoids (50%), rugosan corals (50%)
DOLOMITE: (20%) finely-crystalline, euhedral rhombs disseminated in matrix, and rimming pores.

T.S. 2181'
NAME: Dolomitized fossiliferous biomicrudite (mudstone).
FOSSILS: (5%) unidentified fragments (90%), thin fragmented brachiopods (5%).
DOLOMITE: (95%) microcrystalline, euhedral rhomb matrix and minor very-finely-crystalline, euhedral rhombs rimming pores.

2181'-2183'
NAME: Microcrystalline stromatoporoid dolomite (wackestone)
MINERALS: Dolomite (90%); Calcite (10%) fossils.
COLOR: Light gray 10YR8/1).
ALLOCHEMS: Fossils (10%) tabular stromatoporoids (80%), brachiopods (20%).
ORTHOCHEMS : Dolomitized micrite (90%).
POROSITY: Intercrystalline, pin-point vuggy, partially healed fracture, moldic.
STRUCTURES: Occasional partially healed fractures.
UV OIL TESTS: Show at 2182'.

2183'-2193'
NAME: Microcrystalline brachiopod dolomite (wackestone).
MINERALS: Dolomite (90%); Calcite (10%) fossils.
COLOR: Mottled, reddish gray (7.5R6/1) microcrystalline matrix and light reddish gray (7.5R7/1) medium crystalline euhedral rhombs associated with porosity.
ALLOCHEMS: Fossils (10%) brachiopods (90%), tabular stromatoporoids (10%).
UV OIL TESTS: Absent at 2189'.

T.S. 2185'

NAME: Dolomitized fossiliferous biomicrudite (mudstone)
FOSSILS: (3%) unidentified molds and recrystallized fragments (100%).
DOLOMITE: (97%) microcrystalline, euhedral rhomb matrix and minor very-finely-crystalline, euhedral rhombs rimming pores.

T.S. 2189'

NAME: Dolomitized fossiliferous biomicrudite (wackestone).
FOSSILS: (10%) unidentified molds and recrystallized fragments (95%), cylindrical stromatoporoids (5%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix and minor finely crystalline, euhedral rhombs rimming to partially filling pores.

T.S. 2193'

NAME: Dolomitized fossiliferous biomicrudite (wackestone).
FOSSILS: (10%) unidentified molds-vugs (100%).
DOLOMITE: (90%) very-finely-crystalline.
QUARTZ: (less than 1%) subrounded silt.

2193'-2224.3'

NAME: Very-finely-crystalline fossiliferous dolomite (wackestone).
MINERALS: Dolomite (100%).
COLOR: Light yellow-orange (10YR8/3) with rare dull orange (5YR7/3) diagenetic color-mottling associated with, stromatoporoid replacing, medium crystalline dolomite.
ALLOCHEMS: Unidentified fossil fragments (30%), subspherical stromatoporoids (25%), cylindrical stromatoporoids (20%), brachiopods (10%), bryozoans (10%), corals (5%). Intraclasts (2-5%) with possible bioclast ghosts.
ORTHOCHEMS: Dolomitized micrite (85%).
POROSITY: Moldic, intercrystalline.
STRUCTURES: Occasional healed subvertical fractures.
UV OIL TESTS: Absent at 2198', 2205', 2211', 2215', 2219', 2223'.

T.S. 2197'

NAME: Dolomitized fossiliferous biomicrudite (wackestone).
FOSSILS: (10-15%) unidentified molds-vugs (98%), brachiopods (2%).
DOLOMITE: (80-85%) microcrystalline-very finely crystalline, euhedral rhomb matrix; Occasional dolomite-healed fractures appear as lighter colored, very-finely-crystalline, euhedral rhombs, in a linear trend.

T.S. 2201'

NAME: Dolomitized fossiliferous biomicrudite (mudstone).
FOSSILS: (3-5%) unidentified molds-vugs (100%).
DOLOMITE: (95-97%) microcrystalline, euhedral rhomb matrix with rare very-finely-crystalline, euhedral rhombs rimming to partially filling pores.
QUARTZ: (less than 1%) subrounded silt.

T.S. 2205'

NAME: Dolomitized fossiliferous biomicrudite (mudstone-wackestone).

FOSSILS: (5-10%) unidentified molds-vugs (100%).
DOLOMITE: (90-95%) microcrystalline, euhedral rhomb matrix and minor finely-crystalline, euhedral rhombs rimming pores.

T.S. 2209'
NAME: Dolomitized fossiliferous biomicrudite (wackestone).
FOSSILS: (10%) unidentified molds-vugs (100%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix and minor very-finely-crystalline to finely-crystalline, euhedral rhombs rimming pores.

T.S. 2213'
NAME: Dolomitized brachiopod biomicrudite (wackestone).
FOSSILS: (10%) unidentified molds (95%), brachiopod fragments (5%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix and very-finely-crystalline, euhedral rhombs rimming to filling moldic pores.

T.S. 2217'
NAME: Dolomitized brachiopod biomicrudite (wackestone).
FOSSILS: (10%) unidentified molds (90%), brachiopod fragments (10%).
DOLOMITE: Microcrystalline, euhedral rhomb matrix and minor finely-crystalline, euhedral rhombs rimming pores.

T.S. 2221'
NAME: Dolomitized, peloidal, stromatoporoid biomicrudite (wackestone).
PELOIDS: (10%) Ghosts.
FOSSILS: (15%) subspherical stromatoporoid (90%), unidentified molds (10%).
DOLOMITE: (75%) very-finely-crystalline (lower), euhedral rhomb matrix and occasional very-finely-crystalline (upper), euhedral rhombs rimming pores.

T.S. 2225'
NAME: Dolomitized brachiopod biomicrudite (wackestone).
FOSSILS: (10%) unidentified molds (90%), brachiopod molds (10%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix and minor finely-crystalline, euhedral rhombs rimming pores.

2224.3'-2228'
NAME: Very-finely-crystalline stromatoporoid dolomite (wackestone-packstone).
MINERALS: Dolomite (100%).
COLOR: Light yellow-orange (10YR8/3) with occasional dull orange (5YR7/3).
ALLOCHEMS: Fossils (10-15%) cylindrical stromatoporoid (40%), brachiopods (30%), subspherical stromatoporoid (20%), bryozoan (10%).
ORTHOCHEMS: Dolomitized micrite (85-90%).
POROSITY: Moldic, intercrystalline, fracture-channel.
STRUCTURES: Very-abundant irregularly oriented fractures.
UV OIL TESTS: Absent at 2227.4'.

2228'-2232'

NAME: Microcrystalline stromatoporoid dolomite (wackestone).
MINERALS: Dolomite (100%).
COLOR: Mottled, light gray (5YR8/1) to dull reddish-brown (7.5R4/3).
ALLOCHEMS: Fossils (8-20%) tabular stromatoporoid (25%), subspherical stromatoporoid (25%), cylindrical stromatoporoid (25%), brachiopods (20%), coral (5%). Stromatoporoids are dolomitized with finely crystalline dolomite euhedral rhombs.
ORTHOCHEMS: Dolomitized micrite (80-92%).
POROSITY: Pin-point vuggy, intercrystalline, moldic (stromatoporoids).
STRUCTURES: Rare subvertical fractures.
UV OIL TESTS: Absent at 2230.7'.

T.S. 2229'

NAME: Dolomitized brachiopod biomicrudite (wackestone).
FOSSILS: (10%) Brachiopod molds (70%), unidentified molds (30%).
DOLOMITE: (90%) microcrytstalline euhedral rhombs, with very finely crystalline, euhedral rhombs rimming pores.
HEMATITE: (less than 1%) associated with moldic porosity.
REMARKS: Diagenesis proceeded as follows: Dolomitization of biomicrudite and dissolution of fossils; Oxidation of hematite adjacent to moldic pores; Rimming of moldic pores by very-finely-crystalline dolomite, euhedral, rhombs.

2232'-2234.3'

NAME: Microcrystalline brachiopod dolomite (wackestone).
MINERALS: Dolomite (100%).
COLOR: Mottled, light gray (5YR8/1) to dull reddish brown (7.5R4/3).
ALLOCHEMS: Fossils (10-15%) brachiopods with spiral brachidium (80%), echinoderm fragments (20%).
ORTHOCHEMS: Dolomitized micrite (85-90%).
POROSITY: Intercrystalline, pin-point vuggy, moldic.
STRUCTURES: Diagenetic color-mottling; Occasional dolomite healed fracture.
UV OIL TESTS: Absent at 2233'.

T.S. 2233'

NAME: Dolomitized brachiopod biomicrudite (wackestone).
FOSSILS: (10%) brachiopod molds of disarticulated shells (50%), unidentified fragment molds (40%), echinoderm fragment molds (10%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix and sparse very-finely-crystalline, euhedral rhombs rimming pores.
HEMATITE: (1%) associated with moldic-vuggy pores.

2234.3'-2236.2'

NAME: Microcrystalline brachiopod dolomite (wackestone-packstone).
MINERALS: Dolomite (95%); Calcite (5%) fossils.
COLOR: Mottled, light brownish-gray (7.5YR7/1) and light gray (7.5YR8/2).
ALLOCHEMS: Fossils (20%) brachiopods (100%).
ORTHOCHEMS: Dolomitized micrite (80%).
POROSITY: Moldic, vuggy, intercrystalline.

STRUCTURES: Extensive diagenetic color-mottling; Occasional to abundant subvertical partially healed fractures.
UV OIL TESTS: Absent at 2235.5'.

2236.2'-2237'

NAME: Very-finely-crystalline brachiopod dolomite (mudstone-wackestone).
MINERAL: Dolomite (95%); calcite (5%) fossils.
COLOR: Mottled, light gray (10YR8/1) and dull yellow-orange (10YR7/2).
ALLOCHEMS: Fossils (5-10%) unidentified fossil fragments-molds (50%), brachiopod fragments-molds (40%), echinoderm fragments (10%).
ORTHOCHEMS: Dolomitized micrite (90-95%).
POROSITY: Intercrystalline, moldic-vuggy near top of section.
STRUCTURES: Diagenetic color-mottling.

T.S. 2237'

NAME: Dolomitized brachiopod biomicrudite (waskestone-packstone)
FOSSILS: (30%) brachiopod fragments (50%), unidentified fragments (30%), echinoderm fragments (20%).
DOLOMITE: (70%) microcrystalline, euhedral rhomb matrix.
HEMATITE: (less than 1%) associated with bioclasts.

2237'-2246.3'

NAME: Very-finely-crystalline brachiopod dolomite (wackestone-packstone).
MINERALS: Dolomite (90%); calcite (10%) bioclasts.
COLOR: Mottled, light gray (10YR8/1) with occasionally abundant dark red (7.5R3/6).
ALLOCHEMS: Fossils (10%) articulated brachiopods and fragments (50-60%), ostracods (20%), unidentified fossil fragments (20%), echinoderm fragments (2-10%), gastropods (2%), trilobite fragments (less than 1%), rugosan corals (less than 1%).
ORTHOCHEMS: Dolomitized micrite (90%).
POROSITY: Intercrystalline, vuggy, moldic.
STRUCTURES: Diagenetic color-mottling; Occasional Type II microstyolite swarm with dark red color-mottling due to oxidation of hematite; Occasional subvertical microfractures with proximal dark red color-mottling.
UV OIL TESTS: Show at 2238.5'; Absent at 2238.5', 2242.8' and 2245.5'.

T.S. 2241'

NAME: Dolomitized brachiopod biomicrudite (wackestone).
FOSSILS: (10-15%) brachiopods (35%), unidentified fossil fragments (25%), gastropods (20%), echinoderm fragments (10%), ostracods (10%).
DOLOMITE: (85-90%) microcrystalline, euhedral rhomb matrix and occasional dispersed very-finely-crystalline, euhedral rhombs, and minor dolomite rimming pores.
HEMATITE: (1-2%) associated with moldic porosity.
REMARKS: Oxidation of hematite proximal to moldic pores was followed by dolomite rimming.

T.S. 2245'

NAME: Dolomitized brachiopod biomicrudite (wackestone-packstone).

FOSSILS: (20-30%) articulated and fragmental brachiopods (45%), gastropods (25%), unidentified fragments (20%), ostracods (10%), echinoderm fragments (5%), bryozoan (1%), trilobite fragments (less than 1%).

DOLOMITE: (70-80%) microcrystalline, euhedral rhomb matrix and minor dolomite filling fractures.

HEMATITE: (less than 1%) oxidized, associated with moldic porosity.

REMARKS: A (0.1 mm wide) dolomite filled discontinuous fracture is present.

2246.3'-2249'

NAME: Very-finely-crystalline brachiopod dolomite (wackestone-packstone).

MINERALS: Dolomite (85-90%); Calcite (10-15%) bioclasts.

COLOR: Light gray (10YR8/1).

ALLOCHEMS: Fossils (10-15%) brachiopods (50-60%), ostracods (20%), unidentified fragments (20%), echinoderm fragments (2-10%), gastropods (2%), trilobite fragments (less than 1%).

ORTHOCHEMS: Dolomitized micrite (85-90%).

POROSITY: Intercrystalline, vuggy-moldic.

UV OIL TESTS: Absent at 2248'.

T.S. 2248.5'

NAME: Dolomitized brachiopod biomicrudite (packstone).

FOSSILS: (60%) pseudopunctate and punctate brachiopods (85%), unidentified fragments (10%), echinoderm fragments (5%).

DOLOMITE: (40%) microcrystalline, euhedral rhomb matrix and occasional, very-finely-crystalline, dispersed euhedral rhombs.

REMARKS: Bioclasts commonly recrystallized followed by micritization and dolomitization.

2249'-2254'

NAME: Very-finely-crystalline brachiopod dolomite (wackestone).

MINERALS: Dolomite (100%) matrix and rimming pores.

COLOR: Mottled, light gray (10YR8/1) with very abundant red (7.5R4/8) oxide staining.

ALLOCHEMS: Fossils (10%) articulated and fragmented brachiopods (60%), ostracods (30%), echinoderm fragments (8%), gastropods (2%).

ORTHOCHEMS: Dolomitized micrite (90%).

POROSITY: Intercrystalline, rare vuggy.

STRUCTURES: Very common diagenetic color-mottling associated with microfractures and proximal to bioclasts.

UV OIL TESTS: Show at 2250.3'.

T.S. 2252'

NAME: Dolomitized brachiopod biomicrudite (packstone).

FOSSILS: (50-60%) brachiopod fragments (80%), ostracods (4%), unidentified fragments (4%), echinoderm fragments (2%).

DOLOMITE: (40-50%) Microcrystalline, euhedral rhomb matrix.

2254'-2259.5'

NAME: Very-finely-crystalline brachiopod dolomite (wackestone-mudstone).
MINERALS: Dolomite (100%) matrix and rimming pores.
COLOR: Mottled, light gray (10YR8/1) with minor reddish brown (2.5YR4/6) associated with microfractures.
ALLOCHEMS: Fossils (1-10%) articulated and fragmented brachiopods (60%), ostracods (30%), echinoderm fragments (8%), gastropods (2%).
ORTHOCHEMS: Dolomitized micrite (90-99%).
POROSITY: Intercrystalline, vuggy, microfracture.
STRUCTURES: Occasional Type II microstyolite swarm, Rare Type I suture seam styolite associated with wackestone/ mudstone contact; Occasional irregularly oriented microfracture;
UV OIL TESTS: Show at 2254.1'; Absent at 2259'.

2259.5'-2261'
NAME: Very-finely-crystalline brachiopod dolomite (mudstone).
MINERALS: Dolomite (100%).
COLOR: Light gray (10YR7/1).
ALLOCHEMS: Fossils (0-2%) brachiopod fragments (100%).
ORTHOCHEMS: Dolomitized micrite (98%).
POROSITY: Intercrystalline, fracture (rare), moldic (rare).
STRUCTURES: Occasional partially healed subvertical to irregularly oriented fractures.

T.S. 2261'
NAME: Dolomitized fossiliferous biomicrudite (wackestone).
FOSSILS: (10%) unidentified fragments (80%), ostracod molds (15%), articulated and fragmental brachiopod molds (5%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix and very minor dolomite filling moldic pores.

2261'-2264.5'
NAME: Microcrystalline brachiopod dolomite (wackestone-packstone).
MINERALS: Dolomite (70-90%); Calcite (10-30%) bioclasts.
COLOR: Mottled, light gray (10YR7/1) to grayish red (7.5R6/2).
ALLOCHEMS: Fossils (10-30%) brachiopod fragments (70%), ostracods (30%).
ORTHOCHEMS: Dolomitized micrite matrix (70-90%) and rimming pores.
POROSITY: Intercrystralline, moldic, pin-point vuggy, vuggy.
STRUCTURES: Diagenetic color-mottling; Rare subvertical microfractures, occasionally dolomite filled.
UV OIL TESTS: Absent at 2261.2', 2262.1' and 2264'.

T.S. 2263.8'
NAME: Dolomitized brachiopod biomicrudite (mudstone).
FOSSILS: (less than 1%) brachiopod fragment ghosts (50%), unidentified fragment ghosts (50%).

2264.5'-2268.1'
NAME: Microcrystalline fossiliferous dolomite (wackestone-packstone).
MINERALS: Dolomite (80%); Calcite (20%) bioclasts.
COLOR: Mottled, light gray (10YR7/1) to light gray (10YR8/1) with

rare dark red (7.5R3/6) iron oxide associated with rare microstyolites.
ALLOCHEMS: Fossils (20-30%) ostracod fragments (30%), unidentified fragments (30%), fragmented brachiopods (20%), echinoderm fragments (20%).
ORTHOCHEMS: Dolomitized micrite (70-80%).
POROSITY: Intercrystalline, moldic-vuggy.
STRUCTURES: Diagenetic color-mottling; Occasional irregularly oriented and discontinuous fractures which controlled late fine-medium crystalline dolomitization and healed fractures; Occasional Type I suture seam styolites; Subvertical open fractures which cross-cut all earlier structures.
UV OIL TESTS: Absent at 2267.8' and 2266'.

2268.1'-2268.6'
NAME: Very-finely-crystalline, echinoderm and brachiopod dolomite (wackestone/packstone).
MINERALS: Dolomite (90%); Calcite (10%) bioclasts.
COLOR: Mottled,light gray (10YR7/1) matrix with diagenetic "pseudoburrows" having a red (10R4/6) diffuse outline and a light gray (10YR8/1) interior.
ALLOCHEMS: Fossils (15-20%) brachiopod fragments (40%), echinoderm fragments (40%), unidentified fragments (15%), gastropods (5%).
ORTHOCHEMS: Dolomitized micrite (80-85%).
POROSITY: Intercrystalline.
STRUCTURES: Bioclast associated diagenetic color-mottling resulting in "pseudoburrows".
UV OIL TESTS: Absent at 2268.4'.

2268.6'-2269.3'
NAME: Microcrystalline brachiopod and echinoderm dolomite (wackestone/packstone).
MINERALS: Dolomite (90%); Calcite (10%) bioclasts.
COLOR: Mottled, light gray (10YR8/1) matrix to oxidized dull yellow-orange (10YR7/2).
ALLOCHEMS: Fossils (15-20%) echinoderm fragments (40%), brachiopod fragments (40%), unidentified fragments (15%), gastropods (5%).
ORTHOCHEMS: Dolomitized micrite (80-85%).
POROSITY: Intercrystalline, moldic.
UV OIL TESTS: Absent at 2269'.

T.S. 2269'
NAME: Dolomitized echinoderm biomicrudite (mudstone).
FOSSILS: (5%) echinoderm fragments and molds (100%), dolomite euhedral rhomb replacement along fragment boundaries.
DOLOMITE: (95%) microcrystalline, euhedral rhomb matrix and very-finely-crystalline, euhedral rhomb replacement along echinoderm fragment boundaries.
BITUMENS: (less than 1%) disseminated.
QUARTZ: (less thanless than 1%) disseminated subrounded silt with (0.1 mm) average diameter.
REMARKS: A single discontinuous Type II microstyolite is present in the thin-section.

2269.3'-2269.9'

NAME: Microcrystalline fossiliferous dolomite (mudstone).
MINERALS: Dolomite (100%).
COLOR: Mottled, light gray (10YR8/1) matrix and dull yellow-orange (10YR7/2) associated with diagenetic oxidation.
ALLOCHEMS: Fossils (0-3%) unidentified fragments (70%), gastropods (30%).
ORTHOCHEMS: Dolomitized micrite (97%).
POROSITY: Intercrystalline, moldic (rare).
STRUCTURES: Subhorizontal diagenetic color-mottling.

2269.9'-2270.4'

NAME: Microcrystalline fossiliferous dolomite (packstone).
MINERALS: Dolomite (100%).
COLOR: Mottled, light gray (10YR7/1) with minor red (10R6/8) iron oxide.
ALLOCHEMS: Fossils (30%) unidentified fragments (50%), gastropods (30%), brachiopods (10%), encrusting algae (?) (10%).
ORTHOCHEMS: Dolomitized micrite (70%).
POROSITY: Intercrystalline, moldic, vuggy.
STRUCTURES: Minor diagenetic color-mottling; Occasional, subparallel and subvertical fractureswhich are partially healed by very-finely-crystalline dolomite.
UV OIL TESTS: Absent at 2270.1'.
REMARKS: Base of the Dawson Bay carbonates.

T.S. 2270.4'

NAME: Dolomitized echinoderm biomicrudite (mudstone).
FOSSILS: (5%) echinoderm fragment molds (100%).
DOLOMITE: (95%) microcrystalline-lower, euhedral rhomb matrix and occasional microcrystalline-upper euhedral rhombs, disseminated and associated, with microstyolites or rimming moldic pores.
BITUMENS: (less than 1%) disseminated.
HEMATITE: (less than 1%) associated with Type II microstyolite swarms and proximal to pores.
QUARTZ: (less than 1%) rounded to subangular silt, (0.1 mm) average diameter, disseminated and very commonly associated with microstyolites.
REMARKS: Second Red Bed contact.

2270.4'-

NAME: Very-finely-crystalline, intraclastic dolomite (wackestone).
MINERALS: Dolomite (100%); Hematite (less than 1%).
COLOR: Light gray (10YR7/1) matrix with minor red (10R6/8) iron oxide mottling.
ALLOCHEMS: Intraclasts (10%); Fossils (2%) blue-green algae (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
ORTHOCHEMS: Dolomitized micrite (88%).
POROSITY: Intercrystalline.
STRUCTURES: Cryptalgal laminations (?); Diagenetic color-mottling; Occasional subvertical subparallel partially healed fractures.
UV OIL TESTS: Absent at 2271'.

CAVALIER COUNTY

NDGS #31
LOCATION: T160N-R60W-S32, NW SW
WELL NAME: WOHLETZ #1
COMPANY: UNION OIL COMPANY
DAWSON BAY FORMATION TOP DEPTH: 1721'
TOP OF THE SECOND RED BED MEMBER: 1832'
CORED INTERVAL: 1721'-1785'
KELLY BUSHING ELEVATION: 1612'

INTERVAL AND DESCRIPTIONS

-1721'
NAME: Dolomitic fossiliferous limestone (packstone).
MINERALS: Calcite (80%); Dolomite (20%) microcrystalline euhedral rhombs; Hematite (less than 1%).
COLOR: Dull yellow-orange (10YR7/3) oxidized.
ALLOCHEMS: Fossils (30%) brachiopods (45%) with articulated shells, cylindrical stromatoporoids (40%), tabular stromatoporoids (15%).
ORTHOCHEMS: Micrite (60%); Dolomitized micrite (10%).
POROSITY: Intraparticle, intercrystalline.
UV OIL TESTS: Show at 1720.6'.
REMARKS: Basal Souris River Formation.

1721'-1722'
NAME: Very-finely-crystalline, cryptalgal, dolomite (boundstone).
MINERALS: Dolomite (99%); Hematite (1%).
COLOR: Mottled, light reddish-gray (10R7/1) matrix with dark reddish-brown (7.5R3/3) associated with cryptalgal laminations and diffuse boundaries of "pseudoburrows".
ALLOCHEMS: Fossils (30%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (70%).
POROSITY: Intercrystalline.
STRUCTURES: Cryptalgal laminations; Diagenetic-mottling resulting in subhorizontal cryptalgal controlled "pseudoburrows"; Occasional subvertical cross-cutting microfractures.
UV OIL TESTS: Absent at 1721.2'.
REMARKS: Upper Dawson Bay Formation.

T.S. 1722'
NAME: Dolomitized cryptalgal biolithite (boundstone).
FOSSILS: (30%) blue-green algae (?) (100%).
DOLOMITE: (68%) microcrystalline, euhedral rhomb matrix.
HEMATITE: (1%) oxidized, cryptalgal and "pseudoburrow" diffuse boundary association.
QUARTZ: (1%) subrounded to subangular silt, with occasional very-fine-grained sand, disseminated in mudstone matrix and associated with cryptalgal laminations.
STRUCTURES: Irregularily oriented fenestral fabric; controlled by subhorizontal cryptalgal laminations.

1722'-1722.8'
NAME: Very-finely-crystalline, brachiopod, dolomite (wackestone).
MINERALS: Dolomite (99%); Hematite (1%).

COLOR: Mottled, light gray (5YR8/2) matrix with diffuse dark red (7.5R3/4) boundaries of "pseudoburrows".
ALLOCHEMS: Fossils (10%) brachiopods (100%).
ORTHOCHEMS: Dolomitized micrite (90%).
POROSITY: Intercrystalline, vuggy (occasionally).
STRUCTURES: Irregularily oriented, bioclast associated, "pseudoburrows".
UV OIL TESTS: Absent at 1722.5'.

1722.8'-1723.3'
NAME: Very-finely-crystalline, brachiopod, dolomite (packstone).
MINERALS: Dolomite (99%); Hematite (1%).
COLOR: Mottled, light gray (5YR8/2) matrix with diffuse dark red (7.5R3/4) solution boundaries.
ALLOCHEMS: Fossils (20%) brachiopods (100%).
ORTHOCHEMS: Dolomitized micrite (80%).
POROSITY: Moldic, intercrystalline, pin-point vuggy.
STRUCTURES: Irregularily to vertically oriented color-mottling, occasionally forming "pseudoburrows".

1723.3'-1725.2'
NAME: Very-finely-crystalline, cryptalgal, dolomite (boundstone).
MINERALS: Dolomite (98%); Hematite (1%); Clay (1%).
COLOR: Mottled, light gray (5YR8/2) matrix with minor light reddish-gray (10R7/1) discontinuous subhorizontal oxidation associated with cryptalgal laminations.
ALLOCHEMS: Fossils (20%) blue-green algae (?) (100%) largely obscured by nearly pervasive color-mottling.
ORTHOCHEMS: Dolomitized micrite (80%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Common color-mottling obscured cryptalgal laminations; Occasional light-green clay associated with cryptalgal intraclasts in the upper 15 cm. Subvertical and subhorizontal microfractures in intraclast zones.

1725.2'-1725.6'
NAME: Microcrystalline cryptalgal dolomite (boundstone).
MINERALS: Dolomite (99%); Hematite (1%).
COLOR: Mottled, light gray (5YR8/2) matrix with dark red (7.5R3/4) diffuse boundaries of cryptalgal and vertically oriented, tubular, fenestral pores associated with diagenetic color-mottling.
ALLOCHEMS: Fossils (20%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (80%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Cryptalgal laminations; Relict subvertical tubular fenestral fabric. A single, subhorizontal, anastomosing microfracture near the top of the section.
UV OIL TESTS: Show at 1725.5'.

1725.6'-1727
NAME: Very-finely-crystalline, cryptalgal, dolomite (boundstone).
MINERALS: Dolomite (99%); Hematite (1%).
COLOR: Mottled, light gray (5YR8/2) matrix with dark red (7.5R3/4)

associated with cryptalgal laminations
ALLOCHEMS: Intraclasts (70%) of cryptalgal lamination composition; Fossils (5%) blue-green algae (?).
ORTHOCHEMS: (25%) dolomitized micrite.
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Cryptalgal intraclasts; Cryptalgal laminations with common (mm) scale unconformities.

T.S. 1726'
NAME: Dolomitized cryptalgal biolithite (boundstone).
FOSSILS: (30%) blue-green algae (?) (100%).
DOLOMITE: (69%) microcrystalline, euhedral rhomb matrix, and minor very-finely-crystalline, euhedral rhombs rimming vuggy pores.
HEMATITE: (1%) oxidized, associated with cryptalgal laminations.
QUARTZ: (less than 1%) subrounded silt associated with cryptalgal laminations.

1727'-1727.4'
NAME: Microcrystalline cryptalgal dolomite (boundstone).
MINERALS: Dolomite (100%); Hematite (less than 1%).
COLOR: Mottled, light yellow-orange (7.5YR8/3) with dark red (7.5R3/4) associated with nearly obscured cryptalgal laminations and diffuse boundaries of "pseudoburrows".
ALLOCHEMS: Fossils (15%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (85%).
POROSITY: Intercrystalline, microfracture (rare).
STRUCTURES: Cryptalgal laminations (nearly obscured by color-mottling); Diagenetic color-mottling to the point of nearly complete distruction of original fabric; Diagenetic solution "pseudoburrows"; Subvertically (tubular) and subhorizontal (laminoid) fenestral fabric; Rare, subvertical, cross-cutting microfractures.

1727.4'-1727.5'
NAME: Microcrystalline cryptalgal dolomite (boundstone).
MINERALS: Dolomite (100%); Hematite (less than 1%).
COLOR: Mottled, light yellow-orange (7.5YR8/3) with dark red (7.5R3/4) diffuse iron oxide associated with subhorizontal cryptalgal laminations.
ALLOCHEMS: Fossils (30%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (70%).
POROSITY: Intercrystalline, vuggy (occasionally), channel (occasionally).
STRUCTURES: Diagenetic color-mottling; Cryptalgal laminations; Channel porosity is open and the result of dissolution enlargement of more porous cryptalgal partings.

1727.5'-1727.7'
NAME: Microcrystalline cryptalgal dolomite (boundstone).
MINERALS: Dolomite (99%); Hematite (1%).
COLOR: Mottled, light yellow-orange (7.5YR8/3) with dark red (7.5R3/4) associated with cryptalgal laminations.
ALLOCHEMS: Fossils (30%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (70%).

POROSITY: Intercrystalline.
STRUCTURES: Cryptalgal laminations; Diagenetic color-mottling; Rare anhydrite laths which partially fill microfractures.

1727.7'-1728'
NAME: Microcrystalline, intraclastic, cryptalgal dolomite (boundstone).
MINERALS: Dolomite (99%); Hematite (1%). Anhydrite (less than 1%) laths in moldic-channel porosity.
COLOR: Pale reddish-orange (2.5YR7/3).
ALLOCHEMS: Fossils (20%) blue-green algae (?) (100%); Intraclasts (3%) cryptalgal composition.
ORTHOCHEMS: Dolomitized micrite (77%).
POROSITY: Intercrystalline, moldic-channel.
STRUCTURES: Cryptalgal laminations; Intraclasts of cryptalgal composition; Diagenetic color-mottling; Rare microfracture.

1728'-1728.8'
NAME: Microcrystalline, brachiopod and cryptalgal dolomite (boundstone).
MINERALS: Dolomite (99%); Hematite (1%).
COLOR: Mottled, light gray (5YR8/2) with dark red (7.5R3/4) diffuse "pseudoburrow" boundaries and dull reddish-orange (10R6/3) associated with cryptalgal laminations.
ALLOCHEMS: Fossils (30%) blue-green algae (?) (95%), brachiopods (5%).
ORTHOCHEMS: Dolomitized micrite (70%).
POROSITY: Intercrystalline, pin-point vuggy.
STRUCTURES: Diffuse, relict, cryptalgal laminations; Diagenetic color-mottling controlled by, subhorizontal, cryptalgal laminations and resulting in (6 cm) wide "pseudoburrows" with occasional enclosed cryptalgal laminations.

T.S. 1728.5'
NAME: Dolomitized, peloidal, cryptalgal biolithite (boundstone).
PELOIDS: (10%) associated with diffuse cryptalgal laminations.
FOSSILS: (15%) blue-green algae (?) (100%) as diffuse, oxidized, relict cryptalgal laminations.
DOLOMITE: (73%) microcrystalline, euhedral rhomb matrix.
HEMATITE: (2%) oxidized along diffuse subhorizontal concentrations and disseminated.

1728.8'-1729'
NAME: Very-finely-crystalline, intraclastic, cryptalgal dolomite (boundstone).
MINERALS: Dolomite (98%); Hematite (2%).
COLOR: Mottled, light gray (10YR8/2) with light reddish-gray (7.5R7/1).
ALLOCHEMS: Fossils (20%) blue-green algae (?) (100%); Intraclasts (3%) of diffuse, color-mottled, cryptalgal composition.
ORTHOCHEMS: Dolomitized micrite (77%).
POROSITY: Pin-point vuggy, microfracture.
STRUCTURES: Diffuse, relict, cryptalgal laminations; Diagenetic color-mottling of all structures; Diffuse, relict, laminoid

fenestral fabric; Abundant subvertical microfractures in less color-mottled matrix and healed where color-mottled.
UV OIL TESTS: Absent at 1728.9'.

1729'-1729.5'
NAME: Very-finely-crystalline, brachiopod and cryptalgal dolomite (boundstone).
MINERALS: Dolomite (98%); Hematite (2%).
COLOR: Mottled, light gray (10YR8/2) with light reddish-gray (7.5R7/1).
ALLOCHEMS: Fossils (20%) blue-green algae (?) (90%), brachiopod fragments (10%).
ORTHOCHEMS: Dolomitized micrite (80%).
POROSITY: Intercrystalline.
STRUCTURES: Diffuse, relict, cryptalgal laminations; Diagenetic color-mottling; Diffuse, relict, laminoid fenestral fabric.

1729.5'-1730
NAME: Very-finely-crystalline, cryptalgal, dolomite (boundstone).
MINERALS: Dolomite (100%); Hematite (less than 1%).
COLOR: Mottled, light gray (10YR8/2) matrix with dark reddish-brown (7.5R3/3) diffuse boundaries of cryptalgal laminations, "pseudoburrows", and laminoid fenestral fabric.
ALLOCHEMS: Fossils (15%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (85%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling resulting in the diffuse appearance of all structures and (2-3 cm) wide subhorizontal cryptalgal lamination controlled "pseudoburrows". Diffuse, relict, cryptalgal laminations; Diffuse, relict, laminoid fenestral fabric.
UV OIL TESTS: Absent at 1729.6'.

1730'-1730.9'
NAME: Finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (100%).
COLOR: Light gray (10YR8/1).
ORTHOCHEMS: Dolomitized micrite (100%)
POROSITY: Intercrystalline.
STRUCTURES: Subhorizontal, laminoid fenestral fabric; Abundant subvertical, commonly healed, fractures; Fracture controlled color-mottling.
UV OIL TESTS: Show at 1730'.

1730.9'-1731'
NAME: Microcrystalline cryptalgal dolomite (boundstone).
MINERALS: Dolomite (99%); Hematite (1%).
COLOR: Mottled, light gray (10YR8/2) with dark reddish-brown (7.5R3/3) oxidation of relict structures.
ALLOCHEMS: Fossils (10%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (90%).
POROSITY: Intercrystalline.
STRUCTURES: Diffuse, relict, cryptalgal laminations; Diagenetic color-mottling obscuring all structures;

1731'-1731.1'

NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (98%); Calcite cement filling fractures (2%); Green clay (less than 1%).
COLOR: Light gray.
ORTHOCHEMS: Dolomitized micrite (98%).
POROSITY: Intercrystalline, fracture.
STRUCTURES: Occasional, subvertical, fractures partially filled by sparry calcite cement; Irregularily-oriented fenestral pores filled by sparry calcite.

1731.1'-1731.3'

NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (100%); Hematite (less than 1%).
COLOR: Mottled, light gray (10YR8/1) with minor subhorizontal dark reddish brown (7.5R3/3).
ALLOCHEMS: Possible cryptalgal laminations this section.
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, laminoid fenestral vugs.
STRUCTURES: Subhorizontal tubular fenestrate texture; Subvertical fractures.
UV OIL TESTS: Absent at 1731.2'.

T.S. 1731.3'

NAME: Microcrystalline dolomite (mudstone).
DOLOMITE: (100%) microcrystalline, euhedral rhomb matrix with very abundant, dispersed, very-finely-crystalline, euhedral rhombs.
QUARTZ: (less than 1%) subrounded silt.
REMARKS: Fenestral fabric; Porosity open.

1731.3'-1732'

NAME: Microcrystalline cryptalgal dolomite (boundstone).
MINERALS: Dolomite (98%); Calcite (1%) cement rimming vuggy pores and filling fractures; Clay (1%); Hematite (less than 1%) oxidized, associated with cryptalgal laminations.
COLOR: Mottled, brownish gray (5YR5/1) to light brownish-gray (7.5YR7/2) with occasional dark red (7.5R3/6) to dull orange (7.5YR7/3) associated with oxidized cryptalgal laminations.
ALLOCHEMS: Fossils (10%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (89%).
POROSITY: Fractures, intercrystalline, vuggy.
STRUCTURES: Fenestral fabric; Diagenetic color-mottling; Large vugs (3 cm.-9 cm.) lined with calcite crystals with open pores; Possible SH Stromatolite at 1731.6' on erosional surface with red and green clays and occasional dessication cracks.

1732'-1732.8'

NAME: Finely-crystalline, intraclastic, cryptalgal dolomite (boundstone).
MINERALS: Dolomite (99%); Calcite (1%) cement filled fractures and rimming vuggy pores; Green clay (less than 1%).
COLOR: Mottled. light gray (10YR8/2) and dark red (7.5R3/4) associated with cryptalgal laminations.
ALLOCHEMS: Fossils (20%) blue-green algae (?) (100%); Cryptalgal

intraclasts (2%) at top of section.
ORTHOCHEMS: Dolomitized micrite (79%); Calcite cement (1%).
POROSITY: Pin-point vuggy, intraparticle, fracture-channel.
STRUCTURES: Cryptalgal laminations with common micro-unconformities; Cryptalgal intraclasts near the top of the section with green clay on an erosional surface; Diagenetic color-mottling; Common subhorizontal to irregularly oriented fractures and microfractures displaying minor solution enlargement.
UV OIL TESTS: Absent at 1732'.

1732.8'-1735.5'
NAME: Microcrystalline, intraclastic, cryptalgal dolomite (boundstone).
MINERALS: Dolomite (99%); Hematite (1%) associated with cryptalgal laminations.
COLOR: Mottled, dark reddish brown (7.5R3/2) to pale orange (5YR8/3).
ALLOCHEMS: Fossils (30-60%) blue-green algae (?) (100%); Cryptalgal intraclasts (10%).
ORTHOCHEMS: Dolomitized micrite (30-60%).
POROSITY: Intercrystalline.
STRUCTURES: Cryptalgal laminations with (mm to cm) scale unconformities; Cryptalgal intraclasts; Diagenetic color-mottling.
UV OIL TESTS: Absent at 1734'.

1735.5'-1737'
NAME: Microcrystalline algal dolomite (mudstone).
MINERALS: Dolomite (97%); Hematite (3%) associated with algae (?).
COLOR: Mottled, Pale orange (5YR8/3) matrix to dark reddish-brown (7.5R3/2) associated with algae (?).
ALLOCHEMS: Fossils (5%) Renalysis algae (?) (100%); Intraclasts (less than 1%).
ORTHOCHEMS: Dolomitized micrite (95%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Fenestral fabric, irregularly oriented in lower portion of the section and horizontally oriented in the upper section; Minor (cm) scale intraclasts near top of section.
UV OIL TESTS: Absent at 1736'.

T.S. 1736.9'
NAME: Dolomitized intramicrudite (wackestone).
INTRACLASTS: (30%) rounded and of microcrystalline composition.
DOLOMITE: (70%) microcrystalline with dark colored subhorizontal laminations.
QUARTZ: (less than 1%) silt and occasional fine-grain size, occasionally elongate, all subrounded.
HEMATITE: (less than 1%) oxidized, associated with fractures and disseminated.
REMARKS: Occasional vertical fracture; Disrupted laminae common.

1737'-1737.7'
NAME: Microcrystalline, argillaceous, cryptalgal dolomite (boundstone).

MINERALS: Dolomite (60-90%) matrix; Nontronite clay (10-40%) along subhorizontal, cryptalgal, erosion surfaces.
COLOR: Mottled, light reddish-gray (2.5YR7/2) dolomite matrix and (green) light gray (10Y8/1) nontronite clay.
ALLOCHEMS: Fossils (20%) blue-green algae (?) (100%); Intraclasts (1%).
ORTHOCHEMS: Dolomitized micrite (79%) partially altered to nontronite clay.
POROSITY: fracture, vuggy, fenestral.
STRUCTURES: Diagenetic color-mottling; Cryptalgal laminations; Rounded to subrounded intraclasts and subhorizontal fractures at the base of the section; Subhorizontal laminoid fenestral fabric.
UV OIL TESTS: Absent at 1737.3'.
REMARKS: An X-ray analysis of the green clay suggests smectitite clay (nontronite).

1737.7'-1738.3'
NAME: Microcrystalline cryptalgal dolomite (boundstone).
MINERALS: Dolomite (96%) matrix; Nontronite clay (4%) associated with an erosional surface and filling dessication cracks.
COLOR: Mottled, light reddish-gray (2.5YR7/2) matrix with (green) light gray (10Y8/1) nontronite clay.
ALLOCHEMS: Fossils (5%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (95%) altered to nontronite clay on erosion surface.
POROSITY: Intercrystalline, fracture.
STRUCTURES: Dessication cracks on erosion surface; Cryptalgal laminations; Diagenetic color-mottling; Subhorizontal and subvertical fractures.
UV OIL TESTS: Absent at 1737.9'.

T.S. 1737.8'
NAME: Dolomitized algal biomicrite (mudstone).
CALCITE CEMENT: (2%) blocky and coarse, filling fractures and moldic pores.
FOSSILS: (5%) Renalysis algae (?) (80%), unidentified fossil fragment ghosts (20%).
DOLOMITE: (93%) microcrystalline, euhedral rhomb matrix and common disseminated, finely-crystalline, euhedral rhombs.
HEMATITE: (less than 1%) oxidized, disseminated in matrix and associated with cryptalgal laminations.

1737.7'-1738.3'
NAME: Finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (100%); Hematite (less than 1%).
COLOR: Pale orange (5YR8/3).
ORTHOCHEMS: Dolomitized micrite (100%)
POROSITY: Fenestral, intercrystalline.
STRUCTURES: Subhorizontal laminoid fenestral fabric; Diagenetic color-mottling.

1738.6'-1739.1'
NAME: Finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (98%) matrix; Calcite (2%) cement occasionally

filling fenestral pores.
COLOR: Mottled, light brownish-gray (7.5YR7/2) and pale orange (5YR8/3).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Fenestral (occasionally filled by calcite cement), fracture, intercrystalline.
STRUCTURES: Diagenetic color-mottling, commonly controlled by fractures; Common subvertical and subparallel fractures, and healed microfractures; Subvertical (tabular) and subhorizontal (laminoid) fenestral pores in the top (4 cm) of the section, commonly filled by calcite cement.
UV OIL TESTS: Absent at 1739'.

1739.1'-1739.6'
NAME: Finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (100%).
COLOR: Mottled, light reddish-gray (7.5R7/1) matrix with grayish red (7.5R4/2) and (green) light gray (10Y8/1).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling associated with microstyolites; Occasional Type II microstyolite swarms in upper section; A single Type I suture seam styolite marks the base of this section; Relatively unaltered dolomitized micrite in this section displays subhorizontal, laminoid, fenestral fabric.

1739.6'-1741.5'
NAME: Dolomitic stromatoporoid biomicrudite (wackestone-packstone).
MINERALS: Calcite (45-65%) bioclasts, and occasional sparry crystals lining vuggy pores; Dolomite (35-55%) matrix.
COLOR: Light reddish-gray (7.5R7/1).
ALLOCHEMS: Fossils (40-60%) cylindrical stromatoporoids (60%), subspherical stromatoporoids (30%), brachiopods (5%) with articulated shells, gastropods? (5%).
ORTHOCHEMS: Dolomitized micrite (35-55%).
POROSITY: Intercrystalline, intraparticle, pin-point vuggy, vuggy.
STRUCTURES: Bioclastic.
UV OIL TESTS: Absent at 1740.9'.

T.S. 1741'
NAME: Dolomitic algal biomicrite (packstone-boundstone).
MICRITE: (20%) microcrystalline matrix.
CALCITE CEMENT (5%).
FOSSILS: (70%) Renalysis algae (?) (87%), brachiopods (5%), calcispheres (5%), echinoderm fragments (3%).
DOLOMITE: (1%) disseminated, microcrystalline euhedral rhombs.
HEMATITE: (less than 1%) disseminated.

1741.5'-1742'
NAME: Dolomitic stromatoporoid biomicrudite (packstone).
MINERALS: Calcite (60-70%) bioclasts; Dolomite (30-40%) matrix.
COLOR: Light gray (10YR8/2).
ALLOCHEMS: Fossils (60-70%) subspherical stromatoporoids (50%), cylindrical stromatoporoids (50%).

ORTHOCHEMS: Dolomitized micrite (30-40%).
POROSITY: Intraparticle, intercrystalline, microfracture, vuggy (to 3 cm).
STRUCTURES: Occasional Type I suture seam styolite.

1742'-1749'
NAME: Dolomitized stromatoporoid biolithite (boundstone).
MINERALS: Calcite (40-99%) bioclasts; Dolomite (1-60%) matrix.
COLOR: Mottled, light gray (10YR8/2) to dark red (7.5R3/4) associated with styolites.
ALLOCHEMS: Fossils (40-90%) tabular stromatoporoids (20-100%), subspherical stromatoporoids (0-80%), cylindrical stromatoporoids (0-80%), brachiopods (0-1%).
ORTHOCHEMS: Dolomitized micrite (1-60%) increasing upward.
POROSITY: Intraparticle, intercrystalline, microfracture, fracture.
STRUCTURES: Occasional Type I suture seam styolite, commonly oxidized; Occasional subvertical microfractures and fractures, commonly filled or lined with calcite cement.
UV OIL TESTS: Absent at 1742.5', 1743.2' and 1745.3'. Show at 1747.5'. Absent at 1748.5'.

T.S. 1745'
NAME: Dolomitized stromatoporoid biomicrudite (wackestone).
MICROSPAR: (1%) replacement of dolomite adjacent to pores (dedolomitization).
CALCITE CEMENT: (6%) rimming and filling vuggy pores.
FOSSILS: (20%) tabular stromatoporoids (60%), subspherical stromatoporoids (15%), cylindrical stromatoporoids (10%), unidentified fossil fragment ghosts (10%), brachiopods (5%).
DOLOMITE: (74%) microcrystalline, euhedral rhomb matrix.
REMARKS: Dedolomitization.

T.S. 1748.1'
NAME: Stromatoporoid biolithite (boundstone).
CALCITE CEMENT: (5%) occasionally filling intraparticle pores and fractures.
FOSSILS: (95%) tabular stromatoporoids (94%), cylindrical stromatoporoids (2%), brachiopods (2%).
REMARKS: Occasional Type I suture seam styolite; A subvertical fracture occurs within the tabular stromatoporoid.

T.S. 1749'
NAME: Dolomitized brachiopod stromatoporoid biomicrudite (wackestone).
MICRITE: (10%) matrix.
CALCITE CEMENT: (1%) occasionally filling intraparticle pores.
FOSSILS: (15%) stromatoporoid fragments (60%), brachiopod fragments and ghosts (30%), echinoderm fragments (5%).
DOLOMITE: (74%) microcrystalline to finely crystalline euhedral rhombs disseminated in matrix and bioclasts.
REMARKS: Open microfractures.

1749'-1751.5'
NAME: Very-finely-crystalline, stromatoporoid, dolomite (boundstone).

MINERALS: Dolomite: (99%); Calcite: (1%) cement occasionally filling microfractures and rimming vuggy pores.
COLOR: Mottled, light gray (7.5Y8/1) and dull yellow-orange (10YR7/2).
ALLOCHEMS: Fossils (50-70%) tabular stromatoporoids (70%), subspherical stromatoporoids (18%), cylindrical stromatoporoids (10%), brachiopods (2%) shells disarticulated and articulated.
ORTHOCHEMS: Dolomitized micrite (30-50%).
POROSITY: Intraparticle, microfracture, vuggy.
STRUCTURES: Common subvertical microfractures; A single Type I suture seam styolite near base of section associated with red iron oxide color-mottling.
UV OIL TESTS: Shows at 1749.6' and 1751'.

1751.5'-1757.5'

NAME: Microcrystalline stromatoporoid Dolomite (wackestone).
MINERALS: Dolomite (100%).
COLOR: Mottled, light gray (10YR8/2) with occasional bluish gray (10BG5/1) and light greenish-gray (7.5GY8/1).
ALLOCHEMS: Fossils (20%) cylindrical stromatoporoids (99%), brachiopods (1%) shells articulated.
ORTHOCHEMS: Dolomitized micrite (80%).
POROSITY: Moldic (abundant), pin-point vuggy, microfracture, vuggy, channel (1752'-1752.5'), shelter.
STRUCTURES: Abundant to very abundant, subvertical, generally healed microfractures; Autoclastic.
UV OIL TESTS: Absent at 1751.5'. Show at 1752.1' and 1754.2'.

T.S. 1754'

NAME: Dolomitized brachiopod biomicrudite (wackestone).
FOSSILS: (10%) unidentified fossil fragment molds (80%), brachiopods (20%) shells articulated.
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix and microcrystalline-upper euhedral rhombs associated with microstyolites.
REMARKS: Brachiopod geopetal structure; Type II microstyolite swarm.

T.S. 1757'

NAME: Dolomitized fossiliferous biomicrudite (mudstone-wackestone).
FOSSILS: (10%) unidentified fossil fragment molds (95%), brachiopod molds (5%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix, with very-finely-crystalline, euhedral rhombs, healing microfractures, and common microcrystalline-upper disseminated euhedral rhombs associated with microstyolites.
REMARKS: Fractures partially-healed by dolomite; Occasional Type II individual microstyolite.

1757.5'-1761'

NAME: Microcrystalline stromatoporoid dolomite (wackestone).
MINERALS: Dolomite (98%) matrix and replacement of bioclasts; Calcite (2%) pseudospar recrystallization of bioclasts.
COLOR: Mottled, bluish gray (10BG5/1) microcrystalline matrix and grayish white (N8/) medium-coarsely crystalline dolomite euhedral

rhombs with occasional light greenish-gray (7.5GY8/1) and pale orange (5YR8/4).
ALLOCHEMS: Fossils (20%) tabular stromatoporoids (50%), cylindrical stromatoporoids (50%).
ORTHOCHEMS: Dolomitized micrite (98%).
POROSITY: Moldic, subvertical microfractures, pin-point vuggy.
STRUCTURES: Abundant subvertical microfractures; Occasional subhorizontal microfractures; Diagenetic color-mottling.
UV OIL TESTS: Shows at 1755.5', 1758.7' and 1760.8'.

T.S. 1761'
NAME: Dolomitized stromatoporoid biomicrudite (wackestone).
MICROSPAR: (4%) dedolomitization of matrix proximal to pores.
CALCITE CEMENT: (less than 1%) blocky, filling fractures.
FOSSILS: (20%) cylindrical stromatoporoids (50%), echinoderm fragments and ghosts (15%), brachiopod ghosts (10%).
DOLOMITE: (76%) very-finely-crystalline, euhedral rhomb matrix.
REMARKS: Rare subvertical, discontinuous, and open microfractures.

1761'-1761.9'
NAME: Calcareous, microcrystalline, stromatoporoid dolomite (wackestone).
MINERALS: Dolomite (85%) matrix; Calcite (15%) bioclasts.
COLOR: Mottled, light gray (5YR8/1) with minor subhorizontal patches of more calcareous pale orange (5YR8/4).
ALLOCHEMS: Fossils (20%) cylindrical stromatoporoids (65%), subspherical stromatoporoids (20%), tabular stromatoporoids (15%), brachiopods (less than 1%) shells disarticulated, crinoid fragments (less than 1%).
ORTHOCHEMS: Dolomitized micrite (80%); Calcite pseudospar (less than 1%) proximal to pores.
POROSITY: Intraparticle, intercrystalline, moldic, microfracture.
STRUCTURES: Occasional to rare subhorizontal microfractures; Diagenetic color-mottling.

1761.9'-1771.6'
NAME: Dolomitic stromatoporoid biolithite-biomicrudite (boundstone-packstone-wackstone).
MINERALS: Calcite (60%) bioclasts; Dolomite (40%); Hematite (less than 1%) oxidized in matrix.
ALLOCHEMS: Fossils (10-100%) tabular stromatoporoids (40-70%), subspherical stromatoporoids (25-50%), brachiopods (2-10%) shells disarticulated and fragmented.
ORTHOCHEMS: Dolomitized micrite (0-90%).
POROSITY: Intraparticle, fracture, microfracture, intercrystalline, pin-point vuggy, vuggy.
STRUCTURES: This section consists of an irregularly alternating sequence that begins with fragmental tabular stromatoporoid boundstone, followed by cylindrical-type stromatoporoid wackestone, and finally subspherical stromatoporoid mudstone. Stromatoporoid intraclasts; Occasional fractures and microfractures within bioclasts; Common Type I suture seam styolites with associated solution color-mottling by iron oxides.
UV OIL TESTS: Shows at 1762.3', 1763.9' and 1764.1'; Absent at

1767.1', 1769.7', 1769.8' and 1770.5'; Show at 1771.4'.

T.S. 1765'

NAME: Dolomitic stromatoporoid biomicrudite (wackestone)
MICRITE: (40%) matrix.
CALCITE CEMENT: (2%) rimming to filling fractures and moldic pores.
FOSSILS: (20%) cylindrical stromatoporoids (75%), echinoderm fragments (20%), brachiopod fragments (3%), tabular stromatoporoids (2%).
DOLOMITE: (38%) microcrystalline to finely crystalline euhedral rhombs disseminated in matrix.

T.S. 1769'

NAME: Dolomitic stromatoporoid biolithite (boundstone)
MICRITE: (10%) matrix and occasional micritization of stromatoporoids.
CALCITE CEMENT: (10%) filling and partially filling intraparticle pores.
FOSSILS: (75%) tabular stromatoporoids (98%), echinoderm fragments (2%).
DOLOMITE: (5%) microcrystalline, euhedral rhombs disseminated in matrix and bioclasts with very-finely-crystalline, euhedral rhombs, associated with styolites and fractures.
HEMATITE: (less than 1%) associated with occasional Type I suture seam styolites.
REMARKS: Occasional subvertical and subhorizontal fractures.

1771.6'-1772.6'

NAME: Very-finely-crystalline, stromatoporoid, biomicrudite (wackestone).
MINERALS: Dolomite (90%); Calcite (10%) bioclasts.
COLOR: Mottled, light gray (10YR8/2) with reddish brown (10R4/3) to pale reddish-orange (2.5YR7/4) associated with pores.
ALLOCHEMS: Fossils (15%) tabular stromatoporoids (80%), subspherical stromatoporoids (10%), brachiopods (10%) articulated shells and fragments.
ORTHOCHEMS: Dolomitized micrite (85%); Calcite pseudospar (less than 1%).
POROSITY: Intercrystalline, intraparticle, microfracture.
STRUCTURES: Common subvertical, generally healed, microfractures; Diagenetic color-mottling.

1772.6'-1778'

NAME: Microcrystalline stromatoporoidand brachiopod biomicrudite (wackestone).
MINERALS: Dolomite (90%); Calcite (10%) bioclasts.
COLOR: Mottled, light gray (5YR8/1) matrix with dark reddish-gray (7.5R3/1) diffuse "pseudoburrow" boundaries with pale reddish-orange (2.5YR7/4) transition to matrix.
ALLOCHEMS: Fossils (3-10%) brachiopods (40-60%) articulated shells, subspherical stromatroporoids (40-50%) in upper section, echinoderm fragments (40%) in lower section; Possible rounded bioclastic intraclasts (5%) between 1774.1'-1774.3'.
ORTHOCHEMS: Dolomitized micrite (90%).

POROSITY: Moldic, pin-point vuggy, vuggy, moldic, intercrystalline, intraparticle.
STRUCTURES: Diagenetic color-mottling with color-mottling resulting in subhorizontal to subvertical "pseudoburrows" controlled by bioclasts.
UV OIL TESTS: Absent at 1775', 1775.5', 1776.4' and 1777.5'.

T.S. 1773'
NAME: Dolomitized biomicrudite (wackestone).
MICRITE: (1%) dedolomitization adjacent to pores.
FOSSILS: (10%) unidentified fossil fragment molds (50%), brachiopods (30%) shells articulated, cylindrical stromatoporoids (20%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix and very-finely-crystalline, euhedral rhombs rimming pores.
REMARKS: Abundant diagonal to vertical Type II microstyolite swarms.

T.S. 1777'
NAME: Dolomitized biomicrite (mudstone).
PSEUDOSPAR: (1%) dedolomitization adjacent to pores.
FOSSILS: (less than 1%) unidentified fossil fragment molds-vugs (99%), possible cylindrical stromatoporoid mold (5%), echinoderm fragments (1%).
DOLOMITE: (99%) microcrystalline, euhedral rhomb matrix and rare, very-finely-crystalline, euhedral rhombs rimming to filling pores.
HEMATITE: (1%) oxidized, disseminate to subhorizontally oriented in distribution.
REMARKS: Subhorizontal "pseudoburrow" with paleogroundwater flow suggested by occasional streaming of oxidized hematite color-mottling in the apparent down-current direction.

1778'-1778.3'
NAME: Microcrystalline stromatoporoid biomicrudite (wackestone).
MINERALS: Dolomite (100%).
COLOR: Light gray (10YR8/2).
ALLOCHEMS: Fossils (5%) subspherical stromatoporoid ghosts recrystallized to medium crystalline, sucrosic dolomite, euhedral rhombs.
ORTHOCHEMS: Dolomitized micrite (95%).
POROSITY: Intercrystalline, pin-point vuggy, vuggy, microfracture.
STRUCTURES: Occasional subvertical microfractures.

1778.3'-1784'
NAME: Microcrystalline brachiopod biomicrudite (wackestone).
MINERALS: Dolomite (99%); Calcite (1%) in vugs from 1780.2'-1783.3'.
COLOR: Mottled, light gray (5YR8/1) to dark reddish-gray boundaries of "pseudoburrows" with a pale reddish-orange (2.5YR7/4) transition to the light gray matrix.
ALLOCHEMS: Fossils (5-20%) brachiopods (95-100%) shells articulated, echinoderm fragments (0-5%).
ORTHOCHEMS: Dolomitized micrite (80-95%).
POROSITY: Moldic, intercrystalline, pin-point vuggy.
STRUCTURES: Diagenetic color-mottling with "pseudoburrows" associated with bioclasts.
UV OIL TESTS: Shows at 1779.8' and 1781.5'; Absent at 1783.2'.

T.S. 1779'

NAME: Dolomitized biomicrudite (mudstone).
PELOIDS: (1%) Micritic.
FOSSILS: (4%) brachiopod molds (50%), echinoderm molds (50%).
DOLOMITE: (94%) microcrystalline, euhedral rhomb matrix and finely-crystalline euhedral rhombs rimming pores.
HEMATITE: (less than 1%) oxidized proximal to pores.

T.S. 1781.5'

NAME: Dolomitized, echinoderm and brachiopod biomicrudite (mudstone).
PSEUDOSPAR: (1%) clear microcrystalline euhedral rhombs adjacent to pin-point vuggy pores.
FOSSILS: (2%) brachiopod fragments and molds (60%), echinoderm fragments and molds (40%).
DOLOMITE: (97%) microcrystalline, euhedral rhomb matrix.
HEMATITE: (less than 1%) associated with microfractures.

1784'-1785'

NAME: Microcrystalline biomicrudite (wackestone).
MINERALS: Dolomite (70%); Calcite (30%) bioclasts.
COLOR: Minor mottling, light gray (10YR8/2) matrix with dark reddish-gray (7.5R3/1) to pale reddish-orange (2.5YR7/4) iron oxide.
ALLOCHEMS: Fossils (30-40%) subspherical stromatoporoid (40%), echinoderm fragments (40%), brachiopods (20%) shells articulated.
ORTHOCHEMS: Dolomitized micrite (70%).
POROSITY: Intercrystalline, intraparticle, microfracture.
STRUCTURES: Diagenetic color-mottling; Common irregularly-oriented microfractures.
UV OIL TESTS: Show at 1784.8'.
REMARKS: Base of available core.

T.S. 1785'

NAME: Dolomitic stromatoporoid biolithite (boundstone).
MICRITE: (5%) matrix.
CALCITE CEMENT: (15%) filling intraparticle pores.
FOSSILS: (80%) tabular stromatoporoids (90%), echinoderm fragments (8%), brachiopods (2%).
DOLOMITE: (30%) microcrystalline, euhedral rhombs selectively replacing stromatoporoids.
REMARKS: Echinoderm and brachiopod bioclasts are dolomicrite rimmed; Microfractures within stromatoporoids are healed by dolomite; Base of available core.

CAVALIER COUNTY

NDGS #36
LOCATION: T161N-R60W-S12, NW NE
WELL NAME: ELLIS #1
COMPANY: UNION OIL OF CALIFORNIA
DAWSON BAY FORMATION TOP DEPTH: 1629'
TOP OF THE SECOND RED BED MEMBER: 1763'
CORED INTERVAL: 1610'-1666'
KELLY BUSHING ELEVATION: 1646'
REMARKS: 10 FOOT DIFFERENCE BETWEEN WIRE-LINE LOG AND CORE BOXES

INTERVAL AND DESCRIPTIONS

1610.5'-1612.9'
NAME: Stromatoporoid biomicrudite (packstone).
MINERALS: Calcite (100%).
COLOR: Light gray (7.5YR8/2) with red (10R5/6) patches associated with accumulations of unidentified fossil fragments.
ALLOCHEMS: Fossils (30%) subspherical stromatoporoids (40%), unidentified fossil fragments (20%), cylindrical stromatoporoids (15%), echinoderm fragments (10%), brachiopods (10%) shells articulated, coral (5%).
ORTHOCHEMS: Micrite (70%).
POROSITY: Intraparticle, intercrystalline.
STRUCTURES: Type I suture seam styolite contact with interval above.
REMARKS: Souris River Formation.

1612.9'-1613.2'
NAME: Brachiopod biomicrudite (wackestone).
MINERALS: Calcite (100%).
COLOR: Light gray (7.5YR8/2) with dark red (10R3/4) associated with microfractures and bioclasts.
ALLOCHEMS: Fossils (10-15%) brachiopod fragments and disarticulated shells (100%).
ORTHOCHEMS: Micrite (85-90%).
POROSITY: Intercrystalline, microfracture.
STRUCTURES: Diagenetic color-mottling; Occasional microfractures; Occasional bored (2 mm) bioclast. REMARKS: Souris River Formation.

1613.2'-1614.1'
NAME: Micrite (mudstone).
MINERALS: Calcite (100%).
COLOR: Mottled, light gray (7.5YR8/1) with reddish brown (10R5/3) iron oxide.
ORTHOCHEMS: Micrite (100%)
POROSITY: Intercrystalline, burrowing.
STRUCTURES: Diagenetic color-mottling; Very abundant (0.1-0.2 mm) burrowing.
UV OIL TESTS: Absent at 1613.8'.
REMARKS: Souris River Formation.

1614.1'-1615.5'
NAME: Biomicrudite (mudstone).

MINERALS: Calcite (100%).
COLOR: Mottled, light gray (5YR8/1) to light reddish-gray (10R7/1) with reddish brown (10R5/3) iron oxide concentrations.
ALLOCHEMS: Fossils (0-3%) brachiopods (100%) shells articulated.
ORTHOCHEMS: Micrite (97-100%).
POROSITY: Intercrystalline, microfracture.
STRUCTURES: Diagenetic color-mottling; Occasional subvertical microfractures.
REMARKS: Souris River Formation.

1615.5'-1619.2'
NAME: Microcrystalline, argillaceous, dolomite (mudstone).
MINERALS: Dolomite (89%);Clay (10%); Hematite (1%).
COLOR: Mottled, light gray (5YR8/1) to light reddish-gray (10R7/1) with reddish brown (10R5/3) associated with argillaceous laminations, fractures, and microfractures.
ALLOCHEMS: Fossils (0-1%) unidentified fragments(100%).
ORTHOCHEMS: Dolomitized micrite (90%).
POROSITY: Intercrystalline, microfracture.
STRUCTURES: Diagenetic color-mottling associated with subhorizontal argillaceous laminations and subvertical microfractures; Common, subhorizontal, argillaceous laminations with iron oxide mottling; Occasional subvertical microfractures; Occasional subhorizontal laminae of unidentified calcareous fossil fragments.
UV OIL TESTS: Absent at 1617' and 1618.5'.
REMARKS: Basal Souris River Formation.

T.S. 1616'
NAME: Dolomitized brachiopod biomicrudite (mudstone).
FOSSILS: (2%) Brachiopod fragments (70%) in (0.3 mm) subhorizontal laminae, unidentified fossil fragment ghosts (30%).
DOLOMITE: (96%) Microcrystalline, euhedral rhomb matrix and microcrystalline-upper euhedral rhombs associated with Type II microstyolite swarms.
HEMATITE: (2%) oxidized, disseminated and concentrated along fractures and microfractures.

1619.2'-1621.8'
NAME: Microcrystalline cryptalgal biolithite (boundstone to mudstone).
MINERALS: Dolomite (98%); Hematite (2%).
COLOR: Mottled, light gray (10Y8/1) matrix with purplish gray (5RP3/1) "pseudoburrow" boundaries grading to dull orange (2.5YR6/3).
ALLOCHEMS: Fossils (15%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture (rare), microfracture (rare).
STRUCTURES: Diagenetic color-mottling resulting in common subhorizontal "pseudoburrows" which are controlled by subhorizontal cryptalgal laminations; Cryptalgal laminations very commonly obscured by diagenetic solutioning; Occasional, rare, diagonal fractures and microfractures.
REMARKS: Top of Dawson Bay Formation.

T.S. 1620'

NAME: Dolomitized, intraclastic, cryptalgal biolithite (boundstone).
INTRACLASTS: (5%) rounded, algal stromatolite composition.
FOSSILS: (25%) blue-green algae (?) (100%)
DOLOMITE: (70%) microcrystalline, euhedral rhomb matrix.
QUARTZ: (less than 1%) subrounded silt.
HEMATITE: (1%) oxidized, disseminated.

1621.8'-1631.5'

NAME: Microcrystalline, intraclastic, cryptalgal biolithite (boundstone).
MINERALS: Dolomite (99%); Hematite (1%).
COLOR: Mottled, light gray (10Y8/1) matrix with dull orange (2.5YR6/3) iron oxide along fractures and associated with cryptalgal laminations.
ALLOCHEMS: Fossils (30%) blue-green algae (?) (96%), brachiopod molds (3%) in subhorizontal laminae, echinoderm fragment molds (1%) in subhorizontal laminae with brachiopods; Angular intraclasts (0-80%), offset laminae, and deformed bedding occurring in subhorizontal (4-10 cm) layers.
ORTHOCHEMS: Dolomitized micrite (20-70%).
POROSITY: Intercrystalline, intraparticle, fracture.
STRUCTURES: Very abundant subvertical fractures and microfractures some of which appear to be dessication cracks within cryptalgal laminations; Intraclasts of cryptalgal composition; Diagenetic color-mottling.
UV OIL TESTS: Absent at 1622.3', 1626', and 1629'.

T.S. 1624'

NAME: Dolomitized cryptalgal biolithite (boundstone).
PELOIDS: (2%) dolomitized micrite composition.
FOSSILS: (25%) blue-green algae (?) (100%).
DOLOMITE: (71%) microcrystalline, euhedral rhomb matrix and very-finely-crystalline euhedral rhombs associated with cryptalgal laminations.
QUARTZ: (less than 1%) subrounded-subangular silt associated with cryptalgal laminations.
HEMATITE: (2%) oxidized, associated with cryptalgal laminations.

T.S. 1628'

NAME: Dolomitized cryptalgal biolithite (boundstone).
FOSSILS: (30%) blue-green algae (?) (100%).
DOLOMITE: (67%) microcrystalline, euhedral rhomb matrix and very-finely-crystalline euhedral rhombs associated with cryptalgal laminations.
QUARTZ: (1%) subrounded-subangular silt associated with cryptalgal laminations.
HEMATITE: (2%) oxidized, associated with cryptalgal laminations, fractures, and microfractures.

1631.5'-1633'

NAME: Dolomitized, argillaceous, stromatoporoid biomicrudite (mudstone-wackestone).
MINERALS: Dolomite (70%); Nontrontite clay (30%).

COLOR: Mottled, Dull yellow-orange (10YR7/2) dolomite with minor dull reddish-brown (2.5YR5/3) dolomite grading into light greenish-gray (10GY8/1) nontronite clay.
ALLOCHEMS: Fossils (5%) tabular stromatoporoid fragments (100%); Intraclasts of cryptalgal composition (less than 1%).
ORTHOCHEMS: Dolomitized micrite (67%); Nontronite clay associated with micrite (28%).
POROSITY: Microfracture (very abundant), intercrystalline, intraparticle.
STRUCTURES: Very abundant subvertical, occasional subhorizontal, microfractures; Diagenetic color-mottling; Intraclasts.
UV OIL TESTS: Absent at 1632.5'.

T.S. 1632'
NAME: Dolomitized, intraclastic, cryptalgal biolithite (boundstone).
INTRACLASTS: (15%) rounded, microcrystalline dolomitized micrite composition.
FOSSILS: (25%) blue-green algae (?) (100%).
DOLOMITE: (60%) microcrystalline, euhedral rhomb matrix and occasional finely crystalline euhedral rhombs proximal to cryptalgal laminations.

1633'-1639.7'
NAME: Dolomitic brachiopod biomicrudite (wackestone-packstone).
MINERALS: Calcite (95%) matrix and bioclasts; Dolomite (5%) disseminated.
COLOR: Light gray (7.5YR8/1) to white (N9).
ALLOCHEMS: Fossils (10-50%) percentage increasing down-section, brachiopod fragments (50%) occasionally shells articulated displaying a spiral brachidium, corals (15-30%), unidentified fossil fragments (0-25%), subspherical stromatoporoids (10%), cylindrical stromatoporoids (1-5%), tabular stromatoporoids (0-5%).
ORTHOCHEMS: Micrite (45-85%); Dolomitized micrite (5%).
POROSITY: Intercrystalline, intraparticle, moldic, microfracture, fracture.
STRUCTURES: Occasional-abundant subvertical fractures decreasing up-section.
UV OIL TESTS: Shows at 1635.9', 1634.2', 1637' and 1638.4'.

T.S. 1636'
NAME: Dolomitic anthozoan biomicrudite (wackestone)
MICRITE: (68%) Matrix.
FOSSILS: (30%) corals (50%), unidentified fossil fragments (30%), brachiopod fragments (15%), echinoderm fragments (5%).
DOLOMITE: (2%) microcrystalline euhedral rhombs disseminated and rimming pores.

1639.7'-1651'
NAME: Dolomitic anthozoan, brachiopod and stromatoporoid biomicrudite (wackestone-packstone).
MINERALS: Calcite (85-95%); Dolomite (5-15%).
COLOR: Light gray (7.5YR8/2) with pale orange (5YR8/4) proximal to molds and fractures.

ALLOCHEMS: Fossils (10-40%) tabular stromatoporoids (20-80%), brachiopods (10-40%) commonly with shells articulated, corals (0-40%), cylindrical stromatoporoids (10-20%), subspherical stromatoporoids (0-10%), fan-like bryozoans (1%). At 1644.5' the tabular stromatoporoids are vertically oriented.
ORTHOCHEMS: Micrite (55-65%); Dolomitized micrite (5-25%).
POROSITY: Intercrystalline, moldic, fracture.
STRUCTURES: Abundant subvertical to diagonal fractures; Abundant borings in stromatoporoids; Tabular stromatoporoids commonly encrust other bioclasts.
UV OIL TESTS: Absent at 1639.8', 1640.9', 1642.9', 1644.2', 1646.5' and 1649.3'.

T.S. 1640'
Dolomitic stromatoporoid biomicrudite (packstone).
MICRITE: (15%) matrix.
CALCITE CEMENT: (5%) fibrous-radial and blocky equant, rimming and filling pores.
FOSSILS: (65%) tabular stromatoporoids (60%), corals (35%), echinoderm fragments (5%).
DOLOMITE: (15%) disseminated microcrystalline and euhedral rhombs; and rimming pores.

T.S. 1643'
NAME: Dolomitic stromatoporoid biomicrudite (packstone).
MICRITE: (33%) matrix.
CALCITE CEMENT: (2%) blocky equant spar filling intraparticle pores.
FOSSILS: (40%) cylindrical stromatoporoids (49%), unidentified fossil fragments (20%), tabular stromatoporoids (10%), brachiopod fragments (10%), echinoderm fragments (10%), red algae (?) (1%).
DOLOMITE: (25%) microcrystalline, disseminated, euhedral rhombs with rare, finely crystalline euhedral rhombs, rimming pores.

T.S. 1648'
NAME: Dolomitic biomicrudite (wackestone).
MICRITE: (76%).
CALCITE CEMENT: (1%) sparry, rimming pores.
FOSSILS: (20%) unidentified fossil fragments (45%), echinoderm fragments (30%), brachiopod fragments (20%), subspherical stromatoporoids (5%).
DOLOMITE: (30%) microcrystalline euhedral rhombs rimming pores.

1651'-1654'
NAME: Dolomitic, echinoderm and stromatoporoid, biomicrudite (wackestone-packstone).
MINERALS: Calcite (70%); Dolomite (30%); Hematite (less than 1%).
COLOR: Light gray (5YR8/2) with occasional pale orange (5YR8/3-5YR8/4) iron oxide mottling proximal to pores.
ALLOCHEMS: Fossils (25%) echinoderm fragments (30-50%), brachiopod fragments and disarticulated shells (10-20%), cylindrical stromatoporoids (5-30%), tabular stromatoporoids (0-20%), subspherical stromatoporoids (0-10%), corals (5%).
ORTHOCHEMS: Micrite (45%); Dolomitized micrite (30%).
POROSITY: Intercrystalline, intraparticle, fracture, shelter.

STRUCTURES: Occasional to abundant subvertical fractures; Occasional diagenetic color-mottling proximal to pores; Occasional geopetal structures within whole brachiopod fossils.
UV OIL TESTS: Absent at 1651.9' and 1653.7'.

T.S. 1652'
NAME: Dolomitic biomicrudite (wackestone).
MICRITE: (50%).
CALCITE CEMENT: (less than 1%) equant-blocky-spar filling fractures.
PSEUDOSPAR: (2%) syntaxial overgrowths on echinoderm fragments, radial bladed crystal growth from echinoderm fragments.
FOSSILS: (20%) unidentified fossil fragment ghosts (45%), echinoderm fragments (35%), brachiopod fragments (15%), subspherical stromatoporoids (5%).
DOLOMITE: (20%) microcrystalline euhedral rhombs disseminated in matrix and fossils.

1654'-1659'
NAME: Dolomitized echinoderm biomicrudite (wackestone).
MINERALS: Dolomite (70-80%); Calcite (20-30%) matrix and bioclasts.
COLOR: Mottled, light gray (10YR7/1) matrix with occasional to rare dull reddish-orange (10R6/3) proximal to pores.
ALLOCHEMS: Fossils (15-20%) echinoderm fragments and molds (70-90%), brachiopod fragments and molds (10-30%).
ORTHOCHEMS: Dolomitized micrite (70-80%); Micrite (5-10%).
POROSITY: Intercrystalline, moldic, pin-point vuggy, vuggy, fracture, microfracture.
STRUCTURES: Very abundant diagonal and occasionally subparallel, commonly healed, fractures; Abundant subvertical microfractures; Brecciated with slickensides between 1655.5'-1656'; Diagenetic color-mottling common associated with fractures.
UV OIL TESTS: Show at 1655.6'; Absent at 1656.5'; Show at 1658.6'.

T.S. 1656'
NAME: Dolomitized echinoderm biomicrudite (mudstone).
FOSSILS: (5%) echinoderm fragments (50%), unidentified fossil fragments (50%).
DOLOMITE: (95%) microcrystalline euhedral rhombs, with finely-crystalline euhedral rhombs, rimming pores.

1659'-1666'
NAME: Dolomitized, echinoderm and brachiopod, biomicrudite (wackestone to occasional packstone).
MINERALS: Dolomite (98%); Calcite (2%).
COLOR: Light gray (5YR8/2) with occasional mottling to light yellow-orange (7.5YR8/3) proximal to fractures and moldic pores.
ALLOCHEMS: Fossils (15-20%) whole and fragmented brachiopod molds (70-80%), echinoderm fragments and fragment molds (20-30%).
ORTHOCHEMS: Dolomitized micrite (80-85%).
POROSITY: Fracture-channel, moldic, intercrystalline, pin-point vuggy.
STRUCTURES: Sparry calcite crystals commonly line channel porosity; Very abundant partially healed to healed subvertical, subhorizontal and diagonal fractures and microfractures

(brecciated); Diagenetic color-mottling.
UV OIL TESTS: Shows at 1660.2' and 1662.1'; Absent at 1663.5'; Show at 1665'.
REMARKS: Base of available core.

T.S. 1661.8'
NAME: Dolomitized biomicrudite (mudstone).
FOSSILS: (3%) unidentified fossil fragment molds-vugs (100%).
DOLOMITE: (97%) microcrystalline, euhedral rhomb matrix and finely-crystalline euhedral rhombs rimming pores.

T.S. 1666'
NAME: Dolomitized biomicrudite (wackestone).
FOSSILS: (10%) unidentified fossil fragment molds-vugs (70%), brachiopod molds (30%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix with finely-crystalline euhedral rhombs rimming pores.
QUARTZ: (less than 1%) subangular silt.
REMARKS: Base of available core.

CAVALIER COUNTY

NDGS #37
LOCATION: T162N-R64W-S26, SW NW
WELL NAME: RESTAD #1
COMPANY: UNION OIL COMPANY OF CALIFORNIA-LOS NIETOS
DAWSON BAY FORMATION TOP DEPTH: 2245'
TOP OF THE SECOND RED BED MEMBER: 2395'
CORED INTERVAL: 2295'-2365'
KELLY BUSHING ELEVATION: 1630'

INTERVAL AND DESCRIPTIONS

2240'-2241'
NAME: Argillaceous Intramicrudite (Packstone).
MINERALS: Clay (70%) intraclasts and matrix; Dolomite (30%) intraclasts.
COLOR: Brownish gray (10YR5/1).
ALLOCHEMS: Intraclasts (85%) rounded and subrounded, millimeter to 2.0 centimeter scale, argillaceous and dolomitic composition.
REMARKS: Base of Souris River Formation.

2241'-2264.5'
NAME: Microcrystalline cryptalgal dolomite (mudstone to boundstone).
MINERALS: Dolomite (94%) matrix; Anhydrite (2-4%) filling fractures and locally replacing matrix, a single 1-3 cm nodule; Clay (2%) disseminated and associated with local cryptalgal laminations and Type II microstyolites; Hematite (2%) oxidized, disseminated and associated with local microstyolites.
COLOR: Mottled, light grayish-red (10R7/1) to dark reddish-brown (10R3/3).
ORTHOCHEMS: Dolomicrite (94%).
POROSITY: Intercrystalline, and fracture (rare).
STRUCTURES: Solution-mottling with local cryptalgal controlled pseudoburrows; Common fenestral fabric, compressed horizontally; Wispy laminae; Occasionally abundant Type II microstyolite swarms.
REMARKS: Top of the Dawson Bay Formation, exact contact uncertain with no core above.

NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (96%) matrix; Clay (4%) disseminated.
COLOR: Mottled, light grayish-red (10R7/1) to dark reddish-brown (10R3/3).
ORTHOCHEMS: Dolomitized micrite (96%).
POROSITY: Intercrystalline.
STRUCTURES: Solution-mottling; Intraclasts (millimeter scale) common; Wispy laminations.

2270'-2290' MISSING

NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (95%) matrix; Anhydrite (2%) spar filling fractures; Clay (3%) disseminated.
COLOR: Mottled, light grayish-red (10YR7/1) to dark reddish-brown (10R3/3).

ORTHOCHEMS: Dolomitized micrite (95%).
POROSITY: Intercrystalline, and fracture (minor).
STRUCTURES: Intraclasts (millimeter scale) common; Solution-mottling; Possible cryptalgal laminations.

2293'-2294.7'
NAME: Very argillaceous, fossiliferous, dolomite (mudstone).
MINERALS: Dolomite (40%-70%) matrix; Clay (30%-60%).
COLOR: Brownish gray (10YR5/1) with red (10R4/6) iron oxide mottling and very abundant brownish-black (10YR3/1) laminae.
ALLOCHEMS: Fossils (1%) unidentified fossil fragments (80%), trilobites (20%) articulated and fragmental (very well preserved).
ORTHOCHEMS: Dolomitized micrite (39-69%).
POROSITY: Intercrystalline, non-porous clay.
STRUCTURES: Diagenetic color-mottling; Very-abundant subhorizontal clay laminae.
UV OIL TESTS: Absent at 2294.5'.

2294.7'-2297.1'
NAME: Microcrystalline to very-finely-crystalline, argillaceous, dolomite.
MINERALS: Dolomite (97%) matrix; Clay (3%) wispy subhorizontal orientation; Anhydrite (less than 1%) partially filling fracture.
COLOR: Mottled, light gray (10YR7/1) with dark red (10R3/4) concentrations along fractures.
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture.
STRUCTURES: Diagenetic solution color-mottling; Occasional subvertical to diagonal fractures with proximal iron oxide color-mottling; Occasional dessication cracks; Possible intraclasts.
UV OIL TESTS: Absent at 2295.1'.
REMARKS: Top of Dawson Bay Formation.

T.S. 2295'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (98%) Microcrystalline, euhedral rhomb matrix with occasional, very-finely-crystalline, euhedral rhombs associated with discontinuous subhorizontal laminae (intraclasts?).
ANHYDRITE: (1%) sparry, filling to partially filling fractures.
QUARTZ: (less than 1%) subangular-subrounded matrix disseminated silt.
BITUMENS: (less than 1%) patchy distribution in matrix.
HEMATITE: (1%) oxidized, disseminated and microfracture association.
REMARKS: Multiple stage fracturing. Earlier subhorizontal and discontinuous fractures, partially healed by very-finely-crystalline dolomite. Later fractures partially filled by anhydrite.

2297.1'-2298.6'
NAME: Very-finely-crystalline, intraclastic, anhydritic shaley dolomite (Mudstone with shale-partings).
MINERALS: Dolomite (84-89%), Anhydrite (5-10%) nodular, Clay (5%), Hematite (1%).
COLOR: Mottled, dull yellow-orange (10YR7/2) matrix with dark-red

(10R3/4) to brownish-black (10YR3/1) shale.
ALLOCHEMS: Intraclasts (0-10%) dolomitized micrite composition containing ripple laminations (intraclasts?).
ORTHOCHEMS: Dolomitized micrite (84-89%).
POROSITY: Intercrystalline.
STRUCTURES: Disconformable scour surfaces; Intraclasts; Ripple laminae; Subvertical scour-truncated burrow at 2298.5' (2 cm x 11cm). Occasional subvertical microfractures; Occasional diagonally-oriented shale laminae with very common, subhorizontal, anhydrite nodules (to 8 cm); Diagenetic color-mottling.
UV OIL TESTS: Absent at 2298.5'.

2298.6'-2299.3'
NAME: Argillaceous, bedded-nodular, anhydrite.
MINERALS: Anhydrite (95%) streaky, laminated, bedded-nodular; (5%) millimeter-scale shale partings.
COLOR: Mottled, light grayish-red (10R7/1) anhydrite with dark reddish-brown (10R3/3) shale partings.
STRUCTURES: Anhydrite nodules (to 5 cm); Common, subhorizontal, argillaceous laminae in lower section.

2299.3'-2301'
NAME: Very-finely-crystalline, intraclastic, dolomite (mudstone).
MINERALS: Dolomite (97%) matrix; Anhydrite (3%) Fracture fill.
COLORS: Mottled, light grayish-red (10R7/1) to dark reddish-brown (10R3/3).
ALLOCHEMS: Intraclasts (10%) dolomitized micrite composition with soft sediment deformation structures.
ORTHOCHEMS: Dolomitized micrite (87%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Very abundant, subhorizontal, soft sediment deformation; Abundant subangular to subrounded intraclasts; Occasional diagonal (0.5-0.8 cm) fracture, filled with sparry anhydrite and radial-fibrous recrystallizationof adjacent dolomite matrix; Occasional, subhorizontal, nodular anhydrite concentration.
UV OIL TESTS: Absent at 2300.2'.

T.S. 2300.8'
NAME: Dolomitized intramicrudite (wackestone).
INTRACLASTS: (20%) subangular-subrounded, microcrystalline dolomitized micrite composition.
DOLOMITE: (75%) microcrystalline, euhedral rhomb matrix with abundant very-finely-crystalline euhedral rhombs associated with matrix.
QUARTZ: (1%) subrounded silt.
BITUMENS: (3%) disseminated in matrix.
HEMATITE: (1%) oxidized, disseminated and associated with microfractures and pin-point vuggy porosity.
REMARKS: Very abundant Type II microstyolites which control dolomite crystal size.

2301'-2301.5'
NAME: Dolomitic, streaky-laminated, anhydrite.
MINERALS: Anhydrite (60%) occasionally nodular; Dolomite (35%); Clay

(5%).
COLOR: Mottled, light grayish-red (10R7/1) anhydrite with dark reddish-brown (10R3/3) oxidized dolomite and light gray (10YR7/1) unoxidized dolomite.
ORTHOCHEMS: Dolomitized micrite (20%)
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Abundant (1-4 cm) nodular anhydrite coaleasing subhorizontally within dolomite, followed by common subhorizontal to diagonal fractures which are filled with sparry anhydrite, and radial-fibrous recrystallization of the adjacent dolomite matrix.

2301.5'-2302.6'
NAME: Dolomitic, streaky-laminated, anhydrite.
MINERALS: Dolomite (89%); Anhydrite (10%); Hematite (1%).
COLOR: Mottled, light brownish-gray (7.5YR7/2) to dark red (10R3/6) dolomite with pale orange (5YR8/3) anhydrite.
ALLOCHEMS: Intraclasts (2%) dolomitized micrite composition.
ORTHOCHEMS: Dolomitized micrite (87%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Displacive sparry anhydrite increasing down-section resulting in wispy, subhorizontal, discontinuous dolomite laminae; minor ghost intraclasts.

2302.6'-2304.1'
NAME: Dolomitic, streaky-laminated, anhydrite.
MINERALS: Anhydrite (70%) displacive; Dolomite (30%) intraclastic micrite.
COLOR: Pale orange (5YR8/3).
ALLOCHEMS: Intraclasts (5%).
ORTHOCHEMS: Dolomitized micrite (25%).
POROSITY: Intercrystalline.
STRUCTURES: Wispy, subhorizontal, discontinuous, dolomite laminae within displacive sparry anhydrite.
UV OIL TESTS: Absent at 2303.1'.

T.S. 2303'
NAME: Anhydritic and dolomitized micrite (mudstone).
DOLOMITE: (60%) microcrystalline, euhedral rhomb matrix.
ANHYDRITE: (36%) microcrystalline blocky (29%) disseminated; bladed (5%) associated with microstyolites; sparry (2%) discontinuous subhorizontal patches within dolomite matrix.
QUARTZ: (less than 1%) subrounded to subangular disseminated silt.
INSOLUBLES: (1%) disseminated.
HEMATITE: (3%) oxidized, disseminated.

2304.1'-2304.3'
NAME: Anhydritic, intraclastic, cryptalgal dolomite (boundstone).
MINERALS: Dolomite (80%) Matrix; Anhydrite (20%).
COLOR: Pale orange (5YR8/3) and gray (5Y4/1) laminated anhydrite increasing down-section.
ALLOCHEMS: FOSSILS (30%) blue-green algae (?) (100%); Intraclasts (20%) cryptalgal composition.
ORTHOCHEMS: Dolomitized micrite (55%).

POROSITY: Intercrystalline.
STRUCTURES: Subhorizontal cryptalgal laminations; Diagenetic color-mottling; Subhorizontal displacive anhydrite controlled by cryptalgal laminations.

2304.3'-2306.3'
NAME: Bedded mosaic anhydrite.
MINERALS: Anhydrite (100%).
COLOR: Mottled, gray (5YR4/1) with minor red (10R5/6) and occasional light gray (5YR8/1).
STRUCTURES: Subhorizontal "chicken wire" texture; Diagenetic color-mottling.

2306.3'-2306.4'
NAME: Very-finely-crystalline, cryptalgal, dolomite (boundstone).
MINERALS: Dolomite (100%).
COLOR: Light yellow-orange (7.5YR8/3) with common disseminated pale orange specks (5YR8/3).
ALLOCHEMS: Fossils (30%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (70%).
POROSITY: Intercrystalline.
STRUCTURES: Subhorizontal cryptalgal laminations.

2306.4'-2307.3'
NAME: Streaky-laminated anhydrite.
MINERALS: Anhydrite (60-80%) displacive; Dolomite (20-40%) matrix.
COLOR: Mottled, dull reddish-orange (10R6/4) with reddish gray (10R5/1) and light gray (5YR8/1).
ORTHOCHEMS: Dolomitized micrite (20-40%).
POROSITY: Intercrystalline.
STRUCTURES: Subhorizontal, irregular dolomite laminae which control anhydrite displacement.

T.S. 2307'
NAME: Anhydrite.
ANHYDRITE: (97%) subhorizontally laminated microcrystalline blocky.
BITUMENS: (3%) subhorizontally oriented.
HEMATITE: (less than 1%) oxidized, subhorizontal patches.

2307.3'-2307.8'
NAME: Bedded mosaic anhydrite.
MINERALS: Anhydrite (98%); Clay (2%).
COLOR: Reddish gray (7.5R6) and light gray (7.5YR8/1).
STRUCTURES: Subhorizontal, cryptalgal lamination ghosts which control dolomite replacement by anhydrite.

2307.8'-2308.3'
NAME: Bedded mosaic anhydrite.
MINERALS: Anhydrite (60%) displacive; Dolomite (39%) Cryptalgal dolomite; Clay (1%).
COLOR: Dull reddish-orange (10R6/4) with reddish gray (10R5/1) and light gray (5YR8/1).
ALLOCHEMS: Fossils (5%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (34%).

POROSITY: Intercrystalline.
STRUCTURES: Subhorizontal cryptalgal laminations which control dolomite replacement by anhydrite.

2308.3'-2328.5'
NAME: Anhydritic cryptalgal dolomite (boundstone).
MINERALS: Dolomite (40-60%) matrix. Anhydrite (20-60%) replacive; Calcite (0-20%) micrite matrix.
COLOR: Mottled, light gray (10YR8/2) to red (10R4/6).
ALLOCHEMS: Fossils (30%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (10-30%); micrite (10%).
POROSITY: Intercrystalline.
STRUCTURES: Subhorizontal cryptalgal laminations which control replacement of dolomitized micrite by anhydrite; Rare subvertical fractures lower in section; Rare Type I suture seam styolite lower in section; Very abundant, subhorizontal, laminoid fenestral pores lower in section.
UV OIL TESTS: Absent at 2308.9', 2309.5', 2318.5' and 2323.5'.

T.S. 2311'
NAME: Dolomitic anhydrite.
FOSSILS: (10%) blue-green algae (?) (100%).
DOLOMITE: (28%) microcrystalline, euhedral rhomb matrix with abundant very-finely-crystalline euhedral rhombs porximal to cryptalgal laminations.
ANHYDRITE: (60%) microcrystalline blocky replacement of cryptalgal boundstone, and later filling subvertical fractures by bladed anhydrite.
HEMATITE: (2%) oxidized, disseminated.

T.S. 2315.5'
NAME: Displacive anhydrite.
ANHYDRITE: (97%) microcrystalline blocky anhydrite replacement of cryptalgal boundstone.
INSOLUBLES: (3%) subhorizontal, associated with cryptalgal laminations.

T.S. 2319'
NAME: Anhydritic cryptalgal biolithite (boundstone).
MICROSPAR: (15%) rimming fenestral pores.
PSEUDOSPAR: (10%) filling to partially fillings fenestral pores.
FOSSILS: (35%) blue-green algae (?) (100%).
DOLOMITE: (30%) microcrystalline euhedral rhombs proximal to pores.
ANHYDRITE: (8%) commonly fills pores.
QUARTZ: (less than 1%) subrounded silt.
HEMATITE: (2%) rims existing and filled pores.

T.S. 2322'
NAME: Anhydritic and dolomitic cryptalgal biolithite (boundstone).
MICRITE: (58%) matrix.
FOSSILS: (30%) blue-green algae (?) (100%).
DOLOMITE: (5%) microcrystalline-very-finely-crystalline euhedral rhombs proximal to pores.
ANHYDRITE: (5%) sparry, occasionally filling pores.
QUARTZ: (less than 1%) subangular silt, associated with cryptalgal

laminations.
INSOLUBLES: (2%) associated with cryptalgal laminations.
HEMATITE: (less than 1%) associated with cryptalgal laminations.

T.S. 2327'
NAME: Dolomitic cryptalgal biolithite (boundstone).
MICRITE: (25%) matrix.
MICROSPAR: (15%) rimming pores.
PSEUDOSPAR: (10%) filling to partially filling pores.
FOSSILS: (40%) blue-green algae (?) (100%).
DOLOMITE: (10%) microcrystalline euhedral rhombs disseminated and rimming pores.
ANHYDRITE: (less than 1%) bladed.
INSOLUBLES: (less than 1%) associated with styolite.
HEMATITE: (1%) associated with styolite and disseminated.
REMARKS: Diagenetic color-mottling and occasional Type I sutured seam styolites of high amplitude.

2328.5'-2336.5'
NAME: Fine to medium crystalline, coral and brachiopod, dolomite (mudstone).
MINERALS: Dolomite (94%); Calcite (5%) matrix; Anhydrite (1%).
COLOR: Light yellow-orange (10YR8/3) with trace reddish brown (2.5YR4/6) associated with bioclasts.
ALLOCHEMS: Fossils (2-3%) brachiopods (50%) shells articulated and disarticulated, corals (50%).
ORTHOCHEMS: Dolomitized micrite (94%);
POROSITY: Intercrystalline, pin-point vuggy, moldic.
STRUCTURES: Possible dedolomitization proximal to pores; Occasionlly abundant anhydrite nodules (to 1 cm).
UV OIL TESTS: Absent at 2329.5'; Shows at 2331.5' and 2333.8'; Absent at 2335.1'

T.S. 2331'
NAME: Dolomitized brachiopod biomicrudite (wackestone).
MICRITE: (5%).
FOSSILS: (10%) brachiopods (40%), unidentified fossil fragment ghosts (40%), echinoderm fragments (20%).
DOLOMITE: (85%) disseminated, microcrystalline euhedral rhombs.

T.S. 2335'
NAME: Dolomitized brachiopod biomicrudite (wackestone).
FOSSILS: (10%) unidentified fossil fragment molds-vugs (99%), brachiopod fragments (1%).
DOLOMITE: (88%) microcrystalline, euhedral rhomb matrix with abundant finely-crystalline euhedral rhombs proximal to pores.
INSOLUBLES: (less than 1%) associated with pores.
PYRITE: (less than 1%) rimming pores.
HEMATITE: (2%) disseminated.

2336.5'-2338.1'
NAME: Fine to medium crystalline, brachiopod, dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%).
COLOR: Mottled, light brownish-gray (7.5YR7/2) finely-crystalline

dolomite and grayish red (2.5YR5/2) to dark red (10R3/4) medium-crystalline dolomite.
ALLOCHEMS: Fossils (3%) brachiopods (90%) shells disarticulated and articulated, echinoderm fragments (10%).
ORTHOCHEMS: Dolomitized micrite (97%).
POROSITY: Intercrystalline, moldic, fracture.
STRUCTURES: Diagenetic color-mottling; Rare subhorizontal to diagonal commonly healed fractures.

2338.1'-2339'
NAME: Finely crystalline, brachiopod, biomicrudite (wackestone).
MINERALS: Calcite (80%); Dolomite (20%); Hematite (less than 1%).
COLOR: Mottled, light yellow-orange (7.5YR8/3) with reddish brown (10R4/4) associated with styolites and bioclasts.
ALLOCHEMS: Fossils (10%) brachiopods (50%) fragments and articulated shells, tabulate corals (35%), algae (10%), subspherical stromatoporoids (5%).
ORTHOCHEMS: Micrite (70%); Dolomitized micrite (20%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Occasional subhorizontal Type II microstyolite swarms.

2339'-2346'
NAME: Dolomitic, anthozoan and stromatoporoid, biomicrudite (wackestone-packstone).
MINERALS: Calcite (90%); Dolomite (10%); Hematite (less than 1%).
COLOR: Mottled, light gray (5Y7/2) to dark red (10R3/4).
ALLOCHEMS: Fossils (10-25%) subspherical stromatoporoids (50%), tabulate corals (30%), brachiopod fragments (10%), unidentified fossil fragments (10%).
ORTHOCHEMS: Micrite (65-80%); Dolomitized micrite (10%).
POROSITY: Intercrystalline, intraparticle, moldic.
STRUCTURES: Diagenetic color-mottling; Occasional Type II microstyolite swarm with iron oxide association; Rare Type I suture seam styolite between stromatoporoids.
UV OIL TESTS: Absent at 2339.1', 2342.6' and 2345.3'.

T.S. 2343'
NAME: Dolomitic brachiopod biomicrudite (wackestone-packstone).
MICRITE: (60-70%) matrix.
FOSSILS: (20%) brachiopod fragments (50%), unidentified fossil fragments (29%), echinoderm fragments (20%), subspherical stromatoporoids (1%).
DOLOMITE: (10-20%) disseminated, microcrystalline euhedral rhombs.
HEMATITE: (3%) disseminated.

2346'-2346.7'
NAME: Dolomitic brachiopod biomicrudite (packstone).
MINERALS: Calcite (70%); Dolomite (30%).
COLOR: Mottled, grayish red (2.5YR6/2) to grayish red (2.5YR5/2) with common dark red (10R3/6) iron oxides.
ALLOCHEMS: Fossils (20-30%) subhorizontal orientation, brachiopod fragments and articulated shells (55%), echinoderm fragments (30%), unidentified fossil fragments (10%), ostracods (5%).

ORTHOCHEMS: Micrite (40-50%); Dolomitized micrite (30%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Very abundant scattered Type II microstyolites.

T.S. 2347'

NAME: Dolomitic to dolomitized, brachiopod, biomicrudite (wackestone-packstone).
MICRITE: (30-65%).
FOSSILS: (25%) Brachiopod fragments (40%), unidentified fossil fragments (35%), echinoderm fragments (20%), ostracods (5%).
DOLOMITE: (10-70%) Disseminated to pervasive microcrystalline euhedral rhombs.
QUARTZ: (less than 1%) Subrounded silt, showing calcite replacement (diagenesis).
HEMATITE: (1%) Patchy distribution.
REMARKS: Occasional Type II microstyolite.

2347.7'-2365'

NAME: Dolomitic brachiopod biomicrudite (wackestone-packstone).
MINERALS: Calcite (70%); Dolomite (30%).
COLOR: Mottled, light gray (10YR8/2) with very dark reddish brown (7.5R2/3).
ALLOCHEMS: Fossils (5-40%) brachiopod fragments and articulated shells (50%), unidentified fossil fragments (30%), ostracods (10%), gastropods (0-10%) increasing downward, echinoderm fragments (0-10%) increasing downward, cylindrical stromatoporoids (1%) at 2350.4'.
ORTHOCHEMS: Micrite (60-90%) increasing downward as the percentage of allochems decrease.
POROSITY: Intercrystalline.
UV OIL TESTS: Absent at 2348.4', 2350.4', 2353.6', 2356.4', 2359.5' and 2361.6'.
REMARKS: Base of available core.

T.S. 2351.3'

NAME: Dolomitic, echinoderm and brachiopod, biomicrudite (wackestone-packstone).
MICRITE: (70%).
CALCITE CEMENT: (3%) filling to partially filling pores.
FOSSILS: (25%) brachiopod molds (35%) articulated shell, unidentified fossil fragments (30%), echinoderm fragments (25%), ostracods (5%), gastropods (5%).
DOLOMITE: (1%) microcrystalline euhedral rhombs associated with microstyolites.
INSOLUBLES: (1%) associated with microstyolites and disseminated.
HEMATITE: (2%) rimming moldic pores followed by calcite pseudospar filling of pores.
REMARKS: Occasional Type II microstyolite swarms.

T.S. 2355'

NAME: Echinoderm and brachiopod biomicrudite (packstone).
MICRITE: (69%) matrix.
FOSSILS: (30%) commonly replaced by calcite, brachiopod fragments

(30%), echinoderm fragments (25%), unidentified fossil fragments (25%), gastropods (10%) with occasional geopetal structure, ostracods (10%), algae (?) (less than 1%).
HEMATITE: (2%) disseminated and rimming pores.

T.S. 2359'

NAME: Echinoderm and brachiopod biomicrudite (packstone-wackestone).
MICRITE: (80%) matrix;
MICROSPAR: (1%) rimming of bioclasts.
FOSSILS: (20%) commonly replaced by calcite, brachiopod fragments (60%), echinoderm fragments (30%), gastropods (6%) with occasional geopetal structure, ostracods (4%), bryozoans (less than 1%).
HEMATITE: (less than 1%) associated with bioclasts and styolites.
REMARKS: Type I suture seam styolite at base of section.

T.S. 2363'

NAME: Echinoderm and brachiopod biomicrudite (wackestone).
MICRITE: (78%) matrix.
PELOIDS: (less than 1%).
FOSSILS: (20%) commonly replaced by calcite, brachiopod fragments (35%), echinoderm fragments (30%), unidentified fossil fragments (25%), ostracods (10%).
INSOLUBLES: (1%).
HEMATITE: (1%) associated with bioclasts.

BOTTINEAU COUNTY

NDGS #38
LOCATION: T160N-R81W-S31, SW SE
WELL NAME: BLANCHE THOMPSON #1
COMPANY: THE CALIFORNIA COMPANY
DAWSON BAY FORMATION TOP DEPTH: 6172'
TOP OF THE SECOND RED BED MEMBER: 6279'
CORED INTERVAL: 6171.7'-6279'
KELLY BUSHING ELEVATION: 1526'
REMARKS: NORTH DAKOTA TYPE SECTION.

INTERVAL AND DESCRIPTIONS

6171.7'-6171.8'
NAME: Very-finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%).
COLOR: Light gray (10YR7/1).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture.
STRUCTURES: Occasional, subvertical, fractures partially filled with anhydrite.
UV OIL TESTS: Show at 6171.75'.

6171.8'-6172.2'
NAME: Very-finely-crystalline, cryptalgal, dolomite (boundstone).
MINERALS: Dolomite (100%).
COLOR: Dull yellow-orange (10YR6/3).
ALLOCHEMS: Fossils (5%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (95%).
POROSITY: Intercrystalline.
STRUCTURES: Cryptalgal laminations.
UV OIL TESTS: Show at 6172'.

T.S. 6172'
NAME: Dolomitized cryptalgal biolithite (boundstone).
DOLOMITE: (70%) very-finely-crystalline rhomb matrix and cryptalgal laminations.
FOSSILS: (30%) blue-green algae (?) (100%).

6172.2'-6172.8'
NAME: Very finely crystalline, peloidal, dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%).
COLOR: Dull yellow-orange (10YR6/3).
ALLOCHEMS: Pelloids (5%).
ORTHOCHEMS: Dolomitized micrite (95%).
POROSITY: Intercrystalline, pin-point vuggy, fenestral.
STRUCTURES: Subvertical fractures commonly healed by dolomite; Abundant to absent Type II microstyolite swarms to occasional seams.

6172.8'-6173.3'
NAME: Very-finely-crystalline, cryptalgal, dolomite (boundstone).
MINERALS: Dolomite (100%).
COLOR: Light gray (10YR7/1).

ALLOCHEMS: Fossils (30%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (70%).
POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: Occasional subvertical fractures with abundant tangential microfractures; Cryptalgal laminations.
UV OIL TESTS: Show at 6172.6'.

6173.3'-6174'

NAME: Very-finely-crystalline, cryptalgal, dolomite (boundstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%).
COLOR: Light yellow-orange (10YR8/3).
ALLOCHEMS: Fossils (30%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (70%).
POROSITY: Intercrystalline.
STRUCTURES: Cryptalgal laminations; Intraclasts in the upper 10 centimeters.
UV OIL TESTS: Show at 6173.2'; Absent at 6174'.

T.S. 6173.7'

NAME: Dolomitized, peloidal, cryptalgal biolithite (boundstone).
PELLOIDS: (5%) associated with cryptalgal laminations.
FOSSILS: (30%) blue-green algae (?) (100%).
DOLOMITE: (59%) very-finely-crystalline matrix.
ANHYDRITE: (less than 1%) filling fractures, microfractures, and fenestral pores.
INSOLUBLES: (5%) disseminated.
HEMATITE: (1%) disseminated and patchy distribution.

6174'-6174.5'

NAME: Very-finely-crystalline, intraclastic, dolomite (packstone).
MINERALS: Dolomite (100%), anhydrite (less than 1%).
COLOR: Dull yellowish brown (10YR5/3).
ALLOCHEMS: Intraclasts (40%).
ORTHOCHEMS: Dolomitized micrite (60%).
POROSITY: Intercrystalline, pin-point vuggy.
STRUCTURES: Occasional Type II microstyolite swarms to seams.

6174.5'-6175.7'

NAME: Very-finely-crystalline, intraclastic, cryptalgal dolomite (wackestone).
MINERALS: Dolomite (100%), anhydrite (less than 1%).
COLOR: Light gray (10YR8/1).
ALLOCHEMS: Fossils (40%) blue-green algae (?) (100%); Intraclasts (20-30%).
ORTHOCHEMS: Dolomitized micrite (30-40%).
POROSITY: Intercrystalline, intraparticle, microfracture (commonly filled with anhydrite).
STRUCTURES: Cryptalgal laminations; common subvertical to diagonal microfractures.
UV OIL TESTS: Absent at 6174.3'; Shows at 6174.6' and 6175.5'.

6175.7'-6176'

NAME: Very-finely-crystalline, intraclastic, dolomite (wackestone-packstone).

MINERALS: Dolomite (100%); Anhydrite (less than 1%); Pyrite (less than 1%).
COLOR: Grayish yellow-brown (10YR4/2).
ALLOCHEMS: Intraclasts (30-40%).
ORTHOCHEMS: Dolomitized micrite (60-70%).
POROSITY: Intercrystalline, intraparticle.
STRUCTURES: Common subvertical microfractures; Abundant intraclasts; Abundant disseminated Type II microstyolite swarms to nodular associated with intraclasts.

6176'-6176.6'

NAME: Very-finely-crystalline, ostracod, intraclastic dolomite (wackestone-packstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%).
COLOR: Light gray (10YR8/2).
ALLOCHEMS: Fossils (5-10%) ostracods (100%); Bioclastic intraclasts (30-40%); Peloids (3%) increasing up-section.
ORTHOCHEMS: Dolomitized micrite (52-62%).
POROSITY: Intraparticle, intercrystalline, microfracture.
STRUCTURES: Rare subvertical microfractures.
UV OIL TESTS: Show at 6176'; Show at 6176.5'.

T.S. 6176.5'

NAME: Dolomitized intraclastic biomicrudite (wackestone).
INTRACLASTS: (20%) ghosts.
FOSSILS: (5%) unidentified fossil fragment ghosts (100%).
DOLOMITE: (57%) very-finely-crystalline matrix and finely-crystalline euhedral rhombs filling microfractures.
ANHYYDRITE: (6%) sparry, filling fractures and microfractures.
BITUMENS: (1%) disseminated.
INSOLUBLES: (10%) disseminated.
HEMATITE: (1%) disseminated.
REMARKS: Microstyolites are controlled by prior fractures.

6176.6'-6183'

NAME: Finely crystalline, fossiliferous, intraclastic dolomite (packstone).
MINERALS: Dolomite (97-99%); Anhydrite (1-3%).
COLOR: Grayish yellow-brown (10YR6/2).
ALLOCHEMS: Intraclasts (10-50%) ghosts of microcrystalline dolomite composition accentuated by microstyolites.
FOSSILS: (2-10%) echinoderm fragments (80%), Unidentified fossil fragment ghosts (20%).
ORTHOCHEMS: Dolomitized micrite (40-88%).
POROSITY: Intercrystalline, fracture, moldic, and pin-point vuggy.
STRUCTURES: Occasional to abundant diagonal and vertical fractures; Occasional, subvertical, healed microfracture; Burrow-mottled; Abundant individual, swarm, and seam, Type II microstyolites.
UV OIL TESTS: Shows at 6177', 6178.7', 6181' and 6182.5'.

T.S. 6180'

NAME: Dolomitized biomicrudite (mudstone).
FOSSILS: (2%) unidentified fossil fragments ghosts (95%), brachiopod fragments ghosts (5%).

DOLOMITE: (92%) very-finely-crystalline matrix; filling microfractures; and filling to rimming moldic pores.
ANHYDRITE: (3%) fracture fill.
INSOLUBLES: (1%) disseminated, intercrystalline, and microstyolite association.

T.S. 6182'

NAME: Dolomitized biomicrudite (wackestone).
FOSSILS: (5%) fossil fragment ghosts and vuggy molds (100%).
DOLOMITE: (89%) disseminated very-finely-crystalline euhedral rhombs with occasional finely-crystalline euhedral rhombs filling fractures and replacing fossils.
ANHYDRITE: (1%) sparry, filling fractures.
INSOLUBLES: (1%) disseminated and microstyolite association.
BITUMENS: (less than 1%) disseminated.
HEMATITE: (2%) disseminated and patchy with color-mottling from oxidation.
REMARKS: Fractures filled by dolomite euhedral rhombs and cut by very abundant, anhydrite filled, microfractures.

6183'-6190'

MISSING

6190'-6198.2'

NAME: Very finely crystalline, stromatoporoid, dolomite (wackestone).
MINERALS: Dolomite (98%); Anhydrite (2%) filling fractures.
COLOR: Mottled, finely-crystalline dull yellow-orange (10YR7/3) and very-finely-crystalline grayish yellow-brown (10YR5/2).
ALLOCHEMS: Fossils (5-20%) cylindrical stromatoporoids (80%), echinoderm fragments (10%), bryozoans (5%), brachiopod fragments (5%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Fracture, microfracture, moldic, pin-point vuggy.
STRUCTURES: Occasional to abundant vertical fractures with slickensides and abundant black insoluble material; Common to very abundant Type II microstyolite swarms.
UV OIL TESTS: Shows at 6191.5',6192.5', 6194', 6195', and 6197.5'.

T.S. 6192'

NAME: Dolomitized biomicrudite (wackestone).
FOSSILS: (5%) unidentified fossil ghosts and vugs (100%).
DOLOMITE: (89%) rhombic, very-finely-crystalline matrix; finely-crystalline fracture fill; fossil replacement; and rimming to filling porosity.
ANHYDRITE: (1%) sparry, filling fractures.
INSOLUBLES: (1%) disseminated and microstyolite association.
BITUMENS: (1%) disseminated.
HEMATITE: Oxidized, disseminated and patchy distribution.
REMARKS: Abundant subvertical fractures with very abundant cross-cutting microfractures; Fractures and microfractures filled to partially filled by dolomite euhedral rhombs; Anhydrite filling remaining fractures.

T.S. 6195.5'

NAME: Dolomitized pelmicrudite (wackestone)

PELOIDS: (10%) ghosts.

FOSSILS: (4%) unidentified fossil molds-vugs (70%), cylindrical stromatoporoid ghosts (15%), echinoderm fragment ghosts (10%), brachiopod fragment ghosts (5%).

DOLOMITE: (79%) very-finely-crystalline matrix, with rare finely-crystalline euhedral rhombs, filling fractures and associated with microstyolites.

ANHYDRITE: (3%) filling fractures and moldic pores.

INSOLUBLES: (3%) disseminated and microstyolite association.

HEMATITE: (1%) oxidized, disseminated and microstyolite association.

6198'-6199'

NAME: Very-finely-crystalline, echinoderm, dolomite (wackestone).

MINERALS: Dolomite (100%); Anhydrite (less than 1%) filling vuggy pores.

COLOR: Mottled, very-finely-crystalline light gray (10YR7/1) and finely-crystalline dull yellow-orange 10YR7/3).

ALLOCHEMS: Fossils (10-15%) echinoderm fragments and molds (85%), possible moldic bryozoans (15%).

ORTHOCHEMS: Dolomitized micrite (85-90%).

POROSITY: Intercrystalline, moldic, pin-point vuggy, microfracture.

STRUCTURES: Occasional to abundant Type II microstyolite swarms and seams with finely-crystalline dolomite association; Rare, commonly healed, microfractures.

UV OIL TESTS: Show at 6198.5'.

6199'-6200.6'

NAME: Finely crystalline dolomite (mudstone).

MINERALS: Dolomite (100%).

COLOR: Dull yellow-orange (10YR7/3).

ALLOCHEMS: Fossils (less than 1%) brachiopod fragments (50%), Echinoderm fragments (50%).

ORTHOCHEMS: Dolomitized micrite (100%).

POROSITY: Intercrystalline, pin-point vuggy, moldic.

STRUCTURES: Occasional Type II discontinuous individual microstyolite.

UV OIL TESTS: Show at 6199.5'.

T.S. 6200'

NAME: Dolomitized biomicrudite (mudstone).

FOSSILS: (3%) unidentified fossil fragments and molds (80%), Echinoderm fragments (20%).

DOLOMITE: (94%) very-finely-crystalline.

BITUMENS: (less than 1%) disseminated.

INSOLUBLES: (2%) disseminated and microstyolite associated.

HEMATITE: (1%) disseminated and microstyolite associated.

6200.6'-6203.5'

NAME: Very-finely-crystalline, echinoderm and brachiopod dolomite (wackestone-packstone).

MINERALS: Dolomite (100%); Fibrous mat anhydrite filling vugs between 6202'-6202.5' to 10-20% of the rock.

COLOR: Mottled, very-finely-crystalline light gray (10YR7/1) and finely-crystalline dull yellow-orange.
ALLOCHEMS: Fossils (10%) brachiopod fragments (80%), echinoderm fragments (20%).
ORTHOCHEMS: Dolomitized micrite (70-90%).
POROSITY: Moldic, intercrystalline, vuggy, pin-point vuggy, fracture, microfracture.
STRUCTURES: Abundant, commonly healed, subvertical microfractures and fractures; Rare, discontinuous, individual, Type II microstyolites.
UV OIL TESTS: Shows at 6201.8', 6202.6', 6202.5' and 6203'.

6203.5'-6206.7'
NAME: Very-finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (100%); Pyrite (less than 1%) associated with microstyolites.
COLOR: Dull yellow-orange (10YR7/2).
ALLOCHEMS: Fossils (less than 1%) possible cylindrical stromatoporoid molds (70%), unidentified fossil fragment molds (30%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Pin-point vuggy, vuggy, intercrystalline, microfracture, and moldic.
STRUCTURES: Occasional, healed, subvertical microfracture; Rare to absent individual Type II microstyolites.
UV OIL TESTS: Show at 6205'.

T.S. 6204'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (98%) Microcrystalline matrix, with occasional very-finely-crystalline euhedral rhombs, rimming to filling pores.
INSOLUBLES: (1%) microstyolite associated and disseminated.
HEMATITE: (less than 1%) disseminated and microstyolite associated.

6206.7'-6210.5'
NAME: Very-finely-crystalline, echinoderm and brachiopod, dolomite (mudstone).
MINERALS: Dolomite (100%); Pyrite (less than 1%) associated with microstyolites.
COLOR: Mottled, very-finely-crystalline light gray (10YR7/1) and finely-crystalline light yellow-orange (10YR8/3).
ALLOCHEMS: Fossils (0-2%) brachiopod fragments (70%) and echinoderm fragments (30%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, pin-point vuggy.
STRUCTURES: Abundant Type II microstyolites, continuous individual and swarms dominate, with minor discontinuous individual and echinoderm associated nodular forms; Occasional healed subvertical microfractures.
UV OIL TESTS: Shows at 6207'and 6209'.

T.S. 6208'
NAME: Dolomitized echinoderm biomicrudite (mudstone).
FOSSILS: (1%) Echinoderm fragments, molds and vugs (100%).

DOLOMITE: (98%) microcrystalline to very-finely-crystalline euhedral rhombs.
INSOLUBLES: (2%) microstyolite associated and disseminated.
HEMATITE: (1%) disseminated and microstyolite associated.
REMARKS: Microstyolites occasionally are controlled by fractures.

6210.5'-6214.2'

NAME: Very-finely-crystalline, echinoderm, dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%) associated with fractures.
COLOR: Dull yellow-orange (10YR7/3).
ALLOCHEMS: Fossils (less than 1%-3%) echinoderm fragments (100%), possible cylindrical stromatoporoid (less than 1%).
ORTHOCHEMS: Dolomitized micrite (99%).
POROSITY: Pin-point vuggy, intercrystaline, vuggy, microfracture.
STRUCTURES: Abundant to absent subhorizontal discontinuous Type II microstyolite swarms.
UV OIL TESTS: Shows at 6211', 6212.5' and 6213.4'.

T.S. 6212'

NAME: Dolomitized, brachiopod and echinoderm, biomicrite (mudstone).
FOSSILS: (3%) echinoderm fragments (40%), unidentified molds (40%), brachiopod fragments (20%).
DOLOMITE: (93%) microcrystalline to very finely crystalline euhedral rhombs healing fractures and partially filling pores.
ANHYDRITE: (1%) fibrous, filling fractures and vuggy-moldic pores.
INSOLUBLES: (2%) microstyolite association.
HEMATITE: (1%) associated with microstyolites, disseminated, and oxidized along subhorizontal, subparallel, discontinuous microfractures.

6214.2'-6219'

NAME: Very-finely-crystalline echinoderm dolomite.
MINERALS: Dolomite (100%); Pyrite (less than 1%); Anhydrite (less than 1%).
COLOR: Mottled, very-finely-crystalline brownish gray (10YR6/1) and finely-crystalline dull yellow-orange (10YR7/3).
ALLOCHEMS: Fossils (1%) echinoderm fragments (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, pin-point vuggy, vuggy.
STRUCTURES: Abundant individual Type II microstyolites and occasional swarms and seams.
UV OIL TESTS: Shows at 6214.5', 6215', 6216.5', 6217.5' and 6218.5'.

T.S. 6216'

NAME: Dolomitized echinoderm biomicrudite (mudstone).
FOSSILS: (2%) echinoderm fragments (50%), unidentified fossil fragment molds (50%).
DOLOMITE: (98%) very-finely-crystalline euhedral rhombs.
ANHYDRITE: (less than 1%) rare, filling pores.
BITUMENS: (less than 1%) disseminated patches.
INSOLUBLES: (1%) microstyolite associated, and disseminated.
HEMATITE: (1%) disseminated, and microstyolite associated.

6219'-6221.7'
NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%) partially filling fractures; Pyrite (less than 1%) associated with microstyolites.
COLOR: Mottled, brownish gray (10YR6/1), and in microcrystalline- upper core, dull yellow-orange (10YR7/4).
ALLOCHEMS: Fossils (less than 1%)unidentified fossil fragments (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, microfracture, pin point vuggy.
STRUCTURES: Abundant Type II microstyolite swarms, occasional nodules; Abundant subvertical microfractures.
UV OIL TESTS: Shows at 6219.8', 6220.5' and 6221.5'.

6221.7'-6225'
NAME: Very-finely-crystalline echinoderm dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%) associated with microfractures; Pyrite (less than 1%) oxidized, associated with microstyolites.
COLOR: Dull yellow-orange (10YR7/2).
ALLOCHEMS: Fossils (1%) echinoderm fragments (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, pin-point vuggy, microfracture.
STRUCTURES: Common, Type II microstyolite seams; Common, partially healed, subvertical microfractures.
UV OIL TESTS: Shows at 6222.8', 6223.8' and 6224.6'.

T.S. 6223'
NAME: Dolomitized biomicrite (mudstone).
FOSSILS: (less than 1%) echinoderm fragments (100%) associated with microstyolites.
DOLOMITE: (96%) microcrystalline with very finely crystalline euhedral rhombs associated with microstyolites, microfractures, and rimming to filling pores.
ANHYDRITE: (1%) partially filling fractures and microfractures.
BITUMENS: (less than 1%) disseminated as millimeter scale blebs.
INSOLUBLES: (less than 1%) microstyolite associated and disseminated.
HEMATITE: (1%) oxidized, microstyolite associated and disseminated.

T.S. 6224'
NAME: Dolomitized biomicrite (mudstone).
FOSSILS: (1%) unidentified fossil ghosts and molds-vugs (100%).
DOLOMITE: (97%) microcrystalline matrix; very finely-crystalline euhedral rhombs healing fractures; and rimming moldic-vuggy pores.
ANHYDRITE: (less than 1%) filling sparry fractures.
INSOLUBLES: (2%) microstyolite associated, patchy distribution, and disseminated.
HEMATITE: (1%) disseminated and microstyolite associated, oxidized.

6225'-6229'
NAME: Microcrystalline echinoderm biomicrite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%) partially

filling fractures and microfractures; Pyrite (less than 1%) oxidized in association with fractures and microstyolites.
COLOR: Mottled, brownish gray (10YR6/1) and dull yellow-orange (10YR7/4).
ALLOCHEMS: Fossils (less than 1%) echinoderm fragments (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
STRUCTURES: Solution-enlarged fractures; Rare diagonal fractures; Abundant-common diagonal microfractures; Occasional subhorizontal Type II microstyolite swarms and occasional nodules.
UV OIL TESTS: Shows at 6225.8', 6227' and 6228'.

6229'-6232'
NAME: Microcrystalline echinoderm dolomite (mudstone).
MINERALS: Dolomite (20-90%); Anhydrite (10-80%) filling breccia porosity, and replacing dolomite at 6230.1' (mineralogy confirmed by X-ray analysis); Pyrite (less than 1%) in fractures and microstyolites.
COLOR: Mottled, grayish yellow-brown (10YR6/1) and dull yellow-orange (10YR6/3).
ALLOCHEMS: Fossils (less than 1%) echinoderm fragments (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Fracture (very high), microfracture, intercrystalline.
STRUCTURES: Solution-mottling; Very-abundant diagonal fractures; Very-abundant microfractures tangential to fractures; Common subhorizontal-diagonal Type II microstyolite swarms.
UV OIL TESTS: Shows at 6229.4', 6230.5' and 6231.6'.

T.S. 6228'
NAME: Dolomitized biomicrite (mudstone).
FOSSILS: (1%) unidentified fossil fragment ghosts (100%).
DOLOMITE: (97%) microcrystalline euhedral rhombs; Very-finely-crystalline euhedral rhombs healing early fractures and associated with microstyolites.
ANHYDRITE: (1%) fibrous-mat crystals filling late fractures, occassional individual laths.
INSOLUBLES: (1%) microstyolite association and patchy.
HEMATITE: (less than 1%) oxidized in microstyolite association and disseminated.
REMARKS: Fractures abundant with early fractures healed, then offset, then partially dolomite healed and filled by anhydrite, lastly microstyolite development.

T.S. 6232'
NAME: Dolomitized echinoderm biomicrite (mudstone).
FOSSILS: (1%) echinoderm fragment ghosts (25%), unidentified fossil ghosts (75%).
DOLOMITE: (95%) microcrystalline, euhedral rhomb matrix and microcrystalline-upper euhedral rhombs healing earlier fractures and rimming later fractures.
ANHYDRITE: (2%) fibrous, partially filling fractures.
INSOLUBLES: (1%) microstyolite association.
HEMATITE: (1%) disseminated and microstyolite association.
REMARKS: Abundant fractures, with early fractures healed by dolomite, then refractured with subsequent rimming by

microcrystalline, clear, euhedral dolomite rhombs, followed by partial filling of fractures by anhydrite, then lastly microstyolite development.

6232'-6234.5'

NAME: Microcrystalline echinoderm dolomite (mudstone).
MINERALS: Dolomite (98%); Anhydrite (2%) partially filling fractures; Pyrite (less than 1%) microstyolite associated.
COLOR: Mottled, microcrystalline brownish gray (10YR6/1) and very-finely-crystalline grayish yellow-brown (10YR5/2).
ALLOCHEMS: Fossils (less than 1%) echinoderm fragments (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture, microfracture, pin-point vuggy.
STRUCTURES: Abundant subhorizontal Type II microstyolite swarms; Occasional to common, subvertical, fractures and microfractures.
UV OIL TESTS: Shows at 6232.5' and 6233.8'.

6234.5'-6239'

NAME: Microcrystalline echinoderm dolomite (mudstone).
MINERALS: Dolomite (99%) matrix; Anhydrite (less than 1%) associated with fractures; Pyrite (1%) associated with microstyolites.
COLOR: Mottled, microcrystalline brownish-gray (10YR6/1) matrix and very-finely-crystalline, dull yellow-orange (10YR6/2), associated with microstyolites.
ALLOCHEMS: Fossils (less than 1%) echinoderm fragments (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Pin-point vuggy, intercrystalline, fracture, microfractuture.
STRUCTURES: Occasional subvertical fractures and microfractures; Occasional subhorizontal Type II nodular microstyolites.
UV OIL TESTS: Shows at 6235', 6236' and 6236.5'.

T.S. 6236'

NAME: Dolomitized micrite (mudstone).
DOLOMITE: (98%) Microcrystalline matrix with very-finely-crystalline euhedral rhombs filling to partially filling fractures.
BITUMENS: (less than 1%) microstyolite and fracture associated.
INSOLUBLES: (1%) microstyolite association.
HEMATITE: (1%) oxidized, microstyolite association and disseminated.
REMARKS: Multiple stages of fracturing with fractures cut by microstyolites.

6239'-6249'

NAME: Microcrystalline echinoderm dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%) associated with fractures and vugs; Pyrite (less than 1%) oxidized and associated with microstyolites.
COLOR: Mottled, light gray (10YR7/1) microcrystalline matrix; and light yellow-orange (10YR8/4), very-finely-crystalline dolomite, associated with fractures.
ALLOCHEMS: Fossils (less than 1%) echinoderm fragments (100%).
ORTHOCHEMS: Dolomitized micrite (100%).

POROSITY: Pin-point vuggy, vuggy, intercrystalline, fracture, microfracture.
STRUCTURES: Abundant subvertical fractures and microfractures (healed where cut by subhorizontal microstyolites); Abundant subhorizontal Type II microstyolite swarms.
UV OIL TESTS: Shows at 6241', 6241.5', 6242.6', 6243.5', 6244.2', 6245.6', 6246.5', 6247.6', and 6248.4'.

T.S. 6240'
NAME: Dolomitized biomicrudite (mudstone).
FOSSILS: (1%) echinoderm fragment ghosts (50%), unidentified fossil fragment ghosts (50%).
DOLOMITE: (98%) microcrystalline, euhedral rhomb matrix, healing to partially healing fractures.
BITUMENS: (less than 1%) microstyolite association.
INSOLUBLES: (1%) microstyolite associated.
HEMATITE: (less than 1%) disseminated and oxidized in association with microstyolites.
REMARKS: Fractures cut by microstyolites.

T.S. 6244'
NAME: Dolomitized, brachiopod and echinoderm, biomicrudite (mudstone-wackestone).
FOSSILS: (7%) echinoderm fragments (60%), articulated brachiopod ghosts (40%).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix; very-finely-crystalline euhedral rhombs filling moldic pores and healing fractures.
BITUMENS: (less than 1%) microstyolite associated.
INSOLUBLES: (2%) microstyolite associated, and disseminated.
HEMATITE: (1%) disseminated, and patchy distribution.
REMARKS: Fractures cut by microstyolites.

T.S. 6248'
Dolomitized micrite (mudstone).
DOLOMITE: (96%) microcrystalline, euhedral rhomb matrix, with very-finely-crystalline euhedral rhombs, associated with microstyolites and healing fractures.
BITUMENS: (1%) disseminated.
INSOLUBLES: (2%) disseminated.
HEMATITE: (1%) disseminated, and oxidized adjacent to microstyolites and fractures.
REMARKS: Fractures cut by microstyolites; Highest intercrystalline porosity is the result of recrystalization to very-finely-crystalline euhedral rhombs adjacent to fractures and microstyolites.

6249'-6258'
NAME: Very-finely-crystaline, echinoderm and brachiopod, dolomite (mudstone).
MINERALS: Dolomite (100%); Pyrite (less than 1%) disseminated; Anhydrite (less than 1%) filling fractures.
COLOR: Mottled, light dull yellow-orange (10YR7/3) very-finely-crystalline matrix; and dark, dull yellow-orange (10YR6/4) finely-

crystalline euhedral rhombs, adjacent to fractures and microstyolites.
ALLOCHEMS: Fossils (less than 1%) echinoderm fragments (50%), articulated and fragmented brachiopods (50%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture.
STRUCTURES: Occasional Type II microstyolite swarms; Common subvertical fractures.
UV OIL TESTS: Shows at 6249.6' and 6250.8'.

T.S. 6252'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (97%) microcrystalline, euhedral rhomb matrix; and healing to rimming of fractures.
ANHYDRITE: (1%) filling fractures.
INSOLUBLES: (1%) disseminated and microstyolite associated.
HEMATITE: (1%) disseminated and microstyolite associated.

T.S. 6256'
NAME: Dolomitized brachiopod biomicrudite (mudstone).
FOSSILS: (1%) brachiopod ghosts (100%).
DOLOMITE: (99%) microcrystalline, euhedral rhomb matrix; with, minor, euhedral rhombs healing fractures.
INSOLUBLES: (less than 1%) disseminated.
HEMATITE: (less than 1%) disseminated.

6258'-6263.5'
NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (99%); Anhydrite (1%) filling fractures, and occasional nodules; Pyrite (less than 1%) disseminated.
COLOR: Mottled, grayish yellow-brown (10YR5/2) microcrystalline matrix; and dull yellow-orange (10YR7/2), very-finely-crystalline euhedral rhombs, associated with healed fractures and microstyolites.
ORTHOCHEMS: Dolomitized micrite ((100%).
POROSITY: Pin-point vuggy, fracture, intercrystalline, microfracture.
STRUCTURES: Occasional Type II microstyolite swarms which control recrystallization to very-finely-crystalline euhedral rhombs. Common subvertical and diagonal fractures; Occasional subvertical microfractures.
UV OIL TESTS: Shows at 6259', 6261', and 6262.5'.

T.S. 6260'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (100%) microcrystalline, euhedral rhomb matrix and common, microcrystalline-upper, clear, euhedral rhombs filling fractures.
BITUMENS: (less than 1%) disseminated.
INSOLUBLES: (less than 1%) disseminated.
HEMATITE: (less than 1%) disseminated and oxidized.

6263.5'-6269'
NAME: Microcrystalline dolomite (mudstone).

MINERALS: Dolomite (100%); Anhydrite (less than 1%) filling fractures; Pyrite (less than 1%) disseminated.
COLOR: Mottled, brownish gray (10YR5/1) microcrystalline matrix and grayish yellow-brown (10YR6/2) finely-crystalline euhedral rhombs associated with fractures and microstyolites.
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture, pin-point vuggy.
STRUCTURES: Common subvertical and subparallel fractures; Common subvertical microfractures; Occasional Type II microstyolite swarms, occasionally approaching nodular.
UV OIL TESTS: Shows at 6264' and 6268'.

T.S. 6264'
NAME: Dolomitized brachiopod biomicrudite (mudstone).
FOSSILS: (less than 1%) brachiopods ghosts (100%) articulated and of a thin-shelled variety.
DOLOMITE: (97%) microcrystalline, euhedral rhomb matrix and occasional, clear, euhedral rhomb replacement adjacent to fractures, and rimming fractures.
ANHYDRITE: (1%) sparry, filling fractures.
BITUMENS: (1%) disseminated.
INSOLUBLES: (less than 1%) disseminated and associated with microstyolites.
HEMATITE: (1%) oxidized, disseminated and microstyolite associated.

T.S. 6268'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (97%) microcrystalline, euhedral rhomb matrix and occasional, clear, euhedral rhombs healing fractures.
ANHYDRITE: (1%) sparry, partially filling fractures.
BITUMENS: (2%) disseminated.
HEMATITE: (less than 1%) disseminated.

6269'-6273'
NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%) filling fractures; Pyrite (less than 1%).
COLOR: Grayish yellow-brown (10YR5/2) microcrystalline matrix and light gray (10YR8/2) very-finely-crystalline euhedral rhombs associated with fractures.
ORTHOCHEMS: dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture, microfracture, and channel.
STRUCTURES: Very extensive fracturing with dissolution enlarged fractures; Occasional subhorizontal Type II microstyolite swarms.
UV OIL TESTS: Show at 6271.2'.

T.S. 6272'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (90%) microcrystalline, euhedral rhomb matrix; occasional, clear euhedral rhombs, partial healing fractures.
ANHYDRITE: (3%) sparry, filling fractures.
BITUMENS: (1%) disseminated and patchy.
INSOLUBLES: (less than 1%) patchy and microstyolite associated.
HEMATITE: (1%) disseminated.

6273'-6275.8'

NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%) filling fractures.
COLOR: Mottled, grayish yellow-brown (10YR6/2) microcrystalline euhedral rhombs, and light yellow-orange (10YR8/3) cryptocrystalline patches.
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: Common subvertical and diagonal fractures, occasionally with black, insoluble covered, slickensides; Common subhorizontal Type II microstyolite swarms-seams.
UV OIL TESTS: Show at 6273'.

6275.8'-6279'

NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (100%); Anhydrite (less than 1%) filling fractures.
COLOR: Dull yellow-orange (10YR7/2), microcrystalline, euhedral rhomb matrix with light yellow-orange (10YR8/3) very-finely-crystalline euhedral rhombs proximal to microstyolites.
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: Occasional subvertical fractures and microfractures, commonly healed in microstyolite zones; Occasional subhorizontal Type II microstyolite swarms-seams.
UV OIL TESTS: Shows at 6276' and 6278'.

T.S. 6276'

NAME: Dolomitized micrite (mudstone).
DOLOMITE: (96%) microcrystalline, euhedral rhomb matrix; occasional, clear, euhedral rhombs partial healing fractures.
ANHYDRITE: (2%) sparry, filling fractures.
BITUMENS: (1%) disseminated.
INSOLUBLES (1%) disseminated and microstyolite associated.
HEMATITE: (less than 1%) disseminated.
REMARKS: Fractures and anhydrite cut by microstyolites.

T.S. 6279'

NAME: Dolomitized micrite (mudstone).
DOLOMITE: (95%) microcrystalline euhedral rhombs and occasional, clear, euhedral rhombs healing fractures.
ANHYDRITE (2%) sparry, filling fractures and replacing dolomite.
BITUMENS: (1%) disseminated.
INSOLUBLES: (1%) microstyolite associated and disseminated.
HEMATITE: (1%) disseminated.
REMARKS: Base of Dawson Bay Formation carbonate section.

6279'-6280'

NAME: Dolomitized intraclastic micrudite (wackestone).
MINERALS: Dolomite (97%); Hematite (3%) associated with oxidized red clay and reduced bluish-black clay; Anhydrite (less than 1%) filling fractures, and nodular.
COLOR: Dull yellow-orange (10YR6/3) to bluish black (5B2/1)

ALLOCHEMS: Intraclasts (10%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystaline, fracture, microfracture.
STRUCTURES: Common subvertical and rare subhorizontal fractures and microfractures; Unconformable contact with the Second Red Bed.
UV OIL TESTS: SHOW AT 6279.5'.

WELLS COUNTY

NDGS #207
LOCATION: T146N-R73W-S27, SE SE
WELL NAME: JOHN LUETH #1
COMPANY: CONTINENTAL OIL COMPANY
DAWSON BAY FORMATION TOP DEPTH: 4583'
TOP OF THE SECOND RED BED MEMBER: 4637'
CORED INTERVAL: 4583'-4643'
KELLY BUSHING ELEVATION: 1933'

INTERVAL AND DESCRIPTIONS

4581'-4583'
NAME: Micrite (mudstone).
MINERALS: Calcite (80%); clay (20%).
COLOR: Light olive-gray (2.5GY7.1).
ORTHOCHEMS: Micrite (80%); Micrite altered to nontronite clay (20%).
POROSITY: Intercrystalline, fracture.
STRUCTURES: Diagenetic color-mottling; Subvertical fractures.
UV OIL TEST: Absent at 4581.5'.
REMARKS: Basal Souris River Formation.

4583'-4587.4'
NAME: Gastropod biomicrudite (mudstone).
MINERALS: Calcite (99%); Anhydrite (1%).
COLOR: Light gray (5Y8/1).
ALLOCHEMS: Fossils (2-5%) gastropods (70%), echinoderm fragments (15%), ostracods (10%), brachiopods (5%) shells disarticulated and articulated.
ORTHOCHEMS: Micrite (95-98%).
POROSITY: Intercrystalline.
STRUCTURES: Occasional Type II microstyolite swarms, subhorizontal seams, and occasional nodular-type.

T.S. 4583'
NAME: Ostracod and gastropod, intraclastic, pelmicrudite (packstone).
MICRITE: (20%) matrix.
MICROSPAR: (1%) occasional partial replacement adjacent to bioclasts.
CALCITE CEMENT: (2%) filling fractures and moldic pores.
INTRACLASTS: (1%) peloidal and bioclastic composition.
PELOIDS: (65%) micritic composition.
FOSSILS: (10%) ghosts, gastropods (25%), ostracods (25%), unidentified fossil fragments (26%), echinoderm fragments (12%), thin-shelled brachiopods (12%), blue-green algae (?) (1%), calcispheres (less than 1%).
ANHYDRITE: (1%) filling moldic pores and replacing adjacent micrite.
HEMATITE: (less than 1%) disseminated.

T.S. 4587'
NAME: Dolomitized brachiopod biomicrudite (mudstone).
MICRITE: (1%) matrix.
FOSSILS: (less than 1%) unidentified fossil molds (60%), brachiopod

fragments (40%).
DOLOMITE: (100%) microcrystalline, euhedral rhomb matrix replacement.
ANHYDRITE: (less than 1%) disseminated laths.
HEMATITE: (less than 1%) disseminated.
REMARKS: Very minor moldic pores.

4587.4'-4597.2'
NAME: Dolomitic, brachiopod and echinoderm, biomicrudite (mudstone-wackestone).
MINERALS: Calcite (94%); Dolomite (5%); Insolubles (1%); Anhydrite (less than 1%) rare nodule (less than 3 cm); Pyrite (less than 1%).
COLOR: Brownish gray (5YR6/1) to grayish brown (5YR6/2).
ALLOCHEMS: Fossils (5-10%) echinoderm fragments (45%), brachiopods (35%) shells articulated and disarticulated, gastropods (15%), ostracods (5%), trilobites (less than 1%) at 4594'.
ORTHOCHEMS: Micrite (80-90%).
POROSITY: Intercrystalline.
STRUCTURES: Subvertically oriented patches of reduced hematite and pyrite; Occasional Type II microstyolite swarm; Occasional irregularly oriented microfracture.
UV OIL TEST: Absent at 4596.5'.

T.S. 4591'
NAME: Dolomitic and fossiliferous pelmicrudite (packstone).
MICRITE: (21%) Matrix.
MICROSPAR: (less than 1%) rimming pores.
CALCITE CEMENT: (2%) filling to partially filling pores.
PELOIDS: (70%) micritic ghosts.
FOSSILS: (2%) unidentified fossil fragment ghosts (75%), brachiopod molds (10%), ostracods (10%), gastropods (5%).
DOLOMITE: (5%) disseminated, microcrystalline euhedral rhombs.
HEMATITE: (2%) disseminated and bioclast associated.

T.S. 4594'
NAME: Dolomitic, echinoderm, intraclastic pelmicrudite (packstone).
MICRITE: (35-45%) matrix.
MICROSPAR: (less than 1%) rimming moldic pores.
CALCITE CEMENT: (2%) filling to partially filling moldic pores.
INTRACLASTS (1%) peloidal biomicrudite composition.
PELOIDS: (40%) micritic ghosts.
FOSSILS: (10-20%) echinoderm fragments (35%), brachiopod fragments (25%), unidentified fossil fragments (20%), trilobites (15%), gastropods (5%).
DOLOMITE: (2%) disseminated, microcrystalline euhedral rhombs.
ANHYDRITE: (less than 1%) disseminated, laths filling sparry molds, laths partially micritized.
HEMATITE: (2%) rimming pores.
REMARKS: Abundant geopetal structures and trilobites.

4597.2'-4598.5'
NAME: Peloidal biomicrudite (mudstone-wackestone).
MINERALS: Calcite (99%) matrix and bioclasts; Dolomite (1%).

COLOR: Brownish gray (5YR6/1).
ALLOCHEMS: Fossils (2-10%) unidentified fossil fragments (20-30%), gastropods (20%), ostracods (15%), articulated and fragmental brachiopods (15%), echinoderm fragments (15%), cylindrical stromatoporoids (5%); Peloids (0-5%) micritic.
ORTHOCHEMS: Micrite (90-95%); Dolomitized micrite (1%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Peloidal mudstone and wackestone are intermixed with the wackestone increasing downward.
UV OIL TESTS: Show at 4598.7' (very weak).

4598.5'-4581.5'
NAME: Peloidal, brachiopod and echinoderm, biomicrudite (wackestone).
MINERALS: Calcite (99%) matrix and bioclasts; Dolomite (1%); Anhydrite (less than 1%) Rare (2-3 cm) nodule.
COLOR: Light brownish-gray (5YR7/2).
ALLOCHEMS: Fossils (10%) echinoderm fragments (40%), articulated and fragmental brachiopods (25%), cylindrical stromatoporoids (10%), ostracods (10%), unidentified fossil fragments (5-15%), tabular stromatoporoids (5%), gastropods (2%); Peloids (6%) micritic.
ORTHOCHEMS: Micrite (83%); Dolomitized micrite (1%).
POROSITY: Intercrystalline, intraparticle.
STRUCTURES: Occasional subhorizontal Type II microstyolite swarm.

T.S. 4599'
NAME: Peloidal, brachiopod and echinoderm, biomicrudite (packstone).
MICRITE: (10%) matrix and very common micritization of bioclast rims to entire bioclast.
PSEUDOSPAR: (less than 1%) recrystallized micrite interior of calcispheres to equant blocky spar, and rimming of calcispheres by bladed, now micritized spar.
INTRACLASTS: (less than 1%) bioclastic composition.
PELOIDS: (38%) micritic.
FOSSILS: (48%) unidentified fossil fragments (40%), brachiopod fragments (30%), echinoderm fragments (30%), calcispheres (less than 1%).
DOLOMITE: (1%) occasional, dispersed, microcrystalline euhedral rhombs.
BITUMENS: (1%).
INSOLUBLES: (1%) disseminated and microstyolite associated.
HEMATITE: (1%) microstyolite associated.

4601.5'-4627.6
NAME: Echinoderm and brachiopod biomicrudite (wackestone-packstone).
MINERALS: Calcite (80-100%) matrix and bioclasts; Dolomite (0-20%); Hematite (less than 1%) associated with pores.
COLOR: Mottled, light reddish-gray (10R7/1) to reddish gray (10R6/) associated with microstyolites.
ALLOCHEMS: Fossils (10-20%) brachiopods (40-50%) shells articulated and disarticulated, echinoderm fragments (20-45%), unidentified fossil fragments (0-15%), ostracods (10%), corals (0-5%) decreasing downward, cylindrical stromatoporoids (0-5%) decreasing downward, bryozoans (0-5%) decreasing downward, cephalopod (less

than 1%) at 4606.8'; Peloids (2%) at top of section.
ORTHOCHEMS: Micrite (55-70%); Dolomitized micrite (0-20%).
POROSITY: Intercrystalline, intraparticle (very minor), shelter.
STRUCTURES: Diagenetic color-mottling; Very abundant, subhorizontal, bioclast controlled Type II microstyolite swarms and occasional nodules.
UV OIL TESTS: Shows at 4610.6', 4610.8', and 4612.5'; Absent at 4614'; Shows at 4615.9', 4619' and 4622.1'; Absent at 4623.7'.

T.S. 4603'
NAME: Ostracod biomicarenite (mudstone).
MICRITE: (90%) matrix.
CALCITE CEMENT: (1%) filling pores.
FOSSILS: (3%) ostracods (40%), brachiopods (25%), calcispheres (15%), echinoderm fragments (10%), gastropods (10%).
DOLOMITE: (2%) disseminated, microcrystalline euhedral rhombs.
INSOLUBLES: (less than 1%) disseminated and associated with microstyolites.
HEMATITE: (2%) associated with microfractures and microstyolites.
REMARKS: Abundant Type II microstyolite swarms; Ostracod geopetal structure in center of thin-section; Diagenetic color-mottling.

T.S. 4607'
NAME: Peloidal, echinoderm and calcisphere, biomicarenite (wackestone).
MICRITE: (78%) matrix and micritized bioclasts.
MICROSPAR: (1%) rimming microfractures.
PELOIDS: (5%) Micritic.
FOSSILS: (15%) commonly micritized, calcispheres (40%), echinoderm fragments (30%), ostracods (20%), brachiopod fragments (10%).
DOLOMITE: (less than 1%) disseminated and microfracture associated, microcrystalline euhedral, rhombs.
HEMATITE: (1%) microfracture association and patchy distribution.
REMARKS: Geopetal structures.

T.S. 4611'
NAME: Dolomitic brachiopod biomicrudite (wackestone).
MICRITE: (68%) matrix.
PSEUDOSPAR: (less than 1%) radial-fibrous rimming of calcispheres.
FOSSILS: (10%) brachiopods (60%) articulated and fragmented, echinoderm fragments (20%), ostracods (9%), calcispheres (1%).
DOLOMITE: (20%) disseminated microcrystalline and rare finely-crystalline euhedral rhombs.
INSOLUBLES: (less than 1%).
HEMATITE: (2%) disseminated and patchy distribution.

T.S. 4615'
NAME: Dolomitic biomicrudite (wackestone).
MICRITE: (75%) matrix and micritized rimming of bioclasts.
MICROSPAR: (less than 1%) recrystallized from micrite in stromatoporoid borings.
FOSSILS: (15-20%) echinoderm fragments (30%), ostracods (25%), cylindrical stromatoporoids (20%), coral fragments (20%), brachiopod fragments (5%).

DOLOMITE: (10%) disseminated, microcrystalline, and occasional very-finely-crystalline euhedral rhombs.
INSOLUBLES: (2%) disseminated and microstyolite associated.
HEMATITE: (less than 1%) disseminated and oxidized where associated with microstyolites.
REMARKS: Microstyolites occasionally intersect bioclasts.

T.S. 4619'

NAME: Dolomitic brachiopod biomicrudite (mudstone).
MICRITE: (75%) matrix and common micritization of bioclasts.
PSEUDOSPAR: (1%) recrystallization of micrite adjacent to brachiopods.
FOSSILS: (5%) thin and thick-shelled articulated and fragmented brachiopods (65%), ostracods (15%), Rugosan corals (10%), echinoderm fragments (10%).
DOLOMITE: (20%) disseminated, microcrystalline euhedral rhombs.
ANHYDRITE: (3%) blocky rimming and sparry filling of coralites.
INSOLUBLES: (less than 1%) disseminated and microstyolite associated.
HEMATITE: (1%) disseminated and microstyolite associated.
REMARKS: Bioclasts associated with Type II microstyolite swarms are oriented subhorizontally.

T.S. 4623'

NAME: Dolomitic brachiopod biomicrudite (packstone).
MICRITE: (49%) matrix.
FOSSILS: (15%) articulated and fragmented brachiopods (90%), echinoderm fragments (10%).
DOLOMITE: (30%) disseminated, very-finely-crystalline euhedral rhombs within matrix and occasionally within bioclasts.
INSOLUBLES: (5%) microstyolite associated and disseminated; Note deflection on resistivity log.
HEMATITE: (1%) rimming bioclasts and disseminated.

T.S. 4627'

NAME: Dolomitic brachiopod biomicrudite (mudstone).
MICRITE: (85%) matrix, and micritization of echinoderm fragments.
FOSSILS: (6%) articulated and fragmented brachiopods (60%), echinoderm fragments (30%) commonly micritized, ostracods (10%).
DOLOMITE: (5%) disseminated, microcrystalline and occasionally very-finely-crystalline euhedral rhombs in matrix.
INSOLUBLES: (2%) associated with microstyolite swarms-nodular.
HEMATITE: (1%) oxidized, rimming bioclasts within microstyolite swarms-nodules.
REMARKS: Very common Type II microstyolite swarms-nodular; Occasional Type I suture seam styolite; Note argillaceous deflection on resistivity log.

4627.6'-4636.7'

NAME: Dolomitic, brachiopod and echinoderm, biomicrudite (wackestone and occasional packstone).
MINERALS: Calcite (60-80%) matrix and bioclasts; Dolomite (20-40%).
COLOR: Mottled, light brownish-gray (5YR7/1) with red (7.5R4/8) and dark red (10R3/4) associated with microstyolites.

ALLOCHEMS: Fossils (10%) echinoderm fragments (40-80%), brachiopod fragments and articulated shells (20%), unidentified fossil fragments (0-40%).
ORTHOCHEMS: Micrite (50-70%); Dolomitized micrite (20-40%).
POROSITY: Intercrystalline, fracture, pin-point vuggy, microfracture.
STRUCTURES: Diagenetic color-mottling; Very abundant to occasional Type II microstyolite swarms-nodule; Occasional to abundant, vertical to horizontal, fractures with proximal color-mottling low in the section.
UV OIL TESTS: Shows at 4627.9' and 4630.7'. Absent at 4631.9', 4632.5', 4634.4' and 4636.3'.
REMARKS: Base of the carbonate section of the Dawson Bay Formation.

T.S. 4631'
NAME: Dolomitic, brachiopod and echinoderm, biomicrudite (wackestone).
MICRITE: (55%) matrix.
FOSSILS: (10%) thin-shelled brachiopod fragments (49%), echinoderm fragments (49%), trilobites (2%).
DOLOMITE: (35%) disseminated, microcrystalline to very-finely-crystalline euhedral rhombs.
INSOLUBLES: (less than 1%) disseminated.
HEMATITE: (less than 1%) patchy distribution and oxidized proximal to microstyolites.

T.S. 4635'
NAME: Very dolomitic echinoderm biomicrudite (mudstone).
MICRITE: (55%) matrix.
FOSSILS: (1%) partially dolomitized, echinoderm fragments (80%), brachiopod fragments (20%).
DOLOMITE: (40%) disseminated, microcrystalline and very-finely-crystalline euhedral rhombs, in matrix and rimming pores.
ANHYDRITE: (less than 1%) patchy distribution and partially dolomitized.
QUARTZ: (¼less than 1%) very-fine grained, subrounded.
INSOLUBLES: (5%) disseminated.
HEMATITE: (less than 1%) occasional patches.
REMARKS: Minor fracture and moldic porosity; Common Type II microstyolite swarms-nodular.

4636.7'-4643'
NAME: Dolomite (mudstone).
MINERALS: Dolomite (100%).
COLOR: Mottled, grayish white (N8/) and dull reddish-orange (10R6/3).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline.
UV OIL TEST: Absent at 4638.3'.
REMARKS: Top of the Second Red Bed Member of the Dawson Bay Formation.

BOTTINEAU COUNTY

NDGS #286
LOCATION: T164N-R78W-S32, NW NE
WELL NAME: ERICKSON #1
COMPANY: LION OIL
DAWSON BAY FORMATION TOP DEPTH: 4831'
TOP OF THE SECOND RED BED MEMBER: 4963'
CORED INTERVAL: 4831'-4878' (RUBBLE)
KELLY BUSHING ELEVATION: 1539'

INTERVAL AND DESCRIPTIONS

4830'-4831'
NAME: Microcrystalline Dolomite (mudstone).
MINERALS: Dolomite (99%) matrix; Anhydrite (1%) filling fractures.
COLOR: Gray (10Y5/1).
ORTHOCHEMS: Dolomitized micrite (99%).
POROSITY: Fracture, intercrystalline.
STRUCTURES: Brecciated.
REMARKS: Basal Souris River Formation.

4831'-4833.4'
NAME: Microcrystalline, intraclastic, argillaceous, peloidal dolomite (mudstone).
MINERALS: Dolomite (90%) matrix; Clay (10%) laminae.
COLOR: Light gray (10YR7/1) to brownish black (10YR3/1).
ALLOCHEMS: Fossils (0-2%) blue-green algae (?) (100%); Peloids (0-2%) micritic; Intraclasts (5%) cryptalgal dolomite composition.
ORTHOCHEMS: Dolomitized micrite (90%).
POROSITY: Fracture, intercrystalline.
STRUCTURES: Subhorizontal argillaceous laminations; Soft sediment deformation; Brecciated. Dessication fractures associated with argillaceous laminations; Abundant subhorizontal microbreccia.
UV OIL TESTS: Absent at 4831.5' and 4832'.

T.S. 4831'
NAME: Dolomitized, intraclastic, peloidal, argillaceous (mudstone).
INTRACLASTS: (5%) cryptalgal dolomite composition.
PELOIDS: (5%) micritic.
DOLOMITE: (85%) microcrystalline, euhedral rhomb matrix, and healing fractures.
ANHYDRITE: (3%) sparry, filling microfractures.
HEMATITE: (2%) disseminated.

T.S. 4832.5'
NAME: Dolomitized, peloidal, intraclastic, argillaceous (mudstone).
INTRACLASTS: (3%) cryptalgal dolomite composition.
PELOIDS: (1%) associated with cryptalgal laminations.
DOLOMITE: (90%) microcrystalline euhedral rhombs.
INSOLUBLES: (5%) subhorizontal, associated with argillaceous laminations.
HEMATITE: (1%) oxidized, associated with argillaceous laminations.

4831'-4833.4'

NAME: Cryptalgal, bedded-mosaic, anhydrite.
MINERALS: anhydrite (96%); Insolubles (3%); Hematite (1%).
COLOR: Mottled, brownish gray (7.5YR4/1).
STRUCTURES: Relict cryptalgal laminations; Brecciated.
UV OIL TESTS: Absent at 4832.6' and 4833.1'.

T.S. 4833.8'
NAME: Cryptalgal replacive anhydrite.
FOSSILS: (30%) blue-green algae (?) (100%).
ANHYDRITE: (70%) metasomatic replacement.
INSOLUBLES: (5%) associated with relict cryptalgal laminations, and disseminated.
HEMATITE: (less than 1%) oxidized, cryptalgal association.

4834'-4835.7'
NAME: Anhydritic, peloidal, cryptalgal dolomite (boundstone).
MINERALS: Dolomite (95%) Matrix; Anhydrite (5%).
COLOR: Light brownish-gray (7.5YR7/1).
ALLOCHEMS: Fossils (30%) blue-green algae (?) (100%); Peloids (10-15%) associated with cryptalgal laminations.
ORTHOCHEMS: Dolomitized micrite (95%).
POROSITY: Fracture, intraparticle, intercrystalline.
STRUCTURES: Subhorizontal to crenulated cryptalgal laminations; Brecciated.
UV OIL TESTS: Show at 4835.5'.

T.S. 4835'
NAME: Pelloidal, cryptalgal, replacive anhydrite.
PELOIDS: (5%) micritic.
FOSSILS: (20%) blue-green algae (?) (95%), unidentified fossil ghosts (5%).
DOLOMITE: (15%) microcrystalline, euhedral rhomb matrix.
ANHYDRITE: (59%) sparry, filling fractures; microcrystalline; and amorphous anhydrite replacement of matrix.
INSOLUBLES: (1%) disseminated.
HEMATITE: (less than 1%) disseminated.

4835.7'-4836.2'
NAME: Cryptalgal, bedded-massive, anhydrite.
MINERALS: Anhydrite (80%); Dolomite (20%).
COLOR: Mottled, brownish black (7.5YR3/1) with brownish gray (7.5YR6/1).
ALLOCHEMS: Fossils (20%) blue-green algae (?) (100%).
ORTHOCHEMS: Dolomitized micrite (20%).
STRUCTURES: Cryptalgal laminations; Brecciated.

4836.2'-4836.6'
NAME: Pelloidal cryptalgal dolomite (boundstone).
MINERALS: Dolomite (100%).
COLOR: Mottled, brownish black (7.5YR3/1) with brownish gray (7.5YR6/1).
ALLOCHEMS: Fossils (30%) blue-green algae (?) (100%); Peloids (10-15%) micritic.
ORTHOCHEMS: Dolomitized micrite (55-60%).

POROSITY: Fracture, intraparticle, intercrystalline.
STRUCTURES: Cryptalgal laminations; Brecciated.

4836.6'-4837'

NAME: Microcrystalline, gastropod, peloidal dolomite (mudstone).
MINERALS: Dolomite (98%) matrix; Anhydrite (2%) filling fractures.
COLOR: Light brownish-gray (7.5YR7/1).
ALLOCHEMS: Peloids (10%) micritic; Fossils (3%) gastropods (100%).
ORTHOCHEMS: Dolomitized micrite (87%).
POROSITY: Fracture, intercrystalline, pin-point vuggy, vuggy, moldic and fenestral.
STRUCTURES: Common, thinnly-laminated, dolomitized micrite; Brecciated with anhydrite filling fractures; and replacement of adjacent dolomite.

4837'-4868'

NAME: Very-finely-crystalline, fossiliferous, dolomite (wackestone).
MINERALS: Dolomite (99%) Matrix; Anhydrite (1%) filling fractures.
COLOR: Light gray (7.5YR8/2) to light brownish-gray (7.5YR7/2).
ALLOCHEMS: Fossils (10%) whole and fragmented brachiopods (10-45%), rugosan corals (10-20%), cylindrical stromatoporoids (5-10%), echinoderm fragments (0-10%), tabular stromatoporoids (5%), gastropods (5%), cephalopods (1%).
ORTHOCHEMS: Dolomitized micrite (89%).
POROSITY: Fracture, intercrystalline, moldic.
STRUCTURES: Brecciated, with fractures and microfractures.
UV OIL TESTS: Show at 4836.9'; Absent at 4838.5'; Shows at 4842', 4845.5' and 4848.8'; Absent at 4852', 4855.5', 4858', 4861', 4861' and 4864.2'. Show at 4867'.
REMARKS: Rubble.

T.S. 4839'

NAME: Dolomitized biomicrudite (wackestone).
FOSSILS: (10%) unidentified fossil fragment molds-vugs (100%).
DOLOMITE: (94%) very-finely-crystalline euhedral rhomb matrix, with medium-crystalline euhedral rhombs filling early fractures and rimming later moldic pores and fractures.
ANHYDRITE: (5%) bladed-sparry, filling late fractures and replacing adjacent dolomite matrix.
INSOLUBLES: (1%) disseminated in matrix.
HEMATITE: (less than 1%) disseminated in matrix.
REMARKS: High vuggy porosity.

T.S. 4843'

NAME: Dolomitized stromatoporoid biomicrudite (wackestone).
FOSSILS: (10%) unidentified, fossil fragment, molds (90%), subspherical stromatoporoid molds (10%).
DOLOMITE: (89%) very-finely-crystalline euhedral rhomb matrix with finely-crystalline euhedral rhombs rimming pores.
ANHYDRITE: (less than 1%) sparry-bladed, filling fractures.
INSOLUBLES: (1%) disseminated in matrix.
HEMATITE: (less than 1%) disseminated in matrix.

T.S. 4847'

Dolomitized micrite (mudstone).
DOLOMITE: (100%) very-finely-crystalline euhedral rhomb matrix, with medium-crystalline euhedral rhombs rimming pores.
ANHYDRITE: (less than 1%) filling to partially filling fractures.
INSOLUBLES: (less than 1%) disseminated in matrix.
REMARKS: High fracture porosity; Diagenetic color-mottling proximal to fractures.

T.S. 4851'
NAME: Dolomitized stromatoporoid biomicrudite (wackestone).
FOSSILS: (69%) tabular stromatoporoids (99%), brachiopod molds (1%).
DOLOMITE: (30%) very-finely-crystalline to finely crystalline euhedral rhomb matrix, and rimming intraparticle pores.
ANHYDRITE: (1%) filling to partially filling pores.

4868'-4872.8'
NAME: Very-finely-crystalline, brachiopod, dolomite (wackestone).
MINERALS: Dolomite (99%) matrix; Anhydrite (0-1%) bladed crystals occasionally filling fractures and molds.
COLOR: Mottled, brownish gray (10YR6/1) matrix, and dull yellow-orange (10YR7/2) stromatoporoids, with rare to abundant bright brown (7.5YR5/8), and red (10R4/6).
ALLOCHEMS: Fossils (10%) brachiopods (70%) shells articulated, echinoderm fragments (25%), subspherical stromatoporoids (5%).
ORTHOCHEMS: Dolomitized micrite (90%).
POROSITY: Fracture, intercrystalline, intraparticle, moldic, vuggy.
STRUCTURES: Brecciated; Occasional Type II microstyolite swarm.
UV OIL TESTS: Show at 4870'.

4872.8'-4878'
NAME: Very-finely-crystalline, echinoderm, dolomite (mudstone-wackestone).
MINERALS: Dolomite (99%) matrix; Anhydrite (0-1%) bladed crystals, occasionally filling fractures and molds, with adjacent replacement of dolomite.
COLOR: Mottled, brownish gray (10YR6/1) with red (10R4/6) adjacent to fractures
ALLOCHEMS: Fossils: (5-10%) echinoderm fragments (80%), brachiopods (20%) shells disarticulated and articulated.
ORTHOCHEMS: Dolomitized micrite (90-95%).
POROSITY: Fracture, intercrystalline, pin-point vuggy, moldic, vuggy.
STRUCTURES: Brecciated.
UV OIL TESTS: Absent at 4873.5'; Show at 4877'.
REMARKS: Base of available core.

T.S. 4875'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (100%) microcrystalline, euhedral rhomb matrix; and very-finely-crystalline euhedral rhombs filling earlier fractures and rimming later fractures.
INSOLUBLES: (less than 1%) disseminated in matrix.
HEMATITE: (less than 1%) disseminated in matrix.

NDGS #793
LOCATION: T149N-R91W-S22, SE NW
WELL NAME: SOLOMON BIRD BEAR #1
COMPANY: MOBIL PRODUCING COMPANY
DAWSON BAY FORMATION TOP DEPTH: 11052'
TOP OF THE SECOND RED BED MEMBER: 11150'
CORED INTERVAL: 11044'-11150'
REMARKS: THERE IS AN EIGHT FOOT DIFFERENCE BETWEEN CORE AND LOG DEPTHS
KELLY BUSHING ELEVATION: 2102'

INTERVAL AND DESCRIPTIONS

11044'-11052'

NAME: Dolomitic, echinoderm and gastropod, biomicrudite (mudstone).
MINERALS: Dolomite (30%) matrix and bioclasts; Calcite (70%) matrix and bioclasts; Pyrite (less than 1%).
COLOR: Mottled, brownish gray (10YR4/1) microcrystalline-lower and grayish yellow-brown (10YR4/2) microcrystalline-upper.
ALLOCHEMS: Fossils (3-5%), gastropods (40%), echinoderm fragments (40%), ostracods (20%).
ORTHOCHEMS: Micrite (65%); Dolomitized micrite (26%).
POROSITY: Intercrystalline, microfracture, moldic.
STRUCTURES: Diagenetic color-mottling; Common subvertical microfractures within earlier microcrystalline-lower dolomite matrix; Common, microcrystalline-upper dolomite, healing earlier fractures and microfractures; Abundant subhorizontal Type II microstyolite swarms with associated microcrystalline dolomite, and color-mottling.
UV OIL TESTS: Show at 11051.9'.
REMARKS: Basal Souris River Formation.

11052'-11056.7'

NAME: Microcrystalline, gastropod, peloidal dolomite (mudstone).
MINERALS: Dolomite (68%) matrix; Calcite (30%) matrix and bioclasts; Pyrite (2%).
COLOR: Mottled, dull yellow-orange (10YR7/3) with brownish gray (10YR5/1) associated with pyrite.
ALLOCHEMS: Fossils (1%) gastropods (50%), unidentified fossil fragment ghosts (50%).
ORTHOCHEMS: Dolomitized micrite (70%); Micrite (30%).
POROSITY: Intercrystalline.
STRUCTURES: Abundant subvertical discontinuous pyrite filled microburrows (average length of 0.25 cm); Diagenetic color-mottling; Occasional Type II microstyolite swarm-seam; Occasional subhorizontal fractures.
UV OIL TESTS: Show at 11052.1', 11053.4' and 11055'.
REMARKS: Top of the Dawson Bay Formation.

T.S. 11052'

NAME: Dolomitized, ostracod and echinoderm, biomicarenite (mudstone).
MICRITE: (4-34%) matrix.

MICROSPAR: (3%) replaces micrite adjacent to microfractures.
CALCITE CEMENT: (2%) fills brecciated fractures.
PSEUDOSPAR: (1%) replaces micrite adjacent to fractures.
FOSSILS: (5%) echinoderm fragments (50%), ostracods (30%), unidentified fossil fragments (20%).
DOLOMITE: (55-85%) microcrystalline-lower, euhedral rhomb matrix; common, microcrystalline-upper, euhedral rhombs, proximal to fractures.
HEMATITE: (less than 1%) disseminated adjacent to breccia.

11056.7'-11059.3'

NAME: Gastropod biomicrudite (mudstone-wackestone).
MINERALS: Calcite (100%) matrix and bioclasts; Pyrite (less than 1%).
COLOR: Mottled, reddish gray (2.5YR4/1) to reddish gray (2.5YR6/1).
ALLOCHEMS: Fossils (5-10%) gastropods (60%), echinoderm fragments (30%), ostracods (10%).
ORTHOCHEMS: Micrite (90-95%);
POROSITY: Intercrystalline, moldic.
STRUCTURES: Diagenetic color-mottling; Abundant to occasional, subhorizontal Type II microstyolite swarms and seams; Common, microfractures associated with brecciation, occasionally filled by calcite cement.
UV OIL TESTS: Shows at 11056.9' and 11058.5'.

11059.3'-11059.5'

NAME: Echinoderm biomicrudite (wackestone).
MINERALS: Calcite (99%) matrix, and pseudospar replacement of bioclasts; Pyrite (1%) rimming to filling moldic pores.
COLOR: Mottled, brownish gray (10YR5/1) and grayish yellow-brown (10YR5/2).
ALLOCHEMS: Fossils (10-20%) commonly replaced by calcite pseudospar, echinoderm fragments (40%), brachiopods (25%) shells disarticulated and articulated, ostracods (25%), gastropods (10%) occasionally microscopic in size.
ORTHOCHEMS: Micrite (79-89%).
POROSITY: Intercrystalline, moldic (occasionally to 2 cm length).
STRUCTURES: Diagenetic color-mottling; Burrow-mottling; Microfractures associated with brecciation.

11059.5'-11060'

NAME: Argillaceous micrite (mudstone).
MINERALS: Calcite (95%) matrix; Clay (3%) disseminated in matrix; Pyrite (2%) associated with fenestral fabric and disseminated.
COLOR: Brownish gray (10YR4/1).
ORTHOCHEMS: Micrite (99%).
POROSITY: Intercrystalline and fenestral.
STRUCTURES: Occasional, Type II microstyolite swarms, nodules, and occasional microstyolite seams (possible shale partings); Occasional dessication-cracked surfaces; Common to abundant, vertically oriented, tubular fenestral fabric with associated pyrite; Occasional diagonal fracture.

11060'-11060.7'

NAME: Brachiopod intramicrudite (packstone).

MINERALS: Calcite (99%) matrix, intraclasts, and bioclasts. Clay (1%) disseminated and microstyolite associated; Pyrite (1%) lining molds and disseminated.
COLOR: Mottled, brownish gray (10YR4/1) and grayish yellow-brown (10YR6/2).
ALLOCHEMS: Intraclasts (30%) biomicrudite composition; Fossils (20%) brachiopods (60%) shells occasionally articulated, unidentified fossil fragments (20%), ostracods (15%), gastropods (5%).
ORTHOCHEMS: Micrite (49%).
STRUCTURES: Erosional unconformity with very abundant intraclasts; Common, subvertical, tubular fenestral fabric with associated pyrite; Occasional, Type II microstyolite swarms and seams.
UV OIL TESTS: Show at 11060.7'.

T.S. 11060.5'
NAME: Intraclastic brachiopod biomicrudite (mudstone-wackestone).
MICRITE: (20-30%) matrix and intraclasts.
INTRACLASTS: (50%) bored, biomicrudite composition.
FOSSILS: (3-10%) common, calcite pseudospar recrystallization of bioclast shells, brachiopod fragments (50%), unidentified fossil fragments (20%), gastropods (15%), echinoderm fragments (5%), ostracods (5%), calcispheres (5%).
DOLOMITE: (less than 1%) disseminated, microcrystalline euhedral rhombs in matrix.
PYRITE: (1%) replacing and rimming bioclasts.
BITUMENS: (less than 1%) disseminated in matrix.
HEMATITE: (2%) associated with moldic pores and disseminated.

11060.7'-11068.2'
NAME: Intraclastic, peloidal, ostracod and gastropod, biomicrudite (mudstone-wackestone).
MINERALS: Calcite (97%) matrix, intraclasts, peloids, bioclasts; Clay (2%) microstyolite associated and disseminated; Pyrite (1%) Patchy distribution associated with bitumens; Bitumens (less than 1%) patchy distribution in matrix.
COLOR: Mottled, brownish gray (10YR4/1) to grayish yellow-brown (10YR6/2).
ALLOCHEMS: Fossils (2-20%) gastropods (10-80%), ostracods (10-85%), unidentified fossil fragments (5-90%), brachiopod fragments (10-40%), echinoderm fragments (5-60%); Peloids (2-10%) micritic composition; Intraclasts (0-10%) bioclastic composition.
ORTHOCHEMS: Micrite (70-96%); Calcite cement (0-5%) filling moldic pores and fractures.
POROSITY: Intercrystalline, microfracture, fracture, moldic, channel.
STRUCTURES: Diagenetic color-mottling; Very abundant microfracturing due to brecciation; Common subvertical fractures lower in section; Abundant Type II microstyolite swarms; Common Type I suture seam styolite separating subhorizontal layers of varying bioclast composition and quantity.
UV OIL TESTS: Shows at 11063.5', 11064.2' and 11065.7'. Absent at 11067.2'; Show at 11068'.

T.S. 11064'

NAME: Peloidal, echinoderm and ostracod, biomicrudite (mudstone-wackestone).
CALCITE CEMENT: (1%) filling fractures.
MICRITE: (86-93%) matrix.
MICROSPAR: (less than 1%) rimming fractures and moldic pores.
PSEUDOSPAR: (1%) filling fractures, and replacing micrite, adjacent to fractures.
PELOIDS: (1%) micritic composition.
FOSSILS: (3-10%) commonly recrystallized to calcite pseudospar, echinoderm fragments (30%), ostracods (30%), brachiopod fragments (20%), gastropods (15%), unidentified fossil fragments (5%).
DOLOMITE: (1%) disseminated, microcrystalline, euhedral rhombs.
BITUMENS: (less than 1%) disseminated.
INSOLUBLES: (less than 1%) microstyolite associated.
HEMATITE: (1%) microstyolite associated and disseminated.

T.S. 11068'
NAME: Brachiopod, gastropod, and ostracod biomicrudite (wackestone).
MICRITE: (86%) matrix.
CALCITE CEMENT: (2%) filling fractures and microfractures.
FOSSILS: (10%) ostracods (30%), unidentified fossil fragments (25%), gastropods (20%), brachiopod fragments (20%), echinoderm fragments (5%).
DOLOMITE: (1%) disseminated, microcrystalline euhedral rhombs in matrix, and occasional very-finely-crystalline euhedral rhombs proximal to fractures.
BITUMENS: (less than 1%) disseminated in matrix.
INSOLUBLES: (less than 1%) disseminated in matrix.
HEMATITE: (1%) rimming pores and disseminated in matrix.

11068.2'-11069'
NAME: Stromatoporoid biomicrudite (packstone).
MINERALS: Calcite (100%) matrix and bioclasts; Halite (less than 1%) associated with vuggy pores.
COLOR: Brownish gray (10YR5/1).
ALLOCHEMS: Fossils (60-100%) tabular stromatoporoids (70-100%) in upper-section, unidentified fossil fragments (15%), bryozoans (5%), echinoderm fragments (5%), brachiopod fragments (5%).
ORTHOCHEMS: Micrite (0-37%); Calcite cement (0-3%) filling moldic pores.
POROSITY: Intraparticle, intercrystalline, moldic, vuggy.
STRUCTURES: Common, microfractures associated with brecciation; Occasional Type I suture seam styolites; Occasional Type II individual and microstyolites swarms.
UV OIL TESTS: Absent at 11068.5'; Show at 11069'.

11069'-11071'
NAME: Echinoderm biomicrudite (mudstone-wackestone).
MINERALS: Calcite (100%) matrix and bioclasts; Halite (less than 1%) associated with moldic-vuggy pores; Pyrite (less than 1%) filling fractures near base of section.
COLOR: Brownish gray (10YR4/1).
ALLOCHEMS: Fossils (5-10%) echinoderm fragments (40%), unidentified fossil fragments (37%), brachiopod fragments (15%), bryozoans

(5%), gastropods (2%), trilobites (1%).
ORTHOCHEMS: Micrite (89-94%); Calcite cement (1%) filling and rimming moldic pores and fractures.
POROSITY: Fracture, intercrystalline, microfracture, vuggy, moldic.
STRUCTURES: Rubble (11069'-11069.5'); Microfractures commonly associated with brecciation; Occasional Type II microstyolite swarms with flasser-like bioclast ghosts near base of section.
UV OIL TESTS: Show at 11071'.

11071'-11074'
NAME: Intraclastic bryozoan biomicrudite (wackestone-packstone).
MINERALS: Calcite (100%) matrix and bioclasts; Halite (less than 1%).
COLOR: Brownish gray (10YR4/1) with dull yellow-brown (10YR5/3) patches.
ALLOCHEMS: Fossils (20%) bryozoans (60%), brachiopod fragments (20%), cylindrical stromatoporoids (10%), echinoderm fragments (10%); Intraclasts (5-10%) bioclastic composition.
ORTHOCHEMS: Micrite (70%).
POROSITY: Intraparticle, intercrystalline, microfracture.
STRUCTURES: Rubble (11071.5'-11073.5'); Very abundant, subhorizontal, microfractures; Very abundant, subhorizontal, Type II microstyolite swarms.
UV OIL TESTS: Show at 11072.5'; Absent at 11073.9'.

T.S. 11072'
NAME: Dolomitic, peloidal, echinoderm and brachiopod, biomicrudite (packstone).
MICRITE: (75-83%) matrix.
MICROSPAR: (1%) occasionally rimming bioclasts.
PSEUDOSPAR: (3%) replacement of micrite adjacent to bioclasts.
PELOIDS: (5%) micritic.
FOSSILS: (50%) commonly recrystallized to pseudospar, brachiopods (50%), echinoderm fragments (30%), unidentified fossil fragments (7%), cylindrical stromatoporoids (5%) 2-3 mm average diameter, corals (5%), ostracods (5%).
DOLOMITE: (2-10%) disseminated, microcrystalline, euhedral rhombs in matrix and very-finely-crystalline euhedral rhombs rimming pores.
ANHYDRITE: (less than 1%) replacing matrix.
BITUMENS: (less than 1%) disseminated in matrix.
INSOLUBLES: (less than 1%) disseminated in matrix, and microstyolite associated.
HEMATITE: (1%) fracture and microstyolite association.

11074'-11077.3'
NAME: Stromatoporoid biomicrudite (wackestone).
MINERALS: Calcite (97%) matrix and bioclasts; Dolomite (3%); Halite (less than 1%).
COLOR: Mottled, brownish gray (10YR4/1) and dull yellow-orange (10YR6/3).
ALLOCHEMS: Fossils (20%) cylindrical stromatoporoids (55%), bryozoans (20%), tabular stromatoporoids (10%), subspherical stromatoporoids (5%), brachiopods (5%).

ORTHOCHEMS: Micrite (76-78%); Dolomitized micrite (2-4%) associated with porosity.
POROSITY: Intercrystalline, intraparticle, microfracture.
STRUCTURES: Irregularly oriented microfractures; Abundant Type II microstyolite swarms.
UV OIL TESTS: Shows at 11075.5' and 11076.5'; Absent at 11077.1'.

T.S. 11076'
NAME: Peloidal stromatoporoid biomicrudite (packstone).
MICRITE: (43-53%) Matrix.
PSEUDOSPAR: (1%) replacing micrite between bioclasts.
PELOIDS: (2%) micritic.
FOSSILS: (40-50%) commonly micritized, tabular stromatoporoids (50%), echinoderm fragments (30%), brachiopod fragments (30%), Tabulate corals (20%), unidentified fossil ghosts (20%).
DOLOMITE: (2%) disseminated, microcrystalline, euhedral rhombs within matrix and bioclasts.
ANHYDRITE: (1%) occasional matrix disseminated laths and filling pores.
BITUMENS: (less than 1%) associated with pores.
INSOLUBLES: (less than 1%) associated with microstyolites and disseminated.
HEMATITE: (1%) disseminated and associated with microstyolites.
REMARKS: Very abundant Type II microstyolite swarms.

11077.3'-11080.3'
MISSING.

11080.3'-11082.5'
NAME: Brachiopod biomicrudite (Packstone).
MINERALS: Calcite (100%) matrix and bioclasts; Halite (less than 1%).
COLOR: Mottled, brownish black (10YR3/2) matrix with grayish yellow-brown (10YR4/2) very finely crystalline dolomite associated with healed microfractures.
ALLOCHEMS: Fossils (50-70%) brachiopods (20-70%) shells disarticulated, bryozoans (5-20%), echinoderm fragments (5-10%), subspherical stromatoporoids (10%).
ORTHOCHEMS: Micrite (25-40%); Calcite pseudospar (3-5%) replacing micrite adjacent to bioclasts; Dolomitized micrite (2-5%).
POROSITY: Intercrystalline, intraparticle, fracture, microfracture.
STRUCTURES: Diagenetic color-mottling; Abundant subhorizontal to irregularly oriented microfractures in micrite which are commonly healed by dolomite; Occasional subvertical fractures cross-cutting all lithologies; Bioclasts subhorizontally oriented.
UV OIL TESTS: Shows at 11081' and 11082'.

T.S. 11081.9'
NAME: Echinoderm and brachiopod biomicrudite (packstone).
MICRITE: (43%) matrix.
PSEUDOSPAR: (2%) syntaxial overgrowths of echinoderm fragments and recrystallization of micrite adjacent to bioclasts.
FOSSILS: (50%) very commonly micritized, brachiopod fragments (50%), echinoderm fragments (29%), unidentified fossil fragments (20%),

unidentified stromatoporoid (1%).
DOLOMITE: (3%) disseminated, microcrystalline euhedral rhombs in matrix.
HALITE: (1%) cubic molds in matrix.
BITUMENS: (less than 1%) microstyolite associated and disseminated.
INSOLUBLES: (less than 1%) microstyolite associated and disseminated.
HEMATITE: (1%) disseminated and oxidized where associated with microfractures and microstyolites.

11082.5'-11083.2'
NAME: Intraclastic bryozoan biomicrudite (packstone).
MINERALS: Calcite (99%) matrix and bioclasts; Halite (1%) filling moldic pores.
COLOR: Mottled, brownish black (10YR3/2) micrite matrix with grayish yellow-brown (10YR4/2) dolomite associated with microfracture healing.
ALLOCHEMS: Fossils (30-50%) bryozoans (90%), brachiopod fragments (5%), echinoderm fragments (5%).
ORTHOCHEMS: Micrite (40%); Calcite pseudospar (10%); Dolomitized micrite (less than 1%).
POROSITY: Intercrystalline, intraparticle, fracture, microfracture, moldic.
STRUCTURES: Diagenetic color-mottling; Abundant subhorizontal and irregularly oriented microfractures; Occasional Type II scattered microstyolites.

11083.2'-11085.5'
NAME: Brachiopod and bryozoan biomicrudite (wackestone).
MINERALS: Calcite (99%) matrix and bioclasts; Halite (1%) filling moldic pores.
COLOR: Mottled, brownish black (10YR3/2) micrite matrix with grayish yellow-brown (10YR4/2) dolomite associated with microfracture healing.
ALLOCHEMS: Fossils (10-15%) bryozoans (50%), brachiopods (30%), echinoderm fragments (20%).
ORTHOCHEMS: Micrite (83%); Dolomitized micrite (2%).
POROSITY: Intercrystalline, intraparticle.
STRUCTURES: Diagenetic color-mottling; Rubble common.
UV OIL TESTS: Show at 11085'.

11085.5'-11091.5'
NAME: Peloidal, brachiopod and echinoderm, biomicrudite (packstone-wackestone).
MINERALS: Calcite (99%) Matrix and bioclasts; Halite (1%) Molds in matrix.
COLOR: Mottled, grayish yellow-brown (10YR4/2) and brownish black (10YR3/2).
ALLOCHEMS: Fossils (10-20%) Echinoderm fragments (25-50%), brachiopod fragments (10-30%), subspherical stromatoporoids (0-25%), bryozoans (0-25%); Peloids (0-20%) micritic.
ORTHOCHEMS: Micrite (58-88%); Dolomitized micrite (2%) healing microfractures.
POROSITY: Intercrystalline, moldic, intraparticle, fracture,

microfracture.
STRUCTURES: Diagenetic color-mottling; Abundant subvertical (later) fractures; Abundant subhorizontal, dolomite healed, microfractures (earlier); Occasional Type II microstyolite swarm.
UV OIL TESTS: Shows at 11087.3', 11088.9' and 11090.5'.

T.S. 11086'
NAME: Echinoderm and brachiopod biomicrudite (packstone).
MICRITE: (46-50%) matrix.
MICROSPAR: (3%) rimming of bioclasts and recrystallization of micrite in interiors of bioclasts.
PELOIDS: (6%) micritic composition.
FOSSILS: (40%) extensively micritized, brachiopods (40%), echinoderm fragments (40%), unidentified fossil fragment ghosts (15%), ostracods (5%).
DOLOMITE: (0-4%) matrix disseminated, microcrystalline, euhedral rhombs.
BITUMENS: (less than 1%) matrix disseminated.
INSOLUBLES: (less than 1%) matrix disseminated.
HEMATITE: (1%) oxidized, disseminated and associated with microstyolites.
REMARKS: Open moldic, vuggy, and fracture porosity; Color-mottling adjacent to, very abundant vertical and horizontal, subparallel microfractures which cut bioclasts.

T.S. 11088'
NAME: Dolomitic stromatoporoid biomicrudite (packstone).
MICRITE: (14%) matrix.
MICROSPAR: (10%) patchy distribution in micrite.
FOSSILS: (70%) tabular stromatoporoids (63%), echinoderm fragments (15%), brachiopod fragments (15%), rugosan corals (5%), ostracods (1%), gastropods (1%).
DOLOMITE: (4%) disseminated, microcrystalline euhedral rhombs and rimming pores.
ANHYDRITE: (less than 1%) disseminated laths.
HALITE: (1%) cubic molds in matrix.
INSOLUBLES: (less than 1%) Disseminated in matrix.
HEMATITE: (1%) disseminated and rimming pores.
REMARKS: Gastropod enclosed within stromatoporoid.

T.S. 11090'
NAME: Dolomitic, echinoderm and brachiopod, biomicrudite (wackestone-packstone).
MICRITE: (75-85%) matrix.
FOSSILS: (10-20%) articulated and fragmented brachiopods (40%), echinoderm fragments (40%), unidentified fossil fragments (20%).
DOLOMITE: (4%) disseminated, microcrystalline, euhedral rhombs.
INSOLUBLES: (less than 1%) matrix disseminated.
HEMATITE: (1%) matrix disseminated, and rimming microfracture.
REMARKS: Type II individual microstyolites, and swarms.

T.S. 11091'
NAME: Dolomitic, stromatoporoid, brachiopod, echinoderm, biomicrudite (packstone).

MICRITE: (10%) matrix.
PSEUDOSPAR: (20%) recrystallization of micrite adjacent to bioclasts.
PELOIDS: (4%) micritic composition.
FOSSILS: (60%) echinoderm fragments (35%) micritized rims, brachiopod fragments (25%), tabular stromatoporoids (25%), subspherical stromatoporoids (10%), bryozoans (5%) micritized.
DOLOMITE: (4%) disseminated, microcrystalline euhedral rhombs in matrix, and occasionally in echinoderms.
ANHYDRITE: (1%) filling moldic pores.
HALITE: (1%) filling moldic pores and occurring as cubic ghost molds in matrix.
INSOLUBLES: (less than 1%) disseminated in matrix.
HEMATITE: (less than 1%) microfracture associated and matrix disseminated.

11091.5'-11094.8'
NAME: Peloidal echinoderm biomicrudite (wackestone-mudstone).
MINERALS: Calcite (99%) matrix and bioclasts; Halite (1%).
COLOR: Mottled, grayish yellow-brown (10YR4/2) and brownish black (10YR3/2).
ALLOCHEMS: Fossils (0-10%) echinoderm fragments (100%).
ORTHOCHEMS: Micrite (85-95%); Dolomitized micrite (5%).
POROSITY: Intercrystalline, microfracture, moldic.
STRUCTURES: Diagenetic color-mottling; Abundant subhorizontal and subvertical microfractures.
UV OIL TESTS: Show at 11092' and 11093.5'.

11094.8'-11095.2'
NAME: Echionoderm and brachiopod biomicrudite (packstone).
MINERALS: Calcite (99%) matrix and bioclasts; Halite (1%).
COLOR: Mottled, grayish yellow-brown (10YR4/2) and brownish black (10YR3/2).
ALLOCHEMS: Fossils (15-20%) echinoderm fragments (50%), brachiopod fragments (50%).
ORTHOCHEMS: Micrite (80-85%).
POROSITY: Intercrystalline.
STRUCTURES: Diagenetic color-mottling; Subvertical to irregularly oriented microfractures.
UV OIL TESTS: Show at 11095'.

11095.2'-11100.1'
NAME: Echinoderm and brachiopod biomicrudite (mudstone-wackestone with interbedded layers of packstone).
MINERALS: Calcite (99%) matrix and bioclasts; Halite (1%).
COLOR: Mottled, grayish yellow-brown (10YR4/2) and brownish gray (10YR4/1).
ALLOCHEMS: Fossils (0-10%) and occasionally (10-40%) echinoderm fragments (50-100%), brachiopod fragments and occasional disarticulated shells (50-100%), unidentified fossil fragments (0-30%).
ORTHOCHEMS: Micrite (86-96%); Calcite pseudospar (2%) as syntaxial overgrowths of echinoderm fragments; Dolomitized micrite (2%).
POROSITY: Intercrystalline, vuggy, microfracture, moldic.

STRUCTURES: Diagenetic color-mottling; Very abundant subvertical and subhorizontal microfractures commonly healed by dolomite; Occasional Type I suture seam styolites associated with packstones; Occasional to very abundant Type II individual-swarm microstyolites associated with wackestones.
UV OIL TESTS: Shows at 11096' and 11098'; Absent at 11099'.

T.S. 11099'
NAME: Echinoderm biomicrudite (mudstone-wackestone).
MICRITE: (76-91%) matrix.
PSEUDOSPAR: (less than 1%) syntaxial overgrowths of echinoderm fragments.
FOSSILS: (5-20%) commonly micritized, echinoderm fragments (70%), thin-shelled brachiopods (29%), ostracods (1%).
DOLOMITE: (4%) disseminated microcrystalline euhedral rhombs in matrix.
BITUMENS: (less than 1%) disseminated in matrix.
INSOLUBLES: (less than 1%) disseminated in matrix.
HEMATITE: (less than 1%) matrix disseminated and microfracture associated.

11100.1'-11103.2'
NAME: Echinoderm biomicrudite (mudstone-wackestone).
MINERALS: Calcite (99%) matrix and bioclasts; Halite (1%).
COLOR: Mottled, grayish yellow-brown (10YR4/2) and brownish gray (10YR4/1).
ALLOCHEMS: Fossils (0-10%) echinoderm fragments (70%), brachiopod fragments (30%).
ORTHOCHEMS: Micrite (87-97%); Calcite pseudospar (2%); Dolomitized micrite (1%).
POROSITY: Microfractures, intercrystalline, vuggy.
STRUCTURES: brecciation microfractures which control dolomitization and color-mottling; Rubble (11102.2'-11103.2').
UV OIL TESTS: Absent at 11101'; Show at 11102.5'.

11103.2'-11110.4'
NAME: Echinoderm and brachiopod biomicrudite (mudstone-wackestone with interbedded layers of packstone).
UV OIL TESTS: Shows at 11104' and 11105.5'; Absent at 11107'; Shows at 11108.5' and 11110'.
REMARKS: Same as 11095.2'-11100.1' with microfractures associated with brecciation and proximal dolomitization.

T.S. 11104'
NAME: Dolomitic echinoderm biomicrudite (mudstone).
MICRITE: (74-86%) matrix.
CALCITE CEMENT: (4%) filling to partially filling microfractures.
FOSSILS: (6%) micritized and pseudospar replaced echinoderm fragments (70%), thin-shelled brachiopods (20%), unidentified fossil fragments (10%).
DOLOMITE: (3-15%) disseminated microcrystalline euhedral rhombs.
BITUMENS: (less than 1%) disseminated in matrix.
INSOLUBLES: (less than 1%) disseminated im matrix.
HEMATITE: (1%) slightly oxidized along microfractures.

REMARKS: Fracture, microfracture, channel, and moldic porosity.

11110.4'-11114.4'

NAME: Echinoderm and brachiopod biomicarenite (mudstone-wackestone with interbedded layers of packstone).
UV OIL TESTS: Show at 11113.3.
REMARKS: Same as 11095.2'-11100.1'.

T.S. 11108'

NAME: Dolomitic, brachiopod and echinoderm biomicrudite (mudstone).
MICRITE: (68-88%) matrix.
MICROSPAR: (5%) patchy matrix distribution.
FOSSILS: (3-5%) echinoderm fragments (40%), brachiopod fragments (30%), unidentified fossil fragment ghosts (30%).
DOLOMITE: (2-20%) disseminated to pervasive, microcrystalline, euhedral rhombs in matrix; and abundant very-finely-crystalline euhedral rhombs associated with microstyolites.
ANHYDRITE: (less than 1%) filling vuggy pores.
BITUMENS: (1%) microstyolite associated and disseminated.
INSOLUBLES: (less than 1%) disseminated and microstyolite associated.
HEMATITE: (1%) microfracture, microstyolite (oxidized), and disseminated.
REMARKS: Microstyolites cut fractures and microfractures; Common dissolution along subvertical fractures and enhansement of mold-vug porosity; Diagenetic color-mottling due to oxidation of hematite proximal to microstyolites.

11114.4'-11125'

NAME: Echinoderm and brachiopod biomicrudite (mudstone-wackestone with interbedded layers of packstone).
UV OIL TESTS: Shows at 11114.9', 11117.2', 11119.4' and 11121.6'.
REMARKS: Same as 11095.2'-11100.1' with anhydrite nodule at 11118' and common pseudospar overgrowths of bioclasts in packstone.

T.S. 11112'

NAME: Dolomitic echinoderm and brachiopod biomicarenite (mudstone).
MICRITE: (87%) matrix.
MICROSPAR: (3%) patchy distribution.
FOSSILS: (7%) echinoderm fragments (30%), brachiopod fragments (30%), unidentified fossil fragments (25%), ostracods (10%), calcispheres (5%).
DOLOMITE: (2%) disseminated, and microstyolite associated, microcrystalline euhedral rhombs.
INSOLUBLES: (less than 1%) disseminated and microstyolite associated.
HEMATITE: (1%) microfracture, disseminated, and microstyolite distribution.
REMARKS: Vuggy porosity developed at the intersection of microfractures.

T.S. 11116'

NAME: Dolomitic, echinoderm and brachiopod, biomicarenite (mudstone).

MICRITE: (50-88%) matrix.
MICROSPAR:(2%) patchy distribution in matrix.
FOSSILS: (3%) thin-shelled brachiopod fragments (40%), echinoderm fragments (30%), unidentified fossil fragments (20%), ostracods (10%).
DOLOMITE: (2-40%) disseminated to pervasive, microcrystalline euhedral rhombs.
INSOLUBLES: (less than 1%) microstyolite associated and disseminated.
HEMATITE: (2%): microfracture and microstyolite assocciated, and disseminated in matrix
REMARKS: Vuggy porosity associated with intersecting microfractures; Occasional Type I suture seam styolite; Very abundant, subparallel and subhorizontal, microfractures.

T.S. 11120'

NAME: Dolomitic, echinoderm and brachiopod, biomicarenite (mudstone).
MICRITE: (80%) matrix.
MICROSPAR: (15%) patchy distribution in micrite.
FOSSILS: (2%) unidentified fossil fragments as pseudospar ghosts (40%), brachiopod-fragment molds and pseudospar ghosts (30%), echinoderm fragments (30%).
DOLOMITE: (2%) disseminated, microcrystalline euhedral rhombs.
INSOLUBLES: (less than 1%) microstyolite associated and disseminated in matrix.
HEMATITE: (1%) microstyolite associated, disseminated, and rimming pores.

T.S. 11124'

NAME: Dolomitic brachiopod biomicarenite (mudstone).
MICRITE: (60%) matrix.
MICROSPAR: (30%) patchy distribution in matrix.
FOSSILS: (4%) thin-shelled brachiopod ghosts (100%).
DOLOMITE: (4%) disseminated, microcrystalline euhedral rhombs.
BITUMENS: (less than 1%) microstyolite associated and disseminated.
INSOLUBLES: (1%) microstyolite associated and disseminated.
HEMATITE: (1%) microfracture, disseminated, and microstyolite distribution.
REMARKS: Rare vuggy porosity proximal to microstyolites; Diagenetic color-mottling adjacent to pores.

11125'-11141.2'

NAME: Dolomitic brachiopod biomicrudite (mudstone-wackestone).
MINERALS: Calcite (85%) matrix and bioclasts; Dolomite (15%).
COLOR: Mottled, grayish yellow-brown (10YR4/2) and brownish gray (10YR4/1).
ALLOCHEMS: Fossils (1-10%) ghosts, brachiopod with shells disarticulated (80%), echinoderm fragments (20%).
ORTHOCHEMS: micrite (100%); Calcite pseudospar (less than 1%).
POROSITY: Intercrystalline, moldic, fracture.
STRUCTURES: Very-abundant vertical fractures, and irregularly-oriented microfractures, which control adjacent dolomitization; Diagenetic color-mottling proximal to fractures; Occasional Type

II individual-swarm microstyolite.
UV OIL TESTS: Shows at 11124', 11127', 11129', 11130.5', 11133.5', 11136.1', 11137.7', 11139' and 11140.2'.

T.S. 11128'

NAME: Dolomitic, echinoderm and brachiopod, biomicarenite (mudstone).
MICRITE: (60%) matrix.
MICROSPAR: (30%) patchy and disseminated in matrix.
FOSSILS: (2%) unidentified fossil fragment ghosts (50%), thin-shelled brachiopods (30%), echinoderm fragments (20%).
DOLOMITE: (5%) disseminated, microcrystalline euhedral rhombs.
BITUMENS: (1%) microstyolite associated and disseminated.
INSOLUBLES: (1%) disseminated in matrix.
HEMATITE: (1%) disseminated and associated with microfractures and microstyolites.

T.S. 11132'

NAME: Dolomitic brachiopod biomicarenite (mudstone).
MICRITE: (53%) matrix.
MICROSPAR: (20%) rimming pores.
FOSSILS: (5%) thin-shelled brachiopods (40%), unidentified fossil fragments (40%), ostracods (15%), calcispheres (5%).
DOLOMITE: (10%) disseminated and microstyolite associated, microcrystalline euhedral rhombs.
BITUMENS: (2%) microstyolite, microfracture and disseminated distribution.
INSOLUBLES: (4%) microstyolite, microfracture and disseminated distribution.
HEMATITE: (1%) microstyolite, microfracture and disseminated distribution.
REMARKS: Type II pervasive, swarm, and nodular microstyolites.

T.S. 11136'

NAME: Dolomitic brachiopod biomicarenite (mudstone).
MICRITE: (47%) matrix.
MICROSPAR: (35%) patchy distribution in matrix and adjacent to pores.
FOSSILS: (2%) unidentified fossil fragments (45%), brachiopod fragments (30%), ostracods (10%), walled calcispheres (10%), echinoderm fragments and molds.
DOLOMITE: (15%) disseminated, microcrystalline euhedral rhombs within matrix and bioclasts.
ANHYDRITE: (less than 1%) disseminated laths and filling fractures.
BITUMENS: (less than 1%).
INSOLUBLES: (1%).
HEMATITE: (less than 1%).
REMARKS: TYPE II microstyolite swarms.

T.S. 11140'

NAME: Dolomitic brachiopod biomicarenite (mudstone).
MICRITE: (70%) matrix.
MICROSPAR: (5-15%) patchy distribution in matrix.
CALCITE CEMENT: (less than 1%) filling fractures.

INTRACLASTS: (less than 1%) peloidal biomicarenite composition.
FOSSILS: (5%) very abundant in thin subhorizontal laminations, thin-shelled brachiopod fragments and molds (90%), echinoderm fragments and molds (10%) with micritization of rims.
DOLOMITE: (5-15%) disseminated, microcrystalline euhedral rhombs.
HALITE: (less than 1%).
BITUMENS: (2%) microstyolite associated and disseminated.
INSOLUBLES: (2%) disseminated and associated with microstyolites.
HEMATITE: (1%) disseminated and microfracture associated.

11141.2'-11150'

NAME: Gastropod, echinoderm, brachiopod biomicrudite (mudstone-wackestone).
MINERALS: Calcite (95%) matrix and bioclasts; Dolomite (5%) matrix replacement.
COLOR: Mottled, grayish yellow-brown (10YR4/2) and brownish gray (10YR4/1).
ALLOCHEMS: Fossils (0-15%) articulated and fragmented brachiopods (40%), echinoderm fragments (30%), gastropods (30%).
ORTHOCHEMS: Micrite (80-95%); Dolomitized micrite (5%).
POROSITY: Moldic, intraparticle, intercrystalline.
STRUCTURES: Diagenetic color-mottling; Very-abundant subhorizontal microfractures; Occasionally-abundant subvertical fractures; Dolomitization controlled by fractures, microfractures and moldic pores; Occasional, subhorizontal laminations of medium-crystalline euhedral dolomite rhombs, associated with bioclast ghosts.
UV OIL TESTS: Shows at 11142', 11143.6', 11145.1', 11146.2', 11148', 11149.2', 11150.8' and 11152'.
REMARKS: Base of carbonate section of the Dawson Bay Formation and the available core.

T.S. 11145'

NAME: Dolomitic brachiopod biomicarenite (wackestone).
MICRITE: (62%) matrix.
MICROSPAR: (20%) patchy distribution in matrix.
FOSSILS: (10%) thin-shelled brachiopod fragments and molds (80%), echinoderm fragments (20%).
DOLOMITE: (5%) microcrystalline, euhedral rhombs associated with microstyolites.
INSOLUBLES: (2%) microstyolite, disseminated and microfracture distribution.
HEMATITE: (1%) disseminated and microstyolite associated.
REMARKS: Strong subhorizontal orientation of bioclasts associated with pressure-solution response; Open moldic, fracture, and vuggy pores.

T.S. 11148'

NAME: Dolomitic echinoderm biomicrudite (mudstone).
MICRITE: (59%) matrix.
MICROSPAR: (30%) rimming pores, and patchy distribution in micrite.
CALCITE CEMENT: (1%) partially filling to filling pores.
FOSSILS: (5%) ghosts, pseudospar replaced, and calcite cement filled molds, echinoderm fragments (50%), unidentified fossil fragments (40%, brachiopods (10%).

DOLOMITE: (2%) microcrystalline euhedral rhombs associated with microstyolites.
BITUMENS: (1%) microfracture, fracture, and microstyolite association.
INSOLUBLES: (1%) microfracture, fracture, and microstyolite association.
HEMATITE: (1%) disseminated.

11150'-11157'
Interval missing
REMARKS: Contact missing.

11157'-11160'
NAME: Very-finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (100%).
COLOR: Grayish white (N/7).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline.

WILLIAMS COUNTY

NDGS #999
LOCATION: T154N-R100W-S23, SW NE
WELL NAME: JOSEPH M. DONAHUE #1
COMPANY: TEXACO, INC.
DAWSON BAY FORMATION TOP DEPTH: 12000'
DAWSON BAY FORMATION BOTTOM DEPTH: 12108'
CORED INTERVAL: 11723'-11740' and 12026'-12038'
KELLY BUSHING ELEVATION: 2253'

INTERVAL AND DESCRIPTIONS

11723'-11740'
Jumbled dolomite core with unmarked box footages.

12026'-12038'
Jumbled dolomite core with unmarked box footages.
REMARKS: The two intervals available for study are jumbled in a single core box. The core for both intervals consists of dolomite rubble.

WILLIAMS COUNTY

NDGS #1231
LOCATION: T155N-R96W-S2, SE NE
WELL NAME: IVERSON-NELSON #1
COMPANY: AMERADA PETROLEUM CORPORATION
DAWSON BAY FORMATION TOP DEPTH: 10714'
TOP OF THE SECOND RED BED MEMBER: 10842'
CORED INTERVAL: 10714'-10767'
KELLY BUSHING ELEVATION: 2316'

INTERVAL AND DESCRIPTIONS

10712'-10714'

NAME: Interbedded shale and microcrystalline dolomite (shale/mudstone).
MINERALS: Dolomite (60%); Clay (40%).
COLOR: Laminar, light gray (10YR7/1) dolomite and black (7.5YR2/1) shale.
ORTHOCHEMS: Dolomitized micrite (60%).
POROSITY: Intercrystalline (low permeability).
STRUCTURES: Laminae consisting of alternating shale and dolomudstone.
UV OIL TESTS: Show at 10713.7'.
REMARKS: Basal Souris River Formation.

10714'-10716.5' '.of 2;NAME: Microcrystalline, peloidal, algal, intraclastic dolomite (wackestone-packstone).
MINERALS: Dolomite (95%) matrix; Anhydrite (40%) locally at 10715'-10715.4'; Bitumens (1-4%) associated with blue-green algae (?); Clay (1%) associated with algal laminations; Pyrite (less than 1%) near base of section.
COLOR: Mottled light-gray (10YR7/1) and brownish gray (10YR5/1).
ALLOCHEMS: Fossils (20-40%) blue-green algae (?) (100%) as subhorizontal laminations; Intraclasts (5-80%) interlaminated blue-green algae (?) and dolomite composition; Peloids (5-10%) micritic composition.
ORTHOCHEMS: Dolomitized micrite (5-70%).
POROSITY: Intraparticle, intercrystalline, fracture.
STRUCTURES: Very-abundant intraclasts; Soft sediment deformation (crenulated); Abundant subhorizontal laminae of alternating dolomicrite and blue-green algae (?) with associated black bitumens; Massive aphanitic anhydrite at 10715'-10715.4'; Occasional Type II microstyolite swarms; Occasional irregularly oriented cross-cutting fractures.

T.S. 10714'

NAME: Dolomitic algal intramicrudite (packstone).
INTRACLASTS: (45%) subrounded to rounded clasts, of algal laminated dolomite composition, with occasional subhorizontal separations.
FOSSILS: (20%) blue-green algae (?) (100%).
DOLOMITE: (34%) microcrystalline, euhedral rhomb matrix.
ANHYDRITE: (less than 1%) sparry, patchy distribution in matrix.
INSOLUBLES: (1%) disseminated and associated with algal laminations.
HEMATITE: (less than 1%) disseminated.

10716.5'-10719.3'

NAME: Microcrystalline, argillaceous, peloidal, algal dolomite (mudstone).

MINERALS: Dolomite (98-100%) matrix; Clay (0-2%) disseminated and subhorizontal seams; Pyrite (less than 1%) associated with, subvertical, tubular fenestral fabric; Bitumens (less than 1%) associated with clay seams and disseminated.

COLOR: Mottled, brownish gray (10YR5/1) to brownish black (10YR3/1).

ALLOCHEMS: Fossils (15%) blue-green algae (?) (100%); Peloids (5%) micritic composition.

ORTHOCHEMS: Dolomitized micrite (78-80%).

POROSITY: Intercrystalline and fenestral.

STRUCTURES: Diagenetic reduced color-mottling; Common, argillaceous, peloidal and algal laminations; Common burrow-mottling; Common, subvertical, tubular fenestral fabric; Common Type II pervasive, swarm, and seam microstyolites; Rare Type I suture seam styolite disruption of Type II seam microstyolites at 10717'.

UV OIL TESTS: Show at 10717.8'.

T.S. 10718'

NAME: Dolomitized, bitumenous, argillaceous micrite (mudstone).

DOLOMITE: (96%) subhorizontally laminated, with microcrystalline euhedral rhombs.

ANHYDRITE (less than 1%) partially filled microfractures.

QUARTZ: (less than 1%) subrounded silt.

BITUMENS: (1%) disseminated.

INSOLUBLES: (2%) microstyolite associated and disseminated.

HEMATITE: (1%) microstyolite (oxidized) and microfracture associated.

10719.3'-10721'

NAME: Microcrystalline, calcareous, intraclastic, peloidal, ostracod dolomite (mudstone).

MINERALS: Dolomite (98%) matrix; Clay (1-2%) disseminated and microstyolite association; Calcite (2%) relict micrite matrix, within dolomitized micrite matrix; Anhydrite (less than 1%) occasionally abundant disseminated laths; Pyrite (less than 1%) associated with anhydrite lath concentrations.

COLOR: Mottled, brownish black (10YR3/1) and grayish yellow-brown (10YR5/2).

ALLOCHEMS: Fossils (1-5%) ostracods (10%), unidentified fossil fragment ghosts (90%); Peloids (1-5%) micritic composition; Intraclasts (0-2%) ostracod and dolomitized micrite composition.

ORTHOCHEMS: Dolomitized micrite (93-97%).

POROSITY: Intercrystalline, pin-point vuggy, moldic.

STRUCTURES: Diagenetic color-mottling; Abundant burrow-mottling; Abundant Type II microstyolite swarms; Rare intraclasts at 10719.8'.

UV OIL TESTS: Shows at 10719.4' and 10720.4'.

10721'-10722.8'

NAME: Microcrystalline, calcareous, intraclastic, gastropod and echinoderm dolomite (mudstone-wackestone).

MINERALS: Dolomite (97%) matrix; Calcite (3%) relict micrite matrix

and bioclasts; Anhydrite (less than 1%) fibrous nodules; Pyrite (less than 1%) microstyolite associated.
COLOR: mottled, brownish gray (10YR4/1) and brownish black (10YR3/1).
ALLOCHEMS: Fossils (3-5%) echinoderm fragments (80%), gastropods (20%); Intraclasts (0-10%).
ORTHOCHEMS: Dolomitized micrite (92-94%); Micrite (3%).
POROSITY: Intercrystalline, vuggy.
STRUCTURES: Very abundant Type II nodular microstyolites; Occasional subvertical and subhorizontal fractures; Occasional, subhorizontal and subrounded-rounded, intraclast zones.
UV OIL TESTS: Shows at 10721.1', 10721.9' and 10722.6'.

T.S. 10722'
NAME: Dolomitized fossiliferous intramicrudite (wackestone).
MICRITE: (5%) matrix.
INTRACLASTS: (70%) subrounded, microcrystalline, dolomitized micrite composition.
FOSSILS: (2%) unidentified fossil fragment ghosts and molds (100%).
DOLOMITE: (20%) microcrystalline euhedral rhombs disseminated in matrix.
ANHYDRITE: (1%) fibrous nodule.
BITUMENS: (1%) microstyolite associated.
INSOLUBLES: (1%) microstyolite associated and disseminated.
HEMATITE: (less than 1%) disseminated and microstyolite associated.

10722.8'-10727'
NAME: Dolomitic, intraclastic, echinoderm and brachiopod biomicrudite (wackestone).
MINERALS: Calcite (75%) micrite matrix and bioclasts; Dolomite (25%) matrix replacement; Anhydrite (less than 1%) fibrous, filling vuggy pores; Pyrite (less than 1%) associated with microstyolites.
COLOR: Brownish gray (10YR4/1).
ALLOCHEMS: Intraclasts (10-20%) rounded, very-finely-crystalline dolomite composition;
Fossils (2-5%) brachiopods (30-60%), echinoderm fragments (40-50%), gastropods (0-2%) decreasing down-section.
ORTHOCHEMS: Micrite (60%); Dolomitized micrite (25%).
POROSITY: Intercrystalline, fracture, pin-point vuggy.
STRUCTURES: Occasional nodular anhydrite; Very abundant, irregularly oriented, breccia fractures and microfractures which control final dolomitization to very-finely-crystalline dolomite adjacent to fractures; Very common subhorizontal Type II swarm and nodular microstyolites.
UV OIL TESTS: Shows at 10724.2', 10725', 10725.7' and 10726.5'.

T.S. 10725'
NAME: Dolomitic, peloidal, ostracod and brachiopod biomicrudite (wackestone).
MICRITE: (50%) matrix.
PSEUDOSPAR: (less than 1%) radial-axial recrystallization of micrite adjacent to echinoderm fragments.
PELOIDS: (10%) micritic composition, distributed within articulated brachiopod shells and localized within matrix.

FOSSILS: (10%) rare fragments, abundant as recrystallized ghosts and molds, brachiopods (30%), unidentified fossil fragments (25%), ostracods (20%), echinoderm fragments (15%), gastropods (10%).
DOLOMITE (25%) disseminated, microcrystalline euhedral rhombs in matrix, and occasional very-finely-crystalline euhedral rhombs associated with microstyolites.
INSOLUBLES: (1%) microstyolite associated.
HEMATITE: (1%) microstyolite associated and disseminated.
REMARKS: Nodular Type II microstyolites.

10727'-10730.6'
NAME: Very dolomitic, intraclastic, stromatoporoid and echinoderm biomicrudite (mudstone).
MINERALS: Calcite (60%) matrix and bioclasts; Dolomite (40%) recrystallized matrix; Anhydrite (less than 1%) occurrence as nodules and as bladed laths; Halite (less than 1%) partially filling microfractures.
COLOR: Brownish gray (10YR6/1) to grayish yellow-brown (10YR6/2).
ALLOCHEMS: Fossils (2-4%) echinoderm fragments (50%), brachiopod fragments (20%), subspherical stromatoporoids (0-30%), gastropods (1%).
ORTHOCHEMS: Micrite (58%); Dolomitized micrite (38%).
POROSITY: Intercrystalline, microfracture.
STRUCTURES: Occasional nodular anhydrite; Abundant subhorizontal Type II microstyolite swarms.
UV OIL TESTS: Shows at 10726.8' and 10728.3'.

T.S. 10730.5'
NAME: Dolomitized fossiliferous pelmicrite (wackestone).
MICRITE: (20%) matrix.
PELOIDS: (30%) rounded to subrounded, and of micritic composition.
FOSSILS: (10%) pseudospar-recrystallized brachiopod fragments (20%), ostracods (20%), gastropods (20%), unidentified fossil fragments (15%), echinoderm fragments (15%), calcispheres (10%).
DOLOMITE: (35%) disseminated to pervasive very-finely-crystalline euhedral rhombs.
ANHYDRITE: (5%) very micritized laths in bioclasts.
HEMATITE: (less than 1%) disseminated.

10730.6'-10733.7'
NAME: Dolomitic echinoderm biomicrudite (mudstone).
MINERALS: Calcite (60%) matrix and bioclasts; Dolomite (40%) matrix and bioclasts; Anhydrite (less than 1%) laths in matrix; Halite (less than 1%) filling microfractures.
COLOR: Black (10YR2/1).
ALLOCHEMS: Fossils (1%) echinoderm fragments (90-100%), cylindrical stromatoporoid ghosts (0-10%).
ORTHOCHEMS: Micrite (60%); Dolomitized micrite (40%).
POROSITY: Intercrystalline, microfracture, intraparticle.
STRUCTURES: Common subhorizontal Type II microstyolite swarms; Abundant micro-brecciation at 10732.5'.
UV OIL TESTS: Shows at 10730.6', 10733' and 10733.7'.

10733.7'-10734.8'

NAME: Dolomitic stromatoporoid biomicrudite (packstone).
MINERALS: Calcite (60%) matrix and bioclasts; Dolomite (40%) matrix and bioclasts.
COLOR: Brownish black (10YR3/2).
ALLOCHEMS: Fossils (40-60%) cylindrical stromatoporoids (54%), subspherical stromatoporoids (35%), trilobite fragments (10%), bryozoan fragments (1%).
ORTHOCHEMS: Micrite (25-35%); Dolomitized micrite (15-25%).
POROSITY: Intercrystalline, intraparticle, fracture.
STRUCTURES: Occasional subvertical, subparallel, fractures associated with stromatoporoids; Common subhorizontal Type II microstyolite swarms.

T.S. 10734'

NAME: Dolomitized stromatoporoid biomicrudite (packstone).
FOSSILS: (60%) cylindrical stromatoporoids (90%), brachiopods (10%).
DOLOMITE: (37%) microcrystalline, euhedral rhomb matrix, with very-finely-crystalline euhedral rhombs, associated with microstyolites.
ANHYDRITE: (less than 1%) laths disseminated in bioclasts and filling fractures.
BITUMENS: (1%) microstyolite associated.
INSOLUBLES: (1%) microstyolite associated.
HEMATITE: (1%) microstyolite and fracture associated.
REMARKS: Pressure-solution allignment of bioclasts.

10734.8'-10745.9'

NAME: Finely-crystalline, stromatoporoid, dolomite (packstone-boundstone).
MINERALS: Dolomite (97%) matrix and bioclasts; Calcite (2%) bioclasts; Anhydrite (1%) occurring as laths in matrix and paralleling laminae in stromatoporoids, microfractures cut anhydrite laths; Halite (less than 1%) filling fractures.
COLOR: Dull yellowish-brown (10YR5/3) to brownish black (10YR3/1).
ALLOCHEMS: Fossils (60-80%) cylindrical stromatoporoids (60%), subspherical stromatoporoids (15%), unidentified fossil fragments (0-10%), articulated, disarticulated, and fragmented brachiopods (0-10%), articulated and fragmented trilobites (0-15%), echinoderm fragments (2%), ostracods (less than 1%), gastropods (less than 1%).
ORTHOCHEMS: Dolomitized micrite (20-40%).
POROSITY: Intraparticle, intercrystalline, fracture, pin-point vuggy, microfracture, vuggy, moldic.
STRUCTURES: Occasional to very-abundant subhorizontal Type II swarms and pervasive microstyolites; Occasional, irregularly to subhorizontally oriented, fractures and microfractures; Rare subhorizontal fractures and microfractures in stromatoporoids near base of section.
UV OIL TESTS: Shows at 10734.9', 10735.6', 10736.7', and 10737.9'; Absent at 10738.5'(mudstone); Shows at 10740.4', 10741.6', 10743', 10745' and 10745.7'.
REMARKS: Medium-crystalline, euhedral rhomb dolomite is common throughout this section associated with larger porosity types. Rare to occasional microcrystalline dolomite is darker in color,

associated with a decrease in the percentage of bioclasts, and shows an absence of hydrocarbons in the ultra-violet light/chlorothene tests.

T.S. 10742'

NAME: Dolomitized, stromatoporoid and brachiopod, biomicrudite (wackestone).
MICRITE: (less than 1%) matrix.
FOSSILS: (20%) highly micritized, thick-shelled brachiopods (70%), cylindrical stromatoporoids (30%).
DOLOMITE: (73%) microcrystalline to finely-crystalline euhedral rhombs replacing matrix and bioclasts.
ANHYDRITE: (1%) filling moldic pores and replacing adjacent dolomicrite.
HALITE: (3%) cubic molds proximal to moldic pores.
INSOLUBLES: (2%) microstyolite associated.
HEMATITE: (1%) reduced, associated with microstyolites.

T.S. 10745'

NAME: Dolomitized stromatoporoid biomicrudite (packstone).
MICRITE: (1%) matrix.
FOSSILS: (50%) very micritized, cylindrical stromatoporoids (79%), brachiopod fragments (10%), echinoderm fragments (1%).
DOLOMITE: (45%) very-fine to finely-crystalline euhedral rhomb replacement of matrix.
HALITE: (1%).
BITUMENS: (less than 1%) microstyolite association.
INSOLUBLES: (2%) disseminated and microstyolite association.
HEMATITE: (1%) disseminated and microstyolite association.

10745.9'-10748'

NAME: Finely-crystalline, stromatoporoid, dolomite (mudstone).
MINERALS: Dolomite (97%) matrix and bioclasts; Halite (2%) filling moldic pores; Calcite (1%) bioclasts.
COLOR: Brownish black (10YR4/1).
ALLOCHEMS: Fossils (1-5%) cylindrical stromatoporoids (60-90%), subspherical stromatoporoids (0-30%), echinoderm fragments (2-10%)
ORTHOCHEMS: Dolomitized micrite (93-97%).
POROSITY: Intercrystalline, intraparticle, vuggy, channel.
STRUCTURES: Abundant breccia with common healing of fractures by euhedral, medium-crystalline, dolomite rhombs; Abundant Type II diffuse microstyolites.
UV OIL TESTS: Show at 10747.6'.

10748'-10751'

NAME: Finely-crystalline, echinoderm, dolomite (mudstone).
MINERALS: Dolomite (98%) matrix and bioclasts; Halite (2%) filling moldic pores.
COLOR: Mottled, grayish yellow-brown (10YR4/2) associated with finely-crystalline matrix and grayish yellow-brown (10YR5/2) associated with euhedral, coarsely-crystalline, dolomite rhombs which heal fractures.
ALLOCHEMS: Fossils (2-5%) echinoderm fragments (100%).
ORTHOCHEMS: Dolomitized micrite (93-96%).

POROSITY: Intercrystalline, moldic, vuggy.
STRUCTURES: Abundant breccia increasing up-section; Abundant moldic pores increasing up-section; Abundant subhorizontal Type II microstyolite swarms associated with moldic porosity; Color-mottling related to intercrystalline size differences.
UV OIL TESTS: Show at 10750'.

T.S. 10750'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (97%) very-fine to finely-crystalline euhedral rhombs replacing matrix.
HALITE: (2%) microcrystalline to very-finely-crystalline cubic molds and filling pores.
INSOLUBLES: (1%) patchy distribution.
HEMATITE: (less than 1%) disseminated.

10751'-10760.5'
NAME: Finely-crystalline echinoderm dolomite (mudstone).
MINERALS: Dolomite (96%) matrix; Calcite (1-2%) bioclasts; Halite (2%) filling vuggy pores; Anhydrite (less than 1%) nodular, filling moldic pores.
COLOR: Mottled, dull yellowish-brown (10YR4/3) associated with very-finely-crystalline matrix and brownish gray (10YR5/1) associated with medium-crystalline dolomite euhedral rhombs which heal fractures.
ALLOCHEMS: Fossils (1-2%) echinoderm fragments (98%), brachiopod fragments (2%).
ORTHOCHEMS: Dolomitized micrite (96%)
POROSITY: Intercrystalline, pin-point vuggy, vuggy.
STRUCTURES: Very-abundant subvertical microfractures which are partially to completely healed by medium-crystalline, euhedral, dolomite rhombs; Occasionally-abundant to pervasive Type II individual and swarm microstyolites which show medium-crystalline dolomite disruption along healed microfractures; Occasional dolomite matrix "floating" in halite filled 2-3 cm vug.
UV OIL TESTS: Shows at 10752', 10754', 10756' and 10758.5'.

T.S. 10754'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (97%) microcrystalline, euhedral rhomb matrix and finely-crystalline euhedral rhombs proximal to vuggy pores.
HALITE: (3%) cubic molds rimming vuggy pores.
INSOLUBLES: (less than 1%) disseminated.
HEMATITE: (less than 1%) disseminated and microstyolite associated.

T.S. 10758'
NAME: Dolomitized echinoderm biomicrudite (mudstone).
FOSSILS: (1%) unidentified fossil molds (70%), echinoderm fragments (30%).
DOLOMITE: (99%) microcrystalline, euhedral rhomb matrix and finely-crystalline euhedral rhombs proximal to moldic-vuggy pores.
HEMATITE: (less than 1%) disseminated.

10760.5'-10762.8'

NAME: Finely-crystalline, echinoderm, dolomite (mudstone).
MINERALS: Dolomite (95-96%) matrix; Halite (3%) filling and replacing vuggy pores; Calcite (2-3%) bioclasts.
COLOR: Grayish yellow-brown (10YR4/2).
ALLOCHEMS: Fossils (2-3%) echinoderm fragments (100%).
ORTHOCHEMS: Dolomitized micrite (97-98%).
POROSITY: Intercrystalline, vuggy, pin-point vuggy, microfracture, fracture.
STRUCTURES: Very-abundant subvertical fractures and microfractures with medium-crystalline dolomite healing, and occasional solution enlargement; Common subhorizontal Type II microstyolite swarms with associated medium-crystalline dolomite.
UV OIL TESTS: Show at 10761.5'.

T.S. 10762'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (100%) microcrystalline, euhedral rhomb matrix and, rare, finely-crystalline euhedral rhombs rimming pores.
HEMATITE: (less than 1%) oxidized, associated with fractures.

10762.8'-10765'
NAME: Medium crystalline, brachiopod, dolomite (wackestone).
MINERALS: Dolomite (82%) matrix; Calcite (15%) bioclasts; Halite (3%) filling pores.
COLOR: Grayish yellow-brown (10YR4/2).
ALLOCHEMS: Fossils (15%) articulated and moldic brachiopods (70%), echinoderm fragments (30%).
ORTHOCHEMS: Dolomitized micrite (82%).
POROSITY: Pin-point vuggy, intercrystalline, moldic, fracture, vuggy. All larger pores filled by halite.
STRUCTURES: Common, subhorizontal and occasional subvertical, fractures with common solution enlargement and common healing by euhedral, coarsely-crystalline, dolomite rhombs; Occasional subhorizontal Type II individual-swarm microstyolites.
UV OIL TESTS: Show at 10764.2'.

10765'-10767'
NAME: Finely-crystalline, echinoderm, dolomite (mudstone-wackestone).
MINERALS: Dolomite (91%) matrix; Halite (4%) filling moldic-vuggy pores and replacing matrix; Calcite (5%) bioclasts.
COLOR: Brownish black (10YR3/2).
ALLOCHEMS: Fossils (5-10%) echinoderm fragments and molds (100%).
ORTHOCHEMS: Dolomitized micrite (91%).
POROSITY: Vugular, pin-point vuggy, intercrystalline, fracture.
STRUCTURES: Common subhorizontal and subvertical fractures with common healing by coarsely-crystalline euhedral dolomite rhombs, and common solution enlargement; Occasional subhorizontal Type II individual-swarm microstyolites; Rare subhorizontal, 3 mm thick zone, of 2 mm size packstone with moldic porosity.
UV OIL TESTS: Show at 10767'.
REMARKS: Base of available core.

T.S. 10766'

NAME: Dolomitized, echinoderm and brachiopod, biomicrite (mudstone).
FOSSILS: (2%) brachiopod molds (50%), echinoderm fragments (very micritized) and molds (50%).
DOLOMITE: (98%) microcrystalline, euhedral rhomb matrix.
ANHYDRITE: (less than 1%) replacement within echinoderm fragments.

NDGS #1403
LOCATION: T155N-R96W-S15, SW NE
WELL NAME: BOE-OLSON #1
COMPANY: AMERADA PETROLEUM CORPORATION
DAWSON BAY FORMATION TOP DEPTH: 10653'
TOP OF THE SECOND RED BED MEMBER: 10778'
CORED INTERVAL: 10653'-10664'
KELLY BUSHING ELEVATION: 2165'

INTERVAL AND DESCRIPTIONS

10651.5'-10652.6'

NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (100%) matrix; Pyrite (less than 1%) Associated with tubular fenestral fabric and calcite (less than 1%) bioclasts; Anhydrite (less than 1%) filling vugs.
COLOR: Grayish yellow-brown (10YR5/2).
ALLOCHEMS: Fossils (less than 1%) unidentified, fossil fragment, ghosts (100%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline.
STRUCTURES: Abundant, vertically oriented, tubular fenestral texture with associated pyrite.
UV OIL TESTS: Absent at 10652'; Show at 10652.8'.
REMARKS: Basal Souris River Formation.

10652.6'-10653.2'

NAME: Microcrystalline, intraclastic, ostracod dolomite (mudstone).
MINERALS: Dolomite (97-98%) matrix; Calcite (1-2%) bioclasts; Anhydrite (1%) laths associated with fractures; Pyrite (less than 1%) disseminated.
COLOR: Mottled, brownish gray (10YR4/1) to dull yellowish-brown (10YR4/3).
ALLOCHEMS: Fossils (2%) ostracods (100%); Intraclasts (3%) subrounded to subangular near base of section.
ORTHOCHEMS: Dolomitized micrite (94-95%).
POROSITY: Intercrystalline, fracture.
STRUCTURES: Abundant, subrounded to subangular, intraclasts at base of section; Abundant, subhorizontal, Type II microstyolite swarms; Common diagenetic color-mottling associated with reduction of pyrite; Occasional diagonal fractures.
UV OIL TESTS: Show at 10653.6'

T.S. 10653'

NAME: Dolomitized ostracod biomicrite (mudstone).
PELOIDS: (1%) dolomitized micrite composition.
FOSSILS: (5%) ostracods (90%) with hematite rimming the common molds, unidentified fossil-fragment ghosts (10%) with pseudospar recrystallization.
DOLOMITE: (92%) microcrystalline, euhedral rhomb matrix.
ANHYDRITE: (1%) bladed, filling moldic pores and replacing dolomite proximal to moldic pores.
BITUMENS: (less than 1%) disseminated in matrix.

INSOLUBLES: (1%) disseminated in matrix.
HEMATITE: (less than 1%) disseminated in matrix.

10653.2'-10653.6'

NAME: Dolomitic gastropod biomicrite (mudstone).
MINERALS: Calcite (60%) micrite matrix; Dolomitized micrite (39%); Anhydrite (1%) as disseminated laths.
COLOR: Brownish gray (10YR4/1).
ALLOCHEMS: Fossils (2-5%) gastropods (100%) increasing up-section.
ORTHOCHEMS: Micrite (60%); Dolomitized micrite (40%).
POROSITY: Intercrystalline.
STRUCTURES: Abundant Type III non-seam pressure solution phenomena of the uniform-stress and responsiveness variety, ranging to the fitted-lens response variety.

10653.6'-10655.5'

NAME: Dolomitic gastropod biomicrudite (wackestone).
MINERALS: Calcite (60%) matrix and bioclasts; Dolomite (39%) matrix; Anhydrite (1%) laths disseminated in matrix and bioclasts.
COLOR: Brownish gray (10YR4/1).
ALLOCHEMS: Fossils (10%) gastropods (85%), ostracods (10%), echinoderm fragments (5%).
ORTHOCHEMS: Micrite (60%); Dolomitized micrite (39%).
POROSITY: Intercrystalline.
STRUCTURES: Very abundant, subhorizontal, Type II swarm and nodular microstyolites.
UV OIL TESTS: Show at 10654.6'.

10655.5'-10656'

NAME: Dolomitic biomicrudite (mudstone).
MINERALS: Calcite (60%) matrix and bioclasts; Dolomite (40%) matrix; Pyrite (less than 1%) associated with subvertical fractures.
COLOR: Brownish gray (10YR4/1).
ALLOCHEMS: Fossils (1%) unidentified ghosts (100%).
ORTHOCHEMS: Micrite (60%); Dolomitized micrite (39%).
POROSITY: Intercrystalline, fracture.
STRUCTURES: Abundant Type III non-seam pressure-solution response features of the uniform stress and responsiveness variety; Occasional to rare, subhorizontal, fractures; Rare, partially dolomite healed, fracture with pyrite association.
UV OIL TESTS: Show at 10655.7'.

10656'-10661.5'

NAME: Dolomitic gastropod biomicrudite (wackestone).
MINERALS: Calcite (60%) matrix and bioclasts; Dolomite (40%) matrix and bioclasts; Anhydrite (less than 1%) laths in micrite and bioclasts with rare millimeter size nodule.
COLOR: Brownish gray (10YR4/1).
ALLOCHEMS: Fossils (10-15%) gastropod ghosts (85%), brachiopod fragments (5%), echinoderm fragments (5%), ostracods (5%).
ORTHOCHEMS: Micrite (50%); Dolomitized micrite (30%).
POROSITY: Intercrystalline, fracture.
STRUCTURES: Very-abundant Type II microstyolite swarm and nodular; Occasional subhorizontal fracture; Rare, subhorizontal, Type II

pressure-solution seam.
UV OIL TESTS: Show at 10656.5', 10657.5', 10659.1' and 10661.1'.

T.S. 10657'

NAME: Dolomitic-dolomitized, peloidal, biomicrudite (wackestone-packstone).

MICRITE: (5-15%) relict matrix, commonly occurring as "pseudointraclasts" due to pressure-solution dolomitization.

MICROSPAR: (5%) commonly rimming patches of relict micrite. Very commonly located between micritized rim of bioclasts and the recrystallized pseudospar center of bioclasts.

PSEUDOSPAR: (20%) occurring as occasional radial-fibrous overgrowths on sparry or micritized bioclasts; very commonly occurring in the center of micritized bioclasts; and occasionally replacing the entire bioclast and proximal micrite matrix.

PELOIDS: (10-20%) micritic composition, resulting from microspar and pseudospar recrystallization of the micrite matrix, and leaving relict peloidal appearing micrite matrix islands.

FOSSILS: (15-20%) unidentified, micritized fossil fragment, ghosts (50%); micritized and sparry brachiopod fragment ghosts (10%); micritized and sparry trilobite fragment ghosts (5%); ostracod fragments and sparry ghosts (5%); and micritized to sparry gastropod ghosts (5%).

DOLOMITE: (30%) microcrystalline to very-finely-crystalline euhedral rhombs, disseminated to pervasive, in matrix and bioclasts. Very common embayment of bioclasts and pseudointraclasts by dolomite rhombs.

BITUMENS: (less than 1%) disseminated and microstyolite associated.

INSOLUBLES: (1%) disseminated and microstyolite associated.

HEMATITE: (less than 1%) bioclast associated.

REMARKS: Possible, rounded, peloidal and bioclastic intraclasts are present, but are thought to be biomicrite islands formed by sparry recrystallization of the surrounding matrix and bioclasts. Microstyolites enclose nearly all bioclasts and micrite island pseudointraclasts.

10661.5'-10662'

NAME: Dolomitic brachiopod biomicrudite (mudstone).

MINERALS: Calcite (50-60%) matrix and bioclasts; Dolomite (39-59%) matrix; Anhydrite (1%) laths and fracture filling.

COLOR: Brownish gray (10YR4/1).

ALLOCHEMS: Fossils (3%) brachiopods (100%) shells articulated and disarticulated.

ORTHOCHEMS: Micrite (47-57%); Dolomitized micrite (39-59%).

POROSITY: Intercrystalline, fracture, microfracture.

STRUCTURES: Occasional subhorizontal fractures and microfractures.

10662'-10663.2'

NAME: Dolomitic, peloidal, gastropod biomicrudite (wackestone).

MINERALS: Calcite (50-60%) matrix and bioclasts; Dolomite (39-59%) matrix; Anhydrite (1%) individual laths and filling fractures.

COLOR: Brownish gray (10YR4/1).

ALLOCHEMS: Fossils (10%) gastropods (95%), brachiopods (5%) shells disarticulated; Peloids (10%).

ORTHOCHEMS: Micrite (40-50%); Dolomitized micrite (30-50%).
POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: Occasional to abundant Type II swarm-nodule microstyolites; Occasional subhorizontal fractures and microfractures.
UV OIL TESTS: Show at 10662.1'.

T.S. 10663'

Dolomitic, peloidal, brachiopod biomicrudite (wackestone-packstone).
MICRITE: (34-46%) matrix.
MICROSPAR: (3%) distributed between micrite matrix and pseudospar matrix-replacement, or between micrite rim of bioclasts and bioclast-center pseudospar-replacement.
PSEUDOSPAR: (5-7%) radial-fibrous rimming of bioclasts, recrystallization of micrite matrix, and recrystallization of bioclast interiors.
INTRACLASTS: (2%) rounded, peloidal wackestone composition.
PELOIDS: (4%) hematitic, argillaceous, micrite composition.
FOSSILS: (20-30%) all very micritized, unidentified fossil-fragment ghosts (45%), thin and thick-shelled occasionally burrowed brachiopod-fragment ghosts (30%), echinoderm-fragment ghosts (10%), gastropods (10%), trilobite-fragments ghosts (5%).
DOLOMITE: (5-20%) microcrystalline euhedral rhombs associated with microstyolites and disseminated. Very common dolomite rhomb embayment of bioclasts.
INSOLUBLES: (less than 1%) associated with microstyolites.
BITUMENS: (less than 1%) dead-oil rimming pores.
HEMATITE: (less than 1%) associated with microstyolites and bioclasts.
REMARKS: Bioclast fragments, oriented subhorizontally, parallel to microstyolites.

10663.2'-10664'

NAME: Dolomitic brachiopod biomicrudite (wackestone-packstone).
MINERALS: Calcite (60%) matrix and bioclasts; Dolomite (40%) matrix.
COLOR: Brownish gray (10YR4/1).
ALLOCHEMS: Fossils (30-40%) brachiopod fragments, shells articulated (90%); possible subspherical stromatoporoid (10%).
ORTHOCHEMS: Micrite (20-40%); Dolomitized micrite (25-35%).
POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: Abundant type II swarms and nodular microstyolites; Occasional subhorizontal fractures; Common irregularly-oriented microfractures.
UV OIL TESTS: Show at 10664'
REMARKS: Base of available core.

BOTTINEAU COUNTY

NDGS #5277
LOCATION: T162N-R77W-S11, SW SW
WELL NAME: TONNESON #1
COMPANY: McMORON EXPLORATION COMPANY
DAWSON BAY FORMATION TOP DEPTH: 4702'
TOP OF THE SECOND RED BED MEMBER: 4840'
CORED INTERVAL: 4836'-4840'
KELLY BUSHING ELEVATION: 1543'

INTERVAL AND DESCRIPTIONS

4836'-4837.5'
NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (99%) matrix; Pyrite (1%) disseminated, and concentrated in association with fractures and microstyolites.
COLOR: Gray (5Y5/1).
ORTHOCHEMS: Dolomitized micrite (99%).
POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: Abundant, subhorizontal to diagonal, Type III fitted lense response, non-seam, pressure-solution response features; Common, multiple generation, off-setting, horizontal to diagonal fractures with slickensides along most recent fractures.
UV OIL TESTS: Absent at 4836.1' and 4837.4'.
REMARKS: Upper section of the Dawson Bay Formation missing.

T.S. 4837'
NAME: Dolomitized micrite (mudstone).
DOLOMITE: (97%) microcrystalline euhedral-rhomb matrix.
PYRITE: (1%) disseminated.
QUARTZ: (less than 1%) silt to very-fine grains, subrounded to subangular.
INSOLUBLES: (2%) disseminated.
HEMATITE: (less than 1%) disseminated.
REMARKS: Very abundant, subhorizontal, Type II microstyolite swarms.

4837.5'-4838.3'
NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (99%) matrix; Pyrite (1%) disseminated, and concentrations associated with fractures and microstyolites.
COLOR: Gray (5Y5/1).
ORTHOCHEMS: Dolomitized micrite (99%).
POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: Pervasive, subhorizontal to diagonal, swarm and nodular Type II microstyolites; Common laminated mudstone; Multiple generations of off-setting, subhorizontal to diagonal, fractures and microfractures.
UV OIL TESTS: Absent at 4838'.

4838.3'-4840.3'
NAME: Microcrystalline dolomite (mudstone).
MINERALS: Dolomite (99%) matrix; Pyrite (1%) disseminated, and concentrated along fractures; Anhydrite (less than 1%) filling fractures.

COLOR: Gray (5Y6/1).
ORTHOCHEMS: Dolomitized micrite (99%).
POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: Abundant brecciation with subhorizontal and subparallel fractures off-set by diagonal fractures; Earlier subhorizontal fractures and microfractures are commonly healed by dolomite; Later diagonal fractures are commonly, partially, filled by anhydrite.
UV OIL TESTS: Absent at 4838.6', 4839.5' and 4840.2'.
REMARKS: Base of the carbonate section of the Dawson Bay Formation.

T.S. 4840'

NAME: Dolomitized micrite (mudstone).
DOLOMITE: (96%) microcrystalline rhomb matrix.
ANHYDRITE: (1%) sparry, filling fractures and replacing dolomite.
PYRITE: (2%) associated with earlier subhorizontal and subparallel fractures.
QUARTZ: (less than 1%) silt to occasional very-fine grains, subrounded to subangular.
INSOLUBLES: (1%) disseminated.
REMARKS: The subhorizontal and subparallel fractures are off-set by diagonal, anhydrite filled, fractures.

4840.3'-4841'

NAME: Argillaceous microcrystalline dolomite (argillaceous mudstone).
MINERALS: Dolomite (80%) matrix; Clay (19%) thin laminations and disseminated; Pyrite (1%) disseminated, concentrated along fractures and associated with black argillaceous laminae.
COLOR: Dark grayish-yellow (2.5Y5/2) dolomite and brownish-black (2.5Y3/1) clay.
ORTHOCHEMS: Dolomitized micrite (80%).
POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: Abundant subhorizontal to diagonal fractures with slickensides; Abundant irregularlly oriented microfractures; Occasional to abundant Type II microstyolite swarms.
UV OIL TESTS: Absent at 4840.4'.
REMARKS: Top of the Second Red Bed member of the Dawson Bay Formation.

T.S. 4841.5'

NAME: Argillaceous dolomitic micrite (argillaceous mudstone).
DOLOMITE: (97%) microcrystalline, euhedral rhomb matrix.
ANHYDRITE: (less than 1%) disseminated laths.
QUARTZ: (less than 1%) subrounded silt.
INSOLUBLES: (2%) disseminated in matrix.
HEMATITE: (less than 1%) disseminated in matrix.
REMARKS: Occasional open microfracture.

WILLIAMS COUNTY

NDGS #7877
LOCATION: T158N-R95W-S18, SW SE
WELL NAME: PEDERSON NO. 1
COMPANY: NORTHWEST EXPLORATION COMPANY
DAWSON BAY FORMATION TOP DEPTH: 10640'
TOP OF THE SECOND RED BED MEMBER: 10776'
CORED INTERVAL: 10640'-10665'
KELLY BUSHING ELEVATION: 2388'
REMARKS: THIS IS A PRODUCING WELL.

INTERVAL AND DESCRIPTIONS

10639'-10640.2'
NAME: Argillaceous, microcrystalline to finely-crystalline, dolomite (argillaceous mudstone).
MINERALS: Dolomite (90%) matrix; Clay (10%) discontinuous laminae.
COLOR: Dull yellowish-brown (10YR4/3).
ORTHOCHEMS: Dolomicrite (90%).
POROSITY: Intercrystalline, microfractures.
STRUCTURES: Argillaceous laminae; Abundant soft sediment deformation.
REMARKS: Basal Souris River Formation.

10640.2'-10640.5'
NAME: Microcrystalline to finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (100%) matrix.
COLOR: Dull yellowish-brown (10YR4/3) to brownish black (10YR2/2).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fractures.
STRUCTURES: Common subvertical and subparallel fractures; Common, subhorizontal, finely-crystalline dolomite healing subvertical fractures in microcrystalline dolomite. Occasional subhorizontal fractures; Occasional Type II microstyolites.
UV OIL TESTS: Shows at 10640.3 and 10640.5'.

10640.5'-10640.6'
NAME: Finely-crystalline, fossiliferous, dolomite (mudstone).
MINERALS: Dolomite (99%) matrix and bioclasts; Halite (1%) filling to partially filling pores.
COLOR: Dull yellowish-brown (10YR4/3).
ALLOCHEMS: Fossils (2%) subspherical stromatoporoids (?) (100%).
ORTHOCHEMS: Dolomitized micrite (98%).
POROSITY: Intercrystalline, fractures, vuggy.
STRUCTURES: Occasional healed to partially healed subvertical fractures.

10640.6'-10642.8'
Missing interval.

10642.8'-10644.9'
NAME: Microcrystalline fossiliferous intramicrudite (wackestone-packstone).
MINERALS: Dolomite (98%) matrix, intraclasts; Calcite (2%)

bioclasts; Halite (less than 1%).
COLOR: Dull yellowish-orange (10YR7/2) to brownish black (10YR3/1) in lower section.
ALLOCHEMS: Intraclasts (50-80%); fossils (0-2%) subspherical stromatoporoids (?) (90%), brachiopod fragments (?) (10%).
ORTHOCHEMS: Dolomitized micrite (38-48%).
POROSITY: Intraparticle, intercrystalline, fracture.
STRUCTURES: Very abundant, angular to subrounded, intraclasts. Common, subhorizontal, fractures and microfractures; Occasional, subvertical, fractures and microfractures; Occasional, subhorizontal, Type II microstyolite swarms and rare seams increasing near base of section.
UV OIL TESTS: Shows at 10643', 10643.4', 10644.2' and 10644.7'.

T.S. 10643'
NAME: Dolomitic fossiliferous pelmicrite (wackestone).
PELOIDS: (10-60%) irregularly shaped, dark gray, dolomitized micrite composition, diffuse boundaries.
FOSSILS: (5%) unidentified fossil-fragment ghosts and mold-vugs (100%).
DOLOMITE: (20%) microcrystalline, subhedral rhomb matrix, with microcrystalline euhedral rhombs rimming to filling moldic-vuggy pores and fractures.
REMARKS: Subhorizontal microfractures cut peloids.

10644.9'-10645.1'
NAME: Microcrystalline pelmicrite (wackestone).
MINERALS: Dolomite (98%) matrix and bioclast replacement.
COLOR: Grayish white (N8/0).
ALLOCHEMS: Peloid ghosts (20%).
ORTHOCHEMS: Dolomitized micrite (100%).
POROSITY: Intercrystalline, fracture, channel.
REMARKS: The upper 2 cm of this section may contain tabular (?) stromatoporoids.
UV OIL TESTS: Show at 10644.7'.

T.S. 10645'
NAME: Dolomitized biomicrite (mudstone).
FOSSILS: (19%) unidentified fossil fragment ghosts (100%).
DOLOMITE: (80%) very-finely-crystalline, subhedral rhomb matrix and finely-crystalline subhedral rhombs healing fractures.
BITUMENS: (less than 1%) associated with porosity.
INSOLUBLES: (less than 1%) disseminated in matrix.
HEMATITE: (less than 1%) disseminated in matrix.

10645.1'-10646.5'
NAME: Finely-crystalline stromatoporoid dolomite (mudstone-wackestone).
MINERALS: Dolomite (95%) matrix and bioclast replacement; Calcite (5%) pseudospar filling fractures.
COLOR: Grayish white (N8/0).
ALLOCHEMS: Fossils (1-10%) subspherical stromatoporoids (95%), brachiopod fragments (5%).
ORTHOCHEMS: Dolomitized micrite (90%); Micrite (4%).

POROSITY: Intercrystalline, microfracture, fracture.
STRUCTURES: Occasional subhorizontal Type II microstyolite; Occasional, subvertical to diagonal, fractures filled by calcite cement.

10646.5'-10648.8'

NAME: Finely-crystalline, brachiopod, dolomite (mudstone-wackestone).
MINERALS: Dolomite (94-98%) matrix and bioclasts; Calcite (2-6%) sparry cement filling fractures, matrix.
COLOR: Brownish gray (10YR5/1).
ALLOCHEMS: Fossils (0-20%) brachiopod fragments, ghosts and molds (70%), unidentified fossil fragments and ghosts (30%).
ORTHOCHEMS: Dolomitized micrite (75%); Calcite cement (4%).
POROSITY: Intercrystalline, intraparticle, fracture, microfracture, vuggy (increasing down-section).
STRUCTURES: Occasional Type II microstyolites; Occasional, subhorizontal, pressure-solution orientation of bioclasts; Occasional, subhorizontal, late microfractures; Rare Type I suture seam styolite at 10647.4'; Rare subhorizontal fractures.
UV OIL TESTS: Absent at 10646.7'; Shows at 10648' and 10648.7'.

10648.8'-10648.9'

NAME: Microcrystalline fossiliferous dolomite (wackestone).
MINERALS: Dolomite (85-95%) micrite and bioclasts; Calcite (5-15%) bioclasts, and calcite cement filling fractures.
COLOR: Brownish gray (10YR4/1).
ALLOCHEMS: Fossils (20-30%) unidentified, fossil fragment, pseudospar ghosts (100%).
ORTHOCHEMS: Dolomitized micrite (80-90%).
POROSITY: Microcrystalline, intraparticle, fracture.
UV OIL TESTS: Absent at 10648.8'.

10648.9'-10652.4'

NAME: Microcrystalline to very-finely-crystalline, fossiliferous, dolomite (mudstone).
MINERALS: Dolomite (90-95%) matrix; Calcite (4%) bioclasts, and calcite cement filling fractures; Halite (1%) filling pores.
COLOR: Brownish gray (10YR4/1) microcrystalline (earlier) dolomite and dark brown (10YR3/3) very-finely-crystalline cross-cutting (later) dolomite.
ALLOCHEMS: Fossils (0-10%) unidentified fossil fragment, sparry ghosts (95-100%); and brachiopod fragment ghosts (0-5%).
ORTHOCHEMS: Dolomitized micrite (85-95%).
POROSITY: Intercrystalline, fracture, moldic-vuggy, channel.
STRUCTURES: Common, subvertical and subhorizontal, fractures in microcrystalline dolomite; "Pseudointraclastic" texture due to healing of subvertical and subhorizontal fractures, with recrystallization of proximal microcrystalline dolomite matrix to very-finely-crystalline succrosic dolomite; Common, subhorizontal, Type II microstyolites which control very-finely-crystalline dolomite healing of fractures; Rare Type I suture seam styolite at 10650'.
UV OIL TESTS: Shows at 10648.9', 10649.1', 10650.8', 10651' and

10652.3'.

T.S. 10649'

NAME: Dolomitized brachiopod pelmicrite (mudstone).
CALCITE CEMENT: (less than 1%) late, filling to partially filling pores.
PELOIDS: (20%) dark brown, subrounded, dolomitized micrite ghosts.
FOSSILS: (5%) unidentified fossil ghosts (80%), dolomicrite brachiopod-fragment ghosts (20%).
DOLOMITE: (74%) very-finely-crystalline, subhedral rhomb, matrix and finely-crystalline rhombs proximal to fractures and microstyolites.
HEMATITE: (1%) rimming bioclasts, associated with pores, and disseminated.

10652.4'-10654'

NAME: Microcrystalline to finely-crystalline, stromatoporoid, dolomite (mudstone-wackestone).
MINERALS: Dolomite (98%) matrix and bioclasts; Halite (2%) filling pores; Anhydrite (less than 1%) fibrous crystals filling vuggy pores; Calcite (less than 1%) in 1 mm patches (bioclast ghosts ?).
COLOR: Brownish gray (10YR4/1) microcrystalline dolomite and dark brown (10YR3/3) finely-crystalline dolomite.
ALLOCHEMS: Fossils (1-10%) subspherical stromatoporoids (0-70%) decreasing in lower section, tabulate corals (30-100%) increasing in lower section.
ORTHOCHEMS: Dolomitized micrite (90-99%).
POROSITY: Intercrystalline, intraparticle, fracture, channel, moldic, vuggy.
STRUCTURES: "Pseudointraclastic" texture due to healing of subvertical-subhorizontal fractures, and recrystallization of proximal microcrystalline dolomite matrix to finely-crystalline succrosic dolomite; Common, subhorizontal, Type II microstyolites which also control healing of fractures by finely-crystalline dolomite.

T.S. 10653'

NAME: Dolomitized, stromatoporoid and anthozoan, biomicrudite (wackestone).
CALCITE CEMENT: (less than 1%) late, partially filling pores.
FOSSILS: (20%) tabulate corals (50%), cylindrical stromatoporoids (30%), unidentified fossil-fragment ghosts (20%).
DOLOMITE: (80%) very-finely-crystalline, subhedral rhomb matrix, and euhedral rhombs rimming pores and replacing bioclasts.
REMARKS: Residual oil rimming largest moldic pores.

10654'-10656.5'

NAME: Microcrystalline to very-finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (98%) matrix; Halite (2%) partially filling pores.
COLOR: Brownish black (10YR3/1) microcrystalline dolomite matrix and grayish yellow (10YR4/2) very-finely-crystalline healed fractures.
ORTHOCHEMS: Dolomitized micrite (98%).

POROSITY: Intercrystalline, fracture, microfracture.
STRUCTURES: "Pseudointraclastic" texture due to healing of subvertical-subhorizontal fractures, and recrystallization of proximal microcrystalline dolomite matrix to very-finely-crystalline succrosic dolomite; Larger fractures and closely spaced fractures are associated with larger rhomb sizes; Occasional, subhorizontal-diagonal, Type II microstyolites also control very-finely-crystalline dolomite healing and recrystallization of proximal matrix.
UV OIL TESTS: Shows at 10654.5', 10655.8' and 10656.4'.
REMARKS: Residual (dead) oil patch at 10655.3'.

10656.5'-10658.5'
NAME: Microcrystalline to finely-crystalline, fossiliferous, dolomite (mudstone).
MINERALS: Dolomite (98%) matrix and bioclasts; Halite (2%) filling to partially filling pores.
COLOR: Black (10YR2/1) microcrystalline dolomite matrix and grayish yellow-brown (10YR2/1) finely-crystalline dolomite healed fractures and microfractures.
ALLOCHEMS: Fossils (1%) bryozoans (100%).
ORTHOCHEMS: Dolomitized micrite (97%).
POROSITY: Intercrystalline, fracture, channel.
STRUCTURES: Common Type II individual-swarm microstyolites which control finely-crystalline dolomite healing and recrystallization of proximal dolomite matrix; Fractures very commonly intersect, with subsequent development of channel-vuggy porosity.
UV OIL TESTS: Shows at 10656.8', 10657.5' and 10658.4'.

T.S. 10657'
NAME: Dolomitized stromatoporoid biomicrudite (mudstone).
FOSSILS: (2%) stromatoporoid (?) ghosts and molds (100%).
DOLOMITE: (98%) very-finely-crystalline, subhedral rhomb matrix with finely-crystalline, euhedral rhombs, adjacent to larger pores.
INSOLUBLES: (less than 1%) disseminated.
REMARKS: Partial to complete dolomite healing of microfractures; Type II microstyolite swarm present; Residual oil rimming pores.

10658.5'-10658.9'
NAME: Finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (98%) matrix. Halite (2%) partially filling pores.
COLOR: Light gray (10YR8/2).
ORTHOCHEMS: Dolomitized micrite (98%).
POROSITY: Intercrystalline, channel.
STRUCTURES: Common Type II microstyolites; Vugular pores appear to be remnant channel porositywhich has now been healed by dolomitization.
UV OIL TESTS: Show at 10658.7'.

10658.9'-10659.8'
NAME: Microcrystalline to finely-crystalline dolomite (mudstone).
MINERALS: Dolomite (98%) matrix; Halite (2%) partially filling pores.

COLOR: Brownish black (10YR3/1) microcrystalline matrix dolomite to light gray (10YR8/2) finely-crystalline dolomite healing fractures and recrystallizing matrix adjacent to fractures.
ORTHOCHEMS: Dolomitized micrite (98%).
POROSITY: Intercrystalline, fracture.
STRUCTURES: Abundant, subvertical, partially healed fractures in microcrystalline dolomite matrix. Abundant, subhorizontal and subparallel, fractures which cut earlier partially healed, subvertical, fractures; The subhorizontal fractures have been healed by finely-crystalline dolomite as has the proximal dolomite matrix; Common, subhorizontal, Type II microstyolite swarms occasionally control proximal recrystallization to finely-crystalline dolomite.
UV OIL TESTS: Shows at 10659' and 10659.6'.

10659.8'-10661.4'

NAME: Microcrystalline to finely-crystalline, fossiliferous, dolomite (wackstone-packstone).
MINERALS: Dolomite (98%) matrix and bioclasts; Halite (2%) partially-filling pores; Anhydrite (less than 1%) partially-filling pores.
COLOR: Black (10YR2/1) microcrystalline dolomite matrix and dull yellowish-brown (10YR4/3) finely-crystalline, fracture healed, dolomite and proximal recrystallization.
ALLOCHEMS: Fossils (25%) stromatoporoid (?) molds (50%), unidentified fossil-fragment molds (50%).
ORTHOCHEMS: Dolomitized micrite (73%).
POROSITY: Moldic, vuggy, intercrystalline, fracture.
STRUCTURES: Very abundant irregularly-oriented fractures (subvertical dominate);
UV OIL TESTS: Shows at 10660.3' (microcrystalline dolomite) and 10660.4' (finely-crystalline dolomite).
REMARKS: The percentage of fauna falls to zero in the lower ten centimeters of this section.

T.S. 10661'

NAME: Dolomitized fossiliferous pelmicrudite (mudstone).
PELOIDS: (5-15%) dark, dolomitized, micrite ghosts.
FOSSILS: (2%) sparry, unidentified fossil-fragment ghosts and molds.
DOLOMITE: (82-92%) very-finely-crystalline matrix and bioclast replacement.
ANHYDRITE: (1%) sparry, partially filled pores.
REMARKS: Common, residual oil rimming pores.

10661.4'-10663.8'

NAME: Microcrystalline to finely-crystalline stromatoporoid dolomite (mudstone).
MINERALS: Dolomite (86-96%) matrix and bioclasts; Calcite (2-5%) partially filled pores; Halite (2%) partially filled pores.
COLOR: Black (10YR2/1) microcrystalline matrix dolomite, dark brown (10YR3/3) finely-crystalline dolomite healing and proximal to fractures, and light gray (10YR7/1) finely-crystalline dolomite replacement of stromatoporoids.
ALLOCHEMS: Fossils (0-5%) subspherical stromatoporoids (90%),

tabular stromatoporoids (10%).
ORTHOCHEMS: Dolomitized micrite (80-96%); Pseudospar (0-5%).
POROSITY: Moldic, intercrystalline, channel, fracture.
STRUCTURES: Moldic-channel porosity is very high; "Pseudointraclastic" texture due to healing of irregularly-oriented fractures, and recrystallization of proximal, microcrystalline, dolomite matrix to finely-crystalline dolomite; Common, subhorizontal, Type II individual and microstyolite swarms which commonly control finely-crystalline dolomitization; Rare Type I suture seam styolite near top of section proximal to stromatoporoids.
UV OIL TESTS: Shows at 10661.6', 10662.8', 10663.3' and 10663.7'.

T.S. 10662.5'
NAME: Dolomitized, peloidal, stromatoporoid biomicrudite (wackestone).
CALCITE CEMENT: (3%) partially filling pores.
PELOIDS: (0-10%) dark, dolomitized, micrite ghosts.
FOSSILS: (5%) subspherical stromatoporoid ghosts (80%), unidentified fossil ghosts (20%).
DOLOMITE: (80%) very-finely-crystalline, subhedral to euhedral rhomb matrix and finely-crystalline euhedral rhombs associated with bioclast replacement and proximity to fractures.
ANHYDRITE: (1%) sparry, partially filling fractures and adjacent dolomite replacement.
BITUMENS: (less than 1%) microstyolite association.
INSOLUBLES: (1%) microstyolite associated and disseminated.
HEMATITE: (less than 1%) microstyolite associated and disseminated.
REMARKS: Occasional residual oil rimming pores.

10663.8'-10665'
NAME: Microcrystalline to finely-crystalline, stromatoporoid, dolomite (wackestone-packstone).
MINERALS: Dolomite (98%) matrix and bioclast replacement; Halite (2%) partially filling pores.
COLOR: Black (10YR2/1) microcrystalline dolomite matrix, brownish black (10YR3/2) finely-crystalline, dolomite healed fractures, and proximal dolomicrite, and dull yellowish-brown (10YR5/3) finely-crystalline dolomite stromatoporoid replacement.
ALLOCHEMS: Fossils (10-98%) tabular stromatoporoids (45%), subspherical stromatoporoids (40%), brachiopods (10%) shells disarticulated and molds, gastropods (5%).
ORTHOCHEMS: Dolomitized micrite (2-88%).
POROSITY: Intraparticle, intercrystalline, moldic, vuggy, fracture (very common in tabular stromatoporoids).
STRUCTURES: Abundant, subhorizontal, Type II microstyolites which commonly control recrystallization of proximal, microcrystalline, dolomite matrix to finely-crystalline dolomite; Bioclasts occasionally display subhorizontal orientation associated with microstyolites.
UV OIL TESTS: Shows at 10664', 10664.5', 10664.7' and 10664.8'.
REMARKS: Base of available core.

T.S. 10665'

NAME: Dolomitized stromatoporoid biomicrudite (mudstone).
MICROSPAR: (1%) dedolomitization proximal to pores.
CALCITE CEMENT: (10%) partially filling fractures and intercrystalline pores.
FOSSILS: (5%) subspherical stromatoporoids (70%), echinoderm fragment ghosts (30%).
DOLOMITE: (84%) microcrystalline, euhedral to subhedral rhomb matrix with abundant very-finely-crystalline euhedral rhombs, rimming pores and replacing bioclasts.
INSOLUBLES: (less than 1%) associated with Type II microstyolite swarms. 10663.8'-10665'

APPENDIX C

MONTHLY PRODUCTION STATISTICS

Monthly production statistics for Dawson Bay wells in North Dakota through August 1984 (Petroleum Information Corporation, 1980-1984)(NDGS, 1984).

FIELD: TEMPLE
FORMATION: DAWSON BAY
OPERATOR: NORTHWEST EXPLORATION
LEASE NAME: RYE #1

LOCATION: NORTH DAKOTA
WILLIAMS COUNTY
T.158N. - R.95W. - S.19
NW NE

INITIAL PRODUCTION
DATE: 4-80
OIL: 895 BPD
GAS: -
WATER: -

MONTHLY PRODUCTION (BARRELS PER DAY: OIL AND WATER, MILLION CUBIC FEET: GAS)

	J	F	M	A	M	J	J	A	S	O	N	D
1984: OIL	0	0	0	0	0	-	-	-				
GAS	0	0	0	0	0	-	-	-				
WATER	0	0	0	0	0	-	-	-				
1983: OIL	95	351	319	172	64	0	0	0	0	0	0	0
GAS	236	564	604	302	90	0	0	0	0	0	0	0
WATER	2164	3361	2847	2058	960	0	0	0	0	0	0	0
1982: OIL	369	429	843	580	353	104	0	0	0	0	0	0
GAS	936	363	1760	1702	1140	255	0	0	0	0	0	0
WATER	1597	1373	2259	1609	1162	752	0	0	0	0	0	0
1981: OIL	5503	2256	1848	598	106	0	282	134	1588	1228	432	633
GAS	0	0	0	0	0	0	0	0	0	0	0	0
WATER	246	305	335	205	163	0	437	1436	1519	2026	2109	648
1980: OIL							2051	2873	5887	8585	8130	6187
GAS							0	0	0	0	0	0
WATER							11	0	0	47	113	209

FIELD: TEMPLE
FORMATION: DAWSON BAY
OPERATOR: NORTHWEST EXPLORATION
LEASE NAME: PEDERSON #1

LOCATION: NORTH DAKOTA
WILLIAMS COUNTY
T.158N. - R.95W. -S.18
SW SE

INITIAL PRODUCTION
DATE: 9-80
OIL: 515.5
GAS: -
WATER: -

MONTHLY PRODUCTION (BARRELS PER DAY: OIL AND WATER, MILLION CUBIC FEET: GAS)

	J	F	M	A	M	J	J	A	S	O	N	D
1984: OIL	1923	1402	1506	1467	1383	1357	1439	980				
GAS	3836	3004	2762	2675	2608	-	-	-				
WATER	766	612	691	762	787	806	838	827				
1983: OIL	2727	2349	2612	1919	2039	1670	1911	2206	1871	2436	2287	2126
GAS	6234	4829	5044	3811	3754	3016	3703	3629	3430	4516	3731	4194
WATER	174	189	257	291	246	464	279	591	459	445	673	763
1982: OIL	4271	3987	5610	4817	4979	4190	4189	3990	3720	3306	3061	3345
GAS	7973	7237	10144	9542	9968	9735	10540	9475	9314	8196	7712	7774
WATER	70	96	106	169	213	168	181	132	81	94	154	152
1981: OIL	9739	8462	8673	8220	7887	7934	7431	6772	6982	6164	6314	5788
GAS	0	0	0	0	0	0	0	0	0	0	0	0
WATER	226	231	230	120	164	144	133	95	125	90	162	154
1980: OIL									4929	10602	9950	9037
GAS									0	0	0	0
WATER									0	2421	272	184

FIELD: TEMPLE
FORMATION: DAWSON BAY
OPERATOR: NORTHWEST EXPLORATION
LEASE NAME: PEDERSON #3

LOCATION: NORTH DAKOTA
WILLIAMS COUNTY
T.158N. - R.95W. - S.18
SW NE

INITIAL PRODUCTION
DATE: 9-83
OIL: 340
GAS: -
WATER: -

MONTHLY PRODUCTION (BARRELS PER DAY: OIL AND WATER, MILLION CUBIC FEET: GAS)

	J	F	M	A	M	J	J	A	S	O	N	D
1984: OIL	1586	1549	1543	1070	1265	1286	1434	1114				
GAS	4864	4626	5528	4032	4250	-	-	-				
WATER	62	37	53	81	83	72	101	40				
1983: OIL							0	0	1515	1728	1678	1605
GAS							0	0	5125	6330	5358	4529
WATER							0	0	395	211	199	110

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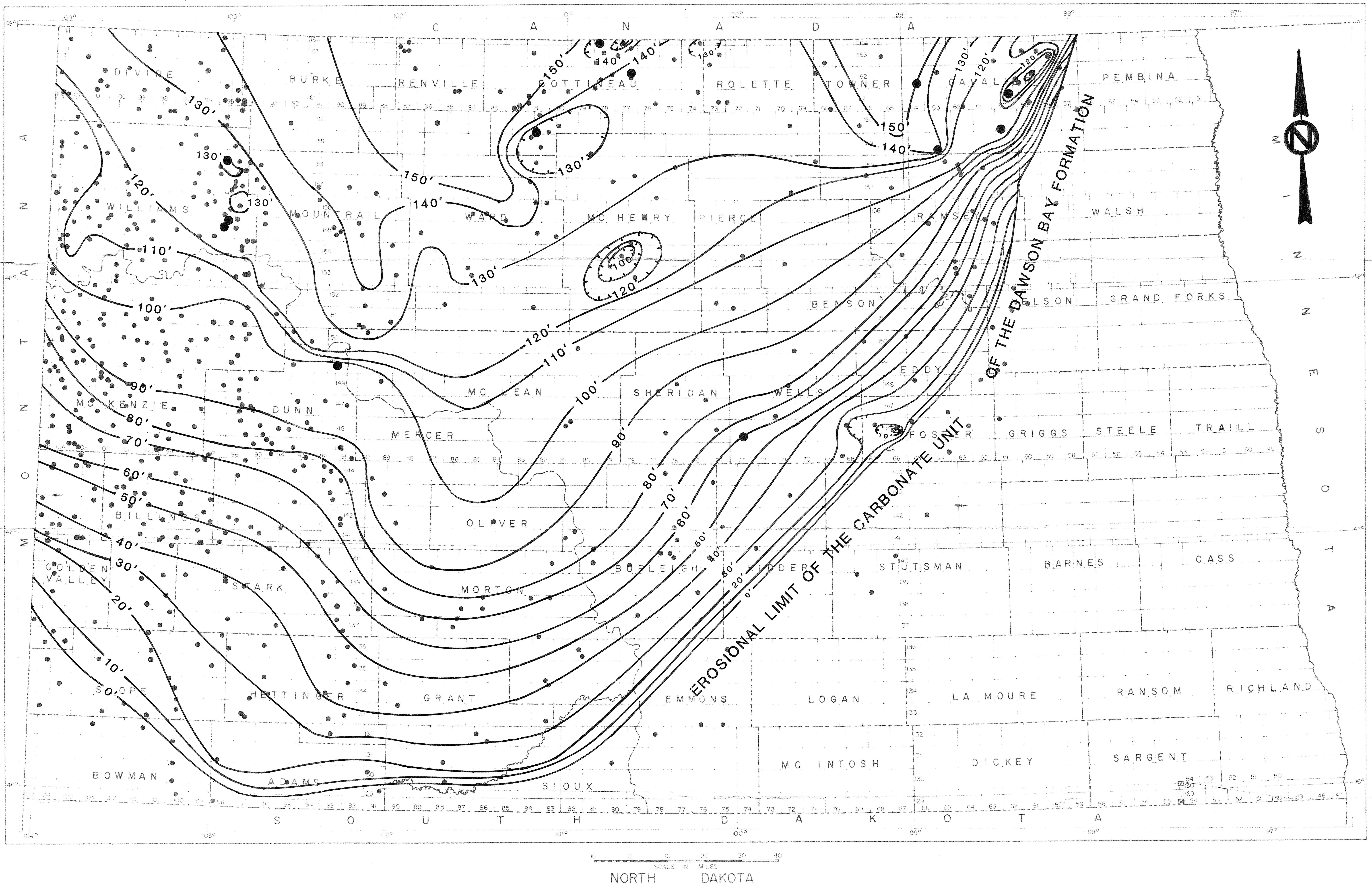


KEY:

• : WELL LOG CONTROL POINT

● : WELL LOG CONTROL POINT WITH CORE

┴┴┴ : THIN

CONTOUR INTERVAL: 10′

PLATE 1

WAYNE R. POUND

U.N.D., 1985

ISOPACH MAP OF THE DAWSON BAY FORMATION CARBONATE UNIT IN NORTH DAKOTA

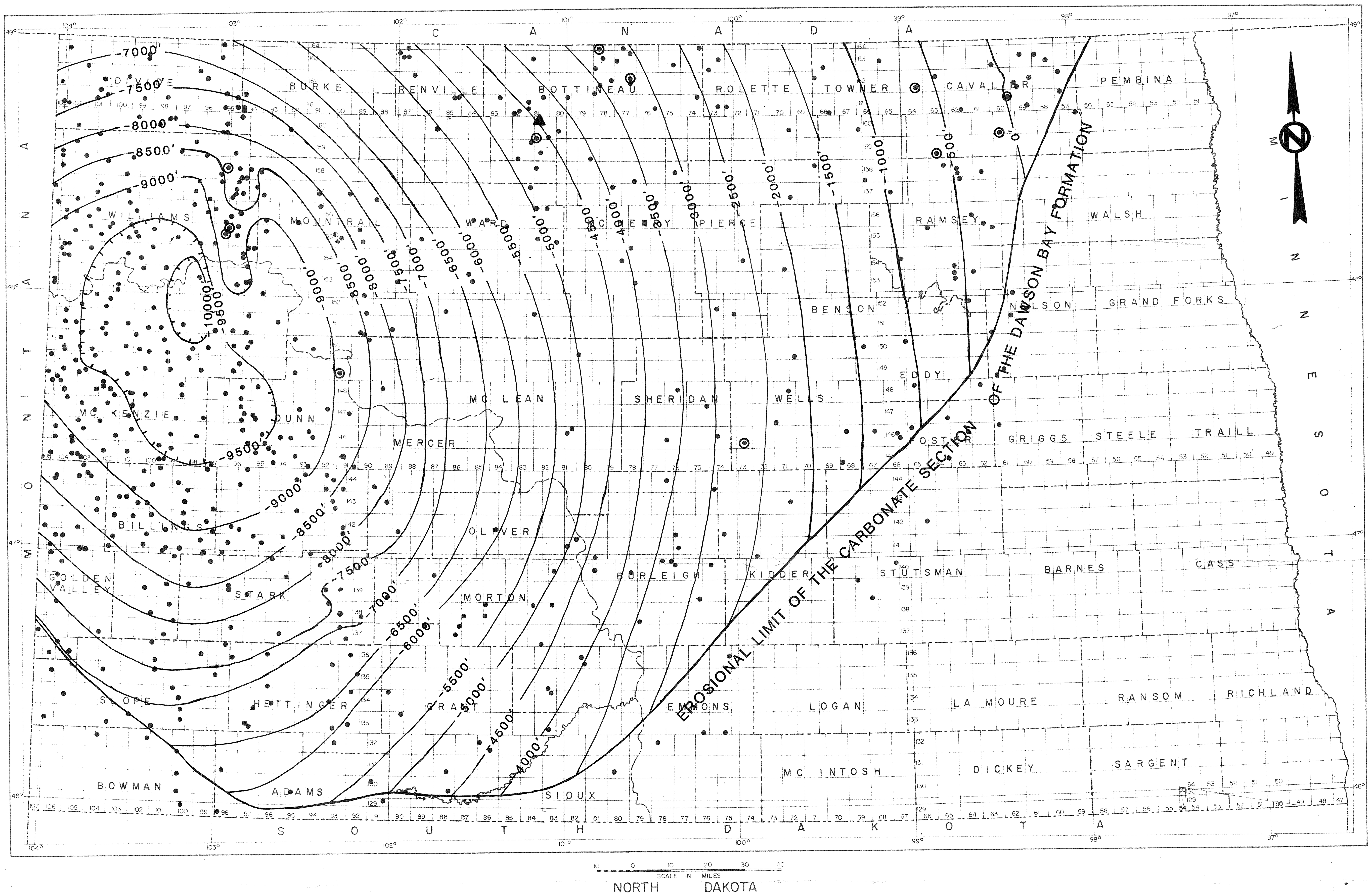


PLATE 2

WAYNE R. POUND

U.N.D., 1985

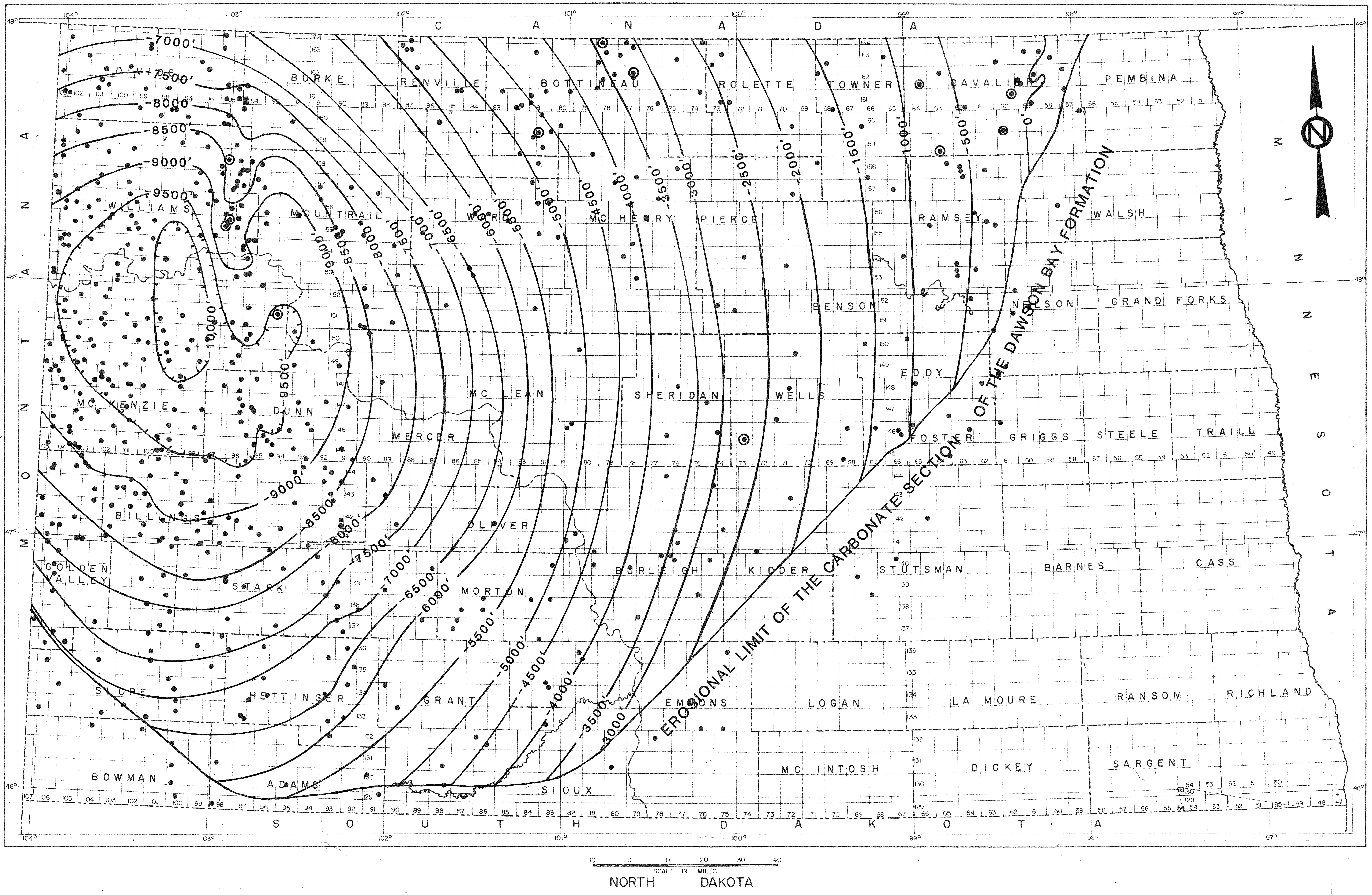
KEY:

- • : WELL LOG CONTROL POINT
- ◎ : WELL LOG CONTROL POINT WITH CORE
- ┴┴ : DEPRESSION
- ▲ : SALT DISSOLUTION (?)

CONTOUR INTERVAL: 500'

DATUM: SEA LEVEL

STRUCTURAL CONTOUR MAP OF THE TOP OF THE DAWSON BAY FORMATION IN NORTH DAKOTA



STRUCTURAL CONTOUR MAP OF THE TOP OF THE SECOND RED BED MEMBER OF THE DAWSON BAY FORMATION IN NORTH DAKOTA

KEY:

- ● : WELL LOG CONTROL POINT
- ◉ : WELL LOG CONTROL POINT WITH CORE
- ┴┴ : DEPRESSION

CONTOUR INTERVAL: 500'

DATUM: SEA LEVEL

PLATE 3

WAYNE R. POUND

U.N.D., 1985

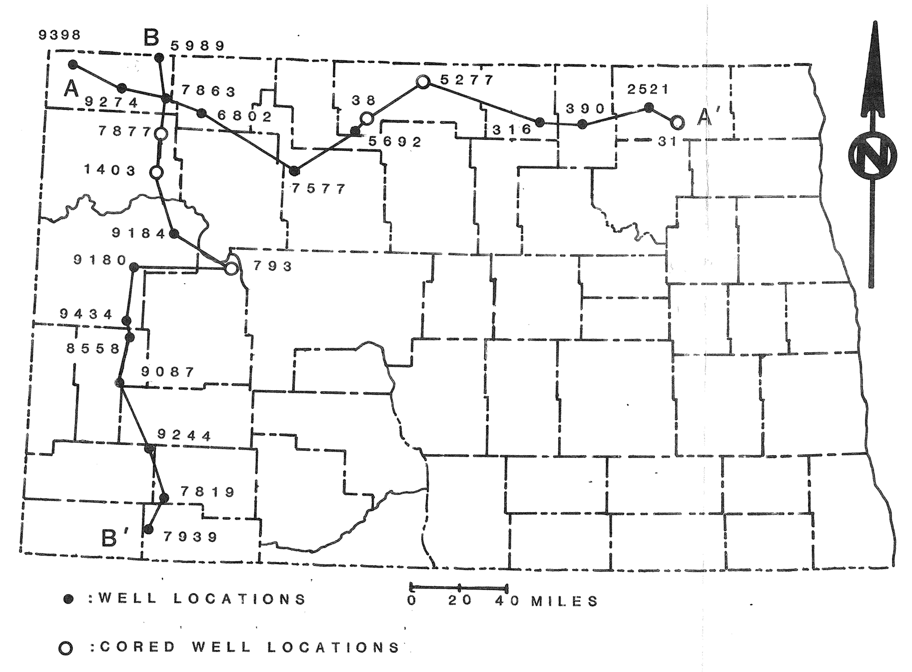
PLATE 4
WAYNE R. POUND
U.N.D., 1985

PLATE 4: DAWSON BAY FORMATION

CARBONATE SECTION

WIRE-LINE LOG CROSS SECTIONS

WEST-EAST (A-A') AND NORTH-SOUTH (B-B')



200'
100'
0'
VERTICAL SCALE IN FEET

KEY :

Ddb : DEVONIAN DAWSON BAY FORMATION CARBONATE SECTION
Dsr : DEVONIAN SOURIS RIVER FORMATION
S.R.B.M. : SECOND RED BED MEMBER OF THE DAWSON BAY FORMATION
——— : FORMATION OR MEMBER BOUNDARY
〰〰 : EROSIONAL UNCONFORMITY
DATUM : TOP OF THE DAWSON BAY FORMATION
G.R. : GAMMA RAY
RS : RESISTIVITY
NEUT. : NEUTRON
S.P. : SELF POTENTIAL