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THE BEAR ROCK FORMATION OF NORTHEASTERN BRITISH COLUMBIA

by

Victor Arthur Fisher

B.A. Washington State University, 1961

Presented in partial fulfillment of the requirements for the degree of

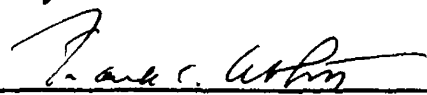
Master of Arts

MONTANA STATE UNIVERSITY

1963

Approved by:


Chairman, Board of Examiners


Dean, Graduate School

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ABSTRACT

The area that was studied is located along the Rocky Mountain front in the region between Summit and Redfern Lakes of northeastern British Columbia. Six detailed stratigraphic sections of the Middle Devonian Bear Rock Formation were measured and described. Field and laboratory descriptions are presented and an attempt is made to correlate among the six sections.

The Bear Rock Formation was divided into two members. The basal member consists of subround to round quartz sands with dolomitic or siliceous cement, and the overlying member consists of thick bedded dense dolomites.

An angular unconformity at the base of the Bear Rock Formation brings the Muncho-McConnell and Middle Silurian Ronning Formations in contact with the Bear Rock Formation. The contact of the overlying Upper Devonian Hume Formation limestone and the Bear Rock Formation dolomite is gradational.

Cut and etched surfaces of dolomite samples were observed in the laboratory and six reoccurring textures were noted. The six textures were classified as types I through VI. Type I is a massive structureless dolomite, the result of rapid deposition of homogeneous sediments. Type II dolomites have laminations which are either straight or undulating. The undulating laminae are due to compression, probably during slump. Type III dolomites are the result of continued compression

until the laminae are broken and swirled. Type IV dolomites have intraclasts caused by currents picking up plastic sediments and re-depositing them. The shape of the intraclasts depends on the distance of transport. Type V dolomites are subdivided into primary and secondary breccias. The primary breccia is the result of strong but sporadic currents breaking up semiconsolidated sediments. The secondary breccia is caused by tectonism after lithification. Type VI dolomites are so mineralized that the original texture has been destroyed beyond recognition.

Correlations of the Bear Rock Formation sections are attempted using these dolomite types and other features. Some measure of success in correlation was obtained.

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INTRODUCTION

Purpose of the Investigation

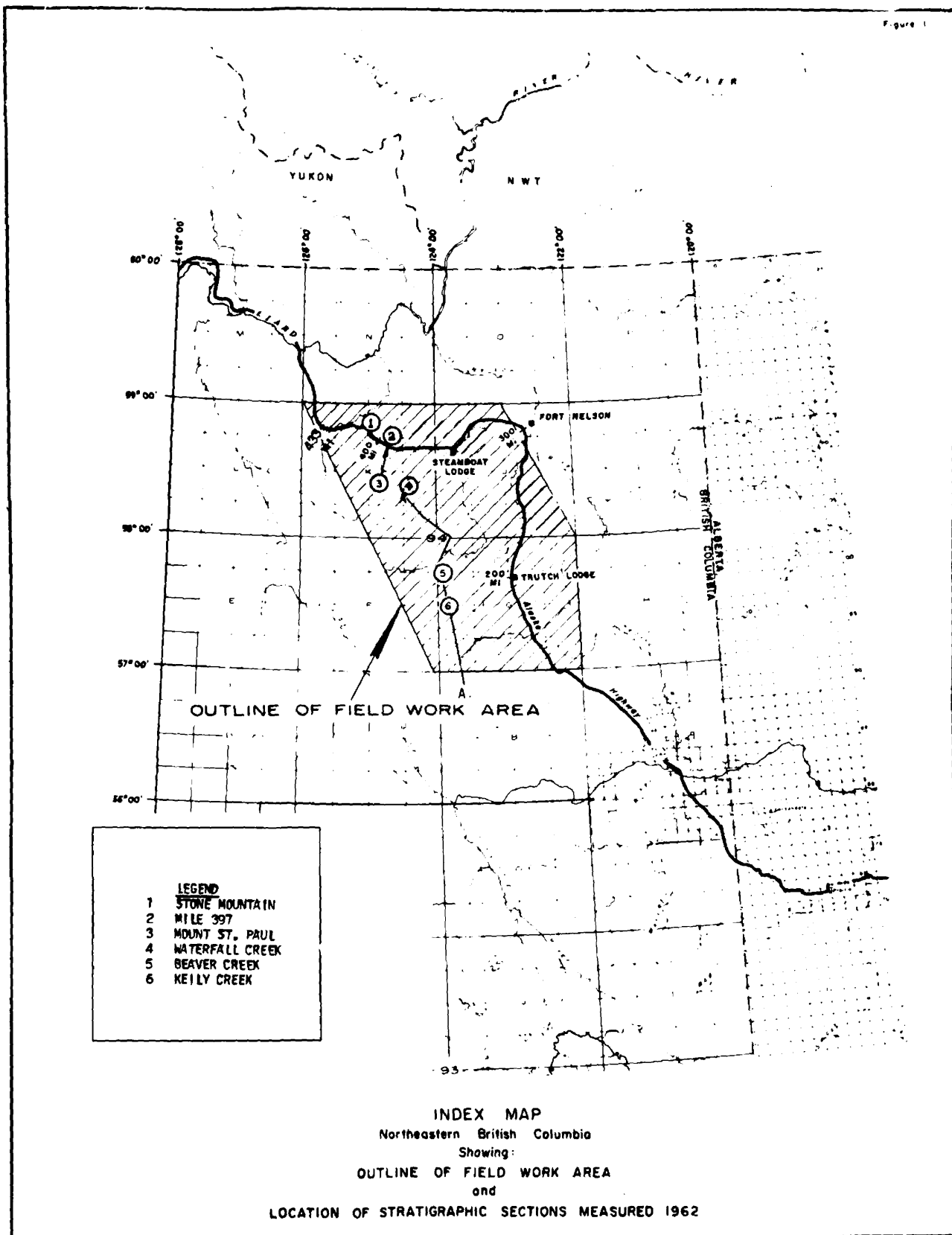
The Bear Rock Formation of Lower Devonian age crops out in northern British Columbia. The purpose of this study is (1) to present six detailed stratigraphic sections of the Bear Rock Formation, (2) to indicate correlative features and units within the formation, (3) to attempt to correlate the formation with equivalent strata in the Northwest Territories and in the subsurface of the plains to the east, and (4) to present a classification of dolomite types which may be useful in working with other Devonian rocks in northeastern British Columbia.

Location and Accessibility

The investigation was conducted in northeastern British Columbia along the Rocky Mountain front. Six sections were measured which are located on an eastward convexed, arcuate line extending a distance of 114 miles, from 18 miles northwest of Summit Lake to 9 miles north of Redfern Lake (see index map, Fig. 1). The following is a brief description of the locations of the six sections.

Section 1 Stone Mountain; $124^{\circ}56'$ longitude, $58^{\circ}51'$ latitude. Section was measured from saddle east, down valley wall and along the creek bottom to the base of the dolomitic sands near the confluence of the streams. Beds dip to the west (see Fig. 2).

Section 2 Mile 398; $124^{\circ}48'$ longitude, $58^{\circ}41'$ latitude. Section was



measured from the bridge located at Mile 398 along Alaska Highway upstream for approximately $1\frac{1}{2}$ miles. Measurements were made on one or the other side of the valley as exposures and accessibility of outcrops dictated. Beds dip to the west (see Fig. 2).

Section 3 Mount St. Paul; $124^{\circ}45'$ longitude, $58^{\circ}40'$ latitude. Section was measured up east wall of stream valley from a point $1\frac{1}{4}$ miles upstream from the bridge at Mile 395.5. The measured section is short because the area is sliced by faults. Beds are nearly horizontal (see Fig. 2).

Section 4 Waterfall Creek; $124^{\circ}26'$ longitude, $58^{\circ}26'$ latitude. Section was measured on Waterfall Creek, located on the west side of the Chischa River, 4 air miles from the mouth of Henry Creek. Section was measured down section along the north wall of the cirque upstream from the waterfall to the base of the dolomitic sand of the Bear Rock Formation. Beds are vertical (see Fig. 2).

Section 5 Beaver Creek; $123^{\circ}56'$ longitude, $57^{\circ}43'30''$ latitude. The section was measured along the north wall of the valley. The dip is vertical at the mountain front but decreases upstream (see Fig. 3).

Section 6 Kelly Creek; $123^{\circ}50'$ longitude, $57^{\circ}28'$ latitude. Section was measured from the floor of the cirque up the mountain side, on the south side of Kelly Creek, 4 air miles from the point where Kelly Creek empties into the Besa River. Beds

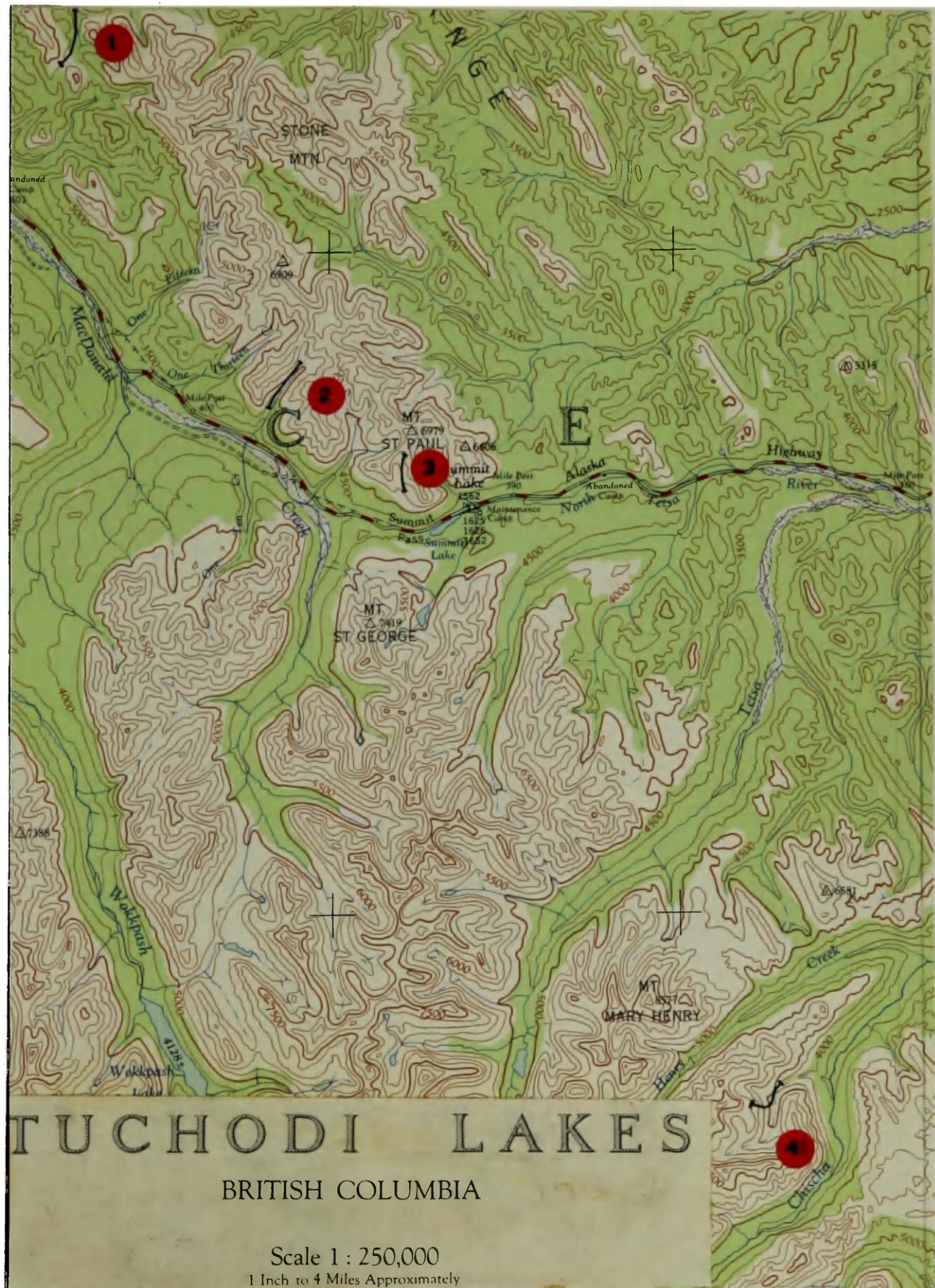


Figure 2. Locations of sections 1, 2, 3, and 4.



Figure 3. Locations of sections 5 and 6.

are horizontal (see Fig. 3).

Travel to all sections was by helicopter. Sections 1, 2, and 3 are within 15 minutes flying time from Summit Lake. Flying times from Summit Lake to section 4 and from Trutch (Mile 200) to sections 5 and 6 are approximately 40 minutes.

All sections can be reached on foot. Sections 2 and 3 are adjacent to the Alaska Highway, and section 1 is about a one hour walk from the Highway. A trail along the mountain front, which is intersected by trails originating from Mile 210 and Mile 162.5, passes close to sections 4, 5, and 6. The condition of these trails is not known, but professional guides use them to pack supplies to their hunting camps at the mountain front. This method of travel to sections 4, 5, and 6 is not recommended because of the hardships and time involved. It takes a few days on horseback to reach the mountain front from the Highway, and the area traversed is covered with muskeg, has many streams, and is infested with insects.

Previous Work

Although considerable geologic exploration has been conducted by petroleum companies along the Rocky Mountain front, very little information has been published. Investigations other than by industry have been limited by the remoteness of the area.

Twenty years ago a Geological Survey of Canada field party, headed by M. Y. Williams, did reconnaissance geology along the newly constructed Alaska Highway between Fort Nelson and Watson Lake, Yukon. Williams

(1944) described the Paleozoic strata in the region between Mile 381 and Muncho Lake but failed to recognize the dolomites in the Devonian carbonate sequence. He subdivided the rocks according to age but did not name formations.

Chronic and Laudon (1947) did detailed Mississippian stratigraphic studies in the area between Mile 380 and Mile 497 of the Alaska Highway and also constructed a composite geologic column for the region from Precambrian to Triassic. They (1949) investigated Silurian and Devonian stratigraphy in detail in the same area and named the Muncho and McConnell Formations of the Devonian age.

Kingston (1955) studied the Paleozoic and Mesozoic sediments of the Rocky Mountain front in northeastern British Columbia. His report includes descriptions of measured sections and a cross section of the geology from Halfway River to the Tuchodi Lakes (see index map, Fig. 1 A-A).

Present Study

During June and part of July of 1962 an Atlantic Refining Company field party measured and described one partial, and five complete Devonian sections along 114 miles of the Rocky Mountain front of northeastern British Columbia. A team composed of Don Scott and the writer described and sampled the rocks every 10 feet or at a significant and recognizable change in lithology. These sections were measured by Brunton compass and Jacob staff.

The Atlantic Refining Company later allowed the writer to use that

portion of the sections which represented the Bear Rock Formation for this study.

The samples were sawed at right angles to the bedding in the laboratory. The cut surfaces were then examined, etched in weak hydrochloric acid, re-examined, and described. After describing in detail 80 samples from one section, the writer was able to recognize six re-occurring textures in the dolomite on which basis he has established dolomites ranging through types I to VI. Thin sections were cut and examined for further information about each type. The six types were found to represent the textures of the other measured sections.

Description forms were constructed to maintain consistency and to incorporate field descriptions with those of the laboratory. Complete descriptions of the rock intervals were made, and the descriptions were then plotted on detailed stratigraphic logs (see Plates 1 to 6).

Acknowledgments

The writer is indebted to the Atlantic Refining Company for permission to use field data collected in 1962. Thanks are extended to the employees of the company, especially F. A. Hildenbrand and Dr. G. W. Crickmay for granting permission to use the information, Dr. M. E. Hriskevich for his constructive suggestions and criticisms, and J. Trifaux for his help in drafting the stratigraphic logs.

The writer expresses his appreciation to Drs. F. S. Honkala, and D. Winston of the Department of Geology and J. S. Preece, Jr. of the Department of Botany, Montana State University, for their critical

reading of the manuscript and for their help during the course of this study.

GENERAL GEOLOGY

Tectonic Setting

Because of the scarcity of information concerning the structural history of the North American Cordillera in British Columbia, writers such as Goodman (1954) and White (1959) have tried to outline the tectonic history by piecing together knowledge gained from scattered geologic investigations.

Based on small area studies White described five orogenies ranging in age from the Proterozoic to the Upper Cretaceous. Of these the Caribou orogeny, which White states took place sometime between the Silurian and Permian, is probably represented by the unconformities at the bases of the Bear Rock and Muncho-McConnell Formations.

The present Rocky Mountain system was built by the compression of the Rocky Mountain miogeosynclinal sediments in late Cretaceous and early Tertiary times. The east side of the system can be divided into three zones: Rocky Mountain front, Disturbed Belt or foothills, and plains. The Rocky Mountain front, which rises abruptly above the foothills to the east, is composed of strongly folded Paleozoic rocks that are generally vertical or overturned to the east. Low angle thrust faults of great displacement created east-facing, parallel scarps formed of carbonates which strike north-northeast. Shales of Upper Devonian age and younger generally acted as glide planes for the thrust faults.

The incompetent Mesozoic clastics of the Disturbed Belt have similar structure to the front range except the thrust sheets are folded and their number multiplied.

The intensity of folding and faulting in the foothills diminishes eastward into low, broad, simple folds, which fade eastward into horizontal strata of the plains.

The intense folding and thrusting of the front range and western foothills are the direct result of compressional forces. The broad folds of the eastern portion of the Disturbed Belt are probably controlled by the basement because it is felt that the incompetent clastics could not transmit the tectonic compression for any great distance.

Physiography

The area from the Alaska Highway to and including the Rocky Mountain front contains three physiographic provinces, the plains, foothills, and the Rocky Mountains, coinciding with the structural provinces.

The plains consist of rolling to slightly undulating upland surfaces incised to a depth of 300 to 400 feet by major rivers. The uplands are a poorly drained area of muskeg, swamps, and poorly integrated, slow-flowing, meandering streams. Because of increased slope and direct stream flow, the areas adjacent to major rivers are better drained. Glaciation has smoothed out the topography by filling preglacial valleys with a thickness of about 400 feet of debris and by covering the uplands with a veneer of till and lake beds.

The foothills are a 16 to 24 mile-wide belt located between the plains and the Rocky Mountain front. The topography of the province has a lineation of N20°W and an elevation of 5,000 to 6,500 feet. The area has high steep ridges where the beds dip steeply and high but gently sloping or flat-topped hills where the beds dip gently. Terraces consisting of glacial till are the result of post glacial stream erosion. The stream courses are controlled by structure as indicated by their trellis pattern. Generally the smaller tributary streams flow north or south in narrow V-shaped canyons, and the larger streams occupy relatively broad U-shaped valleys which trend east-west. Glaciers have eroded the larger preglacial valleys so that now the valleys are abnormally large for the size of the streams that occupy them.

The Rocky Mountain front consists of northwesterly aligned ridges with high, rugged peaks ranging in elevation from 7,000 to 9,000 feet. Today some of the higher peaks such as Roosevelt, Stalin, and Churchill have alpine glaciers and ice fields. Because of mountain glaciation the province has many U-shaped valleys, truncated spurs, hanging valleys, cirques, aretes, kame terraces, and other typically glacial forms. Many valleys have hoodoos of till, which are erosional remnants of glacial debris that once filled the valley.

Strata Below and Above Bear Rock Formation

Before discussing the Bear Rock Formation in detail, general descriptions will be given for the units above and below the formation.

The Cambrian system includes two lithologies. A lower unit is composed of light brown, calcareous, nonfissile shales and an upper unit of thick, uniform beds of medium to coarse grained, buff, siliceous quartz sandstones, which contain shallow water features such as mud cracks, ripple marks, flute casts, and lineations. The Cambrian rocks can be identified even at a distance by their yellowish-brown color. The contact with the overlying rocks is marked by a disconformity, with the relief on the erosion surface of approximately 4 feet. Silurian and Ordovician rocks consist mainly of quartz sandstone with interbeds of dolomitic shale. The sandstones are grayish brown to medium gray with beds 1 to 10 feet thick containing laminations $\frac{1}{4}$ inch to 4 inches thick. Low angle cross beds are present. The fine to medium size quartz grains are cemented by silica and lesser amounts of dolomite and limestone. Near the top of the rocks is a relatively thin interval of finely crystalline, light gray dolomite.

Middle Silurian time is represented by the Ronning Formation, which is a finely crystalline, buff to grayish-brown dolomite with thick sandstone interbeds. The dolomite is mostly thick-bedded and slightly argillaceous. The sandstones are thick-bedded and grayish brown to buff. The quartz sand is fine to medium grained, well sorted, unimodal, and cemented by calcite. The faunal assemblage which consists of algae, stromatoparoids, and corals is of Niagaran age. Irregular-shaped lenses and masses of chert are present and represent replaced alga and stromatoparoid remains. The contact between the Ronning and the underlying Siluro-Ordovician unit is placed at the top of the last cross-bedded sand.

The Devonian system is represented by four formations. The basal formation is the Muncho-McConnell, and it is tentatively placed in the Middle Devonian (Kingston, 1955), although no fossils were found in the sections 2 and 3. Chronic and Laudon (1949, p. 197) originally described the Muncho-McConnell as separate formations. Their type sections descriptions state that both formations resemble each other lithologically, have similar patterns of deposition, light-colored limestones of both formations thin upward, and the contacts of both formations are unconformities.

The author believes that the Muncho and McConnell Formations are identical and represent a single section repeated by faulting. This is supported by the statements of Chronic and Laudon (1949, p. 197) and by the fact that the type section is in a thrust faulted area. The contacts recognized as unconformities may be faults rather than erosion surfaces, although this has not been proven.

The consolidated Muncho-McConnell Formation consists of finely crystalline, light gray to light grayish-brown dolomite. The bedding is generally 1 to 10 feet thick and uniform, although some are thinner ($\frac{1}{4}$ inch to 4 inches) and unevenly bedded due to argillaceous content. Quartz sandstone and arenaceous dolomite are present but compose only a minor portion of the Muncho-McConnell. The sandstone is fine to medium grain, subround to round, and is moderately well sorted. No fossils were found in the formation. The base of the Muncho-McConnell is placed where the rock becomes nonfossiliferous, or in other words, where the silicified fauna of the Ronning Formation disappears. At

most of the measured sections the Ronning, Muncho-McConnell contact appears conformable, but the Muncho-McConnell Formation thins approximately 165 feet between sections 2 and 3 indicating erosional relief at the contact. Kingston (1955) has also observed erosional relief at the contact.

The Bear Rock Formation, which lies unconformably on the Muncho-McConnell and Ronning Formations, will be discussed in greater detail at a later time (see Fig. 4).

The Ramparts Formation, as described by Chronic and Laudon (p. 204), consists of a basal sand unit and a 1,500 foot thick sequence of dolomitic limestones which can be subdivided, on the basis of color, into the Dark and White Ramparts. The lower White Ramparts is dolomite and the upper Dark Ramparts is limestone. The name Ramparts is preempted because the same name is used for a Mississippian group in the Yukon-Tanana region, Alaska (Wilmarth, 1938, p. 1768). Accordingly, the author will use the name Bear Rock Formation Bassett (1960) for the White Ramparts and the basal sand, and the Hume Formation Bassett (1960) for the Dark Ramparts. These names are used because the units occupy the same stratigraphic position and have similar lithologies as do the Bear Rock and Hume Formations in the Northwest Territories. Also the Hume Formations in both areas have the same faunal assemblages.

The contact between the Hume Formation limestone and the underlying Bear Rock Formation dolomite is gradational. The Hume Formation has 10 feet to 4 inch beds and is grayish brown to dark gray. Pelmicrite

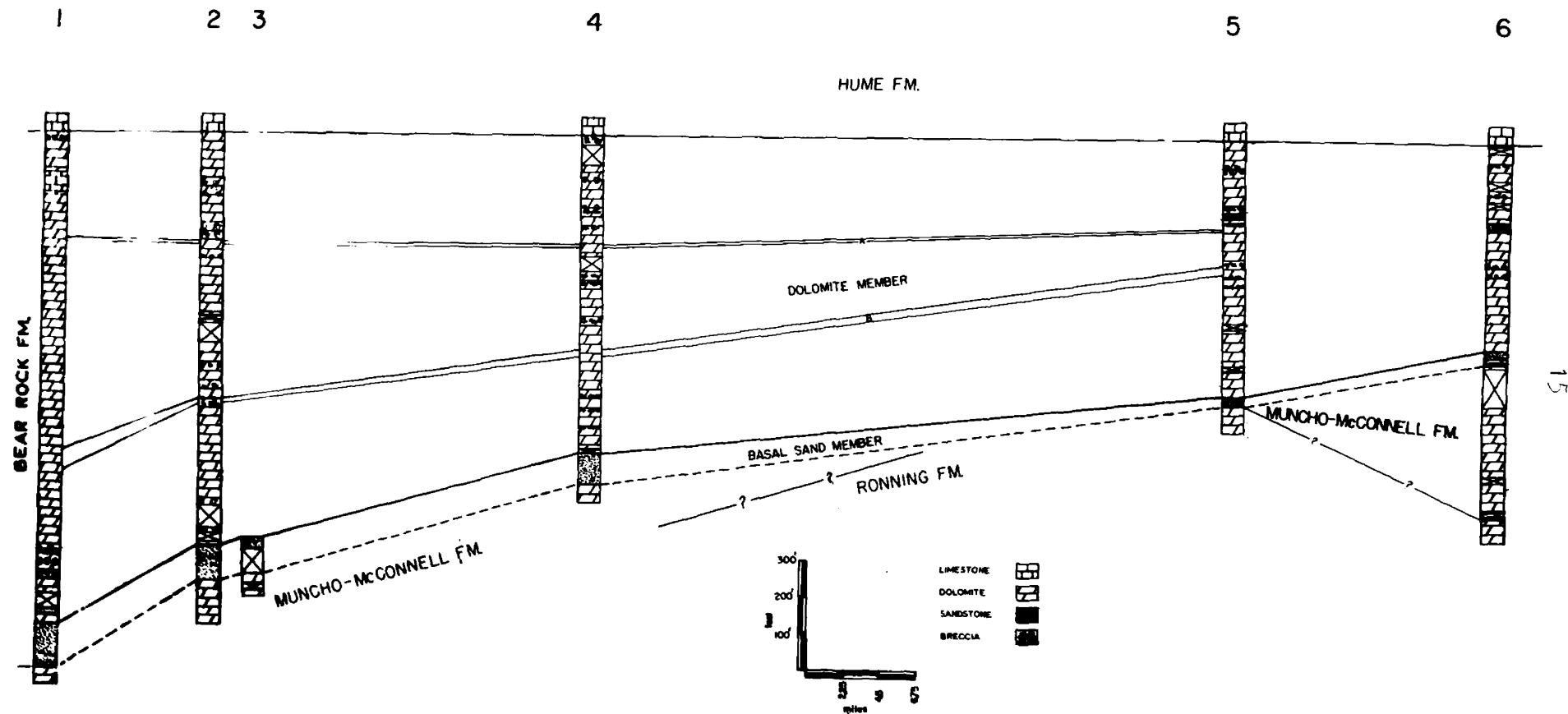


Fig. 4. Cross section showing suggested correlation of Bear Rock Formation members and the relationship to contiguous formations.

(Folk, 1961) is the main limestone type although oolites, skeletal material, and spar cement are found throughout the section. Bedding thickness is related to the argillaceous content of the limestone; the higher the argillaceous content, the thinner the beds. The limestone is locally mottled, especially at the gradational contact. In places the limestone is interbedded with dolomite. Fossils are not abundant, but they are found throughout the formation. The main fauna is made up of stromatoparoids, brachiopods, colonial and some solitary corals, and algae. On the weathered surface the chertified stromatoparoids usually appear in cross section but sometimes weather out as "cabbage heads."

The shale which overlies the Hume Formation was named from the Fort Creek shale by Chronic and Laudon (1949) from exposures near Norman Wells, Northwest Territories. Unfortunately the unit was established on a stratigraphic error and is no longer in use. The author ~~perfers~~ prefers the name Besa River Formation which includes all shales of Upper Devonian and Lower Mississippian age because in this region separation of Mississippian and Devonian shale is difficult. The Besa River Formation is a thick sequence of black, hard, platy, fissile, pyritic shales which are highly contorted when associated with thrust faulting. The basal 10 feet of the formation consists of black, highly argillaceous limestone with many pyrite nodules. The limestone directly overlies the medium gray limestones of the Hume Formation with a sharp contact which, according to Chronic and Laudon (1949), is a sharp unconformable surface. The writer believes this is a conformable contact representing a rapid change in the type of sedimentation.

BEAR ROCK FORMATION

History of Nomenclature

All Canol¹ geologists used the name Bear Rock Formation to describe the brecciated and nonbedded dolomites and limestones lying below Middle Devonian strata and above a sharp disconformity with well-bedded Silurian limestones below it, (Hume, 1954).

The type section at Bear Rock is located at the junction of the Great Bear and Mackenzie Rivers at Fort Norman, Northwest Territories. Stelk, as reported by Hume (1954), stated,

The upper division of the Bear Rock Formation on Bear Rock consists of 175 feet of a breccia of brown dolomitic limestone boulders in a matrix of dolomitic limestone. This is separated from the underlying white basal member by 30 feet of poorly bedded gray dolomite and limestone, and from the overlying Ramparts Formation by 10 feet of bedded limestone and dolomitic breccia.

The basal division is a "white weathering, massive, tough, gypsiferous dolomite...which shows local bedding."

Bassett (1960), accepting Stelk's definition of the unit at its type locality, proposed, "that the term Bear Rock Formation be applied to the strata underlying the Hume Formation and overlying strata of Silurian or Ordovician age."

¹The Canol project, which began in 1942 because of military necessity, was the result of an agreement between the Canadian and United States governments to explore and drill wells for oil in the Norman Wells region, Northwest Territories, transport the oil by pipeline to Whitehorse, Yukon, refine it, and distribute the petroleum products.

Early workers combined the unit now known as the Bear Rock Formation with other units. Kindle (Kindle and Bosworth, 1920) included in his Bear Mountain Formation of Silurian age all the beds from Devonian down to the base of the exposed red and green gypsiferous shales of Cambrian age. He did not record the disconformity at the base of the brecciated beds that are now defined as being in the Bear Rock Formation. Kindle also described the Lone Mountain Formation of Silurian age from Lone Mountain at the mouth of the North Nahanni River. He concluded that "It is not impossible that the Bear Mountain Formation may represent a special facies of the Lone Mountain Formation." According to Hume (1954) this correlation can neither be substantiated nor disproved, but it appears to have doubtful value.

General Description

At the type locality of Bear Rock near Fort Norman, Northwest Territories, the Bear Rock Formation consists of 60 feet of gypsiferous dolomite overlain by 175 feet of brown dolomitic limestone boulders in a dolomitic limestone matrix. In northeastern British Columbia, 400 miles south of the type locality, the Middle Devonian Bear Rock Formation, which consists of miogeosynclinal sediments, has two members, the basal sand and the overlying dolomite member. The basal sand member, which can be definitely identified from section 4 to Mile 433 (see index map, Fig. 1) (Chronic and Laudon, 1949), consists of siliceous or dolomitic, fine to medium grained sandstone ranging in thickness from 158 to 28 feet. The dolomite member, which overlies the basal sand member,

consists of light to medium gray, generally dense dolomite with quartz sandstones and sand grains scattered throughout. This member ranges in thickness from 1425 to 574 feet. The bedding of the Bear Rock is generally 1 to 10 feet thick although some beds are from $\frac{1}{4}$ to 4 inches thick. The total thickness of the formation ranges from 1583 to 602 feet. Fossils are very rare.

The contact of the Bear Rock Formation dolomite and the overlying Hume Formation limestone is gradational. An angular unconformity marks the contact of the Bear Rock Formation and the underlying Ronning and Muncho-McConnell Formations. The correlation of the Bear Rock Formation in northeastern British Columbia with the type section can only be inferred on the basis of indirect evidence. Bassett (1960) correlates the Bear Rock Formation in the Norman Wells, Northwest Territories, area with the Chinchaga Formation evaporites in the subsurface of northeastern British Columbia and Alberta plains.

Regional Extent

As far as is known, nothing has been published about the correlation of the strata considered in this report and the type section of the Bear Rock Formation. As previously mentioned, this correlation can only be inferred by indirect evidence.

Chronic and Laudon (1949) collected a Niagaran fauna from the Ronning Formation, which underlies the Bear Rock and Muncho-McConnell Formations. According to Hume (1954) Niagaran assemblages have been found below the Bear Rock Formation in the lower Mackenzie River area. The fauna collected in the overlying Hume Formation by the field party

of which the writer was a member, and by Williams (1944) and Kingston (1955), is similar to the fauna noted by Hume (1954) and Bassett (1960) from the Hume Formation of the Northwest Territories. Williams (1944, p. 16), when discussing the fossiliferous Devonian limestones of the area of northeastern British Columbia, stated that the fauna "in a general way...suggest Middle Devonian faunas of the Mackenzie River." Laudon and Chronic correlated the fossiliferous Devonian limestones with the Ramparts Formation of the Mackenzie River basin (see Table 1).

The lithologic sequence in northeastern British Columbia and the area around Norman Wells, Northwest Territories, is similar. In the Mackenzie River area the Hare Indian Formation shales overlies the Hume Formation, and the Hume limestone overlies the Bear Rock Formation dolomite. In northeastern British Columbia the Besa River Formation shale overlies the Hume Formation limestone which in turn overlies the Bear Rock Formation dolomite.

The upper contact of the Bear Rock and Hume Formations in northeastern British Columbia and the Mackenzie River area is gradational from dolomite to limestone, and the basal contact of the Bear Rock Formation is marked by an unconformity in both areas.

The correlation between the Bear Rock Formation of northeastern British Columbia and that of the Mackenzie River area is less difficult than the correlation to the subsurface of Alberta because the formations are bracketed between Niagaran and Middle Devonian faunas, they occupy the same stratigraphic position, and are both carbonates.

Bassett (1960) states:

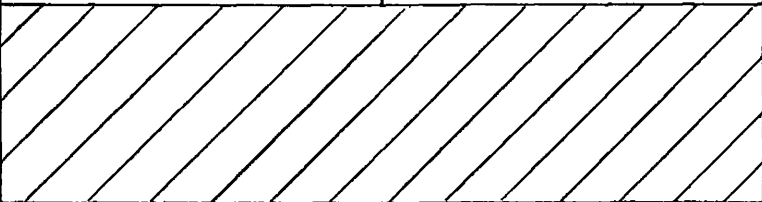
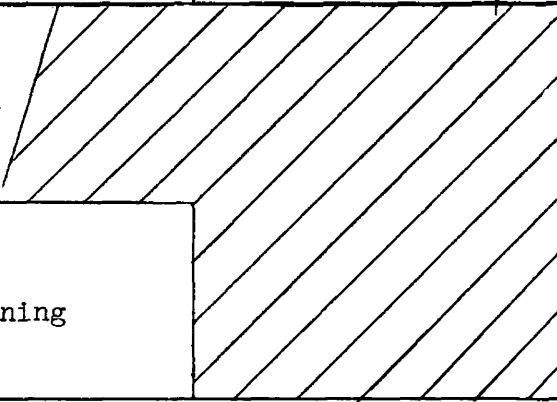

| Northwest Territories | | Northeastern British Columbia | | B. C. Plains | | | |
|-----------------------|--|-------------------------------|-------------------|---|--|-----------------|--|
| Hume 1953 | Bassett 1960 | Chronic & Laudon 1949 | This Study | Belyea 1962 1962 | | | |
| Middle Devonian | Lower Fort Creek | Hare Indian | Fort Creek Shales | Besa River | Horn River | Elk Point Group | |
| | Upper Ramparts | Hume | Dark Ramparts | Hume | Lonely Bay (Keg River) <i>Lonely Bay is not a part of Hume</i> | | |
| | Middle Ramparts | | | | | | |
| | Lower Ramparts | | | | | | |
| | Bear Rock | Bear Rock | White Ramparts | Bear Rock | Chinchaga | | |
| | | | Basal Ramparts | | | | |
| |  | | Muncho | Muncho- McConnell |  | | |
| | | | McConnell | | | | |
| Silurian | Ronning | Ronning | Ronning |  | | | |

Table 1. Stratigraphic Nomenclature

In the Norman Range, north of Norman Wells and east of the Franklin Mountains, the Bear Rock interval is occupied by gypsum and anhydrite beds which extend along the Shield southward to Great Slave Lake and into northern Alberta and the plains of northeastern British Columbia where they are known as the Chinchaga Formation, (Law, 1955).

The Chinchaga Formation, which is considered the basal unit of the Elk Point group in northern Alberta, consists of white to yellowish-brown to brownish-gray anhydrite interbedded with grayish-brown crypto-crystalline dolomite. Correlation of the Bear Rock Formation dolomites with the Chinchaga Formation anhydrites is difficult because very little is known of the facies changes and because of the lack of well control through the dolomite-anhydrite transition zone to the Rocky Mountain front. With these difficulties in mind, the author has attempted to correlate the Bear Rock Formation of northeastern British Columbia with the Chinchaga Formation (see Fig. 5). Law (1955, p. 1968), when discussing the Elk Point group, states,

It is probable that the Elk Point equivalents in the mountains (northern Rocky Mountains) are carbonates with some shales.

Belyea (1962) states that the Lonely Bay Formation that overlies the Chinchaga Formation contains fossils that occur in the Middle Devonian (Ramparts Formation) of the Quiet Lake area, northeastern British Columbia.

Detailed Description

Upper Contact of the Bear Rock Formation

The gradational contact of the Bear Rock and overlying Hume

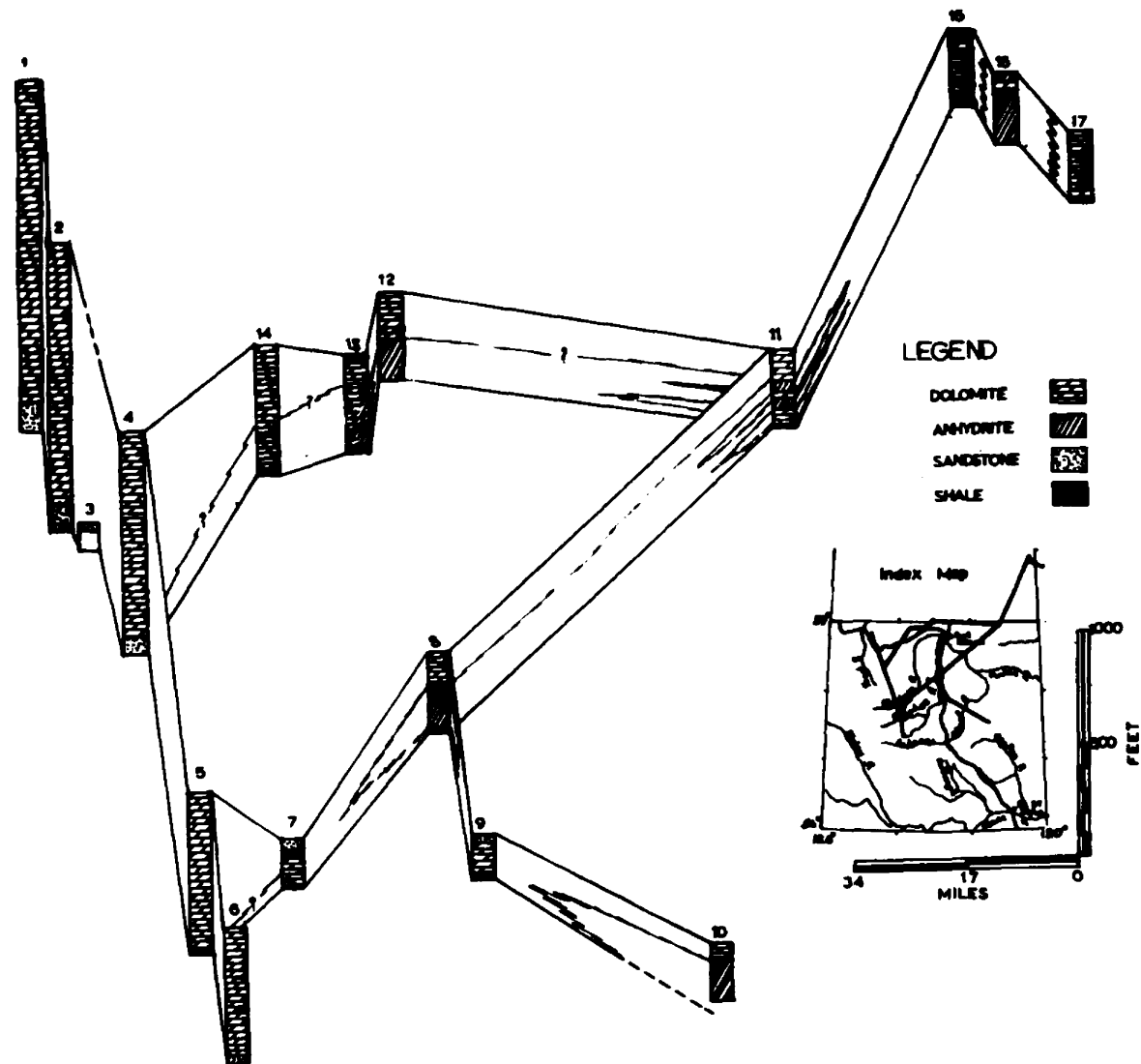


Fig. 5. Suggested correlation of the Bear Rock Formation with the Chinchaga Formation.

List of Well Logs

1-6 Sections measured in field.

- 7 Hudson Bay Oil and Gas Co. Ltd., H.B. Pan Am. Muskwa a-6-G,
6-G-NTS-94-G-13.
- 8 Phillips Petroleum Company, Phillips-Tenaka #1, Long. $122^{\circ}51'30''W$
Lat. $58^{\circ}14'25''N$.
- 9 Phillips Petroleum Company, Phillips Minaker a-25-D,
25-D-NTS-94-G-15.
- 10 Triad Oil Company, Triad B.P. Conroy Creek c-100-A,
c-100-A-NTS-94-H-12.
- 11 Western Natural Gas, West Nat. Kotcho Lake d-39-J, 39-J-NTS-94-I-14.
- 12 Gulf States Petroleum, Gulf States Popular Hills #1, Long. $123^{\circ}04'W$,
Lat. $59^{\circ}04'N$ (NTS-94-O-3).
- 13 Gulf States Petroleum, Gulf States Evie Lake #1, Long. $123^{\circ}14'W$,
Lat. $58^{\circ}54'N$.
- 14 West Canadian Oil Company, West Canadian Kledo Creek c-14-G,
14-G-NTS-94-I-13.
- 15 Pan American Oil Company, Pan Am. July a-65-K, 65-K-NTS-94-P-9.
- 16 Pan American Oil Company, Pan Am. A-1 Kimea Lake a-28-H,
28-H-NTS-94-P-9.
- 17 California Standard Oil Company, Cal. Standard Shekilie River
#9-25, L.S.D. 9, Sec. 26, T. 120, R. 11, Mer 6W.

Formation is arbitrarily placed at the base of the first 25 foot thick sequence of Hume limestone above which no thick sequence of dolomite exists. Generally there are a few interbeds of limestone in the dolomite before the contact is reached. As the contact is approached the dolomites, which are calcareous near the contact, become progressively more calcareous. Continuing upward through the contact dolomite mottles appear and these grade into small thread-size stringers of dolomite rhombohedrons. The stringers decrease so that only small rhombohedrons of dolomite are found in the pelletoid limestones.

Lower Contact of the Bear Rock Formation

The base of the formation is placed at the contact of the cliff-forming, tan, sandy basal member of the Bear Rock Formation and the underlying step-forming dolomites of the Muncho-McConnell and Ronning Formations. The contact is sharp and appears conformable and no evidence of an erosion surface exists. Laudon and Chronic (1949) however observed the contact to be unconformable at all their sections except the Trout River Section where they describe the contact as "distinct and sharp," with "little evidence of relief on the surface." When the contact is considered regionally an unconformity can be shown to exist. The Bear Rock Formation rests upon the Muncho-McConnell Formation in the region north of section 4 and on the Ronning Formation in section 5 (see index map, Fig. 1). In the area north of section 4 the basal sand member is underlain by the nonfossiliferous Muncho-McConnell dolomite. In section 5 the basal sand member overlies the Ronning dolomites of Silurian age which contain silicified stromatoparoids, algae, solitary

and colonial corals, brachiopods, and gastropods.

The presence of the basal sand member in section 6 is not definite. As previously mentioned the Muncho-McConnell is a nonfossiliferous dolomite. This lack of fossils makes it distinct lithologically from the underlying Ronning Formation which contains silicified fossils as noted above. The basal sand member of the Bear Rock Formation, which overlies the Muncho-McConnell Formations, is the unit which differentiates the Bear Rock Formation from the Muncho-McConnell Formation. If the basal sand is absent or difficult to identify, the distinction between the Muncho-McConnell and Bear Rock Formations is very difficult. A problem of identification exists in section 6. If the lowermost sand in section 6 is considered the basal member of the Bear Rock Formation, then it rests upon the fossiliferous Ronning Formation (see Fig. 6). If however, the contact is placed at the base of the sand unit 426 feet above the base of section 6, the formation overlies the Muncho-McConnell because there is an interval of nonfossiliferous dolomite between the Ronning Formation and basal sand member of the Bear Rock Formation (see Fig. 7). The author prefers the latter interpretation because the Bear Rock Formation in the northern five sections appear to thin southward and the placing of the boundary at the upper sand continues this trend.

Lithology

Bedding. The bedding is predominantly from 1 to 10 feet in thickness, though beds of $\frac{1}{4}$ inch thickness can be found. Some massively weathering units are composed of beds of $\frac{1}{4}$ to 4 inches thickness.

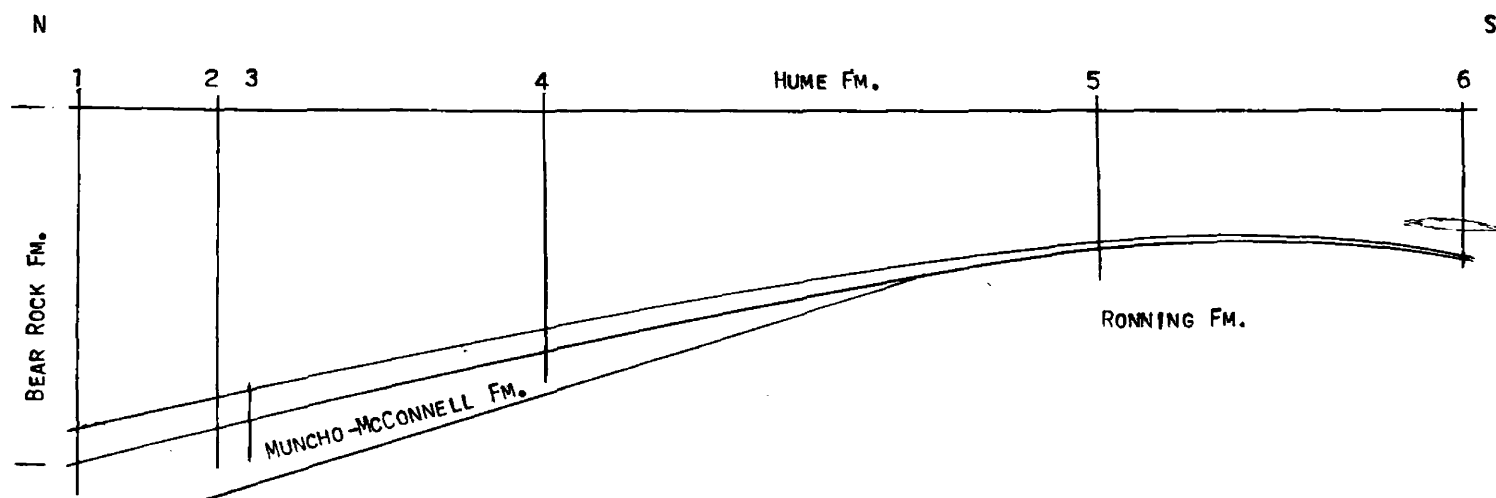


FIG. 6. STRATIGRAPHIC RELATIONSHIPS RESULTING IF THE LOWEST SANDSTONE IN SECTION 6 IS TAKEN AS THE BASAL SAND MEMBER OF THE BEAR ROCK FORMATION. (NOT TO SCALE.)

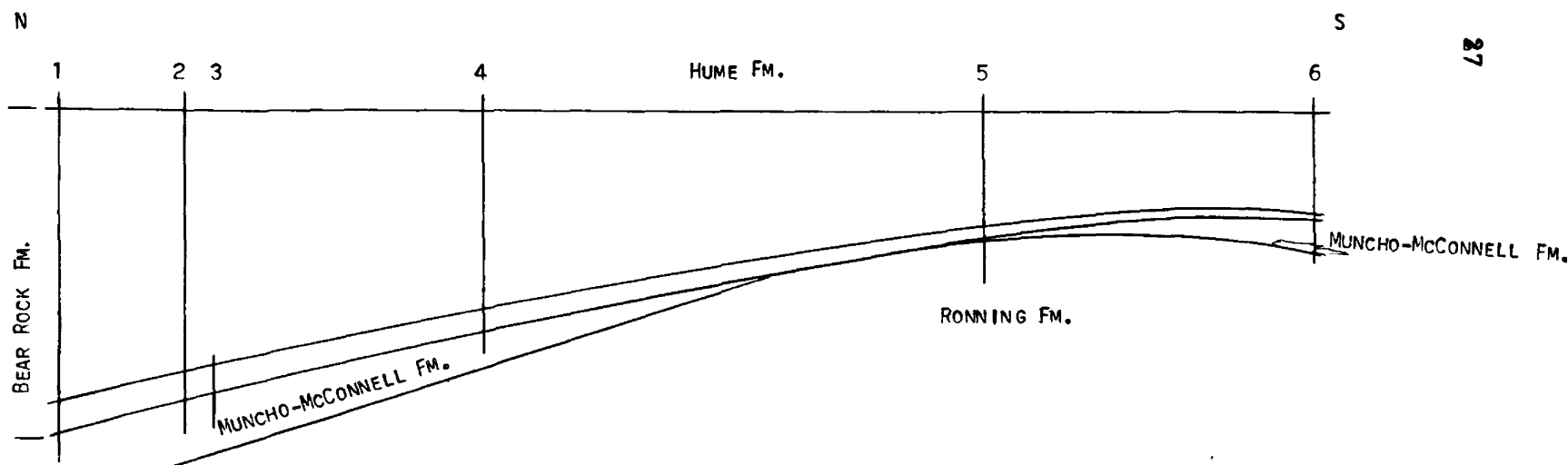


FIG. 7. STRATIGRAPHIC RELATIONSHIPS RESULTING IF THE SANDSTONE 426 FEET ABOVE THE BASE OF SECTION 6 IS TAKEN AS THE BASAL SAND MEMBER OF THE BEAR ROCK FORMATION. (NOT TO SCALE.)

Most beds are parallel and either straight or undulating, but some are lenticular. The majority of the bedding surfaces undulate although a few are straight. It is noteworthy that most of the sections have relatively few undulating beds except for sections 4 and 5 (see index map, Fig. 1), where the beds are vertical. This suggests that the undulations are due to tectonism rather than diagenesis.

Thick beds are predominant in the upper part of the Bear Rock Formation in sections 1, 3, and 4, whereas the lower part has thinner beds. Sections 5 and 6 are exceptions.

Color. The color of the rock was determined by using the Rock Color Chart (Goddard, et. al., 1951). The lightness value was found to be much more useful in comparing the dolomites than the chroma or hue.

The gray strata, which sometimes possess yellow hues, range on the fresh surface from 3 to 7 in lightness values, and on the weathered surface from 4 to 8. On the fresh surface the predominant range is from 5 to 7. Some of the yellow hues are the result of oxidized iron minerals staining the rock. Changing lightness values of the beds give the rock a subtle banded appearance. Chronic and Laudon (1949) have referred to these as cycles, but the corresponding changes in lithology, mentioned in their study, do not exist. Whether these changes in color represent changes in environment is not known.

Dolomite Types. The dolomites of the Bear Rock Formation have six reoccurring textures which have been classed as types I through VI.

Type I dolomite rocks range in color from light gray (N7) to medium light gray (N6), with some being very light gray (N8). Type I

dolomites are massive and lack sedimentary structures, but have many secondary small veins and blebs of clear calcite (see Fig. 8). Sometimes slight changes in shade can be noticed on a cut surface, but these have no definable outline or orientation. The crystal size of the dolomite is generally less than .06 mm (see Folk, 1962). An exception is sacchroidal dolomite which has rhombs up to .25 mm in size (see Fig. 9). This rock comprises nearly 60 per cent of the sections and generally has less clay than the other dolomite types.

Type I dolomite forms a massive outcrop which has a relatively smooth surface. In some places it is pitted because of the differential erosion of calcite blebs and veins in the rock. The color of the weathered surface is a lighter shade of gray than that of the fresh surface.

Type I dolomite possibly represents an environment of high energy in which the sediments have been mixed so much that they are homogeneous or an environment in which there has been deposition of homogeneous sediments. Another alternative is dolomitization has erased all previous structures. The author prefers deposition of homogeneous sediments because it does not require extremes of energy in the environment.

Type II dolomite rocks range in color from medium gray to medium light gray (N5-N6), but some are light gray (N7). The laminae in dolomite type II are its distinguishing feature. They range in thickness from $1/32$ to $\frac{1}{2}$ inch, with the median range being from $1/16$ to $\frac{1}{4}$ inch. These laminae comprise 30 per cent of the section and are subdivided on the basis of color or crystal size. In one type the color

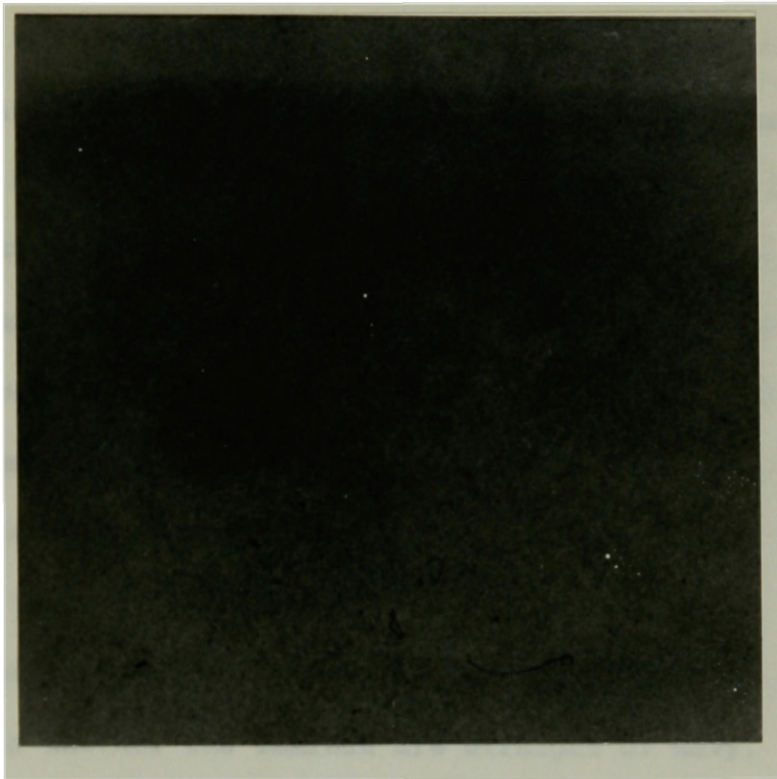


Figure 8. Massive structureless dolomite.

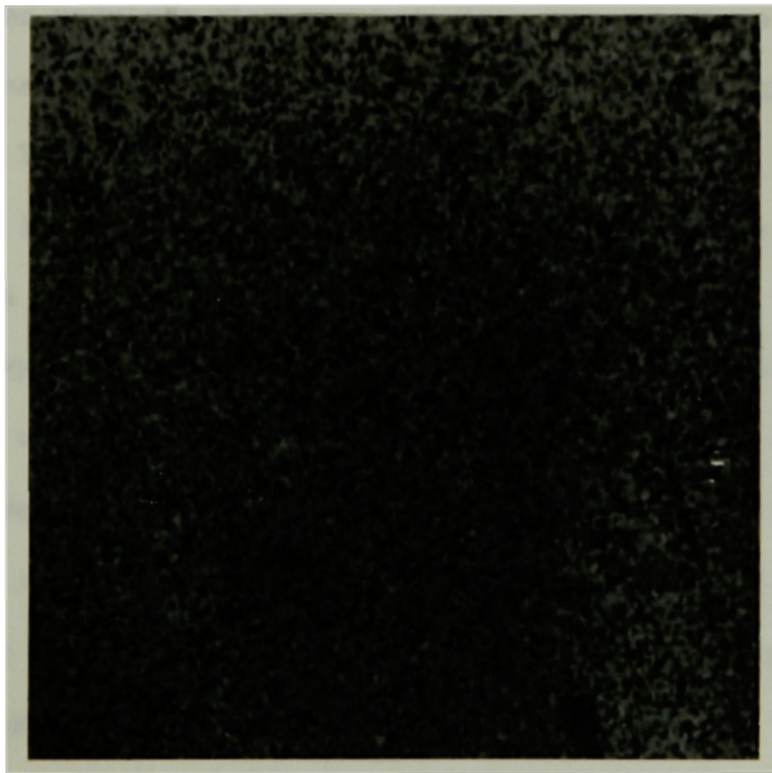


Figure 9. Sucrosic dolomite under crossed nicols.

changes from lamina to lamina with no change in crystal size, in the other type the crystal size changes from one lamina to another but with no change in color. These two types of laminations represent endpoints because in some rocks the changes between laminae are in both color and crystal size, (see Figs. 10, 11, and 12). The laminae which vary in crystal size are herein called grain laminae and the ones which vary in color are called color laminae. The grain laminae classification also includes laminae composed of clastics such as sand and silt. These clastics are noted in the lithology column (see Plates 1 to 6). Color variations of laminae include various shades of gray.

Each of the above types of lamination are further subdivided depending on whether the laminae are straight or wavy. The straight laminae, which are generally parallel and of even thickness, may pinch and swell and undulate slightly (see Fig. 10). In some cases an individual lamina pinches out, and another continues from the point of pinch out. The wavy laminae have amplitudes up to 3/8 inch (see Fig. 13). These laminae are not broken, and the undulations do not fold over on each other.

The wavy laminae represent contemporaneous deformation caused by compression or compaction of straight laminae. If the surface of deposition were undulated, slight differential loading would accentuate these small irregularities. Compression can be created by slumps involving very little movement. The straight laminae are the result of natural moderate deposition possibly in a shallow water environment. The laminae represent variations of sediment influx rate and types of

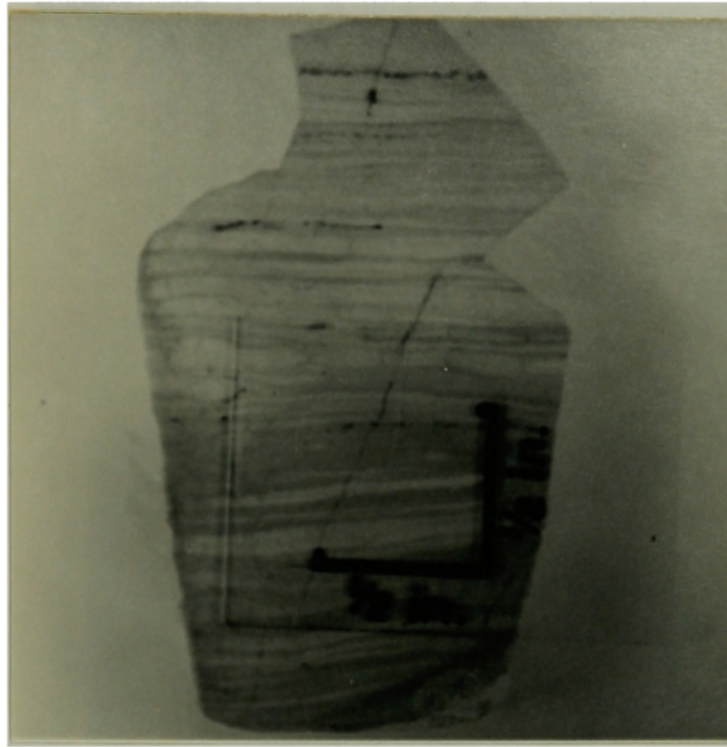


Figure 10. Straight color laminae.

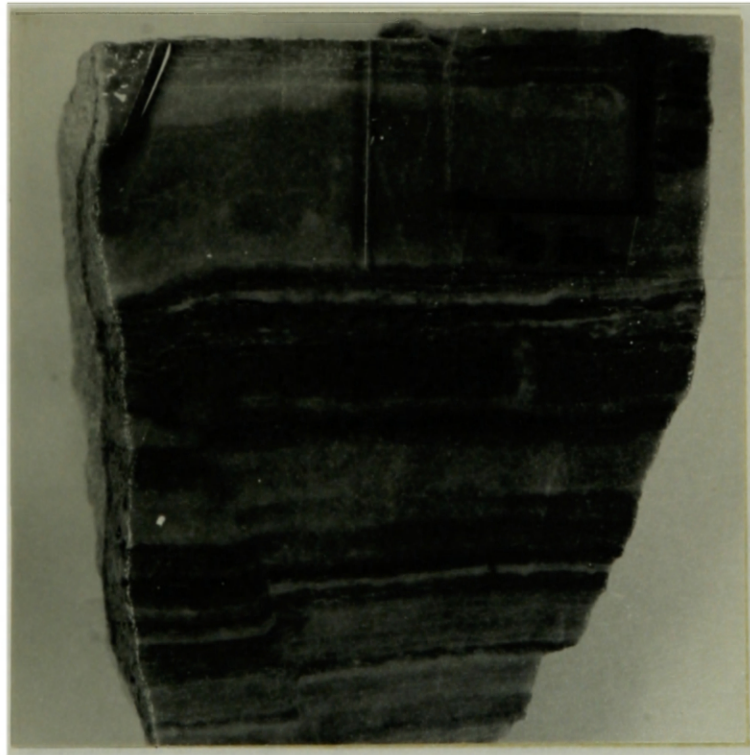


Figure 11. Straight color and grain laminae. Note the soft sediment fault.



Figure 12. Straight grain laminae.

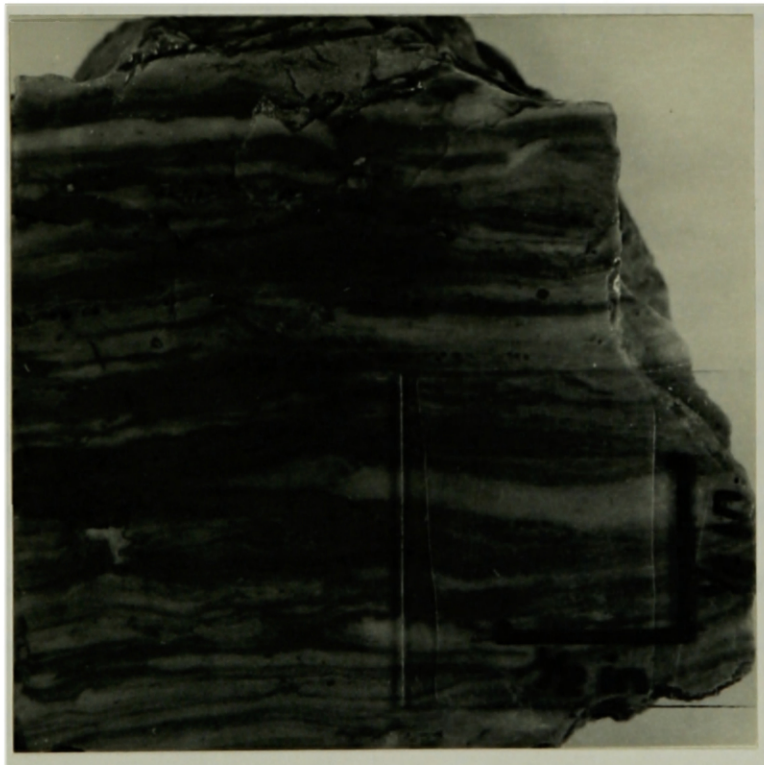


Figure 13. Wavy color and grain laminae.

sediment. Some of these laminae are the result of possible alga and stromatoparoid accumulations.

Most of the type II strata are less than one foot thick. The weathered surfaces of the beds are generally very distinctive because of the lineation of the rock. The grain laminae weather differentially, creating a rough striated surface. The color laminae, although they do not weather in relief, usually have a faint banded appearance. The continuity of color bands is accented by weathered clear calcite pits which parallel the laminae and by the occasional grain laminae that are mixed with the color laminae. The pits caused by the differential weathering of calcite are also found with the grain laminae. The color laminae are best defined on a wetted surface.

Type III dolomite rock types resemble type II in color, ranging from medium gray to medium light gray (N5-N6), with a few being light gray (N7). The main characteristic of type III dolomite is a highly contorted and swirled grain laminae. Color laminae are not usually present. The microstructures consist of complex overturned, asymmetric and recumbent folds which are broken by microthrusts. Broken competent laminae pierce the sediments above and below them (see Figs. 14 and 15). Some of the broken laminae have splayed ends, and others are small rectangular pieces that are randomly displaced. Abundant small calcite blebs are found in the centers of convolutions of the sediments. This calcite is of vein origin because the blebs cut across the laminae as well as paralleling them.

The contorted laminae of type III dolomite are the result of pene-



Figure 14. Massive dolomite overlying type III dolomite.



Figure 15. Enlargement of the above photo showing type I dolomite overlying type III dolomite.

contemporaneous slump of originally horizontally laminated sediments. This represents continued deformation of the wavy laminae of type II dolomite. Such slumping may be due to oversteepening of slopes of the sediment surface or undercutting of plastic sediments by currents. Because of slumping, sand laminae are often broken and individual sand grains are dispersed throughout the sediment (see Fig. 16).



Figure 16. Dispersed sand grains in type III dolomite.

The probable reason for the absence of color laminae is that the colors blended when the sediment was swirled. The contortions are recognizable on weathered surfaces, but they are not as distinct as the grain laminae of type II. The decrease of distinction is because the folded and broken laminae do not have a definite or continuous pattern. Pits caused by the weathering of calcite blebs also help to blur the

distinctness of the laminae.

Type IV dolomite ranges in color from the fresh rock which is medium gray to medium light gray (N5-N6), to the weathered rock which is medium light gray to light gray (N6-N7). Type IV dolomite has two subdivisions based on color and crystal size. Type IV dolomite consists of semiround to irregular plastimorphic dolomite fragments or intraclasts in a dolomite matrix (see Figs. 17 and 18). The fragments are from 1/8 to 1 inch in diameter and generally have a higher argillaceous content than the matrix. The grain intraclasts have the same color as the matrix but their crystal sizes differ from those of the matrix. The color intraclasts are the reverse in that the color is different and the grain size the same. However, as mentioned under type II dolomite, the two subdivisions are the extremes of a continuous series. Some samples differ from the matrix in both color and crystal size.

The intraclast boundaries are either sharp or gradational. Gradational boundaries are more common in color intraclasts. Generally the color of the intraclasts is similar to that of the matrix. Type IV dolomites are very difficult to distinguish on a weathered surface because roughness and shadows on the outcrop surface camouflage the color or grain variations of the intraclasts.

The texture of type IV results from tearing up and redeposition of plastic sediments. Currents, wave action, and/or slump probably break up the plastic sediment. The intraclasts may be deposited immediately or transported for some distance. If deposited directly, the shape of the intraclast is nondescript like the shape of a droplet of water when

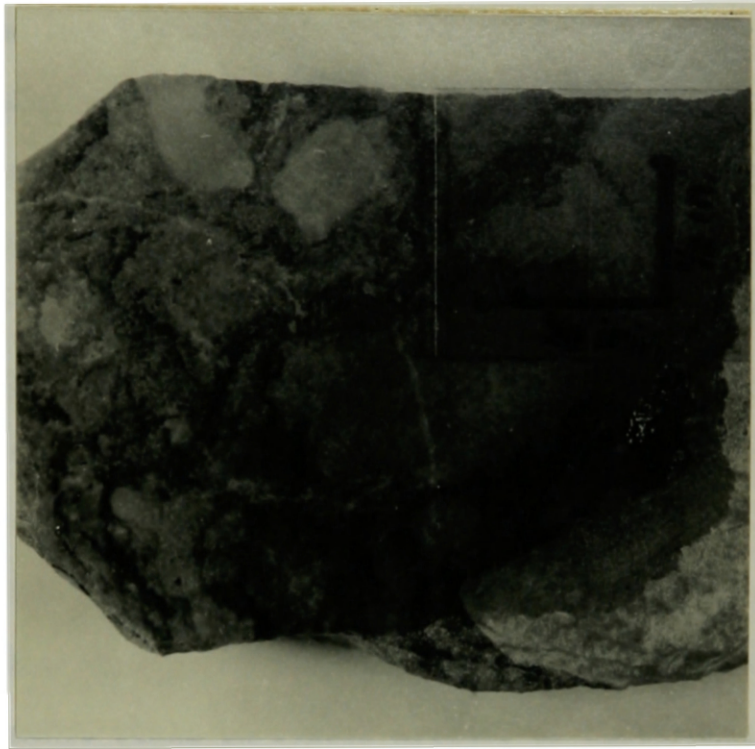


Figure 17. Color intraclast. Note the indistinct boundaries.

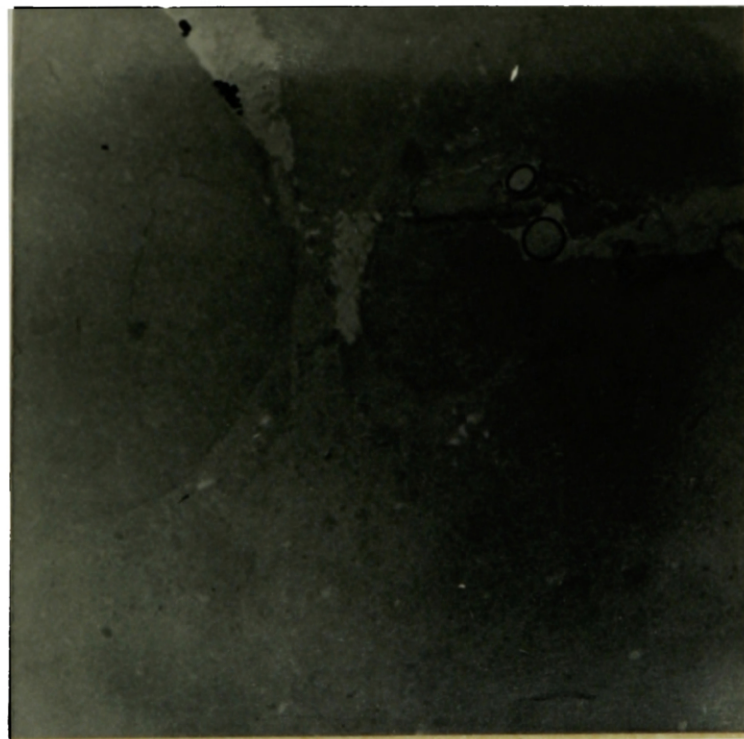


Figure 18. Enlargement of grain intraclasts. Note the hematite in the calcite vein.

it hits a flat surface. If the intraclast is transported, the outline is more rounded and the body is more compact.

Type V dolomite includes primary and secondary breccia. The primary breccia ranges in color from medium gray to medium light gray (N5-N6). The fragments are angular and range in size from $\frac{1}{4}$ to 3 inches. The outline of most fragments is sharp because the dolomite matrix usually is darker and of a different grain size and texture. Most of the primary breccias are composed of randomly scattered fragments (see Fig. 19). In others the fragments appear to be a mosaic pattern that has been slightly spread out and disarranged (see Fig. 20). On the weathered surface the primary breccia is easily identified. Either the cement or fragments stand in relief because of differential erosion. Often the difference in color between fragments and matrix helps identification. Much calcite veining may be found in a brecciated zone.

The primary breccia was formed by the breaking of semiconsolidated sediments, possibly by waves or strong sporadic currents, and redepositing the broken material in a bed of similar composition but of different texture. Another possibility is that the semiconsolidated sediments were slightly spread out and then the intervening fractures were filled with sediment of a different texture. Semirounded and angular fragments may occasionally exist together, indicating a transition from type IV to the primary breccia of type V (see Fig. 21).

The color of the secondary breccia is usually light grayish brown. The fragments are angular and attain lengths up to 3 feet. This breccia formed after lithification. Tectonic forces fractured various strata,

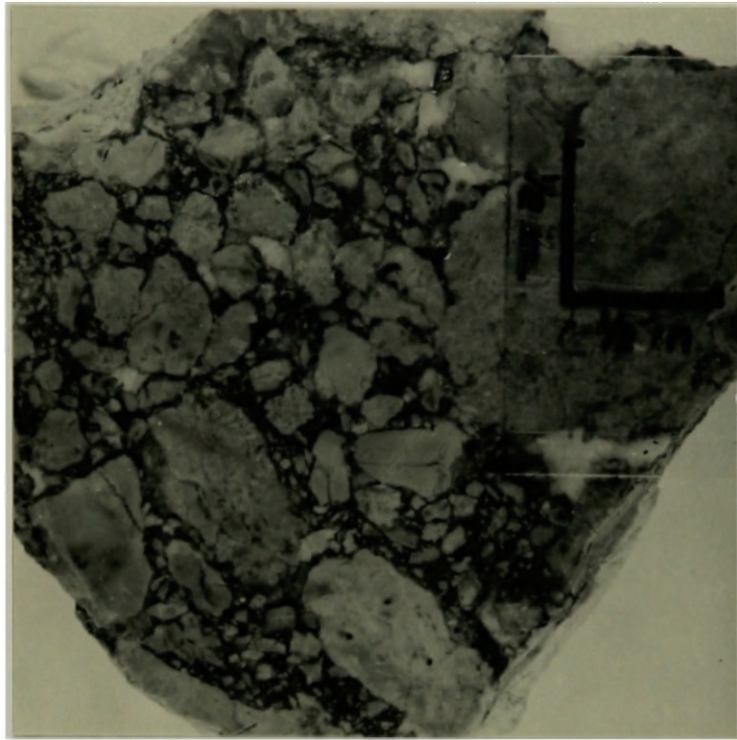


Figure 19. Randomly scattered primary breccia.

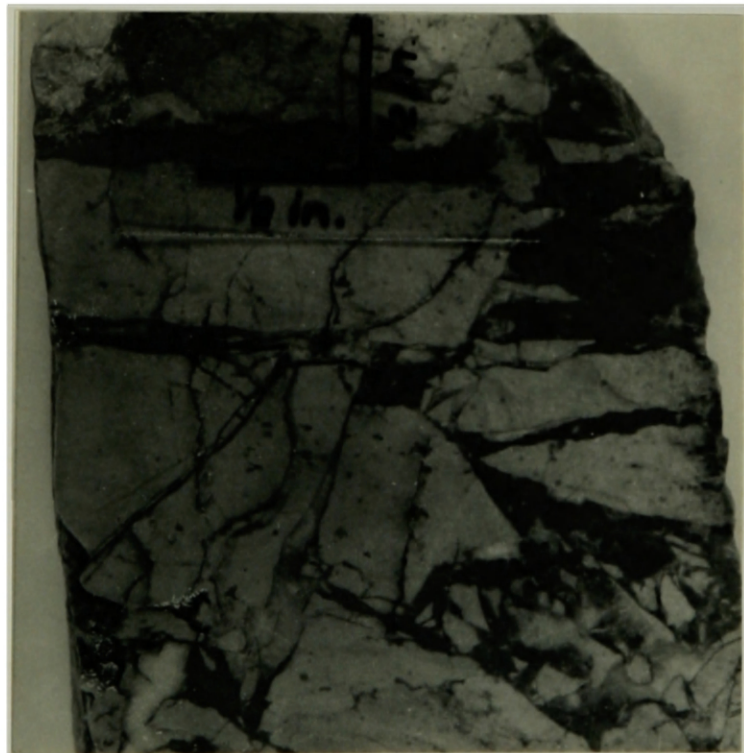


Figure 20. Mosaic pattern primary breccia.



Figure 21. Primary breccia associated with rounded intraclasts.



Figure 22. Secondary breccia. Low temperature hydrothermal calcite has filled the fractures.

and the fractures were later filled with coarse crystalline white calcite brought in by hydrothermal solutions (see Fig. 22). The brecciated zones usually can be identified at a distance by their characteristic color and the white veins.

Type VI dolomite is a small group of dolomites of varying descriptions which are very intensely mineralized by small blebs of calcite so that their original texture is destroyed. This type also includes structures which have been partially destroyed by dolomitization making identification impossible (see Fig. 23).

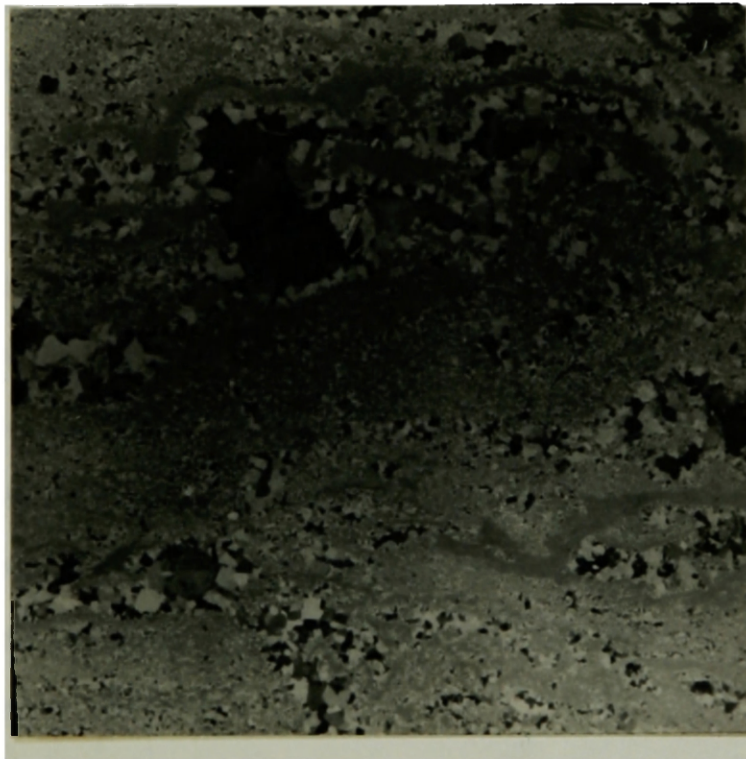


Figure 23. Intense mineralization of dolomite by calcite.

Discussion of Dolomite Types. The distinction between types of dolomite is arbitrary because of the gradational nature of their characteristics. Because of this gradation, rocks occur that are

intermediate between the typical examples of dolomite types. Although this can be noted in most types, it is best displayed in II, IV, and V. In types II and IV a distinction between grain and color is made. Actually grain and color are extremes because some samples have both distinct crystal size and color. The rounded, structureless intraclasts of type IV are sometimes found mixed with sharp fragments of primary breccia indicating a transition from type IV to type V (see Fig. 21).

The dolomite types I through V can be considered to have formed in an environment of increasing energy. This has been inferred in the descriptions of dolomite types. For example, the wavy laminae of type II result mainly from the compression of the straight laminae of the same type. Continued deformation, by compression due to more active slump, produces type III. Strong currents form the intraclasts of type IV by picking up and redepositing plastic sediments of all the previous dolomite types. Stronger currents which tear up the consolidated sediments of all the types form the primary breccias of type V.

One should be aware of the shortcomings of using this as well as any other classification. A classification should be based upon objective criteria and genetic conclusions derived from the data of the objective classification. Some of the dolomite type identifications made were quite subjective.

Superficial Oolites. Superficial oolites are restricted to the interval from 753 to 970 feet of section 2. Their shape is oval to semicircular, and they consist of nuclei surrounded by concentric layers which are usually destroyed by dolomitization (Illing, 1954).

The elongated forms do not have a preferred orientation. Superficial oolites range in size from $\frac{1}{2}$ to 4 mm; the mean size is 1 to $1\frac{1}{2}$ mm (see Fig. 24). The outcrop is medium light gray (N6) on the fresh surface, and the crystal size of the dolomite is less than 1/16 mm.

Basal Sand Member. The basal sand member of the Bear Rock Formation can be identified at all the sections of the region between section 4 and Mile 433 measured by Chronic and Laudon (1949) and the author. The 10 foot thick beds of the unit generally form a prominent cliff which is easily recognized. The basal sand member is cream to light gray on the fresh surface and tan on the weathered surface (see Fig. 25).

The size of the quartz grains range from very fine to coarse, with the median being fine to medium grained. The grains are generally rounded with extremes being subangular to well rounded (Powers, 1953). The sphericity of the grains is between .7 to .9 (Pettijohn, 1949). Most sand is unimodal although some is bimodal. Generally the fine to very fine mode is mixed with medium to coarse mode. The finer fraction is more angular than is the coarse fraction. The sands are generally moderately to well sorted. The cement of the sandstones is either dolomite or silica, very few samples having both cements in equal proportions. In many samples dolomite has replaced the quartz grains which gives the surface an etched appearance. The reentrants of dolomite rhombohedrons produce an angular appearance to an otherwise smooth surface quartz grain, thus producing subangular grains from originally round ones. The silica cement, which commonly inherits the optical orientation of the grain, fills the interstices between quartz grains so

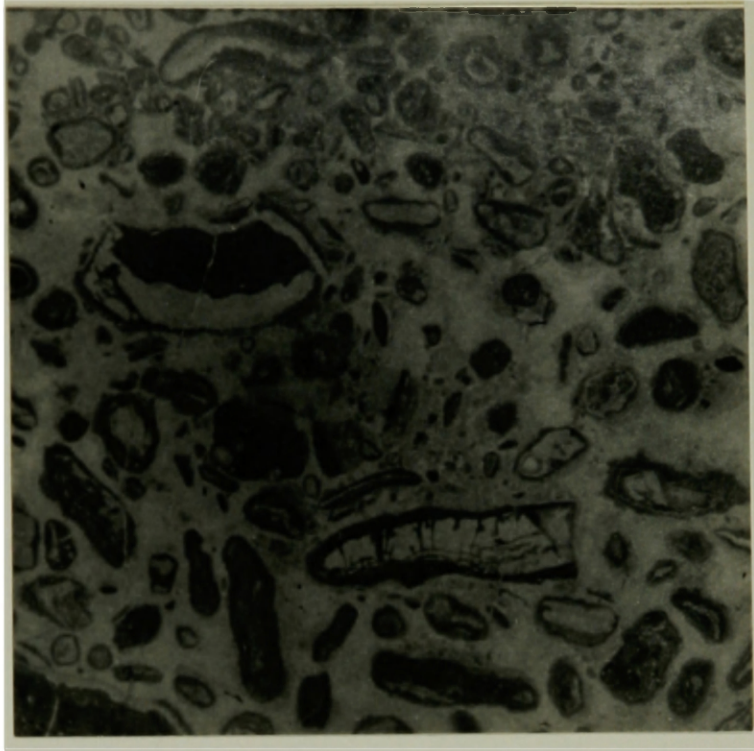


Figure 24. Superficial oolites.



Figure 25. Weathering profile of basal sand member of Bear Rock Formation.



Figure 26. Crossbedding in basal sand member of Bear Rock Formation, section 1.

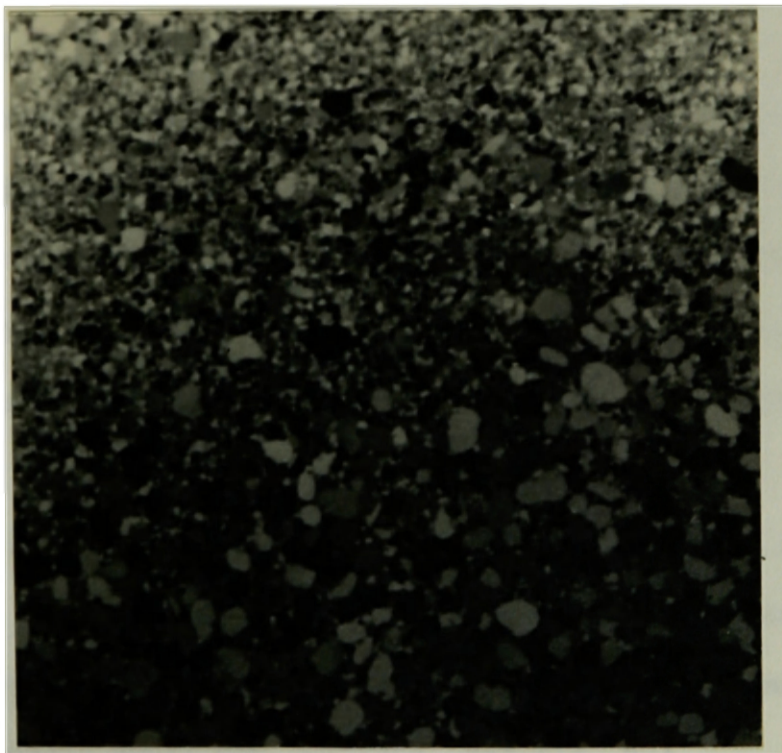


Figure 27. Graded bedding in dolomitic sandstone.

that only ghosts of the original grain appear. Very few detrital grains with overgrowths were noted. No porosity exists because the interstices have been filled with dolomite or silica.

In thin section the grains consist generally of common quartz (Folk, 1961) indicated by the straight to moderate undulose extinction and few vacuoles. Some grains have rounded ends, relatively straight sides, and have slight to moderate undulose extinction indicating a schistose metamorphic origin. The close-packed grains in a silica cemented sandstone have serrated and granulated borders which may explain the moderate undulose extinction of common quartz. Tectonism crenulated these boundaries and strained the grains enough to increase the undulose extinction.

A few rare grains of dolomite and plagioclase are present in the sandstone. They are well rounded and in the smaller fraction of the size range. The feldspar has no evidence of weathering.

Heavy minerals exist in the sandstones but the number is very small. The nonopaque grains consist of tourmaline and zircon. The tourmaline is green and pleochroic, and the zircon has a high birefringence. The opaque minerals consist of hematite and pyrite. The hematite appears red in reflected light and pyrite a yellow metallic cast.

Low angle sandstone crossbeds are found in sections 1, 2, and 3 (see Fig. 26). Although the apparent current direction is to the south, this does not necessarily indicate regional current directions. Graded beds occur in all the sections (see Fig. 27).

In the area studied the sandy member thins from 158 feet at section 1 to 28 feet at section 5. As mentioned previously the position of the basal sand member in section 6 is disputable. Information obtained from thin sections indicates the problem of correlation cannot be solved by optical properties of the quartz grains and heavy minerals because the properties are similar, in both the basal sand member and sand laminae of the overlying dolomite member.

The bimodality and presence of reworked quartz grains indicate more than one possible source. In both modes of the bimodal sandstone the optical properties of the quartz grains and the heavy minerals are similar indicating the two had similar source rock. Reworked grains with overgrowths and dolomite grains indicate a sedimentary source. Because the optical properties of the bimodal quartz sands and the reworked quartz sand are the same, the original source or sources of these sands are similar.

Fauna. Fossils are extremely rare in the Bear Rock Formation and when present they are poorly preserved. Usually fossils cannot be identified because the dolomitization has completely destroyed their diagnostic characters. Many of the fossils have been replaced by clear dolomite or calcite leaving only a mold. Most can be identified as to phylum, but some are known only as bivalves. Other than an impression of a questionable ostracod in the basal sands of section 5, all the sections are devoid of recognizable fossils except sections 1 and 2. Section 1 has a few brachiopods and colonial corals. In the interval between 971 and 982 from the base of section 1 tubular structures contain clear calcite and fluorite. All internal structures are destroyed

so it can only be postulated these are scolecoïd corals. Occasionally, questionable shell fragments are found in section 1. Section 2 has some calcite molds which appear to be solitary corals.

Brown chert is present in all sections. Some of the chert appears to be organic. Internal structure is not present, but the external form of laminated clumps indicates that they are probably stromatoparoids. The external appearance of some fine dolomite laminae found in the sections appears organically controlled, the probable organism being blue-green algae and stromatoparoids. When observed in thin section no internal stromatoparoid structure exists because of dolomitization.

The author believes that the Bear Rock Formation originally had a sparse fauna population because dolomitization has not destroyed the thin laminae, oolites, or gross features of the fossils. If it were fossiliferous the evidence should exist today. Probably very few fossils were ever present in the sediments because the environment was inhospitable to life.

Mineralization. Mineralization is found throughout the Bear Rock Formation but is greatest in fracture zones. In gross appearance these mineralized fracture zones are large lenticular "pods." The pods were caused by the spreading of low temperature hydrothermal solutions as they passed through the rock. The pods are easily recognized because the white veins contrast with the country rock; the weathered surface of the pods is brownish gray, rough, and appears very friable, and the pods are etched out in relief by weathering.

The mineralization occurs as veins and blebs. The veins either

cut across or parallel bedding whereas the blebs usually parallel the bedding and are connected by small stringers. Blebs average $\frac{1}{2}$ inch in diameter, but some are 16 inches in diameter. The veins have thicknesses of $\frac{1}{16}$ inch to approximately 4 feet. For example, at section 3 in the Muncho-McConnell Formation, a very coarsely crystalline (1 to 3 inches) vein 4 feet thick cuts across the bedding. The inclusions contained in the vein came from lower in the section (see Fig. 28).



Figure 28. Calcite vein, 4 feet wide, containing inclusions, section 3.

The coarsely crystalline white calcite veins and blebs contain accessory minerals. In sections 1, 2, and 3 these minerals are fluorite, barite, some pyrite and hematite, and dolomite. The barite and fluorite are disseminated through the calcite veins, but sometimes they occur as small veins and aggregates.

In the southern three sections fluorite and barite are not present, but the amount of dolomite and iron minerals in the veins increases. The dolomite is contained within the calcite vein or appears as individual veins. This "vein" dolomite results from hydrothermal solutions absorbing Mg ions as they pass through the wall rock. Pyrite is present as straited crystals and aggregates, and hematite can also be found in crystal form. Sometimes these minerals coat the sides of the vein, but more commonly they are oxidized, giving the rock a rusty appearance.

Sometimes quartz crystals line vugs, appear in calcite veins, or are disseminated throughout the dolomite, and rarely occur as quartz stringers.

Speculative Correlation of Units Within Bear Rock Formation

Very little correlation can be done among the measured sections of the Bear Rock Formation. Some individual peculiarities and gross units of various characteristics such as color, internal and external bedding, crystal size, dolomite types, and relative argillaceous content can be carried from one section to another, but these tenuous correlations cross each other, indicating most are merely coincidence.

There are two correlative features in the described sections. Correlation A, which will be designated on the cross section (Fig. 4 and Plates 1 to 6) as A, is the first highly argillaceous bed which appears below the Bear Rock-Hume contact. This is a poor criterion for correlation, but it is consistently found in all the sections except section 6. The other unit, which will be referred to as B in the cross section,

is a lenticular bed which can be found in all sections except 6. The trend of correlation A and B closely parallels the basal sand member of the formation which makes them more convincing.

Some sandy beds are correlated between sections, but this is extremely dangerous because most sandy units in the formation are discontinuous and generally pinch out within a short distance.

Petroleum Aspects

The Bear Rock Formation does not possess the qualities of a source bed or the texture of a reservoir rock except where the porosity is developed by fracturing. Most of the fractures seen in outcrop are filled with vein calcite, thus destroying the porosity.

The Bear Rock may be an impervious barrier overlying oil accumulations at the unconformity at the base of the formation. This accumulation could be in the basal sands; however, diagenetic dolomitic and siliceous cementation have destroyed the original porosity at the outcrop and probably at depth.

Geologic History

Near the end of deposition of the Muncho-McConnell sediments epeirogenic uplift ultimately exposed the sediment to erosion. In most areas erosion removed only part of the Muncho-McConnell sediments except for the area around section 5 where the Muncho-McConnell has been completely eroded and the Silurian Ronning Formation is exposed at the erosion surface.

Seas then transgressed the area depositing sediment which now is the Bear Rock Formation. The basal sand represents a transgressive beach. The sand probably derived from crystalline or sedimentary rocks of the craton. Limestone deposition covered the basal sand. Dolomitization of the limestone sediment took place after burial.

The area during Bear Rock deposition was probably a low, broad flat, mostly above wave-base. Shallow water is indicated by intraclasts and primary breccia which were formed by currents and wave action. The general lack of fossils indicates restricted conditions probably in a shallow water environment. Continued deposition produced the overlying Hume Formation. It appears the environment became more hospitable to life as time passed because of the increased fossil content in the Hume Formation.

CONCLUSIONS

The Bear Rock Formation is a miogeosynclinal deposit of dolomite and sandstone in northeastern British Columbia. The upper member generally consists of thick bedded dense dolomite and the lower member dolomitic and siliceous sandstone. The formation apparently thins to the south from 1583 to 602 feet. Correlation to the Bear Rock Formation of the Mackenzie River Basin can be established on the basis of lithology, indirect fossil evidence, and stratigraphic position. Correlation to the Chinchaga Formation evaporites in the subsurface of British Columbia is tenuous because there are few controls through the facies change.

The lower contact of the Bear Rock Formation is an angular unconformity, and the upper contact is gradational from dolomite to limestone.

The subdivision of dolomite textures into types is possible in northeastern British Columbia. Although the author was unable to correlate the sections using dolomite types, it is believed correlation of dolomite types is possible if the measured sections are closer together. When dolomite types are used in a three dimensional study rather than two dimensions such as in this investigation, many subtle sedimentary environments and paleogeographical may be interpreted.

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








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APPENDIX A










Explanation of the Stratigraphic Sections

Most of the units, such as internal and external bedding, color, crystal size, and dolomite types are self-explanatory. Relative argillaceous content is not as obvious. Instead of doing an insoluble residues analysis, the author picked 7 samples which represented increasing amounts of clay materials. All other samples were compared against the 7 type samples and their relative argillaceous contents recorded.

The meanings of the symbols marked on the sections are noted below.

| | | | | |
|---|--------------------------------|---|---|---|
|  | tabular even beds or laminae | | | |
|  | tabular uneven beds or laminae | | | |
|  | lenticular even beds | | | |
|  | lenticular uneven beds | | | |
|  | breccia | 1. primary | | |
| | | 2. secondary | | |
|  | calcite | | | |
|  | calcite and fluorite |  |  |  |
| | | 5% | 5-10% | 10-20% |
|  | calcite, fluorite, and barite | | | |
|  | dolomitic |  |  |  |
| | | 0-10% | 10-25% | 25-50% |
|  | calcareous | | | |
|  | arenaceous | | | |

APPENDIX A (Continued)

| | |
|--|--------------|
| F | fossils |
| P | pyrite |
|  | hematite |
|  | crossbedding |
|  | stylolites |
|  | oolites |
|  | pelletoidal |
|  | limestone |
|  | dolomite |
|  | sandstone |
|  | siltstone |