BRITISH COLUMBIA
DEPARTMENT OF MINES AND PETROLEUM RESOURCES

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BULLETIN No. 50

The Devonian Slave Point, Beaverhill Lake, and Muskwa Formations of Northeastern British Columbia and Adjacent Areas

by
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1965

PREFACE

Since 1947, when the first petroleum and natural gas permits in British Columbia were issued, considerable geological data relating to both surface and subsurface have accumulated, particularly from the Peace River District of northeastern British Columbia where most of the exploratory activity has been centred. These data have increased our knowledge of that portion of the Western Canada Sedimentary Basin lying within this province, not only with reference to Mesozoic strata which have been the source of most of the oil and gas production to date, but also to the Devonian sedimentary sequence which is so prominent in the geology of the Canadian Northwest.

The petroleum and natural gas potential of the Devonian has long been recognized by industry and, although full investigation of its potential in British Columbia has been retarded by lack of a market outlet, sufficient wells have been drilled to date to prove very significant reserves of gas.

This Bulletin presents an interpretation of a part of the stratigraphic sequence currently under active exploration within the general Fort Nelson Area. Material for this study was derived largely from data, samples, and core submitted by industry to the Department, although some field investigation in British Columbia was done by the author.

This study is intended as a contribution toward a better understanding of a part of the Devonian succession which, by virtue of its depositional history, presents sufficient problems to ensure continuing geological research.

J. D. Lineham,
Chief, Petroleum and Natural Gas Branch.

April 22, 1964.

TABLE OF CONTENTS

FIGURES

FIGURES (continued)

PHOTOGRAPHS

PHOTOGRAPHS (continued)

THE DEVONIAN SLAVE POINT, BEAVERHILL LAKE, AND MUSKWA FORMATIONS OF NORTHEASTERN BRITISH COLUMBIA AND ADJACENT AREAS

SUMMARY

The Slave Point Formation in British Columbia and Alberta is a stratigraphic unit composed of limestones and subordinate dolomites. It is underlain by a heterogeneous assemblage of rocks assigned to the Watt Mountain-Sulphur Point assemblage in the west and the Fort Vermilion-Watt Mountain assemblage in the east.

In northeastern British Columbia the Slave Point Formation changes to shale along a linear front, termed the facies front, which trends approximately north-northeast. The formation reaches a thickness of almost 500 feet in northeastern British Columbia. Toward the east the formation thins and in eastern Alberta it is less than 10 feet thick.

The Slave Point Formation in northeastern British Columbia consists of the following:

I. The dark stromatoporoid-bearing calcilutites which form the main lithological component of the formation. These dark calcilutites are very widely distributed in the Slave Point of northeastern British Columbia.

II. The subsidiary components, which are divided as follows:

A. Rocks occurring in the vicinity of the facies front. These comprise:

(i) The dark stromatoporoid-bearing calcilutites with abundant biogenic material.
(ii) The stromatoporoid biosparites.
(iii) The stromatoporoid biomicrites.
(iv) The light coloured micrites and fossiliferous micrites.
(v) The white and grey dolomite.

B. Limestones occurring in the shelf environment usually at distances greater than 25 miles from the facies front. This division includes intramicrites, intrasparites, and biosparites. These rock types occur in addition to the normal dark stromatoporoid-bearing calcilutites in areas lying at some distance from the facies front.

The limestones occurring in the vicinity of the facies front indicate that reefs developed along parts of the front. The strongest evidence indicating reef development is considered to be the great abundance of stromatoporoids which occur adjacent to parts of the facies front. There is not yet sufficient evidence to determine the full lateral extent of the reef zones.

Some of the limestones bordering the facies front have been altered to dolomite which is frequently composed of a light coloured coarsely crystalline and a darker coloured fine to medium crystalline phase. The rock is termed the white and grey dolomite. The close association between the white and grey dolomite and the facies front suggests that proximity to the front was an important factor in bringing about dolomitization.

The white and grey dolomite possesses both vuggy and intercrystalline porosity

and it forms the reservoir rock in the Clarke Lake, Kotcho Lake, and Petitot River gas fields.

The Slave Point Formation is also dolomitized, but only to a moderate extent, in several areas lying at some distance from the facies front. These dolomites are termed the shelf dolomites; at certain localities they contain accumulations of natural gas.

The Beaverhill Lake Formation overlies the Slave Point throughout most of northeastern British Columbia and northern Alberta. In the east the Beaverhill Lake consists mainly of argillaceous limestones and calcareous shales. The western sections of the Beaverhill Lake are composed of slightly calcareous to calcareous shales associated with subordinate amounts of argillaceous limestone.

In eastern Alberta the Beaverhill Lake reaches a maximum thickness of almost 700 feet. The formation thins to a pinch out edge in the northwestern part of the area under consideration.

For the purposes of this study the Beaverhill Lake Formation is divided into two units. The upper is termed the Upper Beaverhill Lake and consists of the combined Mildred, Moberly, and Christina Members of northeastern Alberta. The lower is termed the Lower Beaverhill Lake and consists of the combined Calmut and Firebag Members of northeastern Alberta.

West of about longitude 116 degrees west the Beaverhill Lake was eroded prior to the deposition of the overlying Muskwa. This pre-Muskwa erosion affects mainly the Upper Beaverhill Lake.

Stratigraphic evidence strongly suggests that the Slave Point and the Lower Beaverhill Lake plus the lower part of the Christina are facies equivalents. The main evidence supporting this conclusion is summarized as follows:

1. The distribution and lithology of the Slave Point Formation cannot be satisfactorily explained by normal transgressive, regressive, or static deposition or by the assumption that the formation was eroded prior to the deposition of the Beaverhill Lake Formation.
2. There is a complementary thinning of the Lower Beaverhill Lake to the west as the Slave Point thickens in this direction.
3. Rapid changes from the Slave Point Limestone to calcareous shales of the Beaverhill Lake are especially evident in the area south of the Clarke Lake gas field in northeastern British Columbia.

The Muskwa Formation unconformably overlies the Slave Point and Beaverhill Lake Formations in northeastern British Columbia and northwestern Alberta. The unit grades upward into the overlying Fort Simpson Shale.

The Muskwa consists mainly of greyish black pyritic shales which in places are siliceous. The formation is prominent on Gamma Ray Logs because of its relatively high radioactivity. In most areas the Muskwa is between 50 and 100 feet in thickness. On its northeast margin the formation reaches 150 to 250 feet in thickness, and passes by way of an intertonguing relationship into the Fort Simpson Shale. Toward the northwest the Muskwa also thickens and tends to merge into the Besa River Shale.

In the original description the Muskwa was defined as the uppermost member of the Horn River Formation. Because of its stratigraphic relationships and distinctive lithology, it is proposed here that the Muskwa be separated from the Horn River and be recognized as an independent formation.

Considerable pre-Muskwa erosion took place in the northern part of the area of study in the vicinity of the British Columbia-Alberta boundary. In this area the Muskwa overlies a Slave Point section varying between 175 and 300 feet in thickness.

INTRODUCTION

The Slave Point and Muskwa Formations of Devonian age underlie a major part of northeastern British Columbia. In the north the Muskwa rests directly upon the Slave Point; in the south the Beaverhill Lake Formation lies between them. This bulletin considers the nature of these formations in northeastern British Columbia and relates them to equivalent strata to the east in Alberta. The formations discussed are shown in the Table of Formations (see Fig. 2).

The area where these formations occur and which is considered in detail is bounded on the north by the British Columbia-Northwest Territories boundary (latitude 60 degrees north), on the east by the Alberta-British Columbia boundary (longitude 120 degrees west), and on the southwest by the Rocky Mountain Foothills (see Fig. 1).

The late Middle Devonian (Givetian) deposits of northeastern British Columbia and northern Alberta consist of carbonates and evaporites in the east and central parts of the area under consideration and mainly shales in the extreme west. The zone of facies change is relatively narrow and is referred to as the facies front.

The carbonate and evaporitic section comprises four main stratigraphic divisions. At the base is the evaporitic Chinchaga Formation which may be partly early Middle Devonian (Eifelian) in age. The second division includes the Pine Point-Muskeg-Prairie Evaporite complex (see Fig. 2). This division consists of carbonates in the west (Pine Point Formation), anhydrite and carbonates (Muskeg Formation) in the central area,

Figure 1.--Index map showing areas of detailed and general study.

and evaporites (Prairie Evaporites) in the east. The third division includes the Watt Mountain-Sulphur Point-Fort Vermilion assemblage. It is made up of carbonates and minor amounts of shale in the west and evaporites, dolomite, and shales in the east. The uppermost division is the Slave Point Formation. It consists mainly of limestone and occurs throughout the area east of the facies front.

The upper three stratigraphic divisions change westward into a shale unit known as the Otter Park Member. In part of northeastern British Columbia the Otter Park together with the overlying Muskwa and an underlying limestone and shale unit termed the Evie Member have been considered to be members of the Horn River Formation (see Gray and Kassube, 1963, p. 473). In this bulletin, however, the Muskwa is separated from the Horn River and recognized as an independent formation.

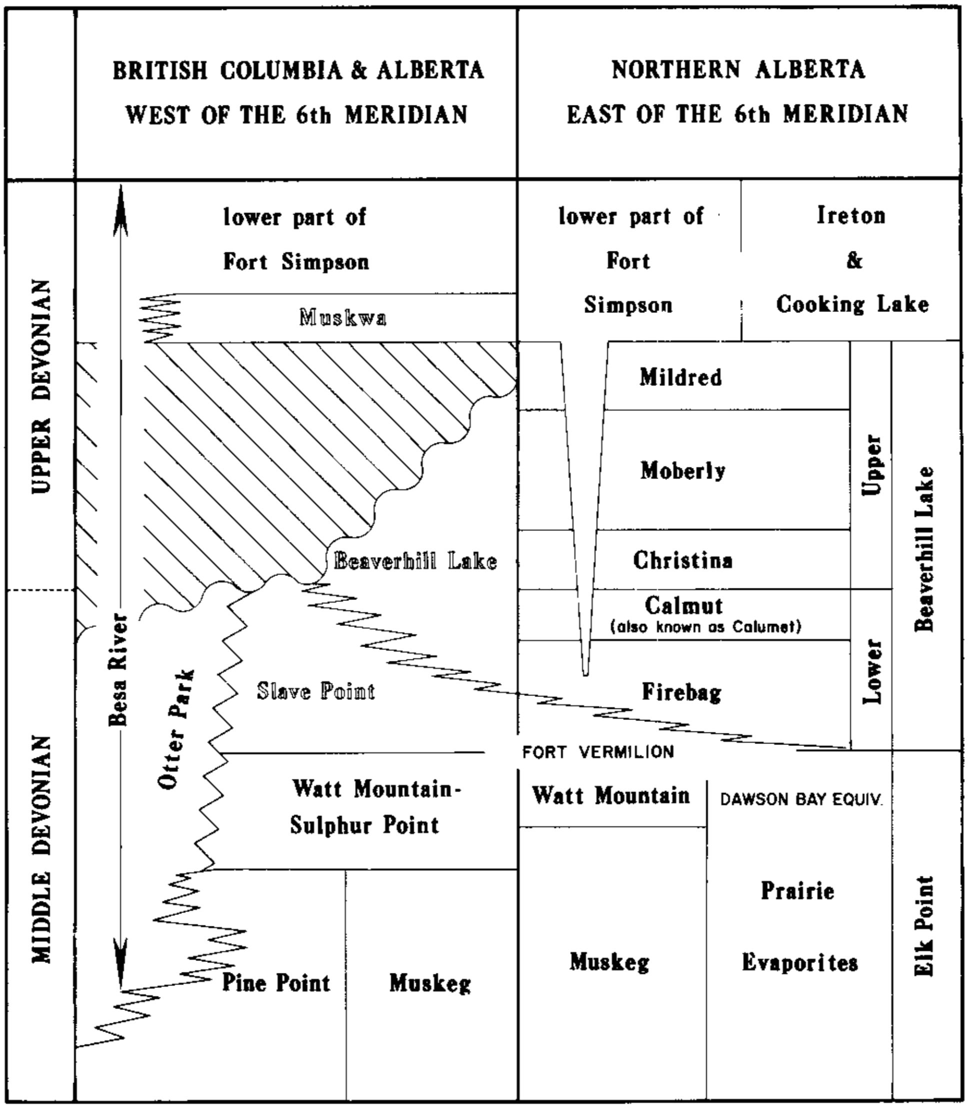

Figure 2.--Table of formations, showing formations which are discussed in detail (in open lettering) and the related formations of northeastern British Columbia and northern Alberta.

The Beaverhill Lake Formation which consists of shales and limestones of Middle to Upper Devonian age overlies the Slave Point Formation in northern Alberta and part of northeastern British Columbia. The dark Muskwa Shale overlies the Slave Point in the northern part of northeastern British Columbia and the Beaverhill Lake in the southern part of this region. The Muskwa grades upward into the lighter coloured shales of the Fort Simpson Formation. In northeastern Alberta the Muskwa Formation is absent and the Fort Simpson rests directly upon the Beaverhill Lake Formation.

In the extreme west of the area of study the separate shale units lose their identity and the combined Middle and Upper Devonian shales, associated in some areas with overlying Mississippian shales, are included in the Besa River Formation.

In this bulletin special attention is given to the lithology of the Slave Point Formation in northeastern British Columbia. Regional correlations of the formation are considered and the concept is developed that the Slave Point and a substantial part of the Beaverhill Lake Formation are complementary facies. In the past authors have tended to restrict their attention either to areas where the Slave Point is dominant (for example Campbell, 1950 and 1957; Belyea and Norris, 1962; Gray and Kassube, 1963) or to areas where the Beaverhill Lake is developed as a distinctive unit (for example, Belyea, 1952; Crickmay, 1957; Carrigy, 1959) and as a consequence the relationship between the two formations has not been readily apparent.

A major exception to this pattern of treatment was the study by Law (1955) in which he made correlations between the Devonian of the Edmonton area, which is the type area for the Beaverhill Lake Formation, and the Devonian of the Great Slave Lake area where the Slave Point Formation was originally described. However, at the time of his investigation only a small amount of drilling had been carried out and the distance between individual control points was too great to allow the stratigraphic changes to be traced in detail. Thus, while Law was able to establish the general correlations there were important stratigraphic relationships which could only be revealed by further drilling.

This study is concerned mainly with stratigraphy, and the palaeontology of the formations is considered only in general terms. The fauna of the Beaverhill Lake Formation has been adequately described in the literature (see Crickmay, 1957; Carrigy, 1959; and Norris, 1963). The Slave Point fauna has not received such detailed attention and this is undoubtedly a field which warrants further investigation.

Although it is somewhat arbitrary to separate a study of the lithology and stratigraphy of a formation from a study of its palaeontology, it is considered that the lithological and stratigraphic information is sufficient to enable valid interpretations to be made of the geological history of the formations described. In some cases more than one interpretation of the stratigraphic relationships of the various formations is possible. Nevertheless, it is felt that the concepts developed provide the most satisfactory explanation of the currently available facts.

The depths to the top of the Muskwa Formation, Beaverhill Lake Formation, Otter Park Member, Slave Point Formation, and Watt Mountain-Sulphur Point assemblage in all the British Columbia wells which penetrated these units at January 1, 1963 are given in Appendix I. Descriptions of British Columbia core are presented in Appendix II. The core descriptions illustrate the lithology of the Slave Point, Beaverhill Lake and Muskwa Formations. Appendix III (in pocket) is a map showing the location of all the British Columbia wells mentioned in the text and figure captions.

ACKNOWLEDGMENTS

The author wishes to acknowledge the generous help given by numerous members of the British Columbia Department of Mines and Petroleum Resources during the course of this study. The critical reading of the manuscript by Dr. H. R. Belyea of the Geological Survey of Canada is much appreciated. The Alberta Oil and Gas Conservation Board assisted greatly in providing facilities for the examination of drill cutting samples from Alberta wells.

SLAVE POINT FORMATION

PREVIOUS DESCRIPTION AND CORRELATION

The term "Slave Point limestones" was introduced by Cameron (1918, p. 26) for a formation exposed on the north and south shores of the west arm of Great Slave Lake. A brief description accompanied the introduction of the new formation which was said to be of Middle Devonian age. Several years later Cameron presented a more detailed account of the Slave Point Formation (Cameron, 1922, pp. 23-24). No type section was designated but rocks of the unit were said to outcrop on the south shore of Great Slave Lake at Sulphur Point and on the Buffalo River near Mellor Rapids. On the north shore the formation was reported to show on Slave Point and on the tops of the hills north of Sulphur Bay. Unfortunately, the exposures at Slave Point which it would seem appropriate to accept as the type section are poor. Only a few feet of strata are exposed (Cameron, 1917, p. 73) and at times these are covered by water (Douglas, 1959, p. 19).

Cameron (1922, pp. 23-24) describes the Slave Point Limestone as grey to brown, thin bedded, fine to medium grained, bituminous, and fossiliferous in parts, interbedded in places with limy shales. He estimated their thickness to be 200 feet.

During the years following Cameron's investigations geological work in the vicinity of the south shore of Great Slave Lake fluctuated in response to exploration activity on the lead-zinc deposits which occur in the area. In the region south and west of Pine Point extensive diamond drilling was carried out by various mining companies. The new data derived from these operations enabled Campbell (1950 and 1957) to present an interpretation of the complicated stratigraphy of the area.

Using subsurface information from the south shore of Great Slave Lake in the area west of the Little Buffalo River, Campbell (1950, pp. 89-92) assigned some 371 feet of limestones and dolomites to the Slave Point Formation. Four divisions of the Slave Point were recognized. The upper two consisted of limestone; the third was an 11-foot band of dark greenish grey shale with argillaceous limestone and dolomite, termed the Amco Shale. The lowermost division was a unit of very variable lithology including limestones, dolomites, greenish shaly material, and clay-limestone breccia.

From 1950 onward, exploratory activity for oil and gas in the southern part of the Northwest Territories, northern Alberta, and northeastern British Columbia steadily increased. The exploratory wells provided new information on the subsurface extension of the Devonian rocks outcropping at Great Slave Lake. Law (1955) used this material as a basis for the recognition of new Middle Devonian formations and for a revision of the stratigraphic limits of the Slave Point Formation. He correlated the upper part of Campbell's fourth Slave Point unit, mentioned above, and the Amco Shale with the uppermost formation of the Elk Point Group (the Watt Mountain Formation) and suggested that the name Slave Point Formation should refer only to the limestone between the Amco Shale and the overlying Upper Devonian shales. He correlated the redefined Slave Point Formation with beds occupying a similar stratigraphic position in the subsurface and gave a detailed description of the formation in the well, California Standard Steen River No. 2-22 (2-22-117-5W6).

A similar interval in the Steen River well had previously been termed the Territories Formation by Hunt (1954, pp. 2297-2300). However, Law considered that the name Slave Point had precedence and thus should be adopted in preference to the name suggested by Hunt. Law's concept of the Slave Point Formation is now generally accepted. Thus Campbell (1957) used the term in a more restricted sense than previously (Campbell, 1950) and the Slave Point of Belyea and Norris (1962) and Gray and Kassube (1963) approximates to that suggested by Law.

Law (1955, pp. 1945 and 1949) considered that the Slave Point Limestone of northern Alberta thinned toward the east and changed in its lower part to an anhydritic facies. The latter he termed the Fort Vermilion Member. Law (op. cit. p. 1949) stated that in central Alberta the Slave Point Formation is represented by about 40 feet of limestone at the base of the Beaverhill Lake Formation.

Several authors have drawn attention to the thin limestone unit which lies at the base of the Beaverhill Lake Formation in the McMurray area of northeastern Alberta and Crickmay (1957, p. 10) and Carrigy (1959, p. 23) considered it to be the equivalent of the Slave Point Formation. Crickmay (1957, p. 10) recognized a separate unit consisting of $5\frac{1}{2}$ feet of buff coloured, fine grained, magnesian limestone lying below the Firebag Member in Bear Biltmore No. 1. On the basis of stratigraphic position and lithological characters he interpreted the unit as the equivalent of the Slave Point Formation.

More recently Norris (1963, pp. 22-25) has expressed the view that the thin limestone at the base of the Beaverhill Lake in the McMurray area does not correlate with the Slave Point of northwestern Alberta. He gave the unit formational status and named it the Livock River Formation. However, it is considered that the interpretation of the Slave Point given later in this bulletin, provides an explanation of the succession in the McMurray area which does not necessitate the use of a new formational name.

Drilling in northeastern British Columbia during the past ten years has revealed the presence of considerable reserves of natural gas in the Slave Point Formation and the rock unit has therefore assumed new importance from an economic standpoint. In the area north of latitude 56 degrees north in northeastern British Columbia more than 100 wells now provide information on the Slave Point and equivalent strata, making it possible to trace these rocks throughout the subsurface of the region.

Belyea and Norris (1962) have used the recent well control to correlate the Slave Point Formation between the Great Slave Lake area and Kotcho Lake in British Columbia and to demonstrate that the formation changes to shale west of Kotcho Lake. Gray and Kassube (1963) recently described the stratigraphy of the extensively drilled Clarke Lake area. They also gave an account of the facies changes occurring in the Slave Point Formation which in many areas provide favourable conditions for the accumulation of natural gas.

LIMITS AND DISTRIBUTION IN BRITISH COLUMBIA

The Slave Point Formation in northeastern British Columbia is a sheet-like body of rock composed largely of limestone. It covers some 30,000 square miles and throughout most of this area varies between 200 feet and 500 feet in thickness (see Fig. 3). Toward the west it passes by way of a sharp facies change to shale; in the south it wedges out against the Peace River Arch. To the east and north the formation extends into adjacent areas of Alberta and the Northwest Territories.

The top of the Slave Point is easily recognized both from mechanical logs and in the drill cutting samples. The base of the formation is much more difficult to establish. The depths of the top and bottom of the formation in almost all wells penetrating the unit in northeastern British Columbia at January 1, 1963, are listed in Appendix I.

In the north the Muskwa Shale directly overlies the Slave Point Formation (north of dotted line on Fig. 3) and the change from the dark, bituminous, radioac-

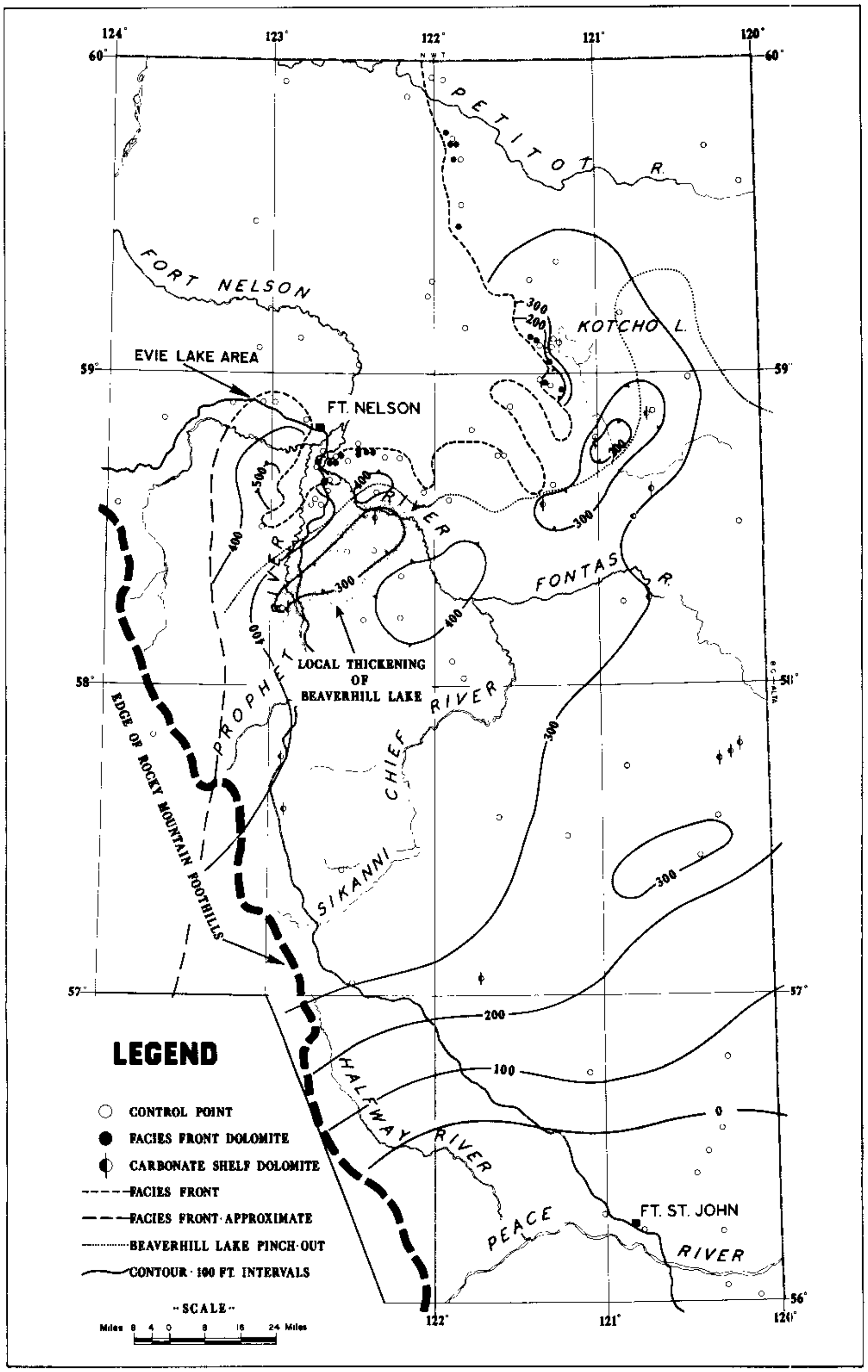

Figure 3.--Isopach map of the Slave Point Formation in northeastern British Columbia. The configuration of the facies front is the simplest that current well control allows.

tive shales to the Slave Point Limestone is well shown by both the samples and logs. Further south the Slave Point is overlain by calcareous shales of the Beaverhill Lake Formation and although the lithological change is not as abrupt as in the case of the Muskwa and Slave Point, it can be recognized without difficulty (see British Columbia wells on Fig. 6).

Two factors make it difficult to establish the lower limit of the Slave Point in northeastern British Columbia. First, the contact with the underlying beds is transitional in most areas, and secondly these beds are variable in lithology. Before discussing how the lower contact of the Slave Point has been established in the area of study it is first necessary to consider briefly the nature of these underlying beds.

Law (1955, pp. 1951-1954) considered that the Slave Point Formation of northern Alberta was underlain by a natural lithological unit consisting of limestone, breccia, green shale, dolomite, and in the vicinity of the Peace River landmass various terrigenous clastics. He termed the unit the Watt Mountain Formation. Belyea and Norris (1962, pp. 10-12), however, working in the Great Slave Lake area recognized a sequence of fossiliferous limestones and their dolomitized equivalent as the most prominent lithological unit underlying the Slave Point. The limestones were termed the Sulphur Point Formation and the dolomites the Presqu'ile Formation. In many areas in the vicinity of Great Slave Lake the Sulphur Point and Presqu'ile Formations are separated from the Slave Point Formation by a band, 1 to 20 feet thick, containing a variable amount of green shale with a waxy lustre.

When traced into the subsurface it is apparent that the Sulphur Point embraces a greater stratigraphic interval than Law's Watt Mountain Formation. On the basis of common usage, Belyea and Norris (1962, p. 12) restricted the Watt Mountain Formation to refer only to the uppermost beds of the original unit and they recognized the full limits of the Sulphur Point Formation in the subsurface.

As noted above one of the major difficulties in separating the Slave Point Formation from the underlying beds lies in the very variable nature of these beds. Thus, if the lithological types represented by Law's Watt Mountain Formation and Belyea and Norris' Sulphur Point and Presqu'ile Formations are listed, it is found that arkosic sand, varicoloured shale and siltstone, anhydrite, cryptocrystalline dolomite, limestone breccia, green shale with a waxy lustre, stromatoporoidal limestone, aphanitic limestone, argillaceous limestone, and coarsely recrystallized vuggy dolomite are all represented. To add to the difficulty of the situation some of these types are similar to those developed within the Slave Point. However, the variability of the beds provides a solution to the problem that they present. As will become apparent from the description which follows, the Slave Point shows only moderate lithological variation and consists for the most part of dark stromatoporoid-bearing limestones. It seems therefore most logical to recognize the Slave Point Formation as an upper fairly homogeneous unit overlying a unit of heterogeneous lithology, the latter being referred to herein as the Watt Mountain-Sulphur Point assemblage.

Regional correlations suggest that the upper part of the Watt Mountain-Sulphur Point assemblage of northeastern British Columbia and northwestern Alberta passes eastward into the combined Fort Vermilion - Watt Mountain assemblage of northeastern Alberta. Evidence presented on pages 35 to 41 bearing on the origin of the Slave Point and underlying beds supports this correlation and it is therefore provisionally adopted in this publication. As a consequence of the correlation of part of the Watt Mountain-Sulphur Point with the Fort Vermilion-Watt Mountain it is advisable to exclude the Fort Vermilion Member from the Slave Point Formation. In this bulletin therefore the term Slave Point Formation refers only to the Slave Point limestones and dolomites and does not include the Fort Vermilion Anhydrite.

The upper part of the Watt Mountain-Sulphur Point assemblage is characterized by beds of limestone breccia and green shale with a waxy lustre. The latter is distinctive and is readily recognized in drill cutting samples. It will be referred to as the green waxy shale. In some sections this shale forms beds up to 5 feet in thickness. However, well to well correlations and the mode of occurrence of the shale suggest that it does not occur as a single correlative bed, but rather as a series of shale lenses which probably occupy a zone up to 100 feet in thickness. This zone forms approximately the upper half of the Watt Mountain-Sulphur Point assemblage. The green waxy shale also occurs as an interstitial material in the limestone breccias of the Watt Mountain-Sulphur Point and also as fragments in the breccias. It is therefore apparent that the shale forms a subordinate but distinctive constituent of the upper part of the assemblage. This fact has been used in establishing the base of the Slave Point Formation in northeastern British Columbia and in the area studied the contact between the Slave Point and the Watt Mountain-Sulphur Point assemblage is taken at the first occurrence of the green waxy shale. It is probable that this horizon is slightly higher than the top of the Watt Mountain selected by Law (1955) in the Steen River well.

Certain difficulties are encountered in using this criterion for establishing the base of the Slave Point but similar or greater difficulties attend other methods of separating the Slave Point from the underlying beds. The shale never makes up a large proportion of the Watt Mountain-Sulphur Point and this fact coupled with the small size of the average drill cutting sample results in only small amounts of the distinctive shale being present in the samples; in some cases it is completely absent. Fortunately, if the latter is the case, the well in question can often be satisfactorily correlated with adjacent wells in which the base of the Slave Point has been established from the samples. The upper part of the Watt Mountain-Sulphur Point frequently shows a series of deflections on the Gamma Ray Log and these can be used as a basis for correlation between closely spaced wells.

The distribution and thickness of the Slave Point Formation in northeastern British Columbia is shown in Figure 3. Several factors influence the distribution of the formation. The contours suggest a regional thickening to the west-northwest. To the south this trend is affected by the Peace River Arch against which the formation wedges out. To the west-northwest the formation passes to shale along a sinuous line which trends approximately north-northeast. The shales equivalent to the Slave Point were included in the Otter Park Member of the Horn River Formation by Gray and Kassube (1963). Wells in the Clarke Lake area close to the facies change demonstrate that the Slave Point can change to shale in a distance of less than 1,000 feet and Gray et al (1962, p. 176) state that in the same area the facies contact is inclined at an angle of at least 25 degrees to 30 degrees. This sharp facies contact will be referred to as the facies front of the Slave Point Formation.

In some areas there is evidence that the carbonates adjacent to the front are derived from the products of reef growth. In many areas, however, it is difficult to determine the original nature of the carbonates of the facies front and thus the extent of reef development along the front is not known. It is for this reason that the term facies front is used in preference to such terms as "reef front" or "barrier reef."

Well control enables the facies front to be traced from the Petitot River area in the north to the Evie Lake area at Mile 320 on the Alaska Highway (see Fig. 3). South of this the well control is sparse, but the control which is available considered in conjunction with the small amount of literature on the area (see Gallup, 1962; Warren and Stelck, 1962) suggests that the facies front trends approximately as shown by the coarsely broken line on Figure 3.

The detailed configuration of the facies front in many parts of northeastern

British Columbia is difficult to establish because of the lack of closely spaced wells. The interpretation presented in Figure 3 is, in general, the simplest that the present well control allows. Seismic data and future drilling will enable the front to be mapped more precisely and this information may show the presence of embayments and promontories which, with the currently available information, can only be the subject of conjecture.

The regional dip on the top of the Slave Point Formation is to the southwest at an average of about 40 feet per mile (Gray et al, 1962, p. 176). At the facies front in the region between the Petitot River and Clarke Lake the top of the Slave Point varies between approximately 4,500 and 5,300 feet below sea level. It is highest in the Kotcho Lake area. To the south at its feather edge on the Peace River Arch the formation is more deeply buried. At the pinch out to the north of Fort St. John, for example, the top of the Slave Point lies at a depth of 8,000 feet below sea level.

LITHOLOGY IN BRITISH COLUMBIA

The following discussion is based mainly on the examination of core from 39 wells in northeastern British Columbia. At January 1, 1963, 90 wells penetrated the Slave Point Formation in British Columbia having a total penetration of the formation of 24,324 feet. Of this total, 3,234 feet has been cored. The cored sections thus represent about 13 per cent of the Slave Point penetrated at that time.

The core was examined megascopically and then representative lithological types were examined with a stereoscopic microscope at magnifications between x 7 and x 30. Most of the limestones were etched and observations were made on the wet surface. In a few instances examination of thin sections of the rock contributed supplementary information.

Samples of drill cuttings do not always provide adequate details of lithology in the limestone sections because of several factors. First, there is a tendency for the Slave Point limestones to be altered during the drilling process to a dense chalky carbonate in which the texture of the original rock is obliterated. Secondly, the recrystallization of stromatoporoid material to a dense very finely crystalline calcite makes it almost impossible to recognize the organic nature of this material when it is fragmented. Finally, shale contamination which takes place in uncased holes, may reduce the limestone content of a sample to such an extent that the sample cannot be considered to be truly representative of the interval in question. The drill cutting samples, however, contribute useful information on gross lithology subject to these reservations.

The Slave Point Formation in British Columbia is composed mainly of dark coloured limestones which contain varying amounts of stromatoporoid and other biogenic material. These rocks are aphanitic to microgranular in texture and as a rule the constituent particles (excluding biogenic material) are unresolved under the stereoscopic microscope at x 30 magnification. This may result from the small size of the particles, the homogeneous nature of the particles and matrix or from the obscuring effect of finely disseminated carbonaceous material.

These dark coloured limestones are the main lithological component of the Slave Point in northeastern British Columbia. They are referred to as the dark stromatoporoid-bearing calcilutites.

In addition to the main component there are a number of subsidiary components which contribute to the total lithology of the Slave Point Formation in northeastern British Columbia. The subsidiary components are described under the following headings: (a) The limestones and dolomites developed in the vicinity of the facies front and (b) the subsidiary components developed at a considerable distance from the facies front.

The system of limestone classification presented by Folk (1959 and 1962) has been found useful in describing the subsidiary components and where appropriate his system of nomenclature has been applied. However, the terms intraclast and micrite are used in a slightly broader sense than as defined by Folk.

The Slave Point limestones contain a complete range of particles between 0.06 millimeter and 0.5 millimeter in diameter and there does not appear to be a natural division between the smaller particles (pellets of Folk) and the larger (intraclasts of Folk). The Slave Point particles will be referred to as intraclasts, a practice which is in keeping with the descriptive nature of the term emphasized by Folk (1962, p. 64). It should be noted that such intraclasts may include allochems of uncertain origin such as faecal pellets and recrystallized biogenic fragments.

Folk (1959, pp. 8 and 17) defines the term micrite in a precise way and gives the term genetic implications. Because the methods of investigation used in this study do not allow the exact measurement of very small particles the term micrite is used in a broader sense to include rocks which are very fine grained or aphanitic in texture and which appear to have been formed by the deposition of lime mud. This is more in keeping with the usage of Leighton and Pendexter (1962, p. 35).

The scale suggested by Folk (1959, p. 19) is used to describe crystal size. The scale is similar to the Wentworth but uses a constant ratio of four between the divisions instead of the more usual two. It can be summarized as follows: aphanocrystalline, < 0.004 millimeter; very finely crystalline, 0.004-0.016 millimeter; finely crystalline, 0.016-0.063 millimeter; medium crystalline, 0.063-0.25 millimeter; coarsely crystalline, 0.25-1 millimeter; very coarsely crystalline, 1-4 millimeters; extremely coarsely crystalline, > 4 millimeters. In describing the colour of the rocks the Rock-Colour Chart distributed by the Geological Society of America has been followed as closely as is practical.

A considerable diversity of stromatoporoids is present in the Slave Point Formation. The descriptive terms of Galloway (1957, pp. 350-360) and his method of classification are used in describing these organisms. In the past there has been a tendency to distinguish between "stromatoporoids" and "Amphipora"; in keeping with modern concepts of classification this practice is not followed. It should be noted that the term "ramose stromatoporoids" is used to refer to Amphipora and other members of the Idiostromatidae. The terms massive, ramose, and laminar are used as defined by Galloway (1957, pp. 350-360 and p. 374). The term nodular is used to refer to stromatoporoid coenostea of rounded form with a maximum dimension of approximately 1.5 to 6 centimeters.

In the following description of the lithology of the Slave Point Formation in British Columbia, the various rock types are described in the following order:

I. Main lithological component of the Slave Point Formation -- the dark stromatoporoid-bearing calcilutites.

II. Subsidiary components of the Slave Point Formation. Two main divisions can be recognized in this category:

   A. Rocks occurring in the vicinity of the facies front. These comprise:

      (i) The dark stromatoporoid - bearing calcilutites with abundant biogenic material.

      (ii) The stromatoporoid biosparites.

      (iii) The stromatoporoid biomicrites.

      (iv) The light-coloured micrites and fossiliferous micrites.

      (v) The white and grey dolomite.

B. Limestones occurring at some distance from the facies front (usually > 25 miles). The rocks of this division are mainly intramicrites, intrasparites, and biosparites.

1. The Main Component of the Slave Point Formation
The Dark Stromatoporoid-bearing Calcilutite

The dark stromatoporoid-bearing calcilutites are the most widely distributed and characteristic limestones of the Slave Point Formation in northeastern British Columbia. The colour of these rocks varies from brownish grey to dark brownish grey to dark grey and appears to be mainly imparted by the presence of organic material, which, following Carozzi (1960, p. 214), will be referred to as carbonaceous material. The etched surface of these limestones when examined under the stereoscopic microscope often has a mat appearance devoid of obvious structure. Carbonaceous material if abundant stands above the etched surface as a fine, black "dust."

Stylolitic partings containing thin films of dark grey to black carbonaceous material occur quite commonly in the dark calcilutites. In some core small patches of sparry calcite are present. They are irregular in shape and are usually less than 0.5 millimeter across but in some instances reach a width of 1 millimeter. Their origin is not known but it seems likely that either they fill small cavities which remained after deposition or that they are derived from micritic material by recrystallization.

On the basis of tests carried out on a number of limestone specimens from different parts of northeastern British Columbia, it is concluded that the dark calcilutites contain only minor amounts of argillaceous material. This conclusion is supported by the features of the Gamma Ray Neutron and Gamma Ray Sonic Logs.

The coenostea of massive, nodular, and ramose stromatoporoids are a most important constituent of the dark calcilutites. The tabulate coral Thamnopora also occurs commonly in these rocks. The quantity of this biogenic material varies considerably from place to place and also in different parts of a single cored interval. It ranges from less than 10 per cent of the rock up to an estimated 60 to 70 per cent (see Plates I to VI). The most widespread type of calcilutite probably contains less than 10 per cent of biogenic material. The rocks containing abundant biogenic material are best developed in the region of the facies front, although they occur as local developments in other areas. Rocks containing intermediate amounts of biogenic material also occur as local developments in the Slave Point Formation throughout northeastern British Columbia.

The examination of many specimens of the dark calcilutite under the stereoscopic microscope and of a small number of thin sections with the petrological microscope, suggests that these rocks may contain abundant allochems of diverse origin. Hand specimen examination often indicates the presence of compacted, vague intraclast-like or pellet-like structures 0.1 to 0.4 millimeter in diameter. The three thin sections examined indicate that allochems 0.06 to 0.25 millimeter in diameter and biogenic fragments 0.1 to 0.4 millimeter in diameter occur quite abundantly in these rocks, at least in some areas (see Plate XVII).

The dark stromatoporoid-bearing calcilutites grade in parts to rocks showing clearly developed intraclasts, 0.1 to 0.5 millimeter in diameter. The intraclasts are commonly round, ovoid, triangular, rectangular, or kidney-shaped in cross section and almost invariably have a rounded outline. In some cases the intraclasts are dispersed in what appears to be a micritic matrix, whilst in other cases they are closely compacted and sometimes separated from each other by a thin carbonaceous film. In another mode of occurrence which is not as common as the others the intraclasts are dispersed in a clearly developed matrix of sparry calcite. The intraclast rocks tend to be slightly lighter in colour than the associated dark calcilutites.

In addition to stromatoporoids of various types, other recognizable biogenic material is often present in the dark calcilutites and associated intraclast rocks. The Slave Point core in the well, BA Shell Klua b-49-F (94-J-9) provides a good section in the fossiliferous dark calcilutites (see Plates I, II, IV, V, and VI and Appendix II). Massive, nodular, ramose, and laminar stromatoporoids and Thamnopora are all represented and in parts of the core stromatoporoids can be seen completely surrounding specimens of Thamnopora. Most of the encrusting organisms show indications of stromatoporoid structure; some, on the other hand, are almost devoid of obvious structure in hand specimen and these may be of algal origin. It should be borne in mind, however, that stromatoporoids, recrystallized to a homogeneous finely crystalline calcite could, in hand specimen, simulate algae belonging to the family Spongiostromata.

Numerous small shell fragments replaced by translucent calcite are also present in the Slave Point core of BA Shell Klua b-49-F (94-J-9). The fragments are usually elongated and range up to 0.2 millimeter in thickness and 5 millimeters in length. It seems likely that most of these fragments are derived from brachiopods.

Although shell fragments are more obvious in the core from the above mentioned Klua well than in many other sections of Slave Point core, careful examination of the calcilutites will often reveal the presence of small, thin-shelled ovoid bodies 1 to 2 millimeters in diameter and thin shell fragments which range up to 5 millimeters in length. There seems little doubt that the ovoid bodies are ostracodes; the larger shell fragments, as in the case of the Klua core, are probably derived from brachiopods.

The dark calcilutites which make up the main part of the Slave Point Formation apparently originated on a broad shelf over which a depositional environment of low energy prevailed. This concept is supported by the fine grained nature of much of the Slave Point carbonate and by the abundance of carbonaceous material in the sediments. The presence of the latter and the common occurrence of various types of biogenic material in the dark calcilutites suggests that biological activity played a very important part in the formation of these limestones.

The limestones of the Slave Point Formation are dolomitized in some areas. The most profound recrystallization occurs in a narrow zone bordering the facies front and these dolomites will be discussed in a later section. At this point, however, it is necessary to consider briefly the dolomites which occur in areas away from the facies front. Most of these dolomites appear to be derived from the dark calcilutites discussed above, and because they are widely distributed over a carbonate shelf they will be referred to as shelf dolomites.

Wells in which the Slave Point Formation shows substantial intervals of dolomite and which lie at some distance from the facies front are shown on Figure 3 by a distinctive symbol and are listed in Appendix I. The importance of these wells lies in the fact that in certain instances the dolomitized sections contain commercial accumulations of natural gas (see Appendix I). The carbonate shelf dolomites are usually medium dark grey to dark brownish grey to dark grey in colour and fine to medium crystalline in texture. Some of the shelf dolomites are similar to the white and grey dolomites of the facies front (to be discussed below) and these probably had a comparable mode of origin. Vuggy and intercrystalline porosity is present in some sections. The causes of dolomitization in the areas away from the facies front are not fully understood and a spatial pattern of dolomitization has not yet emerged.

II. The Subsidiary Components of the Slave Point Formation

A. Rocks of the Facies Front

The rock types belonging to this division occur mainly within 1 to 2 miles of the facies front. The limestones described below provide important information on the environmental conditions which prevailed in the vicinity of the facies front during the deposition of the Slave Point Formation.

(i) The dark stromatoporoid-bearing calcilutites with abundant biogenic material.--This rock type represents a continuation of the dark calcilutites discussed above into the area of the facies front. The rocks possess most of the characters already described but are notable in this area for the abundance of contained stromatoporoid material of all types. Small patches of sparry calcite, usually less than 1 millimeter across, are more common in the dark calcilutites of the facies front than in the calcilutites occurring at some distance from the front. A good section in these dark calcilutites is seen in the Slave Point core of the well, West Nat Imperial Clarke Lake b-78-J (94-J-9) (see Appendix II).

(ii) The stromatoporoid biosparites.--The stromatoporoid biosparites are well displayed in Slave Point core from the Evie Lake area and from certain wells in the Clarke Lake area (see Appendix II). The limestones consist mainly of stromatoporoid fragments showing various degrees of rounding and sorting, set in a matrix of sparry calcite or more dense, very light brownish grey calcite. Brachiopods, corals, gasteropods, Thamnopora, and other fossils which are too poorly preserved for identification are present in some sections. Examples of these limestones are shown in Plates VII, VIII, and IX.

The stromatoporoid material of the biosparites and biosparrudites is often recrystallized to a very finely crystalline, dense, brownish grey to light brownish grey calcite, which shows little evidence of organic structure. In some instances this material is difficult to distinguish from the micrites of similar colour which will be discussed below. In drill cutting samples it would be almost impossible to recognize that this dense, homogeneous calcite was of organic origin and it would probably be described as a micrite or calcite mudstone. Because of its origin and appearance the recrystallized stromatoporoid material will be referred to as dense, biogenic calcite.

Recrystallization can affect the stromatoporoids of any of the rock types, but it is mentioned here because it is often associated with another post-depositional process which is particularly well displayed by some of the biosparites. The stromatoporoids of these rocks frequently contain black carbonaceous material which in some instances is distributed through the coenostea in such a way that it emphasizes the organic structures. When recrystallization to dense biogenic calcite occurs, however, the dark carbonaceous material migrates either to certain areas within the coenosteum or, in the case of small fragments, to the periphery of the fragment.

Three factors thus contribute to obscure the original textures of the stromatoporoid biosparites. They are the recrystallization of the biogenic material, the redistribution of dark carbonaceous compounds within this material and the tendency for the matrix calcite to be very finely crystalline and dense rather than sparry. It appears that certain post-depositional processes tend to convert, by recrystallization, the various components of the rock to a dense calcite, fine to very finely crystalline in texture.

(iii) The stromatoporoid biomicrites.--This rock type consists of closely compacted stromatoporoid coenostea set in a matrix of dense brownish grey micrite. The rock normally contains only small amounts of carbonaceous material and the stromatoporoids are often recrystallized to brownish grey, dense, biogenic calcite. The result is a dense brownish grey rock of uniform appearance (see Plate X) and close examination is necessary to distinguish between the two main components. Small prisms of authigenic quartz are distributed through some of these rocks. Small voids and fissures in the rock may be filled with sparry calcite and in cases where incipient dolomitization is present it is often associated with these areas of sparry calcite. The terms stromatoporoid biomicrite and biomicrudite can be appropriately applied to these rocks. They are well developed in the Slave Point core of West Nat Imp Clarke Lake d-91-L (94-J-9) and West Nat Imp Clarke Lake c-94-L (94-J-9) (see Appendix II).

(iv) The light coloured micrites and fossiliferous micrites.--These rocks are brownish grey to light brownish grey in colour. They have a uniform aphanitic appearance and it seems reasonable to assume that they are true micrites. There are only small amounts of stromatoporoid material in these rocks and most would fall into the fossiliferous micrite (containing 1 to 10 per cent fossils) classification of Folk (1962, p. 76). In parts they grade into intraclast rocks. The intraclasts are 0.1 to 0.3 millimeter in diameter and are mostly round or ovoid in cross section. In some cases they are closely packed whilst in others they rest in a matrix of sparry calcite. Small fissures and cavities filled with sparry calcite, occur quite commonly in the rock.

The light coloured micrites and intraclast rocks are frequently associated with the dark stromatoporoid-bearing calcilutites. Various relationships between the two may be observed in the Slave Point core of Texaco NFA N Tsea d-47-C (94-P-12) (see Appendix II). In some parts of this core the dark rock occurs as thin bands crossing the lighter material; in other parts there is interbedding of the two types on a small scale. Another mode of occurrence is seen where the light micrite takes the form of turbulent "clots" up to 4 centimeters across dispersed in a matrix of the dark limestone. It is possible that some of the banded structures are of algal origin.

Interpretation of the limestones of the facies front.-- Rocks in the vicinity of the facies front have been described as reef beds (see, for example, Gray and Kassube, 1963, pp. 471-472). It has been pointed out by several authors (Henson, 1950; Nelson et al, 1962) that there are numerous local environments associated with areas of reef development and that each environment gives rise to particular types of deposit. The assemblage consisting of the reef and associated fore reef, back reef, and interreef beds is referred to as the reef complex (Nelson et al, 1962, p. 249). It is therefore pertinent to enquire whether any of the rock types of the Slave Point Formation can be assigned to a particular part of a reef complex.

The information currently available unfortunately does not allow a complete and satisfactory interpretation of the area close to the facies front which is the site of potential reef development. Many of the rocks in this area are dolomitized and as a result their original nature is obscure. These dolomites will be discussed below. Also, there is a lack of closely spaced core control in the critical areas. Only tentative suggestions can be made therefore regarding the interpretation of the rock types from the vicinity of the facies front.

Typical biolithites (Folk, 1959, p. 13) derived from the reef core (Nelson et al, 1962, p. 249) cannot be recognized with certainty. The stromatoporoid biomicrites, discussed above, provide the closest approach to this type of lithology. The stromatoporoid biosparites provide adequate evidence of shoal conditions and vigorous wave activity and could well be clastic deposits associated with a true reef. The light coloured micrites and fossiliferous micrites may represent local back reef or interreef deposits and it is possible that some of the dark calcilutites represent the reef talus.

Perhaps the most positive evidence indicating the presence of true reefs in the area of the facies front is the great abundance of numerous forms of stromatoporoids. As these organisms in all probability had the ecologic potential to erect rigid wave resistant structures (see Hadding, 1941, pp. 18, 43, and 73), it can be concluded that reefs in the sense of Nelson et al (1962, p. 242) were present in the area of facies change. However, it should be borne in mind that biolithites have not been recognized with certainty and that there is not yet sufficient information to enable the lateral extent of reefs along the facies front to be determined. It may be that the facies front is characterized by a continuous zone of reefs or alternatively true reefs may occur only intermittently along the front.

(v) The white and grey dolomite.--Many of the limestones in close proximity to the facies front have been altered to dolomite. This occurrence is extremely important from an economic standpoint because the vuggy dolomites of the facies front contain most of the natural gas so far discovered in the Slave Point Formation. In the typical development this dolomite consists of two distinct phases, one being medium grey to medium dark grey in colour and the other very light grey to white in colour. The rock will therefore be termed the white and grey dolomite. The two phases are associated together in a number of different ways and this gives rise to several textural varieties which can be most conveniently described by coining descriptive names in the following manner (see Plates XI-XVI):

1. Microinclusion texture (see Plate XI).--Here small inclusions of the white dolomite, 1 to 5 millimeters across, are scattered in a matrix of dark dolomite.
2. Macroinclusion texture (see Plate XII).--This is similar to the above except for the size of the inclusions. Here they vary between 5 millimeters and 6 to 7 centimeters across. In both the textures the boundary between the inclusions and the matrix is well marked.
3. Banded texture (see Plate XIII).--In this case the white and grey phases occur as alternating bands which vary from a few millimeters to several centimeters in thickness.
4. Clotted texture (see Plate XIV).--Rocks with this texture show irregular "clots" of the white dolomite, with indistinct margins, suspended in a matrix of the dark dolomite. The inclusions vary from less than 1 centimeter up to 7 to 8 centimeters in width.
5. Nebulous texture (see Plate XV).--Here the white phase occurs as "wisps" and fine irregular bands in the dark phase.
6. Pseudo-brecciated texture (see Plate XVI).--In this case the dark dolomite appears to be in the form of irregular "blocks" dispersed in an interstitial matrix of the light phase; if the dark phase forms the matrix separating "blocks" of the light coloured dolomite then the reverse relationship is apparent.

These terms are useful for descriptive purposes only and it is not intended to suggest that they represent fundamentally different types of dolomite. Various gradations between the types can be seen and it is probable that many of them have a common mode of origin.

The dark phase is normally dominant. Microscopic examination reveals that it is usually fine to medium crystalline in texture with occasional gradation into the lower part of the coarsely crystalline size class (0.25-1 millimeter). The medium to coarsely crystalline material often has dark carbonaceous material between the crystals and this imparts the greyish colour to the rock. The finely crystalline material may also possess intercrystalline carbonaceous material but more frequently the crystals are uniformly pigmented.

The light phase consists of coarse to very coarsely crystalline dolomite. Intercrystalline carbonaceous material may or may not be present. Many of the dolomite crystals which compose the two phases are of the same very light grey colour; the actual colour of the phases is related to the crystal size and the amount of carbonaceous material present in the rock.

Vugs occur in considerable number in the light coloured phase; they range from about 1 centimeter across up to the full width of the core (mostly 3.5 inches in diameter). Many of the vugs are lined with rhombohedrons of coarse to extremely coarsely crystalline, light coloured dolomite and some quartz. Sphalerite crystals and a yellow mineral which may be sulphur are present in a few of the vugs. The sphalerite occurs either in a dark metallic form or as a yellowish brown translucent mineral. Carbonaceous material is common between the crystals of the vug lining; it is frequently referred to as gilsonite. In areas very close to the facies front carbonaceous material fills some of the fissures and small cavities within the rock. It is hard and in places contains authigenic dolomite crystals.

Vugs are not restricted entirely to the light phase, but even when they occur directly in the dark phase they are often lined with crystals of white dolomite. The poor recovery obtained from many cored sections in the white and grey dolomite and the lost circulation which often occurs in these zones is adequate testimony to the fact that the dolomite is extremely vuggy.

The textures developed in these dolomites suggest that in most cases they are derived from the dark stromatoporoid-bearing calcilutites. A comparison between the dark calcilutite and the white and grey dolomite in the well Imp Junior c-98-C (94-I-11) (see Appendix II), for example, indicates an obvious relationship between the two. Here the calcilutite has recrystallized to form the dark phase of the dolomite and the biogenic material is represented by the light phase of the altered rock. During the replacement of the dark matrix it appears that the carbonaceous material of the original rock is excluded from the growing dolomite crystals, thus giving rise to the intercrystalline carbonaceous material of the secondary dolomite.

Partly dolomitized rocks in West Nat Imp Clarke Lake d-91-L (94-J-9) and Imp Junior c-98-C (94-I-11) (see descriptions of Slave Point core from these wells in Appendix II) suggest that stromatoporoid fragments are altered to dolomite first at the periphery and that dolomitization then extends inwards from the outer rim of dolomite so formed. Some of the biogenic fragments are completely replaced by dolomite, others retain a central core of calcite. The calcite core is apparently susceptible to solution and if it is dissolved away a cavity is produced which may then become a vug lined with dolomite and quartz.

These conclusions are in general agreement with those presented by Gray and Kassube (1963, p. 477) for the dolomitization of the Slave Point limestones in the Clarke Lake field. They considered that dolomitization occurs first in the calcarenitic material of the reef and that in the early stages the smaller skeletal fragments are entirely replaced and rims of coarsely crystalline dolomite develop on the larger fossils. It was pointed out that subsequently solution removes the remaining calcite and produces a rock with intercrystalline and vuggy porosity. Inward growth of dolomite may then occur which, in some cases, completely closes the vugs.

A point of difference between the concepts relating to dolomitization presented by Gray and Kassube (1963, p. 477) and those presented here lies in the interpretation of the dark coloured intercrystalline material. The former authors consider that the intercrystalline material is probably an early hydrocarbon residue, whereas in this study it is suggested that the intercrystalline matter is derived from the carbonaceous material of the original rock by a process of redistribution and possible alteration during dolomitization.

It is evident that the textures of the white and grey dolomite could result mainly from the mode of occurrence and distribution of the biogenic material in the original rock. Thus stromatoporoid fragments of various sizes dispersed in a matrix of dark calcilutite could give rise to the microinclusion and macroinclusion textures upon dolomitization (compare, for example, the dark calcilutite of Plate IV with the white and grey dolomite of Plate XII). Large angular stromatoporoid fragments with relatively little matrix could produce the pseudo-brecciated texture, and very small biogenic fragments with irregular distribution in a dark matrix might give rise to the nebulous texture upon recrystallization.

In some cores the white dolomite alone occurs over intervals of up to 6 or 7 inches. It is not clear how these intervals developed but it is likely that they result from the replacement of fairly homogeneous sediment or biogenic material. Thus, these bodies of white dolomite might be formed by the replacement of large stromatoporoids or alternatively by the recrystallization of a homogeneous micrite. It is worth noting in this connection that the Presqu'ile Dolomite (the dolomitized equivalent of the Sulphur Point Limestone) often contains a much higher percentage of the white dolomite than the Slave Point Dolomite. There is considerable evidence that the former is derived from fairly homogeneous light coloured micrites and sparites. It is also possible that some of the substantial intervals of white dolomite fall into the category of vein dolomite discussed by Gray and Kassube (1963, p. 477).

The white and grey dolomites of the Slave Point Formation occur mainly at, or closely adjacent to, the facies front. Normally the zone of dolomitization is narrow. In the Clarke Lake area the zone is approximately $1\frac{1}{2}$ miles wide; in the Kotcho Lake area tongues of dolomite may reach several miles from the facies front. This association strongly suggests that proximity to the front is an important factor in determining whether or not dolomitization takes place. A possible explanation of this relationship could lie in the fact that the facies front provided a passage for migrating solutions, which played an important part in introducing new compounds or in bringing about solution and redistribution of existing material.

B. Limestones Occurring at Some Distance from the Facies Front

It is now necessary to consider briefly the lithological types and faunal assemblages which occur mainly at distances greater than 25 to 30 miles from the facies front and which differ from the stromatoporoid-bearing calcilutites with which they are interbedded. These rocks, although not as abundant as the dark calcilutites, may provide important information on the environmental conditions in areas distant from the zone of potential reef development.

In the area which lies at some distance from the facies front, well developed intraclast rocks are more common than in the broad zone lying immediately behind the facies front. Clearly developed intrasparites and intramicrites, conspicuous over considerable intervals, can be discerned in the Slave Point core from the wells, HB Imp Union Gutah a-99-K (94-H-10) and HB Imperial Union Paddy a-49-B (1) (94-H-16) (see Appendix II and Plates XVIII and XIX). Most of the intraclasts in these rocks are between 0.1 and 0.5 millimeter in diameter. The shapes encountered are similar to those previously described for the intraclast rocks (see p. 20).

The fauna of the rocks which lie at a considerable distance from the facies front also shows points of interest which may eventually prove significant. The various elements of lithology and fauna are well illustrated by the Slave Point core in the well, HB Imp Union Gutah a-99-K (94-H-10). In this well the upper part of the core consists mainly of the dark calcilutites with abundant Amphipora and subordinate occurrences of other Idiostromatidae and massive stromatoporoids.

The central part of the cored interval of the Gutah well is slightly lighter in colour (brownish black-medium brownish grey) and contains well developed intraclast rocks, some of which contain Calcisphaera (see Plate XIX). Clearly developed biosparites containing foraminifera and broken brachiopod shells also occur in the central part of the core. The foraminifera range up to 2 millimeters across whilst the shell fragments may reach 5 millimeters in length (see Plate XX). Complete brachiopod valves occur sporadically in this part of the core. Massive, nodular, ramose, and laminar stromatoporoids and Thamnopora are also present. The lower section of the Gutah core comprises dark stromatoporoid-bearing calcilutites.

Other wells which illustrate various elements of the Slave Point fauna in areas away from the facies front are Imp Fontas d-37-B (94-I-7) and Texaco NFA Townsoitoi d-44-C (94-I-10). It should be noted that it is difficult to determine the precise location of the facies front in relation to these wells but it is assumed at the present time that they do not lie in close proximity to the front. In the Fontas well brachiopods are common and gasteropods occur sporadically. In both wells there are numerous occurrences of small cylinders of calcite 2 to 8 millimeters long and approximately 1 millimeter in diameter. These bodies often possess a central canal or cavity and in some instances their ends show suggestions of radial serrations. It is probable that the bodies are derived from crinoids or some related organism.

It is concluded that a moderate diversity of sedimentary environments and associated faunas existed in areas lying at some distance from the facies front. The presence of well developed biosparites, intrasparites, and other intraclast rocks, even though they are a subordinate element in the total lithology, suggests local areas of deposition in an environment of moderately high energy.

LITHOLOGY IN ALBERTA

Figure 4 shows a cross section of the Slave Point Formation along a line that runs from the Fort Nelson area in British Columbia to the McMurray area in eastern Alberta (see Fig. 11). As far east as approximately the 6th Meridian in Alberta the Slave Point Formation maintains the lithology developed in the eastern part of northeastern British Columbia. Darker colours are dominant (medium brownish grey-brownish black) and most of the limestones are dense in texture. In parts of the area there are subordinate developments of intraclast rocks.

Further east the Slave Point Formation thins considerably and east of Bison Lake it is less than 70 feet in thickness. In the area of northeastern Alberta shown on Section HIJ (see Fig. 4) the Slave Point limestones are medium brownish grey to very light brownish grey in colour. The most commonly developed rock types are calcilutites and fine to medium grained intraclast rocks which contain superficial oölites in places.

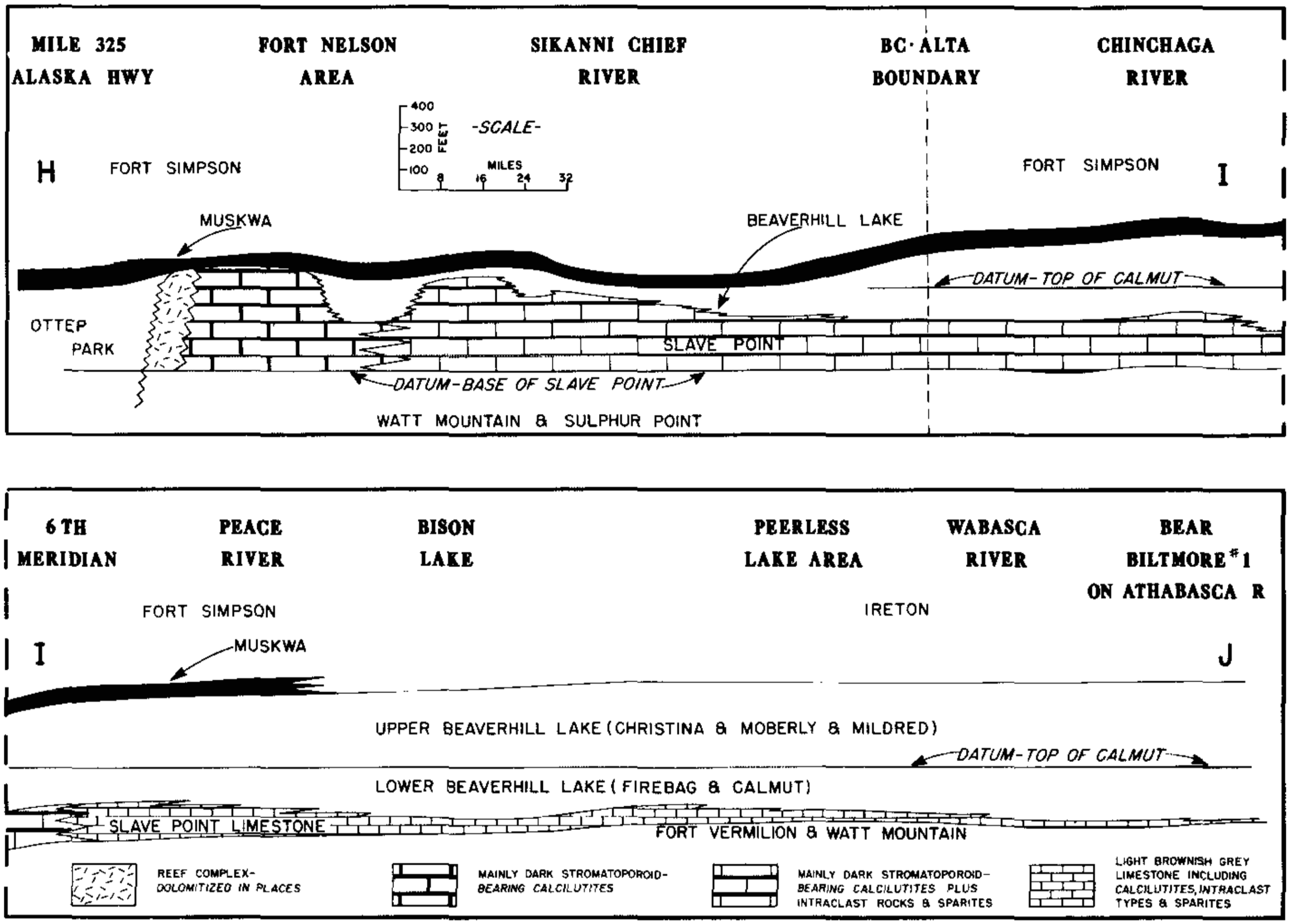

Figure 4.--Diagrammatic cross section (HIJ) from Fort Nelson area of northeastern British Columbia to Athabasca River, Alberta, showing the Slave Point, Beaverhill Lake, and Muskwa Formations. Major lithological changes in the Slave Point are shown. Note that toward the west the Lower Beaverhill Lake (Firebag and Calmut) is gradually replaced by the Slave Point Limestone. Line of section is shown on Figure 11.

BEAVERHILL LAKE FORMATION

PREVIOUS DESCRIPTION AND CORRELATION

The Beaverhill Lake Formation was originally described in the Edmonton area of central Alberta and the studies of Belyea (1952) subsequently demonstrated that the formation can be traced into the McMurray area of northeastern Alberta. Law (1955) did not recognize the Beaverhill Lake as an independent unit in northern Alberta, but instead considered that it merged into the lower part of his Shale Unit. Both Crickmay (1957) and Carrigy (1959) discussed the Beaverhill Lake in northern Alberta, their attention being mainly directed to the development of the formation in the McMurray area.

The McMurray succession of the Beaverhill Lake forms a convenient reference section to which other sections of the Beaverhill Lake in northern Alberta and British Columbia can be related.

The rocks equivalent to the Beaverhill Lake outcropping at McMurray were originally termed the Waterways Formation by Warren (1933, p. 149). However, the subsurface extension of these rocks in the same area is often referred to the Beaverhill Lake Formation and this practice will be adopted in the account which follows.

Crickmay (1957, pp. 6-9) using information from outcrops in the vicinity of McMurray and subsurface information from the well, Bear Biltmore No. 1, divided the Beaverhill Lake Formation (Waterways Formation of Crickmay) of the locality into five members. They were named, in ascending order, the Firebag, Calmut (also known as the Calumet), Christina, Moberly, and Mildred Members. Carrigy (1959, pp. 23-28) and Norris (1963, pp. 25-39) contributed new information on the Beaverhill Lake of the McMurray area and gave very useful accounts of the stratigraphy and palaeontology of the formation.

The Beaverhill Lake Formation as divided by Crickmay (1957, pp. 6-9) consists of three members which are dominantly argillaceous and two which consist mainly of limestone. The limestone members alternate with the argillaceous members. The lowermost member, termed the Firebag, consists of approximately 170 feet of shales and argillaceous limestones. The overlying Calmut Member consists of about 102 feet of fine grained and clastic limestones grading in some wells to argillaceous limestones. The Christina Member, which succeeds the Calmut, is made up of about 90 feet of argillaceous limestone and calcareous shale. This unit is overlain by the Moberly Member which comprises some 200 feet of clastic limestones with subordinate argillaceous limestones. The uppermost unit of the Beaverhill Lake Formation in the McMurray area is termed the Mildred Member. It consists of approximately 140 feet of argillaceous limestones and calcareous shales. The faunas of these members are well documented by Crickmay (1957), Carrigy (1959), and Norris (1963).

REGIONAL CROSS SECTIONS

The cross sections ABC (Fig. 6, in pocket) and FG (Fig. 7, in pocket) have been prepared in order to illustrate the changes which take place in the Beaverhill Lake Formation in northern Alberta and northeastern British Columbia and also to demonstrate the relationship between the Slave Point and Beaverhill Lake Formations.

Section ABC is based on Gamma Ray Neutron and Gamma Ray Sonic Logs whereas Section FG is a lithological section showing selected wells from the mechanical log section. Section ABC runs from Kotcho Lake near Fort Nelson to the Athabasca

River near McMurray (see Fig. 5). Section FG is entirely within northern Alberta running between the wells, Imperial Long Lake 11-10-107-7 W6 and Texaco R.O. Corp Mackay River 6-13-91-18 W4 (see Fig. 5).

No mechanical logs were run on the well used by Crickmay (1957) for the description of the Beaverhill Lake Members. However, there are now sufficient wells in the McMurray area to enable the members to be correlated to wells which have adequate mechanical log coverage. On section BC (see Fig. 6), the members have been traced out in the wells in which they show sufficiently distinctive log features. To the northwest the log character of each member is gradually lost so that beyond the well, California Standard Mikkwa 12-23-98-21 W4, it is no longer practical to recognize the separate members.

Although Crickmay's members can only be recognized in the eastern quarter of the area covered by Section ABC, it may be noted that in the east central part of the section the Beaverhill Lake Formation tends to fall into two natural units which bear a direct relationship to the members of the McMurray area. There is an upper unit which consists of an alternating sequence of argillaceous limestones and calcareous shales and a lower unit consisting mainly of calcareous shales with subordinate argillaceous limestones. The upper unit corresponds to the combined Mildred, Moberly, and Christina Members and the lower unit to the Calmut and Firebag Members of the Beaverhill Lake Formation. It is proposed to term the upper unit the Upper Beaverhill Lake unit and the lower unit the Lower Beaverhill Lake unit. The top of the Calmut and its equivalent to the west represents the horizon separating these two units.

It will be seen from the cross sections (see Figs. 6 and 7) that over much of the western half of the area of study (west of about R16 W5) even this twofold division of the Beaverhill Lake Formation tends to break down and the formation comes to consist of calcareous shales with subordinate interbedded argillaceous limestones. It is thus difficult to recognize the upper and lower units of the Beaverhill Lake Formation in this area, but the persistence of thin "marker" zones with a high calcareous content enables the horizon correlative with the top of the Calmut Member to be followed through to the well, HB Union Imperial Paddy #2 (c-74-B/94-H-16), in the eastern part of northeastern British Columbia.

The horizon corresponding to the top of the Calmut Member has been selected as the datum for Section FG and most of Section ABC. In the extreme western part of Section ABC this datum can no longer be used because of the loss of the Beaverhill Lake Formation. The base of the Slave Point Formation has therefore been used as the datum for the most westerly five wells of the Section ABC. The selection of a datum within the Beaverhill Lake enables stratigraphic changes taking place at the top and bottom of the formation to be demonstrated more readily than would be the case if the datum were placed either above or below the formation.

Most of the correlation lines shown on Figures 6 and 7 are based on a comparison of mechanical log features, which in turn usually reflect lithological changes. In those instances where the correlation between adjacent wells of the section was somewhat tenuous additional well control and other types of logs were used to corroborate the correlations shown. Some important lithological changes cannot be recognized from the mechanical logs. In the case of Section ABC it was not possible to recognize the break between the Slave Point Limestone and Fort Vermilion Anhydrite using mechanical logs alone. The correlations shown on the section for this horizon are derived from information kindly provided by Canadian Stratigraphic Service, Ltd. of Calgary, Alberta. Information provided by this agency has also been used as a guide in establishing the top of the Prairie Evaporites and Muskeg Formation in the wells shown in Figure 6.

The lithological section of Figure 7 supplements the mechanical log section and demonstrates the lithological changes which take place in the Beaverhill Lake Formation. The section was prepared from drill cutting samples examined by the writer at the Core Storage Centre of the Alberta Oil and Gas Conservation Board, Calgary.

The actual direction and form of Section ABC is governed by three main factors. First, the section is arranged so that its overall orientation is approximately at right angles to the facies strike of the Beaverhill Lake and Slave Point Formations. Secondly, the section has been kept well to the north of the Peace River Arch so that it lies in an area where the influence of this tectonic feature is slight. Thirdly, the individual control points were selected to form a zigzag pattern so that the line between adjacent control points lies at a low angle to the facies strike, thus keeping the lithological differences between these points to a minimum.

A consequence of the zigzag nature of Section ABC is the slight variation in thickness shown by the Beaverhill Lake Formation especially in the eastern half of the section. The Beaverhill Lake thins and eventually passes out over the Peace River Arch. As a result the wells of Section BC (see Fig. 6) closest to the Peace River Arch (see Fig. 5) show slightly thinner sections of the Beaverhill Lake than those farther to the northeast.

LITHOLOGY AND DISTRIBUTION IN NORTHERN ALBERTA

The Beaverhill Lake Formation is widely distributed in northern Alberta (see Fig. 11). The formation is underlain by the Slave Point Formation and overlain conformably by the Fort Simpson Formation in the east and unconformably by the Muskwa Formation in the west.

In the subsurface of the central part of northern Alberta a more or less complete succession of the Beaverhill Lake Formation is developed. It varies between about 500 and 600 feet in thickness. In the southwest of the area the Beaverhill Lake wedges out on the northern and eastern flanks of the Peace River Arch.

In the extreme eastern part of northern Alberta the Beaverhill Lake Formation was subjected to erosion before the deposition of the overlying Cretaceous sediments. As a result of recent erosion the Beaverhill Lake is now exposed in a broad area of Devonian outcrops which parallel the edge of the Precambrian Shield in the northeast corner of the province.

Changes occur in both the thickness and lithology of the Beaverhill Lake Formation as it is traced across northern Alberta. The changes in the thickness of the formation can be attributed to two principal causes. First, there are what are believed to be facies changes in the Lower Beaverhill Lake unit. These are dealt with more fully in the following section. Secondly, there are the effects of the pre-Muskwa erosion as shown in Figure 6 which demonstrates that as the Beaverhill Lake is traced to the northwest the uppermost beds are successively truncated, indicating that the Beaverhill Lake Formation was eroded before the deposition of the overlying Muskwa Formation. At Ohio Bede Creek 10-23-106-20 W6 the Muskwa lies above almost 500 feet of Beaverhill Lake; in the Kotcho Lake area, however, the Muskwa lies directly upon the Slave Point. The line of pinch out of the Beaverhill Lake is shown in Figure 11.

That there was depositional thinning of part of the Beaverhill Lake in the area of truncation is possible but correlations suggest that it was not a major cause of the stratigraphic thinning of the Beaverhill Lake.

The lithological changes in the Beaverhill Lake are illustrated by Section FG (see Fig. 7). In the east the Upper Beaverhill Lake unit consists mainly of dense, argillaceous, light grey with subordinate light brownish grey limestones alternating with medium light grey to light grey and minor brownish grey calcareous shales. Toward the west the argillaceous limestones become less common and in the central part of Section FG calcareous shale is the dominant constituent of the Upper Beaverhill Lake.

In the western part of Section FG the Upper Beaverhill Lake unit is made up largely of medium dark grey to dark grey and brownish grey, slightly calcareous shales. The darker colour of these rocks is probably due to the fact that they contain less calcareous material than the shales to the east.

The Lower Beaverhill Lake unit also shows a westward change from a sequence consisting of argillaceous limestones and calcareous shales to one consisting largely of shale. However, in the east the Lower Beaverhill Lake contains a higher proportion of shale than the overlying unit, and in the western areas the shales of the lower unit are more calcareous than those of the Upper Beaverhill Lake.

LITHOLOGY AND DISTRIBUTION IN NORTHEASTERN BRITISH COLUMBIA

The Beaverhill Lake Formation of northeastern British Columbia varies between zero and 350 feet in thickness. An isopach map of the formation is shown in Figure 8 and the depths to the top and bottom of the formation in all the British Columbia wells which penetrated it at January 1, 1963, are given in Appendix I. The formation attains its greatest thickness in the Chinchaga area (approximately latitude 57 degrees 30 minutes north, longitude 120 degrees 30 minutes west). To the south of this area the formation pinches out against the Peace River Arch. Possibly it is represented by arenaceous and silty deposits in the wells, Imperial Pacific Siphon Creek 1-26-86-16 W6 and Southern Production Atlantic B7-1 (12-33-85-16 W6). To the northwest the formation thins and is lost completely north of about latitude 59 degrees north in northeastern British Columbia.

In northeastern British Columbia the Beaverhill Lake Formation is underlain by the Slave Point Formation and unconformably overlain by the Muskwa Formation. The nature of the contact between the Beaverhill Lake and Slave Point Formations is considered in a later section (see pp. 35-38).

It is important for the purposes of the present investigation to interpret the stratigraphic equivalence, in terms of the Alberta section, of the Beaverhill Lake Shale developed in northeastern British Columbia. As noted above the maximum thickness of the Beaverhill Lake in the subsurface of northeastern British Columbia is in the Chinchaga area. The current evidence suggests that the 300 to 350 feet of Beaverhill Lake present in this area is a local thickening of the Beaverhill Lake Formation in the Paddy area. The Slave Point is similarly thickened in the Chinchaga wells. Thus an interpretation of the succession in the Paddy area gives a good indication of the maximum development of the Beaverhill Lake Formation in the subsurface of northeastern British Columbia.

The Beaverhill Lake Formation in the well, HB Union Imperial Paddy No. 2 (c-74-B/94-H-16) is represented by the upper part of the Lower Beaverhill Lake unit and the lower part of the Upper Beaverhill Lake unit (see Fig. 6). In terms of the succession at McMurray therefore the Beaverhill Lake of the Paddy well is equivalent to the upper part of the Firebag Member, the Calmut Member, and a substantial part of the Christina Member of that area.

The Beaverhill Lake Formation is cored in four wells in northeastern British Columbia to give a total cored footage of 59 feet. The cores indicate that the Beaverhill Lake consists mainly of medium dark grey, calcareous to non-calcareous shales (see

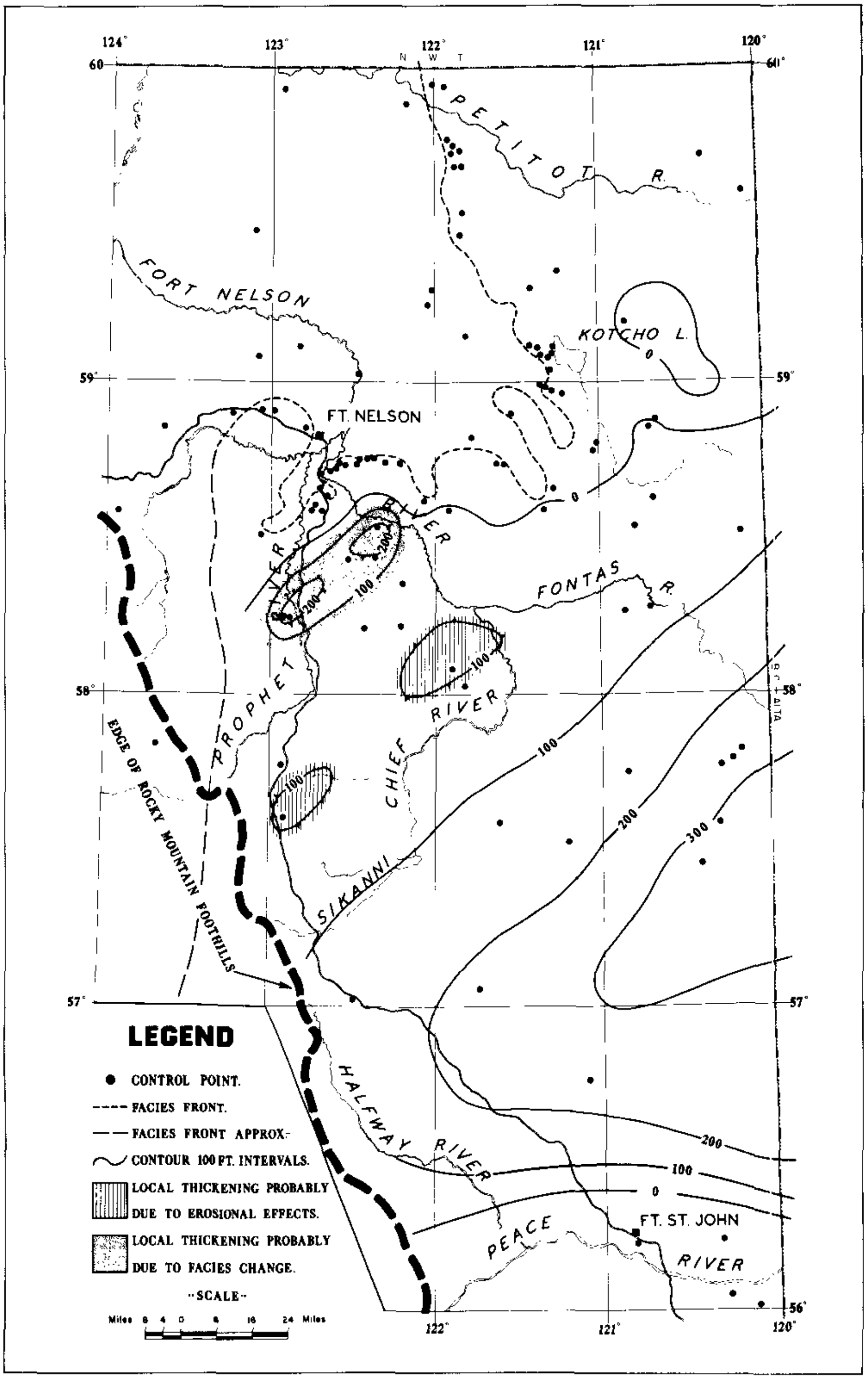

Figure 8.--Isopach map of the Beaverhill Lake Formation in northeastern British Columbia.

Appendix II). The shales are pyritic in places with the pyrite occurring either finely disseminated or as single crystals up to 1.5 millimeters across. In some parts of the Beaverhill Lake Shale small chitinous brachiopods occur; chitinous material may also occur as small fragments generally less than 1 millimeter in diameter.

In places the Beaverhill Lake Shale grades to argillaceous limestone which in some instances contains poorly preserved brachiopods. Fragmented biogenic material in the size range 1-2 millimeters may also be present in the zones of argillaceous limestone.

Drill cutting samples from the wells which penetrate the Beaverhill Lake Formation in northeastern British Columbia indicate that brownish grey and grey, mainly argillaceous limestones make up a small but important part of the formation. Other rock types which occur in the drill cutting samples from the Beaverhill Lake are brownish grey calcareous shale and occasional calcareous siltstone.

Similarities and differences between the Beaverhill Lake Formation and the associated shale units are as follows: The Beaverhill Lake shales are similar to those of the Otter Park Member, but Gray and Kassube (1963, p. 483) noted that in the latter unit limestone beds are absent or very rare. In this respect then the Otter Park differs from the Beaverhill Lake in which limestone beds are relatively common. The Beaverhill Lake shales differ from those of the Fort Simpson Formation in containing higher proportions of calcareous material and interbedded limestone. The Beaverhill Lake and Otter Park show similar mechanical log features and both can be distinguished from the Fort Simpson by their lower radioactivity and the lower readings on the interval transit time log.

CORRELATION OF THE SLAVE POINT AND BEAVERHILL LAKE FORMATIONS

In the past it has usually been assumed that the Beaverhill Lake Formation was deposited conformably upon the Slave Point Limestone after deposition of the latter had terminated. Law (1955, p. 1945) considered the contact between the Slave Point Formation and overlying shales to be in places abrupt but probably conformable. His conclusion was based on the study of the Slave Point throughout northern Alberta. Belyea (1952, p. 12) who likewise considered an extensive area noted that there was a sharp contact between the units now defined as the Beaverhill Lake and Slave Point Formations. She did not, however, consider that the contact was disconformable.

Crickmay (1957, p. 10) on the other hand states that a disconformity is present between the Slave Point equivalent and the Beaverhill Lake in the well, Bear Biltmore No. 1. Norris (1963, pp. 22-25), however, who examined numerous sections in the vicinity of the Biltmore well does not consider that there is strong evidence of a disconformity at the top of the Slave Point (Norris' Livock River) in the area. In fact he presented evidence which suggests that in the McMurray area the Slave Point and overlying beds (the Firebag Member) are genetically related. In the Gypsum Cliffs area on the Peace River, however, Norris (op. cit. pp. 61-65) considered that an unconformity was present between the Slave Point Formation and the overlying Peace Point Member (probably equivalent to the Firebag Member); his strongest evidence for the unconformity being the sharp faunal and lithological break between the two units. However, Norris was dealing with a comparatively small area and the faunal and lithological changes can be explained by other means.

The usual concept of a sharp but conformable contact between the Slave Point and Beaverhill Lake Formations appears to be quite in keeping with the facts when only the eastern sections are considered. Further west, however, both the Slave Point and Beaverhill Lake Formations undergo changes which suggest that an alternative interpretation is required to explain the regional stratigraphic relationships of the two.

In the following discussion the term Slave Point refers only to the Slave Point Limestone; the Fort Vermilion Anhydrite is not included. The reason for this usage has been mentioned previously (see p. 16) and will become more apparent as the discussion proceeds.

Two main alternative explanations for the observed stratigraphic relationship between the Slave Point and Beaverhill Lake Formations may be interpreted from Figures 6 and 7. Either the Beaverhill Lake lies upon the Slave Point as a result of having been deposited during a later period, or the Slave Point and Beaverhill Lake are correlative facies of a single period of sedimentation, the former facies being gradually replaced by the latter as deposition progressed. The facies concept is suggested by the thinning of the Lower Beaverhill Lake unit toward the west as the Slave Point thickens. With regard to the first interpretation two slightly different variations may be recognized--either the Beaverhill Lake overlies the Slave Point conformably or there is a disconformable relationship between the two formations. These various alternatives are discussed below and are shown diagrammatically in Figure 9.

1. (a) The possibility that the Beaverhill Lake was deposited upon the Slave Point after a period of uplift and erosion and thus overlies it disconformably will be considered first. As noted previously both Belyea (1952) and Law (1955) discounted the possibility of a disconformity between the Slave Point and the overlying shales in northern Alberta. The cross section ABC (see Fig. 6) lends support to their view. The thinning of the Slave Point Formation to the east is extremely gradual and is compensated

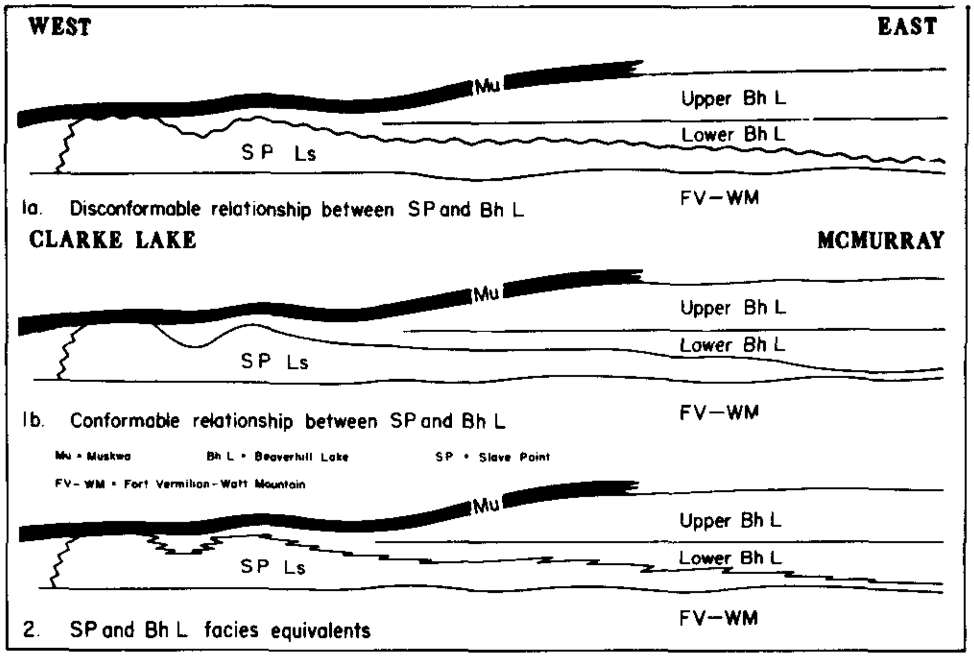

Figure 9.--Diagrammatic sections showing the Slave Point and associated formations between Clarke Lake and McMurray to illustrate the alternative interpretations of the relationship between the Slave Point and Beaverhill Lake Formations. 1a. Disconformable relationship. 1b. Normal conformable relationship. 2. Facies equivalence.

for, to a considerable extent, by a thickening of the Lower Beaverhill Lake unit.

In northern Alberta the Slave Point thins at a rate of less than 1 foot per mile. This is considerably less than the rate of thinning shown by formations in the same area which are known to have been truncated by erosion.

A relatively thin sequence of Slave Point is distributed over a very wide area and it would be reasonable to expect that if erosion accounted for the thinning of the formation, inliers of Elk Point evaporites would be present within the Slave Point subcrop. This phenomenon has not been observed. There seems little basis for the assumption that there is an erosional break between the Slave Point and the Beaverhill Lake Formations in the area under discussion.

1. (b) *If the Beaverhill Lake was deposited after the deposition of the Slave* Point and overlies it conformably then a satisfactory explanation of the thinning of the Slave Point within the limits imposed by the concept of normal depositional thinning is required. This interpretation provides three main alternatives. Either the thin Slave Point section in the east is an attenuated sequence resulting from nearshore deposition, or the thinning of the formation is a consequence of regressive deposition, or as a final alternative the thinning may be considered to result from transgressive deposition.

The first possibility which involves the concept of nearshore deposition is con- sidered unlikely because of the extremely gradual thinning of the formation over a large area. The effect of a landmass or other positive area on the depositional thickness of a unit is usually most marked in the immediate vicinity of the positive area. The Elk Point

Group, for example, is fairly uniform in thickness over much of northwestern Alberta as the map of Law (1955, Fig. 7, p. 1946) and the Elk Point isopach map and section of Govett (1961, p. 40) demonstrate. There is, however, a rapid thinning of the Upper Elk Point toward a positive area in the 50 miles between the well, Bear Biltmore No. 1 and McMurray town. A similar situation exists in northeastern British Columbia where various units of the Middle Devonian Series maintain their thickness over much of the area in question but thin rapidly against the Peace River Arch. The extremely gradual thinning of the Slave Point over a large area therefore does not favour the interpretation that it results from deposition against a landmass lying to the east.

The second possibility which assumes that the thinning of the Slave Point Formation is a result of deposition from a regressive sea is similarly difficult to accept in view of the established facts. If the Slave Point were essentially a regressive deposit it would be reasonable to expect that there would have been considerable evaporite deposition to the east of the area of potential reef development in British Columbia and the Northwest Territories. This is not the case and in fact one of the distinctive features of the Slave Point Formation as compared with the underlying Elk Point Group, which was largely regressive in the sense of Link (1950), is the fact that it consists mainly of limestone whereas the Elk Point is composed largely of dolomite and anhydrite.

It may be argued that the Fort Vermilion Member is an anhydritic basal unit of the Slave Point Formation and thus provides evidence for the regression hypothesis, but as pointed out previously there is strong evidence that this member belongs genetically with the Watt Mountain-Sulphur Point assemblage. Even if it were included with the Slave Point as a transitional basal member it would constitute only a subordinate component of the formation.

Finally, there is the possibility that the Slave Point Formation is a transgressive deposit thinning to the east because of onlap in that direction. This concept might be acceptable if it could be shown that the Slave Point lay upon an erosion surface or that there had been a period of marked regression in the area now occupied by the Slave Point prior to the deposition of the formation. Neither of these conditions can be demonstrated, however, and all the available evidence indicates that the change from the underlying beds to the Slave Point is of a transitional nature, particularly in the west. The concept that the Slave Point Formation is a single, simple transgressive deposit must therefore be discounted.

The above considerations provide strong evidence against interpreting the Slave Point Formation as having been deposited as a single, complete unit, which was followed by the deposition of the overlying argillaceous and calcareous sediments of the Beaverhill Lake Formation.

2. The Slave Point Formation may be interpreted as the facies equivalent of the lower part of the Beaverhill Lake Formation. This hypothesis implies that the Beaverhill Lake shales of the more eastern sections are gradually replaced by the Slave Point facies toward the west. This offers the most satisfactory solution of the Slave Point-Beaverhill Lake problem.

The uniform thickness of 250 to 300 feet between the top of the Calmut Member and the base of the Slave Point Limestone over much of northern Alberta provides strong evidence for the concept that the Slave Point and Beaverhill Lake Formations are facies equivalents. Toward the British Columbia border this interval thickens to about 400 feet. This may be attributed to two factors. There is probably a slight regional thickening of the interval toward the west and the differential compaction of limestone and shale would cause the sections with a considerable amount of limestone to be thicker than the correlative sections to the east in which shale is dominant.

The lateral change of the Beaverhill Lake shales to limestones of the Slave Point Formation is particularly evident in the area south and southeast of the Clarke Lake gas field in British Columbia (see Fig. 10 and isopach maps of Figs. 3 and 8). It will be seen from the section of Figure 10 that just to the south of the field the upper part of the thick section of Slave Point Limestone is replaced to the south by the shales of the Beaverhill Lake Formation. Further south again the pattern is repeated, so that the thick sequence of Slave Point in Woodley Imperial Klua a-27-G (94-J-8) and Pure Imperial Bull b-67-J (94-J-1) is replaced laterally by an upper section of Beaverhill Lake Shale and a lower interval of Slave Point Limestone in Imperial Sikanni Chief No. 1 (b-92-D/94-I-14). The facies interpretation of the Slave Point-Beaverhill Lake interval provides the most satisfactory explanation of the distribution of these limestones and shales.

The concept that the Beaverhill Lake Formation is laterally equivalent to dense stromatoporoid-bearing limestones is, of course, not new. Belyea (1952, p. 13) demonstrated that the Beaverhill Lake of the Edmonton area contains stromatoporoid limestones and Fong (1960, p. 207) demonstrated the equivalence of the Swan Hills Limestone with part of the Beaverhill Lake Formation. Furthermore, the concept that the Slave Point itself is laterally equivalent to calcareous shales is in keeping with the accepted interpretation of the relationship between the Otter Park Shale and the Slave Point Limestone (see Gray and Kassube, 1963).

If the concept of the stratigraphic equivalence of the Slave Point and Beaverhill Lake Formations be accepted then it is possible to relate the Slave Point of northeastern British Columbia to the correlative beds of eastern Alberta in some detail. As noted previously (see p. 32) the Beaverhill Lake in the Paddy area is equivalent to the upper part of the Firebag Member, the Calmut Member, and a substantial part of the Christina Member.

As the Beaverhill Lake-Slave Point interval is traced from the Paddy area to the Clarke Lake area there is only a slight increase in the thickness of the whole interval. In the western part of the Clarke Lake area, however, the Beaverhill Lake has passed completely to the Slave Point facies. On thickness correlations therefore it is reasonable to conclude that the thickest sections of the Slave Point Formation in northeastern British Columbia are equivalent to the Firebag Member, Calmut Member, and at least the lower part of the Christina Member of the Beaverhill Lake Formation. This interpretation allows for a slight truncation of the Slave Point-Beaverhill Lake interval between the Paddy wells and the western Clarke Lake area.

In general terms it can be stated that the Slave Point Formation of northeastern British Columbia is equivalent, depending on the location, either to all or part of the Lower Beaverhill Lake unit plus the basal Upper Beaverhill Lake unit. The actual section of Slave Point present at any one location depends on the extent to which the Beaverhill Lake has passed to the limestone facies and also on the amount of pre-Muskwa erosion. These factors are variable, but in general the erosional influences are dominant in the north whereas facies change is the main factor accounting for variations in thickness toward the west.

Koch (1962, p. 621) demonstrated that the fauna of the Swan Hills Member belongs to the *Allanaria allani* and *Eleutherokomma hamiltoni* zones of the middle Waterways Formation (approximately middle Beaverhill Lake). It can be reasonably inferred *therefore that the maximum development of the Slave Point Formation correlates approx*imately with the Swan Hills Member of the Beaverhill Lake Formation. Koch (op. cit.) however, did not consider the Slave Point and Beaverhill Lake Formations to be contemporaneous deposits. This is no doubt because his study of the Slave Point was restricted

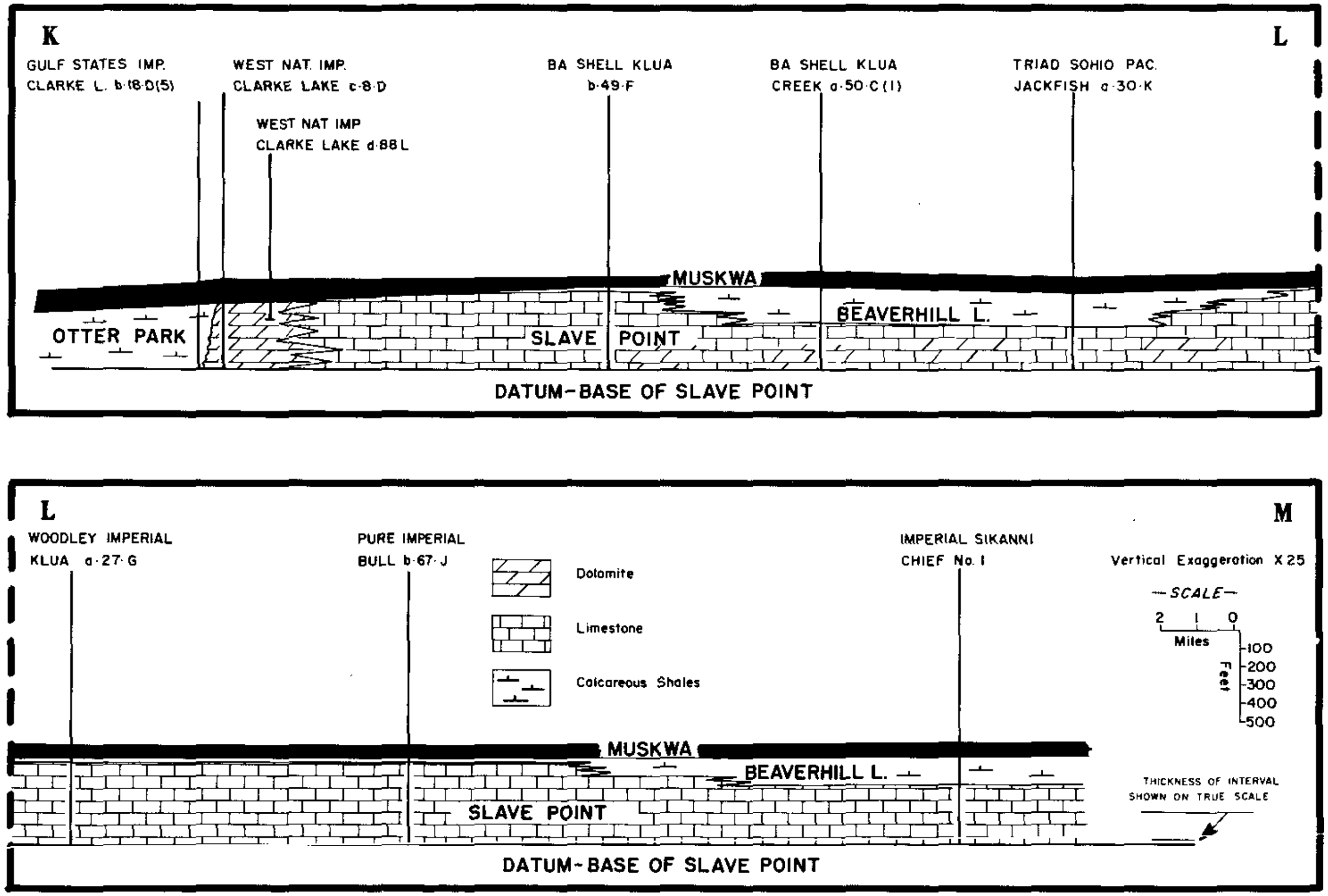

Figure 10.--Cross section KLM in the area south of Clarke Lake to show the relationship between the upper part of the Slave Point Formation and the Beaverhill Lake Shale. The line of section is shown on Figure 12.

to northwestern Alberta, an area in which this formation does not reach its full development.

Despite their correlation there is an important difference between the Slave Point Formation and the Swan Hills Limestone. The dimensions of the Swan Hills and associated reefs can be expressed in terms of tens of miles and they thus provide a depositional assemblage of reef, fore reef, and back reef beds of relatively small areal extent. In the case of the Slave Point and Beaverhill Lake Formations, however, the natural depositional assemblage is of basin-wide proportions and one is thus dealing with a phenomenon of a comparable nature but developed on a very different scale. It is rather like the comparison between a single platform reef such as Batt Reef (see Fairbridge, 1950, p. 345) in the Australian barrier reef complex and the whole complex itself which covers a considerable proportion of the eastern continental shelf of Australia between the favourable latitudes. It is probably the basin-wide extent of the Slave Point-Beaverhill Lake phenomenon which has tended to obscure its true nature.

A corollary to the correlation of the Slave Point Formation with part of the Beaverhill Lake Formation is the correlation of the upper part of the Otter Park Member of the Horn River Formation with the lower portion of the Beaverhill Lake (see Fig. 2). The equivalence of these two units could lead to some confusion in nomenclature, but it is suggested that this can be avoided by continuing the present practice of naming the calcareous shales below the Muskwa Formation to the west of the facies front the Otter Park Member and the corresponding shales to the east of the front the Beaverhill Lake Formation.

DEPOSITION OF THE SLAVE POINT FORMATION

On the basis of the facies interpretation it can be inferred that Beaverhill Lake sediments gradually spread westward encroaching on the areas of Slave Point sedimentation, slowly replacing them. At some time during the Upper Beaverhill Lake the Slave Point must have been completely engulfed by Beaverhill Lake sediments bringing an end to Slave Point deposition. In view of the apparent mutually exclusive nature of the Beaverhill Lake and Slave Point sediments, it seems reasonable to enquire why the Beaverhill Lake so successfully terminated the deposition of the Slave Point in the areas in which it became established. There are two lines of evidence which may be pursued in this connection; one deals with the lithological nature of the two formations and the other with the faunas of the formations.

The main and apparently most significant difference between the lithology of the Slave Point and the Beaverhill Lake Formations lies in the high argillaceous content of the latter and the relatively pure calcareous composition of the former. Here then lies an explanation of the sharp termination of Slave Point deposition. The Beaverhill Lake simply represents an influx of terrigenous material into an area which had previously been dominated by evaporitic and carbonate deposition. In view of this it might be argued that the Beaverhill Lake merely represents a sort of "argillaceous Slave Point," but considerations of the fauna of the formations indicate that this is not the case.

The Slave Point fauna is dominated by stromatoporoids, especially toward the west. Other important elements of the fauna are tabulate corals, brachiopods, crinoids (?), and ostracodes. Gasteropods, rugose corals, and foraminifera are less common members of the fauna. These organisms in conjunction with the numerous soft-bodied creatures or "occult benthos" of Beales (1963, p. 681) must have formed a complex biota adjusted to conditions in an environment almost free of terrigenous material. It is also probable that the physicochemical environment in which this biota lived, and in fact was partly responsible for producing, had an important influence on the sedimentary processes resulting in the formation of the Slave Point limestone. In such a balanced complex or fabric of interacting organic and inorganic elements it is easy to envisage that if part of the fabric were broken by the intrusion of some deleterious agency then the whole system might soon break down.

It is concluded therefore that if some element of the Slave Point fauna or flora was not viable in the conditions of increased argillaceous sedimentation and probable reduced salinity which accompanied the onset of Beaverhill Lake sedimentation, then the biota and physicochemical environment responsible for the formation of the Slave Point limestone could soon be sufficiently upset to bring about an end to its deposition. In these circumstances of changed sedimentation a new biota would soon become established which was adapted to the more argillaceous environment of the sea floor.

The stromatoporoids provide an obvious example of a group of organisms which were not well adapted to a muddy environment (see Galloway, 1957, pp. 400-403) and they may well have been stenohaline as are the modern corals. It is tempting to suggest therefore that these organisms were the "weak" link in the chain which enabled the Beaverhill Lake sediments to slowly eliminate the Slave Point biota.

In any event it is clear from the fossil record that once Beaverhill Lake conditions of sedimentation were established in parts of northern Alberta and British Columbia, a biota differing from that of the Slave Point became established. Brachiopods form the main element of the preserved fauna of the Beaverhill Lake Formation whilst pelecypods are an important subordinate element (see Carrigy, 1959 and Norris, 1963 for description of megafauna). Ostracodes are a well represented group of microfossils in the formation (see McGill, 1963 and Loranger, 1963a, 1963b). Since the Slave Point and Beaverhill Lake Formations each has its own distinctive facies fauna, palaeontological correlation between the two formations is likely to be difficult.

The Slave Point is here interpreted as a limestone deposited during the widespread Beaverhill Lake transgression. The transgressive nature of the deposit explains why it differs markedly from the underlying evaporitic strata which are the deposits of a regressive or static sea. This genetic concept of the Slave Point Formation is of assistance in the interpretation and classification of the underlying beds. The Fort Vermilion Anhydrite for example naturally belongs with the main evaporitic sequence even though it is separated from the latter by the clastic Watt Mountain of the eastern sections. It appears that the upper part of the Sulphur Point Formation, the Watt Mountain Formation, and Fort Vermilion Anhydrite were all deposited during oscillating conditions which prevailed prior to the onset of the main transgressive phase.

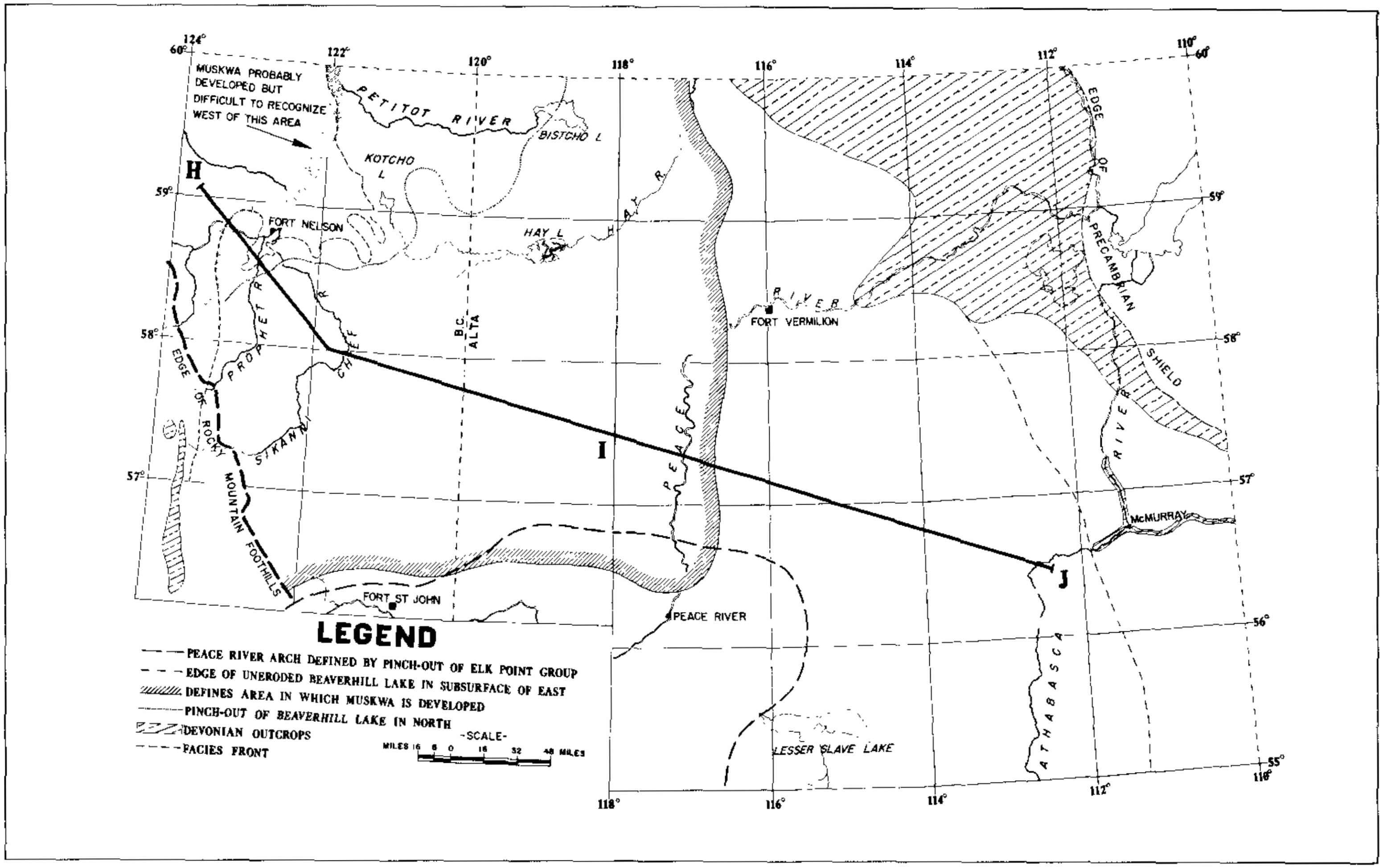

Figure 11.--Map of northeastern British Columbia and northern Alberta showing the major features of the distribution of the Muskwa and Beaverhill Lake Formations and the line of Section HIJ.

MUSKWA FORMATION

PREVIOUS DESCRIPTION AND CORRELATION

Gray and Kassube (1963, p. 473) introduced the term Muskwa Member and applied it to a sequence of black bituminous shales which overlie the Slave Point Formation in the vicinity of the Clarke Lake gas field in northeastern British Columbia. They considered the Muskwa to be the uppermost member of the Horn River Formation. However, for reasons which will be discussed below it is suggested that the Muskwa Member should be separated from the Horn River Formation and recognized as an independent formation. Gray and Kassube (op. cit., p. 480) designated the interval between 6,510 and 6,630 feet in the well, Gulf States Fort Nelson No. 2 (a-95-J/94-J-10) as the type section of the Muskwa. The following lithological description was given: "The member consists of black bituminous shale with abundant pyrite as isolated or clustered medium crystalline cubes, or finely disseminated; the shale is locally soft, micaceous and flaky, in places hard and siliceous. Its outstanding characteristic is its high radioactivity on well logs."

The Muskwa Formation has previously only been recognized in northeastern British Columbia. In the Clarke Lake area Gray and Kassube (1963, p. 483) demonstrated that the Muskwa lies either between the Fort Simpson and Slave Point Formations or, in areas where the Slave Point has changed to shale, between the Fort Simpson Formation and Otter Park Member. South of Clarke Lake they considered that the Muskwa Shale merged into part of the Beaverhill Lake Formation.

DISTRIBUTION

The Muskwa Shale can be traced, using Gamma Ray Logs, from the area of type section through most of northeastern British Columbia and into northwestern Alberta. The distribution of the formation in Alberta and British Columbia is shown in Figure 11.

In British Columbia the Muskwa varies between 50 and 100 feet in thickness over most of its area of distribution (see Fig. 12). There are a few local areas in which it exceeds 100 feet in thickness. To the south the formation thins and finally wedges out on the flanks of the Peace River Arch. In the northwest the Muskwa varies considerably in thickness and the Gamma Ray Logs suggest that the unit thickens and passes westward, by way of an intertonguing relationship, into the Besa River Shale. It is difficult to recognize the Muskwa with certainty west of the zone of variable thickness shown in Figure 12.

In Alberta the Muskwa Formation can be recognized in the area bounded on the south approximately by Township 84 and on the east by Range 15 west of the 5th Meridian. Throughout most of this area the formation is between 50 and 100 feet in thickness. To the northeast, however, the formation attains a thickness of between 150 and 250 feet, gradually loses its distinctive character, and finally passes into the Fort Simpson Formation.

The Gamma Ray Log provides the best means of establishing the top and base of the Muskwa Formation. The typical Gamma Ray curve of the formation gradually moves to higher values from the normal shale line of the overlying Fort Simpson Formation, until a maximum is reached near the base of the Muskwa. The curve then returns rapidly to the low values of the Slave Point Limestone, or to intermediate values in areas where the Muskwa is underlain by calcareous shales.

The drill cutting samples from the zones of high radioactivity often contain

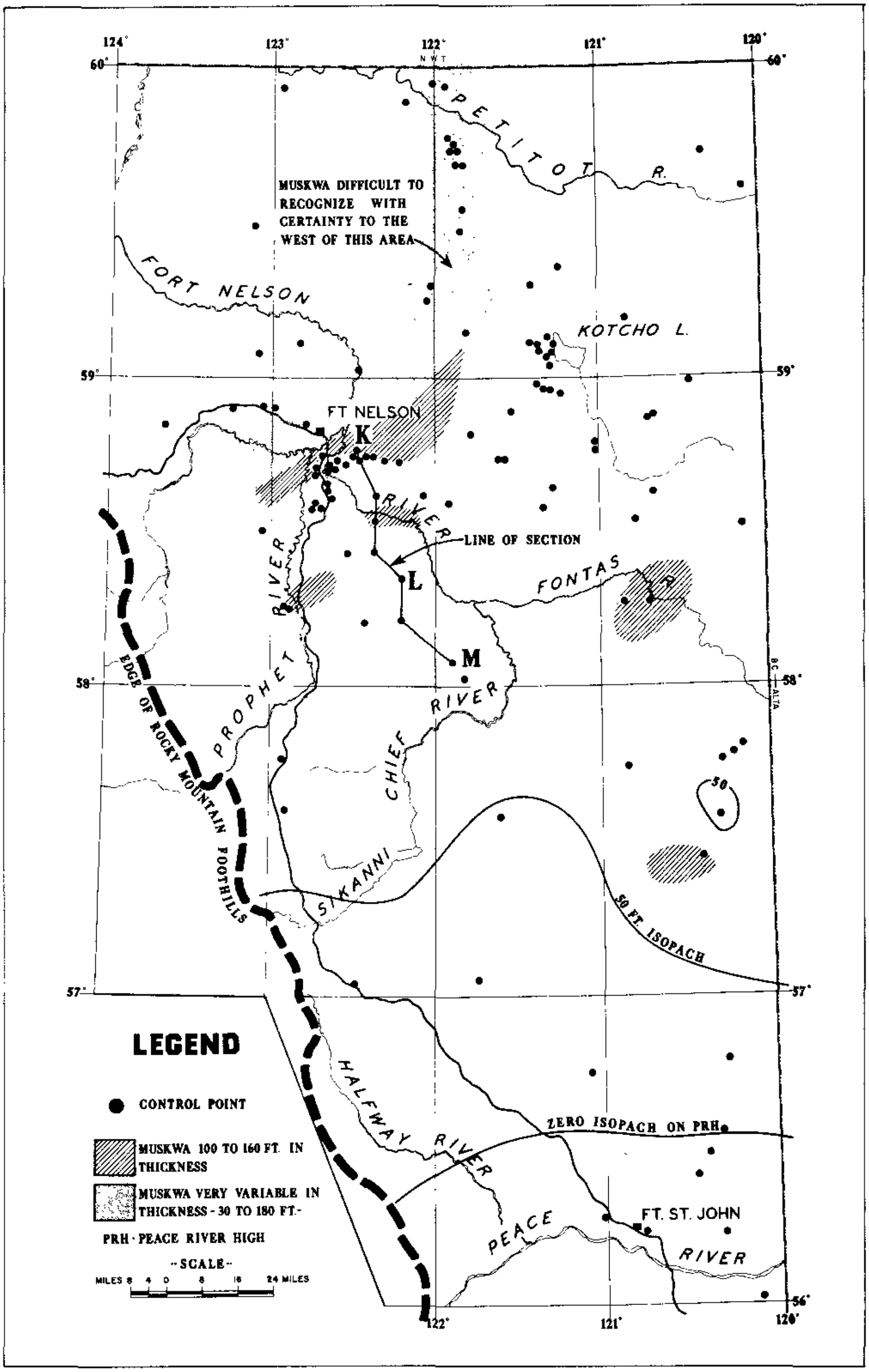

Figure 12.--Map showing distribution and thickness of Muskwa Formation in northeastern British Columbia.

abundant greyish black shale. In most cases, however, the samples do not enable the precise limits of the formation to be established, largely because of shale contamination.

As a consequence of the shape of the Gamma Ray curve of the Muskwa it is a straightforward matter to pick the base of the formation. The transitional nature of the upper part of the curve, however, means that the upper limit must be established on an arbitrary basis. In this study the top of the formation is taken 30 to 40 feet below the point at which the increasing radioactivity associated with the Fort Simpson-Muskwa contact first becomes evident. The depths of the top and base of the Muskwa Formation in all wells in northeastern British Columbia which penetrated the formation at January 1, 1963, are listed in Appendix I.

In the northwest and northeast of the area of development of the Muskwa in British Columbia and Alberta the Gamma Ray curve does not show the typical form, and zones of high radioactivity alternate with zones of intermediate radioactivity over an interval of 100 to 250 feet. It is thus difficult to establish the exact limits of the Muskwa in these areas. This is especially so in the northwest where the underlying Otter Park Member also contains radioactive zones which can easily be confused with the Muskwa.

LITHOLOGY

The Muskwa Formation has been cored in the wells West Nat Kotcho a-9-F (94-P-3) (see Appendix II) and Pan Am et al A-1 Snake River c-28-D (94-O-1). The best of the cored sections lies between the depths 6,636 and 6,656 (?) feet in the former well. The major part of the cored interval consists of greyish black, non-calcareous to slightly calcareous, moderately pyritic shale which shows brown coloured score marks when scratched. At the base of this cored section the contact between the greyish black shale and the brownish grey Slave Point Limestone is preserved. However, this contact is not simple and a short sequence at the base of the core may belong to the Otter Park Member (see Appendix II).

The Muskwa core of West Nat Kotcho a-9-F (94-P-3) shows numerous zones in which crystals of authigenic barite are common. Seven such zones were counted in the cored section; the thickest zones cover an interval of 2½ inches.

The lithology of the Muskwa has not been extensively studied in northern Alberta. However, there is no reason to believe that it differs greatly from the unit as developed in northeastern British Columbia.

STRATIGRAPHIC RELATIONSHIPS

The form of the typical Gamma Ray curve of the Muskwa Shale enables certain suggestions to be made regarding the relationship of the formation to the underlying and overlying beds. The sharp decrease in radioactivity defining the base of the Muskwa suggests a stratigraphic break between the Muskwa and the underlying beds. Also, the Gamma Ray curve shows evidence of a transitional contact between the Muskwa and the overlying Fort Simpson Formation.

The abrupt lower contact of the Muskwa Formation is readily explained in view of the fact that the formation overlies an erosion surface (see Fig. 6 and discussion of Beaverhill Lake Formation, p. 31). Over most of northeastern British Columbia and Alberta the Muskwa overlies the eroded Beaverhill Lake Formation. In the northwest of this area, however, the formation lies upon the eroded Slave Point Formation. The pinch out of the Beaverhill Lake shown on Figure 11 indicates the line of demarcation between these two areas. In the area where the Slave Point has passed to shale the Muskwa unconformably overlies the Otter Park Member of the Horn River Formation.

In the area of study considerable pre-Muskwa erosion occurred north of latitude 58 degrees 30 minutes north in the vicinity of the British Columbia-Alberta boundary (see Fig. 11). There the Muskwa lies on a Slave Point section varying between 175 and 300 feet in thickness. Regional stratigraphic trends suggest that more extensive erosion occurred further to the west. In the western areas, however, the position of the unconformity cannot as yet be established because of the difficulty of recognizing the Muskwa Shale as an independent unit within the Besa River Shale.

At the upper contact of the Muskwa, it is concluded that the transitional nature of the contact, suggested by the Gamma Ray Logs, results from a gradual change in the sedimentary environment which prevailed during the deposition of the Muskwa and the lower part of the Fort Simpson Formation.

The Muskwa thus constitutes a basal unit of the Fort Simpson Formation and as such it is appropriate to consider it either as a member of the Fort Simpson Formation or as an independent formation. It is proposed here that the unit should be given formational status. This course is thought preferable to maintaining the member status of the Muskwa with transfer to the Fort Simpson Formation, because future studies may again result in a modified interpretation of the unit and in such circumstances reclassification will be unnecessary if the formational status is adopted.

GEOLOGICAL HISTORY

Prior to the deposition of the Slave Point Limestone the area under consideration had been subjected to fluctuating conditions, which resulted in the deposition of argillaceous sediments and evaporites in the east and limestone and dolomite breccias together with both fine and coarse clastic deposits in the west. These sediments form the Watt Mountain-upper Sulphur Point-Fort Vermilion assemblage. This phase of sedimentation was followed by a marked change in environmental conditions and waters of normal salinity spread eastward over areas in which evaporitic sedimentation had previously been dominant. This in turn resulted in the eastward migration of the stromatoporoid biota which had previously been restricted to areas of reef development in the west. For a relatively brief period carbonate sedimentation prevailed over a very broad shelf occupying northeastern British Columbia, northern Alberta, and the adjacent part of the Northwest Territories.

Regional tectonic movements probably accompanied by climatic changes (these may have been more profound than the former) then brought about changes in the sedimentary pattern which were eventually to lead to the almost complete destruction of the stromatoporoid biota in the area being considered. Prior to this culmination, however, parts of northeastern British Columbia and northwestern Alberta were the site of prolific organic activity accompanied by carbonate sedimentation. These processes were especially marked along a line trending approximately north-northeast through northeastern British Columbia. To the west of this line, here termed the facies front, argillaceous sedimentation was dominant.

During this phase of limestone deposition argillaceous sediments of the Beaverhill Lake Formation gradually spread westward, resulting in the replacement of the Slave Point biota with one more suited to a muddy environment. Finally, at some time during the Upper Beaverhill Lake the argillaceous material covered much of the area in which limestone sedimentation had previously prevailed thus effectively bringing an end to Slave Point deposition. In the final stages of the Beaverhill Lake transgression it is possible that argillaceous sediments were deposited over the whole of the area under consideration, but proof of this has been destroyed by the post-Beaverhill Lake erosion.

At the end of Beaverhill Lake time uplift took place in northeastern British Columbia and in the northwestern part of Alberta. The erosion which followed was more severe in the north and as a result the Slave Point Formation was exposed and subjected to subaerial erosion north of about latitude 58 degrees 30 minutes north in British Columbia. Following this period of erosion submergence again took place and the dark radioactive shales of the Muskwa Formation were deposited over an area extending from just north of the present Peace River to the Northwest Territories and beyond. The deposition of the Muskwa marked the beginning of a new phase of sedimentation in which a thick sequence of argillaceous deposits (the Fort Simpson Formation) was laid down over much of northeastern British Columbia and northwestern Alberta.

Post-depositional changes resulted in the dolomitization of parts of the Slave Point Limestone and in the accumulation of natural gas in the vuggy secondary rock. The most extensive dolomitization occurred along the facies front. The facies contact probably provided a passage for migrating fluids which played an important part in the recrystallization process. Some of these migrating fluids were no doubt forced by compaction from the great body of shales lying to the west of the facies front. The natural gas which accumulated in the secondary dolomites was probably derived from the Slave Point Limestone itself. The abundance of fossils and carbonaceous material in the limestone supports this conclusion.

The Slave Point Formation was also dolomitized in areas lying at some distance from the facies front. In these instances, however, the dolomitization is not as extensive as that associated with the facies front. The cause of dolomitization in areas away from the facies front is not known with any degree of certainty but it may be associated with zones of faulting.

GAS IN THE SLAVE POINT FORMATION OF BRITISH COLUMBIA

At the present time there are three fields in northeastern British Columbia capable of producing gas from the Slave Point Formation. From north to south they are the Petitot River, Kotcho Lake, and Clarke Lake fields (see Fig. 13). The reservoir rock in these three fields consists largely of the white and grey dolomite of the facies front. In addition to the designated fields there are numerous other areas in which commercial quantities of gas have been obtained from the Slave Point Formation. Most of these are associated with the dolomitized rocks of the facies front; some however, are associated with dolomitized sections of the Slave Point lying to the east of the facies front. Wells capable of producing gas from the two different geological environments are listed and identified by distinctive symbols in Appendix I. They are also shown in the Slave Point isopach map of Figure 3.

The estimated gas reserves of the Slave Point Formation at January 1, 1963, were approximately two trillion cubic feet.* No Slave Point gas has been produced because the areas of potential production have not yet been tied into the provincial pipeline system.

Gray and Kassube (1963) recently gave a full account of the Clarke Lake gas field. The dolomite reservoir at Clarke Lake is of sinuous form, being approximately 1½

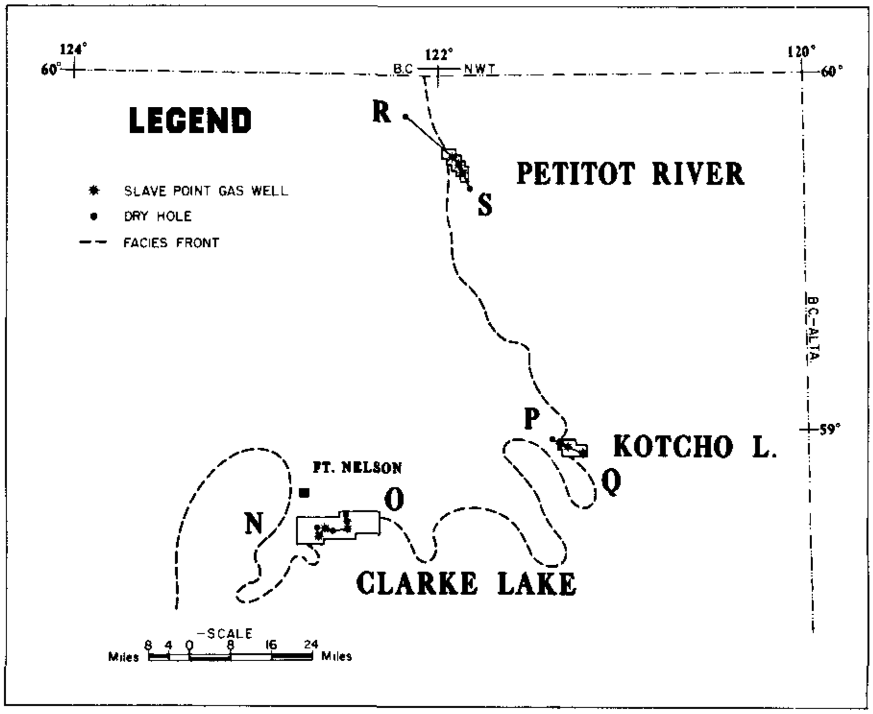

Figure 13.--Map showing Slave Point gas fields of northeastern British Columbia at January 1st, 1963 and lines of Sections NO, PQ, and RS.

*Departmental estimate of established disposable gas.

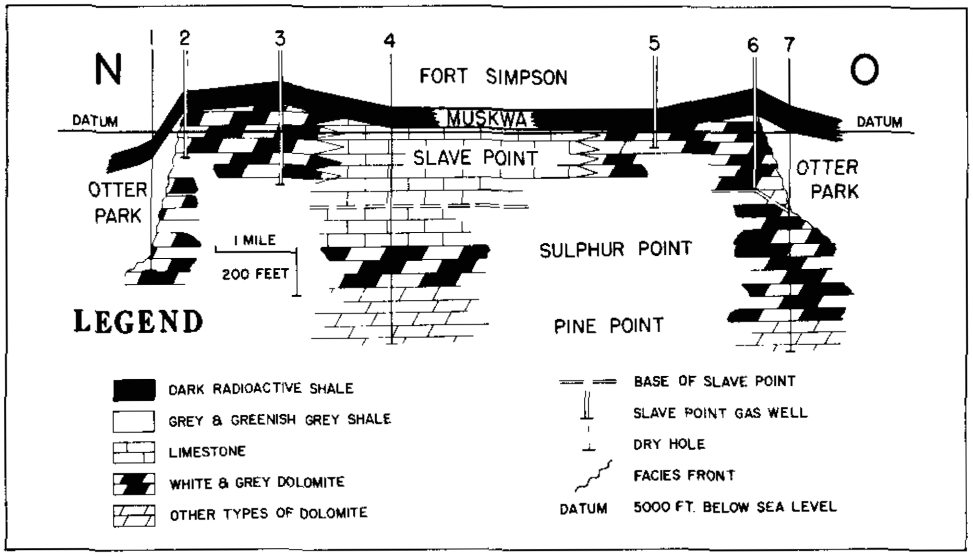

Figure 14.--Cross section NO--Clarke Lake field. Line of section is shown in Figure 13. Wells shown in section: (1) West Nat et al Fort Nelson c-70-I (94-J-10). (2) West Nat et al Clarke b-70-I (94-J-10). (3) West Nat et al Clarke c-78-I (94-J-10). (4) Gulf States-Imp Clarke L c-64-I (4) (94-J-10). (5) West Nat Imp Clarke Lake d-88-L (94-J-9). (6) West Nat Imp Clarke Lake c-8-D (94-J-16). (7) Gulf States Imp Clarke L b-18-D (94-J-16).

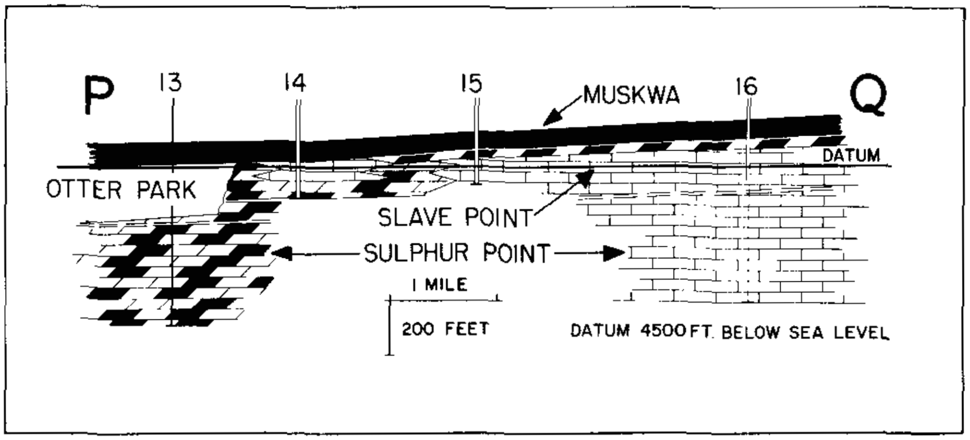

Figure 15.--Cross section PQ--Kotcho Lake field. See Figure 16 for legend. Wells shown in section: (13) Gulf States Kotcho Lake No. 2 d-79-K (94-I-14). (14) West Nat Kotcho Lake c-67-K (94-I-14). (15) West Nat Kotcho b-54-K (94-I-14). (16) West Nat Kotcho Lake d-39-J (94-I-14).

miles wide, more than 20 miles in length and reaching 360 feet in thickness (see Fig. 14). A gas/water contact has been established at 5,230 feet below sea level. The gas in the Clarke Lake and other Slave Point fields is of the sweet, dry type. Carbon dioxide and nitrogen are the main secondary constituents of the gas.

The discovery well of the Kotcho Lake field is West Nat Kotcho Lake c-67-K (94-I-14). It was completed on February 27, 1959. Three wells capable of production now lie in the field area. However, there are indications that several wells to the north have penetrated the same producing zone. As in the previous case the reservoir consists of the white and grey dolomite, but the form of the reservoir does not appear to be as simple as that of the Clarke Lake field (see Fig. 15). Although it is possible that a considerable interval of the white and grey dolomite is developed right at the facies front, wells which are interpreted as being a short distance to the east of the front show the development of thinner sections of dolomite which lie at various depths within the Slave Point Formation.

It seems probable that the producing zone, although well developed at the facies front, extends eastwards from the front as a series of thinner dolomitic tongues. A maximum of 120 feet of gross pay has been recognized in the field. At the present time the depth of the gas/water contact has not been established with certainty but is believed to lie at approximately 4,660 feet below sea level.

The Petitot River field lies close to the northern border of the province and currently contains three wells capable of producing gas from the Slave Point Formation (see Fig. 16). The discovery well is West Nat Petitot River d-24-D (94-P-13) which was completed on March 13, 1959. It is probable that the well, Pan Am et al Dilly a-30-K (94-P-12) which lies just 2 miles south of the field also produces from the same reservoir. The gross pay in the field reaches 142 feet in thickness and the gas/water

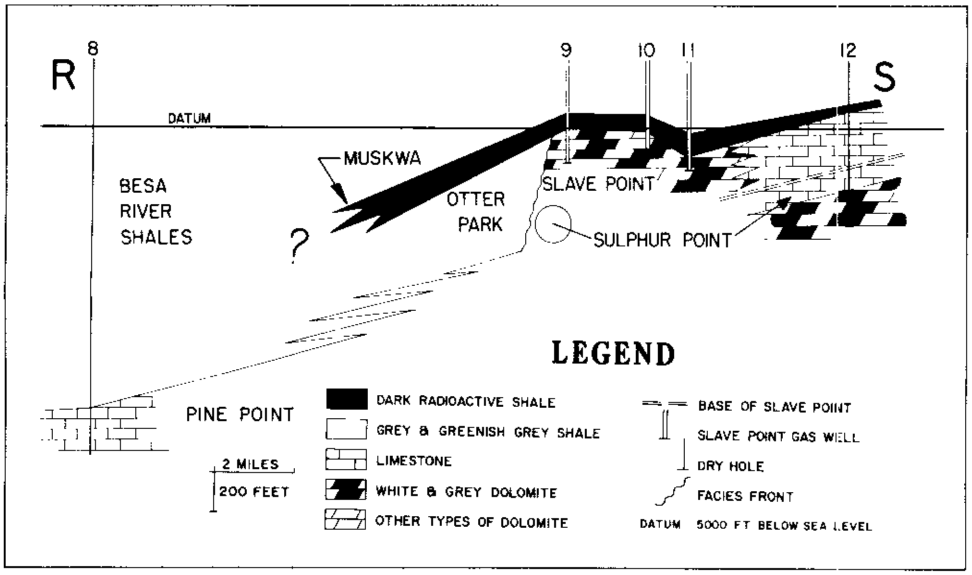

Figure 16.--Cross section RS--Petitot River field. Line of section is shown in Figure 13. Wells shown in section: (8) Pan Am Philis a-65-G (94-O-16). (9) West Nat Petitot River d-24-D (94-P-13). (10) West Nat Petitot River b-1-D (94-P-13). (11) West Nat Petitot b-90-K (94-P-12). (12) Pan Am et al Dilly a-27-K (94-P-12).

contact has been established at 5,167 feet below sea level. Production is from dolomitized rocks of the facies front and there is reason to believe that the reservoir is of linear form not unlike that of the Clarke Lake field. Potential Slave Point production also associated with the facies front has been found 12 miles north of the Petitot field in the Cam Lake area and 18 miles south of the field in the Tsea area.

A small amount of natural gas has been discovered in dolomitized sections of the Slave Point Formation lying to the east of the facies front. As indicated previously the dolomite of these areas is referred to as shelf dolomite. Examples of wells penetrating the shelf dolomite which are capable of production are HB Imperial Union Paddy a-49-B (1) (94-H-16) and BA Shell Klua Creek a-50-C (1) (94-J-9).

There are some cases in which it is difficult to be certain whether one is dealing with production from the facies front dolomite or the shelf dolomite. In these instances the well is so placed that the dolomitization could be explained satisfactorily by the assumption that the well lies on an indentation of the facies front and the dolomite in question is of the facies front type, or by the assumption that the well lies to the east of the front and the dolomite is of the shelf type (in Appendix I the designation of the dolomite type in these wells is followed by a query). This situation will be resolved only by further drilling which will enable the configuration of the facies front to be established with certainty.

During the 1961-62 drilling season several wells drilled to the south of the Kotcho Lake area encountered varying amounts of dolomite in the Slave Point Formation, but they did not obtain commercial quantities of natural gas. As in the case of the potentially productive wells just discussed the location of these wells is such that it is difficult to classify them with certainty as either facies front or shelf dolomite wells. In this study they are tentatively classified in the latter category (see Fig. 3 and Appendix I).

Assuming then that the shelf dolomite is not uncommon and bearing in mind that commercial quantities of gas have already been obtained from this dolomite in several wells, it is reasonable to conclude that the shelf dolomite offers an important second source of natural gas which will supplement the prolific reservoirs of the facies front. It is apparent, however, that seismic methods will not be as easily adapted to finding the shelf dolomite as they are to locating the facies front. No doubt other techniques will have to be used in addition to the seismic surveys in order to locate favourable areas for the development of this potentially productive dolomite.

REFERENCES

Beales, F.W. (1963): "Baldness of bedding surface," Am. Assoc. Pet. Geol., Bull., Vol. 47, No. 4, pp. 681-686.

Belyea, H.R. (1952): "Notes on the Devonian System of the north-central plains of Alberta," Geol. Surv., Canada, Paper 52-27.

Belyea, H.R. and Norris, A.W. (1962): "Middle Devonian and older Palaeozoic formations of southern District of Mackenzie and adjacent areas," Geol. Surv., Canada, Paper 62-15.

Cameron, A.E. (1917): "Reconnaissance on Great Slave Lake, Northwest Territories," Geol. Surv., Canada, Sum. Rept., 1916, pp. 66-76.

________ (1918): "Explorations in the vicinity of Great Slave Lake," Geol. Surv., Canada, Sum. Rept., 1917, Pt. C, pp. 21-28.

________ (1922): "Hay and Buffalo Rivers, Great Slave Lake, and adjacent country," Geol. Surv., Canada, Sum. Rept., 1921, Pt. B, pp. 1-44.

Campbell, N. (1950): "The Middle Devonian in the Pine Point area, N.W.T.," Proc., Geol. Assoc. Canada, Vol. 3, pp. 87-96.

________ (1957): "Stratigraphy and structure of Pine Point area, N.W.T.," in Structural Geology of Canadian Ore Deposits, Vol. II, 6th Commonwealth Mining and Metallurgical Congress, Canada, pp. 161-174.

Carozzi, A.V. (1960): Microscopic sedimentary petrography, John Wiley and Sons, New York.

Carrigy, M.A. (1959): "Geology of the McMurray Formation, Pt. III: General geology of the McMurray area," Res. Coun. Alberta, Mem. 1.

Crickmay, C.H. (1957): "Elucidation of some Western Canada Devonian formations," published by the author, Imperial Oil Ltd., Calgary.

Douglas, R.J.W. (1959): "Great Slave and Trout River map-areas, Northwest Territories (85 S½ and 95A, H)," Geol. Surv., Canada, Paper 58-11.

Fairbridge, R.W. (1950): "Recent and Pleistocene coral reefs of Australia," Jour. Geol., Vol. 58, No. 4, pp. 330-401.

Folk, R.L. (1959): "Practical petrographic classifications of limestones," Am. Assoc. Pet. Geol., Bull., Vol. 43, No. 1, pp. 1-38.

________ (1962): "Spectral subdivision of limestone types," Am. Assoc. Pet. Geol., Mem. 1: Classification of carbonate rocks, edited by W.E. Ham, pp. 62-84.

Fong, G. (1960): "Geology of Devonian Beaverhill Lake Formation, Swan Hills area, Alberta, Canada," Am. Assoc. Pet. Geol., Bull., Vol. 44, No. 2, pp. 195-209.

Gallant, B.T. (1962): "Brief notes on the Lower Palaeozoic rocks of the Rocky Mountains along the Peace River, B.C.," Edmonton Geol. Soc., Fourth Annual Field Trip Guide Book, pp. 102-108.

Galloway, J.J. (1957): "Structure and classification of the Stromatoporoidea," Bull. Am. Paleont., Vol. 37, No. 164, pp. 345-480.

Govett, G.J.S. (1961): "Occurrence and stratigraphy of some gypsum and anhydrite deposits in Alberta," Res. Coun. Alberta, Bull. 7.

Gray, F.F., Kassube, J.R., and Van de Venter, J.H. (1962): "Devonian gas exploration in northeastern British Columbia: geology, operations and economics," Jour. Can. Pet. Tech., Vol. 1, No. 4, pp. 175-179.

Gray, F.F. and Kassube, J.R. (1963): "Geology and stratigraphy of Clarke Lake gas field, northeastern British Columbia," Am. Assoc. Pet. Geol., Bull., Vol. 47, No. 3, pp. 467-483.

Hadding, Assar (1941): "The pre-Quarternary sedimentary rocks of Sweden, VI, reef limestones," Lunds Univ. Arssk., New Ser., Pt. 2, Vol. 37, No. 10.

Henson, F.R.S. (1950): "Cretaceous and Tertiary reef formations and associated sediments in Middle East," Am. Assoc. Pet. Geol., Bull., Vol. 34, No. 2, pp. 215-238.

Hunt, C.W. (1954): "Normal Devonian sequence in southern Mackenzie basin, western Canada," Am. Assoc. Pet. Geol., Bull., Vol. 38, No. 11, pp. 2290-2301.

Koch, N. G. (1962): "Correlation of the Devonian Swan Hills Member, Alberta," Abstract of M. Sc. Thesis, University of Alberta, 1959, in Alta. Soc. Pet. Geol., Jour., Vol. 10, No. 11, p. 621.

Law, J. (1955): "Geology of northwestern Alberta and adjacent areas," Am. Assoc. Pet. Geol., Bull., Vol. 39, No. 10, pp. 1927-1978.

Leighton, M.W. and Pendexter, C. (1962): "Carbonate rock types," Am. Assoc. Pet. Geol., Mem. 1: Classification of carbonate rocks, edited by W. E. Ham, pp. 33-61.

Link, T.A. (1950): "Theory of transgressive and regressive reef (bioherm) development and origin of oil," Am. Assoc. Pet. Geol., Bull., Vol. 34, No. 2, pp. 263-294.

Loranger, D.M. (1963a): "Devonian microfauna from northeastern Alberta, Part 1: Ostracoda, Orders Leperditicopida and Palaeocopida," published by the author, Calgary, Alberta.

__________ (1963b): "Devonian microfauna from northeastern Alberta, Part 2: Ostracoda, Order Podocopida," published by the author, Calgary, Alberta.

McGill, P. (1963): "Upper and Middle Devonian ostracodes from the Beaverhill Lake Formation, Alberta, Canada," Can. Pet. Geol., Bull., Vol. 2, No. 1, pp. 1-26.

Nelson, H.F., Brown, C.W., and Brineman, J.H. (1962): "Skeletal limestone classification," Am. Assoc. Pet. Geol., Mem. 1: Classification of carbonate rocks, edited by W. E. Ham, pp. 224-252.

Norris, A.W. (1963): "Devonian stratigraphy of northeastern Alberta and northwestern Saskatchewan," Geol. Surv., Canada, Mem. 313.

Warren, P.S. (1933): "The age of the Devonian limestone at McMurray, Alberta," Can. Field-Naturalist, Vol. 47, No. 8, pp. 148-149.

Warren, P.S. and Stelck, C.R. (1962): "Western Canadian Givetian," Alta. Soc. Pet. Geol., Jour., Vol. 10, No. 6, pp. 273-291.

APPENDIX I

List of British Columbia wells showing the depths at which the following units were penetrated: Muskwa, Beaverhill Lake, Otter Park, Slave Point, Watt Mountain-Sulphur Point. Depths are given in feet below K.B. except for Sinclair wells where the depths are quoted in feet below ground level. All wells which were available at January 1, 1963, and which definitely penetrated one or more of the above units are included. Wells lying in the west of the area of study in which these units are replaced by the Besa River Shale and wells to the south which lie beyond the pinch out of the units are not included.

ABBREVIATIONS

K.B.	Kelly Bushing
Mu	Muskwa
Bh.L.	Beaverhill Lake
OP	Otter Park
SP	Slave Point
WM-SuP	Watt Mountain-Sulphur Point

* In this column Sh indicates that the top of the Watt Mountain - Sulphur Point is picked on the first occurrence of green waxy shale; Cl indicates that the pick is based on the first occurrence of sandstone near the base of the Slave Point; C indicates that the top is established by correlation with adjacent wells based on thickness, log characters, and general lithology. Number of wells in which top is established by the various means is as follows: Sh - 30; Cl - 6; C - 35.

/ In this column Fd indicates a well close to the facies front in which the Slave Point is completely or partly dolomitized. Dd indicates a well distant from the facies front in which the Slave Point is dolomitized, usually only in part. The dolomite of these wells is referred to in the text as the shelf dolomite.

\# In this column G indicates that the well is classified as a well capable of producing gas from the Slave Point Formation.

** Indicates true vertical depth in the case of an inclined hole.

WELL NAME AND LOCATION		K.B.	Mu	Bh.L.	OP	# SP ≠	WM-SuP *	T.D.
Southern Production Atlantic B7-1	12-33-85-16 W6	2317		9780 ?			?	10917
Imperial-Pacific Siphon Creek	1-26-86-16 W6	2415		9900 ?			10145 ?	10913
Texaco N.F.A. La Garde	7-21-87-15 W6 (2)	2532	9808	9828			10010 ?	10740
Texaco N.F.A. Buick Creek d-98-I (1)	94-A-11	2324	10320	10360		10600	10720 Cl	11424
Sinclair-Canadian Atlantic #B-8-1 d-43-C	94-A-16		9518	9550		9790 ?	9880 Cl	10447
Sinclair Julienne a-50-D (B13-2)	94-G-1	3718	12790	12825		12990	13290 Cl	13734
Dome et al Stanolind-Buckinghorse #1 d-95-H	94-G-7	2825	10200	10260		10330	10680 Sh	10949
Sinclair-Canadian Atlantic #B-3-1 a-23-E	94-G-10		11441	11510		11620 Dd?	12000 Cl	12450
Phillips Minaker a-25-D	94-G-15	2582	9420	9500		9548 Dd?	9950 C	11361
Texaco N.F.A. Nig Creek a-79-B (1)	94-H-4	2984	10678	10710		10930 Dd	11215 C	11999
Sinclair Pac Chinchaga a-34-L (B9-1)	94-H-8	3087	8950	9050		9400 ?	9725 Cl	9858
HB Union Chinchaga a-96-C	94-H-9	2404	7878	7920		8222	8485 C	8739
HB Imp Union Gutah a-99-K	94-H-10	2136	7740	7820		7970	8220 Sh	9213
Texaco N.F.A. Beatton River #2 b-27-B	94-H-11	2781	9082	9123		9310	9570 C	10445
Triad BP Conroy Creek c-100-A	94-H-12	2512	9004	9053		9190	9550 C	9896
HB Imperial Union Paddy a-49-B (1)	94-H-16	2371	7490	7549		G 7835 Dd	8100 Sh	10034
HB-Union-Imperial Paddy #2 c-74-B	94-H-16	2408	7480	7558		7837 Dd	8090 Sh	8216
HB-Union-Imperial Paddy c-14-C	94-H-16	2254	7405	7500		7780 Dd	8030 C	8131
Pure Imperial Bigfoot d-27-C	94-I-4	2129	7910	7975		8014	8390 C	8472*
Imperial Sikanni Chief #1 b-92-D	94-I-4	1920	7540	7608		7750	8090 C	9930
Imp Fontas d-37-B	94-I-7	1461	6150	6255		6330 Dd	6630 C	7636
Imperial Kahntah #1 b-29-C	94-I-7	1434	6180	6280		6343	6653 C	8439
Texaco N.F.A. Hay River #1 d-22-B	94-I-9	1272	5308	5400		5490	5750 Sh	7409
Texaco N.F.A. Townsoitoi d-44-C	94-I-10	1314	5785	5853		5890 Dd	6190 C	6959
Sohio C&E Ekwan a-55-G	94-I-10	1239	5625	5705		5740 Dd		6050 ?
Imp Junior c-98-C	94-I-11	1465	6100	6177		G 6207 Dd?	6500 Sh	6632
Imp Kyklo b-73-F	94-I-11	1381	5885			5950	6272 C	7914
Dome et al Elleh a-14-E	94-I-12	1486	6418	6484		6502	6880 Sh	7296
Mobil W Sahtaneh d-88-I	94-I-12	1622	6315		6408	6650 ?	6750 C	8261
Mobil W Sahtaneh c-89-I	94-I-12	1613	6290			6381	6700 C	7650
Pacific Utahn b-83-C	94-I-13	1694	6555		6648			8230
West Nat et al Yoyo a-74-H	94-I-13	1895	6493		6562	G 6608		6790
Sinclair Pacific Lichen d-31-A	94-I-14	1595	6040			6095 Dd?	6270 Sh	6470
Sinclair Pacific Lichen c-41-A	94-I-14		5970			6028		6310
West Nat Kotcho Lake d-39-J	94-I-14	2011	6350			G 6410 Fd	6600 Sh	8413
West Nat Kotcho b-54-K	94-I-14	2030	6430			G 6490		6630

WELL NAME AND LOCATION		K.B.	Mu	Bh.L.	OP	#	SP ≠	WM-SuP *	T.D.
West Nat Kotcho Lake c-67-K	94-I-14	2073	6480			G	6570 Fd		6702
(Gulf States) Kotcho Lake No. 2 d-79-K	94-I-14	2138	6550		6630			6828 C	7240
Sinclair et al Datcin b-46-G	94-I-15	1611	5770	5862			5880 Dd	6135 Cl	6306
Sinclair et al Datcin a-54-G	94-I-15		5740				5827		5960
Texaco N.F.A. Walrus b-86-L	94-I-16	1753	5700	5775			5805	6120 Sh	6501
Pure Imperial Bull b-67-J	94-J-1	1970	7343	7420			7440	7890 C	8271
Sinclair Pac Klua Ck a-55-L (B11-1)	94-J-1	2440	8070	8140			8198	8550 C	8614
(Phillips) Tenaka No. 1 b-91-L	94-J-2	1830	7375	7480			7690 Dd?	8000 C	9220
Pure Pacific Tenaka c-94-L	94-J-2	1867	7535	7620			7825	8110 C	8472
Triad et al Jackfish c-13-I	94-J-7	1800	6880	6955			7135	7365 Sh	7770
Woodley-Imperial Klua a-27-G	94-J-8	1608	6764	6840			6858	7300 Sh	7630
Triad Sohio Pac Jackfish a-30-K	94-J-8	1668	6720	6790		G	6980	7190 Sh	7431
B.A. Shell Klua Creek a-50-C (1)	94-J-9	1556	6470	6570		G	6770 Dd	7030 C	8893
B.A. Shell Klua b-49-F	94-J-9	1383	6260	6310			6320	6775 Sh	7972
B.A.-Shell Klua Creek No. 2 a-56-H	94-J-9	1490	6432		6520		6720	6800 C	7400
West Nat Imp Clarke Lake b-78-J	94-J-9	1309	6100 ?			G	6205		6520
Gulf States Imp Clarke L c-75-K (3)	94-J-9	1329	6222				6340	6650 C	7400
West Nat Imp Clarke Lake d-88-L	94-J-9	1364	6260			G	6357 Fd		6443
West Nat Imp Clarke Lake d-91-L	94-J-9	1366	6185			G	6290 Fd		6550
West Nat Imp Clarke Lake c-94-L	94-J-9	1372	6233			G	6355 Fd	6700 C	8039
Pacific S Ft. Nelson b-96-B (1)	94-J-10	1605	6470				6530	7020 Sh	7477
Apache Pacific Fort Nelson a-91-C	94-J-10	1609	6575				6640	7130 ? Sh	7560
Pacific Fort Nelson No. 2 a-19-G	94-J-10	1619	6504		6550 ?		6580	7050 C	7480
Pacific Fort Nelson a-44-G (3)	94-J-10	1533	6528				6621	6990 Sh	7595
Pacific Apache Fort Nelson b-76-G	94-J-10	1516	6350		6420	G	6618 Fd		6691
Apache Pacific Fort Nelson d-76-G	94-J-10	1457	6545		6635			7078 ?	7265
Gulf States-Imp Clarke L c-64-I (4)	94-J-10	1310	6193				6290	6655 Sh	7316
West Nat et al Clarke b-70-I	94-J-10	1309	6118			G	6205 Fd		6422
West Nat et al Fort Nelson c-70-I	94-J-10	1298	6354		6430			6887 C	6950
West Nat et al Clarke c-78-I	94-J-10	1295	6054			G	6152 Fd		6533
West Nat et al Fort Nelson d-38-J	94-J-10	1357	6430		6547			7043 C	7103
West Nat et al Clarke c-47-J	94-J-10	1343	6282		6390	G	6510 Fd	6750 C	6957
West Nat et al Clarke a-52-J	94-J-10	1328	6205		6288	G	6315 Fd		6412
Gulf States Fort Nelson No. 2 a-95-J	94-J-10	1299	6470		6630				7889
Pure Pac Cheves c-5-A	94-J-11	1776	7385				7466	7940 Sh	8596
West Nat et al Evie Lake b-85-H	94-J-14	1948	6510			G	6566	6866 C	7720

WELL NAME AND LOCATION		K.B.	Mu	Bh.L.	OP	#	SP ≠	WM-SuP *	T.D.
West Nat et al Evie Lake b-89-E	94-J-15	1943	6496				6555	6930 C	8240
West Nat et al Evie d-14-F	94-J-15	1728	6550				6610	6985 C	7925
West Nat Imp Clarke Lake c-8-D	94-J-16	1380	6150**			G	6270 Fd**		6650**
Gulf States-Imp Clarke L b-18-D (5)	94-J-16	1379	6258		6372			6716 C	7405
Pan Am et al A-1 Snake River c-28-D	94-O-1	954	6370		6550				7614
Pan Am East Poplar a-37-F	94-O-2	1224	6780 ?		6890				8139
Pan Am A-1 Cam Lake a-31-I	94-O-16	1494	6710				6750	7000 Sh	7500
TGT Tooga Lake c-27-K	94-P-2	2103	6180	6248			6270	6610 Sh	6725
Pacific North Kotcho b-44-C	94-P-3	2160	6505			G	6589 Fd	6800 Sh	6835
Pacific North Kotcho d-85-C	94-P-3	2190	6605				6670	7020 Sh	7500
Pacific North Kotcho c-93-C	94-P-3	2153	6500				6572	6920 Sh	7000
Gulf States Kathy a-34-E (1)	94-P-3	2228	6890		6980		7125 Fd		7150
West Nat Kotcho a-9-F	94-P-3	2191	6585				6656	6820 Sh	6966
Atlantic Pac North Kotcho c-22-F	94-P-3	2147	6500				6556	6900 SH	7023
West Nat Kathy b-30-F	94-P-3	2196	6600			G	6670 Fd		6785
Atlantic Pac E Kotcho b-19-G	94-P-3	2070	?				6485	6830 C	7072
West Nat Lesellen b-75-F	94-P-4	1741	6820		6950				7796
Texaco N.F.A. Tsea b-68-K	94-P-5	2070	6780			G	6875 Fd		7110
Texaco N.F.A. Judy c-53-D	94-P-6	2206	6525		6600 ?		6685	7000 Sh	7327
Texaco N.F.A. Thetlaandoa No. 1 c-40-G	94-P-6	1945	6270				6353	6700 C	8080
Pan Am A-1 Kimea Lake a-28-H	94-P-9	1733	5430				5515	5720 C	7257
Pan Am July a-65-K	94-P-9	1544	5350				5427	5700 C	6913
Texaco N.F.A. N Tsea d-47-C	94-P-12	1924	6770				6860	7116 Sh	8320
Pan Am et al Dilly a-27-K	94-P-12	1677	6550				6586	6868 Sh	7154
Pan Am et al Dilly a-30-K	94-P-12	1724	6705		6740 ?	G	6803 Fd		6900
West Nat Petitot b-90-K	94-P-12	1539	6575			G	6680 Fd		6732
West Nat Petitot River a-81-L	94-P-12	1539	6550				6696 Fd		6720
West Nat Petitot River b-1-D	94-P-13	1534	6460			G	6536 Fd		6628
West Nat Petitot River d-24-D	94-P-13	1503	6442			G	6520 Fd		6680
Pan Am Cam Lake c-25-L	94-P-13	1496	6490 ?				6518	6780 Sh	7090

APPENDIX II

CORE DESCRPTIONS

The wells are arranged in alphabetical order. All depths are quoted in feet. Core recovery is complete, or almost so, unless otherwise indicated. Where the size of the constituent allochems of limestones is referred to as either fine, medium, or coarse grained, it can be assumed that the allochems in question belong to the arenaceous size class.

BA Shell Klua b-49-F
Location: b-49-F/94-J-9
Status: abandoned
K.B. 1,383 T.D. 7,972 Completed: March, 1962
Slave Point core: 6,475-6,585 (Recovery: 97 feet)
Slave Point top: 6,320 Base: 6,775

UPPER INTERVAL: 6,475-6,520. This interval consists of organisms of various types set in a matrix of dark brownish grey calcilutite. Much of the biogenic material appears to be fragmented. The dark calcilutite is generally unresolved at x 30, but in some instances suggestions of fine to medium grained intraclasts can be seen in a micritic matrix. The biogenic material consists of:

a. Very abundant Thamnopora.
b. Occasional Amphipora.
c. Large ramose stromatoporoids.
d. Laminar stromatoporoids varying from 2 millimeters to 2 centimeters in thickness. These structures reach the full diameter of the core (3.5 inches); they are usually flat but sometimes undulating, and are parallel or slightly inclined to the horizontal.
e. Nodular stromatoporoids, 1-3 centimeters across, sometimes with irregular growth forms; usually showing reticulate structure.
f. A very large, massive stromatoporoid occurs in the upper 5 feet of the interval. It occupies 22 inches of the core.
g. Occasional solitary corals.
h. Occasional crinoid fragments.
i. Small fragments of brachiopod shells recrystallized to a light coloured translucent calcite. The fragments are usually about 0.2 millimeter in thickness and range up to 5 millimeters in length.

LOWER INTERVAL: 6,520-6,585. This interval is made up of stromatoporoid material of various types set in a matrix of dark calcilutite; in parts intramicrites and intrasparites (?) are developed. In the upper half of the interval nodular stromatoporoids are common and in places they attain a diameter of 5 to 6 centimeters. Massive stromatoporoids also occur. Parts of the rock contain various types of shell fragments replaced by translucent calcite; in some instances the translucent calcite is seen completely surrounding a central nucleus apparently consisting of micrite. Encrusting stromatoporoids surrounding specimens of Thamnopora are present in the upper part of this interval.

In the lower half of the interval (approximately 6,555-6,585) Amphipora is common; the coenostea are of small size, rarely reaching more than 2.5 millimeters in diameter. Nodular and occasional massive stromatoporoids are also present in the rock. Patches of coarsely crystalline sparry calcite are present in parts of this section of core, most are less than 1 centimeter across. Minor incipient dolomitization occurs in places.

HB Imperial Union Paddy a-49-B (1)
Location: a-49-B/94-H-16
Status: Gas well in Slave Point Formation
K.B. 2,371 T.D. 10,034 Completed: August, 1955
Beaverhill Lake core: 7,825-7,835
Beaverhill Lake top: 7,549 Base: 7,835

Core consists of medium dark grey, slightly calcareous to very calcareous shale. Moderate amounts of pyrite occur in the rock usually as crystals averaging about 0.5 millimeter across; some, however, reach 2 millimeters in maximum dimension. The core breaks into blocks which show irregular fracture surfaces. In the lower 18 inches of the interval recovery is very poor and the contact with the Slave Point Limestone appears to be lost.

Slave Point core: 7,835-7,885; 7,950-7,990
Slave Point top: 7,835 Base: 8,100

FIRST SLAVE POINT CORE: 7,835-7,885. The upper part (7,835-7,865) of this section consists of brownish grey to dark brownish grey calcilutite containing very abundant biogenic material. The latter is mostly medium brownish grey in colour and consists largely of massive, nodular and ramose (including abundant Amphipora) stromatoporoids. Thamnopora also occurs. Much of the stromatoporoid material is recrystallized to dense biogenic calcite.

Crinoid (?) ossicles reaching up to 6 millimeters in diameter are abundant in some intervals. Brachiopods are also present but they are only a minor element in the total fauna. Carbonaceous material is common in parts of the matrix. In places the matrix calcilutite grades into intramicrites and intrasparites; the former are the most common intraclast rocks represented.

The lower part (7,865-7,885) of this interval is darker in colour than the interval above and contains less biogenic material. The dominant rock type is dark brownish grey calcilutite. In places intramicrites and fine to medium grained intrasparites with Calcisphaera are developed. Moderate amounts of stromatoporoids occur; they are mainly of the smaller ramose type. Carbonaceous material is common in parts.

SECOND SLAVE POINT CORE: 7,950-7,990. This interval consists mainly of brownish grey to brownish black calcilutite containing moderately abundant stromatoporoid material, medium brownish grey in colour. Massive, nodular and ramose stromatoporoids including Amphipora are present in the rock. Brachiopods occur occasionally in the calcilutite. Carbonaceous material is present in varying amounts throughout the interval.

In the interval 7,956-7,957 the limestones have been altered to a uniformly pigmented, dark brownish grey, medium crystalline dolomite. Dark brownish grey fine to medium crystalline dolomite also occurs at 7,964 and 7,969 feet. Incipient dolomitization is evident in other parts of the core.

Well developed intrasparites occur in the interval 7,983-7,990. The intraclasts of these rocks are irregular in shape and ovoid, rectangular, and triangular forms are present; they are rounded in outline. The intraclasts vary in diameter between 0.12 and 0.5 millimeter (fine to medium grained). Oölites and superficial oölites are present in some of these intrasparites. A well developed Amphipora biosparite occurs in the interval characterized by the presence of intraclast rocks.

HB Imp Union Gutah a-99-K
Location: a-99-K/94-H-10
Status: abandoned
K.B. 2,136 T.D. 9,213 Completed: March, 1962
Slave Point core: 8,036-8,164 (Recovery: 112 feet)
Slave Point top: 7,970 Base: 8,220

UPPER INTERVAL: 8,036-8,060. This interval consists mainly of dark brownish grey to brownish black calcilutites which contain abundant stromatoporoids (mainly Amphipora). The calcilutite is quite carbonaceous. There are subordinate occurrences of ramose stromatoporoids other than Amphipora. Nodular stromatoporoids also occur. The matrix rock, in general, is unresolved at x 30 of the stereoscopic microscope; in parts there are vague suggestions of included intraclasts. It is of interest to note that in this section the Amphipora are consistently of small size, being 1 to 3 millimeters in diameter, whereas stromatoporoids of other genera of the Idiostromatidea present in the rock are mostly between 4 and 6 millimeters in diameter.

CENTRAL INTERVAL: 8,060-8,140. This central section of the Slave Point core grades from brownish black to medium brownish grey in colour. Dark stromatoporoid-bearing calcilutites make up most of the section. However, the most notable feature of the interval is the common occurrence of intraclast rocks. The intraclasts belong to the fine and medium arenaceous size classes. Few of the rocks can be definitely said to be intrasparites and most would fall into the intrasparite-intramicrite classification.

Between 8,081 and 8,083 there is an intramicrite-intrasparite containing abundant Calcisphaera, most of which are approximately 150 microns in diameter. The peripheral spines can be seen in some instances. At 8,102 there is an occurrence of a biosparite containing abundant foraminifera up to 2 millimeters across and broken shell fragments (brachiopods ?) up to 5 millimeters in length.

Brachiopods occur sporadically in the central interval of the Gutah core. Stromatoporoids are common; massive types reaching the full width of the core, nodular forms 3 to 5 centimeters in diameter, large ramose forms and Amphipora are all represented. There are subordinate occurrences of laminar stromatoporoids, some of which reach several centimeters in thickness and occupy the full width of the core. The tabulate coral Thamnopora is also present.

LOWER INTERVAL: 8,140-8,164. The lower interval of the Gutah core consists mainly of the dark stromatoporoid-bearing calcilutite. Various types of stromatoporoids are present and massive and nodular forms are in evidence; however, Amphipora appears to be the dominant type. Thamnopora is present in parts.

Incipient dolomitization is evident in the lower 10 feet of the core. In parts of this lower interval small dark brown crystals of fluorite are present in the limestone.

HB Union Imperial Paddy #2
Location: c-74-B/94-H-16
Status: abandoned
K.B. 2,408 T.D. 8,216 Completed: March, 1958
Beaverhill Lake core: 7,822-7,837
Beaverhill Lake top: 7,558 Base: 7,837

This interval consists of medium dark grey, calcareous shale which grades in parts to non-calcareous shale. Occasional brachiopods occur in the rock. Minor amounts of pyrite are present in the shale. The contact between the Beaverhill Lake Shale and the Slave Point Limestone does not appear to be preserved in the core.

Slave Point core: 7,837-7,864; 7,866-8,001 (Recovery: 130 feet)
Slave Point top: 7,837 Base: 8,090

UPPER INTERVAL: 7,837-7,916. (Note that 2 feet between 7,864 and 7,866 were not cored). This interval consists of a fairly uniform sequence of dark brownish grey to brownish black calcilutites. Carbonaceous stylolitic partings are common. Occasionally there are suggestions of intraclasts in the calcilutite but these structures are vague. Stromatoporoid material is fairly common in the interval and massive, nodular and ramose forms including abundant Amphipora are represented.

Abundant crinoid (?) ossicles occur in some zones. Other elements of the fauna include Thamnopora and occasional gasteropods. Thick veins of calcite occur over short sections of the core. A small proportion of the calcilutites have been altered to dark brownish grey dolomite, fine to medium crystalline in texture.

LOWER INTERVAL: 7,916-8,001. This section of the Slave Point core is made up of dark brownish grey to brownish black calcilutites similar to those of the overlying interval. The lower section, however, contains subordinate developments of fine to medium grained intrasparites and intramicrites, mainly in the interval 7,965-8,001.

Stromatoporoids are common in parts of the core and massive, nodular, and ramose types are present. Occasional brachiopods occur in the calcilutites.

Thick veins of very coarsely crystalline to extremely coarsely crystalline calcite are present in a few zones. There are minor developments of dark brownish grey, fine to medium crystalline dolomite in the section.

HB Union Imp Paddy c-14-C
Location: c-14-C/94-H-16
Status: abandoned
K.B. 2,254 T.D. 8,131 Completed: March, 1959
Slave Point core: 7,850-7,901 (Recovery: 33 feet)
Slave Point top: 7,780 Base: 8,030

UPPER INTERVAL: 7,850-7,889. This section of core consists mainly of dolomite, dark grey to dark brownish grey in colour and medium crystalline in texture. There are indications that the original limestone contained abundant ramose stromatoporoids which were subsequently altered to a light brownish grey, fine to medium crystalline dolomite which grades in parts to white, coarse to very coarsely crystalline dolomite. The altered stromatoporoid material contains central cavities in some instances.

The dolomite of this interval is moderately vuggy; as a rule the vugs are small and are usually less than 1 centimeter across. They are in some instances associated with altered biogenic material; in other cases they occur within irregular patches of white, coarse to very coarsely crystalline dolomite. In parts of the rock intercrystalline porosity is developed.

In some sections, which together constitute only a small part of the total interval, the Slave Point has not been dolomitized; these sections consist of dark brownish grey stromatoporoid-bearing calcilutite.

LOWER INTERVAL: 7,889-7,901. This interval is made up of dark brownish grey to brownish black calcilutites, very fine grained to dense in texture. Ramose stromatoporoids are common in the rock. The limestones show slight dolomitization in parts.

Imperial Kahntah #1
Location: b-29-C/94-I-7
Status: abandoned
K.B. 1,434 T.D. 8,439 Completed: August, 1955
Slave Point core: 6,400-6,420; 6,570-6,600
Slave Point top: 6,343 Base: 6,653

FIRST SLAVE POINT CORE: 6,400-6,420. This interval consists of dark brownish grey to brownish black calcilutites, containing occasional thin shelled brachiopods and Amphipora. Carbonaceous material is very abundant in parts of the interval. The carbonaceous rock is associated with the less carbonaceous rock in a variety of ways; in many cases the former occurs as a matrix in which inclusions of the less carbonaceous material are disseminated. Etching is required before these two slightly different limestone phases can be recognized. On the wet, etched rock surface the carbonaceous rock is slightly darker in colour than the less carbonaceous material.

SECOND SLAVE POINT CORE: 6,570-6,600. This lower section of core is made up of a fairly uniform sequence of dark brownish grey to brownish black calcilutites which contain varying amounts of carbonaceous material. Minor amounts of biogenic material occur in the interval. Laminar and nodular stromatoporoids are present and a few restricted zones contain numerous ramose stromatoporoids. Fragmented brachiopod (?) shells, usually not more than 1 centimeter in length, are abundant in places. Some of the limestones show incipient dolomitization.

Imperial Sikanni Chief #1
Location: b-92-D/94-I-4
Status: abandoned
K.B. 1,920 T.D. 9,930 Completed: June, 1955
Beaverhill Lake core: 7,658-7,678
Beaverhill Lake top: 7,608 Base: 7,750

The Beaverhill Lake core of this well consists of a fairly uniform sequence of calcareous, medium grey to medium dark grey shales. The shale tends to break into blocks, often the full diameter of the core, rather than show the fissile character which can be observed in the overlying non-calcareous Fort Simpson Shale.

In some intervals the Beaverhill Lake Shale grades into argillaceous limestone which contains poorly preserved brachiopod shells and also smaller fossil fragments. The latter are approximately 1 to 2 millimeters in maximum dimension. The zones of argillaceous limestone are only a minor development in the total interval.

Fracture planes developed in the Beaverhill Lake Shale are undulating and show numerous irregularities; they are not smooth as are those developed in the Fort Simpson Shale.

Imp Fontas d-37-B
Location: d-37-B/94-I-7
Status: abandoned
K.B. 1,461 T.D. 7,636 Completed: March, 1962
Slave Point core: 6,348-6,466 (116 feet cut; 113 feet recovered)
Slave Point top: 6,330 Base: 6,630

The Slave Point in this core consists of dark coloured calcilutite. Two slightly different types can be recognized: one is dark brownish grey to brownish black in colour and shows abundant carbonaceous material on the etched surface of the rock, the other is very slightly lighter in colour and shows little evidence of carbonaceous material on the etched surface. The two types are most easily distinguished when the rock specimens are examined wet, and the colour relationships described above apply to the wet rock. The lighter coloured rock often occurs as inclusions in the darker limestone.

Thin shelled brachiopods are common in the rock; when they occur in the darker limestone they are often infilled with lighter coloured rock. Fragments of brachiopod shells are also quite common and in some cases they are replaced by translucent calcite. There are abundant inclusions of small cylinders of calcite ranging up to several millimeters in length, especially in the upper part of the core. These bodies are similar to those described from the core of Texaco NFA Townsoitoi d-44-C and are probably derived from crinoids.

The interval 6,394-6,420 is made up largely of the lighter calcilutite crossed by dividing and anastomosing veins and stringers of carbonaceous calcilutite. This relationship gives rise to a rock which appears to consist of irregularly shaped bodies, 1 to 8 centimeters in maximum dimension, of the lighter coloured limestone, separated from each other by bands and veins of the carbonaceous rock.

In other parts of the core (especially the interval 6,348-6,375) irregularly shaped inclusions of light brownish grey siliceous dolomite are present. These inclusions vary from a few centimeters in maximum dimension to the full width of the core (3.5 inches). They are usually elongated in form and approximately horizontal. It seems likely that the bodies represent inclusions in the dark calcilutites of a rock type which was particularly prone to silicification and dolomitization.

In the lower part of the core the darker calcilutite is dominant and in the interval 6,446-6,466 stromatoporoids are common. Massive, nodular, and ramose types are present. Thamnopora also occurs. Incipient dolomitization is evident in parts of this interval.

Stromatoporoids are not common in this cored section except in the lower 20 feet. However, brachiopods are more common in this core than in many other sections of the Slave Point and gasteropods are also occasionally present. In these respects this section differs from what may be considered the "normal" Slave Point development of northeastern British Columbia.

Imp Junior c-98-C
Location: c-98-C/94-I-11
Status: Gas well in Slave Point Formation
K.B. 1,465 T.D. 6,632 Completed: March, 1962
Slave Point Core: 6,210-6,500 (283 feet cut; 233 feet recovered)
Slave Point top: 6,207 Base: 6,500

UPPER INTERVAL: 6,210-6,347. This interval is made up predominantly of limestone. Stromatoporoids and Thamnopora are dispersed in a matrix of dark brownish grey to brownish black calcilutite. There are subordinate amounts of a brownish grey to medium brownish grey, dense, aphanitic limestone. Biogenic material makes up approximately 14 to 18 per cent of the rock. The light aphanitic limestone represents approximately 3 to 4 per cent of the cored interval.

The dark calcilutite, which is the dominant rock type, is in general unresolved under the stereoscopic microscope at x 30 magnification. In parts of the core there are suggestions that the calcilutite grades into an intramicrite and in some places the rock is made up of intraclasts separated by thin films of carbonaceous material. The dark calcilutite contains moderate to abundant amounts of carbonaceous material.

The lighter coloured aphanitic limestone (micrite ?) usually shows a bedded relationship with the darker rock. Thus intervals of the core up to 1 to 2 feet in thickness consist of interbedded light and dark phases. In other places the light phase forms continuous zones reaching up to 1 to 2 feet in thickness. The lighter coloured aphanitic limestone contains abundant inclusions of sparry calcite which are frequently elongated parallel to the bedding. In some areas this limestone grades to an intrasparite with allochems in the fine to medium arenaceous size class.

Much of the brownish grey aphanitic rock is probably a true micrite. Support for this concept is provided by the fact that in places it contains inclusions of Amphipora. There is a possibility that some of the aphanitic limestone is in reality a "welded" intraclast rock and there is evidence of this origin in places.

In some parts of the core there are small inclusions (fine to coarse grained) of the lighter brownish grey limestone in the dark calcilutite; this relationship is frequently seen in the dark calcilutite in zones adjacent to the thicker beds of the light coloured rock.

Most types of stromatoporoid material are present in the core. In some parts Amphipora is dominant; in others large ramose forms are the main type represented. Nodular stromatoporoids (2 to 6 centimeters across) are common and massive types reaching up to 20 centimeters in length occur in some zones. Thamnopora is abundant in certain intervals. In one section of the core stromatoporoids can be seen encrusting Thamnopora. Occasional solitary corals are present in the dark calcilutite.

LOWER INTERVAL: 6,347-6,500. This section of core consists of the dolomitized equivalent of the overlying limestone. Throughout the rock two distinct phases can be recognized; there is a dark coloured matrix phase and a lighter coloured phase consisting of inclusions. Parts of the core clearly demonstrate that the dark matrix phase is the equivalent of the dark calcilutite of the overlying rock and that the light coloured phase represents altered biogenic material.

Intervals of the core up to 4 feet in length may be made up almost exclusively of the dark phase; alternatively the two phases occur together over intervals up to 2 to 3 feet in length giving rise to the white and grey dolomite.

The dark phase is medium grey to medium dark grey in colour and for the most part is made up of fine to medium crystalline dolomite; only rarely do the crystals reach the coarse grade, and even then they fall into the lower part of this size class.

Interstitial carbonaceous material is present between the crystals of the coarser grades although it is not inevitably present. The finely crystalline dolomite is uniformly pigmented with dark material; some of the medium crystalline dolomite also shows uniform pigmentation.

The light phase of this dolomite (described on page 24 as the white and grey dolomite) is white to very light grey in colour and in most cases it is coarse to very coarsely crystalline. As noted above much of this light phase clearly represents altered biogenic material, and in many cases the nature of the original material can be recognized. However, when dolomitization is sufficiently advanced the original forms of the biogenic components become blurred and to some extent united, and give rise to such textures as the clotted, nebulous, banded and the macroinclusion (see text for description of terms).

Vugs are frequently developed in the centres of the light coloured dolomite inclusions and they range in size from less than 1 centimeter across to the full width of the core (3.5 inches). They are lined with very coarse to extremely coarsely crystalline dolomite which often shows curved crystal faces. Dark carbonaceous material is frequently present between these crystals. Quartz crystals often form part of the vug lining. Some of the vugs are almost completely filled with large crystals of calcite.

It can be assumed from the amount of white dolomite in this core that the original limestone of the total interval contained approximately 5 to 8 per cent biogenic material. It appears to have been of the usual type seen in the dark calcilutites, that is, mainly stromatoporoids and Thamnopora.

Some of the rock in this section of core provides examples of the stages by which biogenic material is altered to the white dolomite. The process can be summarized as follows:

1. Dolomitization starts at periphery of fragment and extends inward.
2. Fragment may be completely replaced by dolomite.
3. Alternatively, a soluble core may be left which is dissolved out thus forming a vug.

The process is more fully described on page 25 of the text.

Imp Kyklo b-73-F
Location: b-73-F/94-I-11
Status: abandoned
K.B. 1,381 T.D. 7,914 Completed: March, 1962
Slave Point core: 5,992-6,133
Slave Point top: 5,950 Base: 6,272

UPPER INTERVAL: 5,992-6,058. Dark brownish grey to dark grey calcilutites, containing abundant Amphipora coenostea, make up this interval of Slave Point core. Some of the Amphipora reach 4.5 millimeters in diameter. Idiostromatidae other than Amphipora, nodular stromatoporoids, and Thamnopora are also present in the rock but they are not as common as Amphipora. The calcilutite shows little structure at x 30 magnification under the stereoscopic microscope. In parts, however, there are suggestions of fine to medium grained intraclasts dispersed in a micritic matrix. Minor amounts of brownish grey micrite occur; it is commonly in bands, some reaching up to 7 centimeters in thickness, interbedded with the darker rock. Carbonaceous stylolitic breaks are developed in parts of the cored interval.

LOWER INTERVAL: 6,058-6,133. The lower part of the Slave Point core is similar in many respects to that described above, but in this lower interval massive and nodular stromatoporoids are common and occur in addition to Amphipora. There are also subordinate occurrences of Idiostromatidae other than Amphipora. The matrix rock consists of dark calcilutite which grades in parts into a rock showing suggestions of fine to medium grained intraclasts. This interval of core contains little of the brownish grey micrite seen in the upper interval. However, one prominent 5-inch band of this rock type occurs at approximately 6,074 feet.

In the lower 20 feet of this interval Amphipora occurs only rarely and nodular stromatoporoids are very common.

Pan Am A-1 Cam Lake a-31-I
Location: a-31-I/94-O-16
Status: Gas well in Slave Point and Sulphur Point Formations
K.B. 1,494 T.D. 7,500 Completed: May, 1960
Slave Point core: 6,759-6,795 (Recovery: 25 feet);
6,839-6,859 (Recovery: 10 feet);
6,885-6,895
Slave Point top: 6,750 Base: 7,000

All three cores consist largely of dark grey calcilutite, very fine grained to dense in texture, containing abundant stromatoporoid remains in places. In parts the calcilutite grades to a rock which shows vague suggestions of being made up of fine to medium grained intraclasts. Amphipora appears to be the most common stromatoporoid in the section; other genera of the Idiostromatidae and Thamnopora are also present. Amphipora is very abundant in some zones. Occasional massive stromatoporoids occur. Stylolitic breaks are present in places; they are usually highly irregular in form and contain accumulations of dark carbonaceous material. Veins of calcite cut the rock in some intervals; they are often vertical or inclined at 20 to 30 degrees from the vertical.

Pan Am et al Dilly a-27-K
Location: a-27-K/94-P-12
Status: abandoned
K.B. 1,677 T.D. 7,154 Completed: February, 1961
Slave Point core: 6,615-6,675
Slave Point top: 6,586 Base: 6,868

Core consists of dark grey and subordinate brownish grey to dark brownish grey calcilutite, very fine grained in texture which grades in parts to an intraclast rock. The latter is made up of fine grained allochems and may be classed as an intramicrite-intrasparite. Carbonaceous material is abundant in some of the limestones. Stromatoporoids are abundant in parts of the core; Amphipora is the most common type. Ramose stromatoporoids other than Amphipora, nodular stromatoporoids, and Thamnopora also occur. Stylolitic partings containing carbonaceous material occur intermittently throughout the cored section.

Pan Am et al Dilly a-30-K
Location: a-30-K/94-P-12
Status: Gas well in Slave Point Formation
K.B. 1,724 T.D. 6,900 Completed: January, 1962
Slave Point core: 6,822-6,858 (Recovery: 31 feet)
Slave Point top: 6,803 Base: not penetrated

Core is composed of medium dark grey to dark grey dolomite, fine to medium crystalline in texture. Some sections of the core contain inclusions (varying in maximum dimension from 1 to 5 millimeters) of white, medium to coarsely crystalline dolomite. These parts of the core may be said to exhibit the microinclusion texture of the white and grey dolomite. One 6-centimeter section of the core contains abundant inclusions of dolomitized Amphipora coenostea. They range up to several centimeters in length and are made up of white dolomite. The inclusions lie at angles ranging between 45 and 70 degrees from the horizontal; they often show the development of medial cavities.

Vugs occur in the dolomite of this core, but they are not common. They are mostly small, reaching a maximum dimension of approximately 2 to 3 centimeters. The vugs are lined in many cases with white dolomite and/or quartz crystals and in addition often contain carbonaceous material. In some instances the vugs are almost completely infilled with quartz. Pyrite occurs sporadically in this Slave Point core.

Pan Am July a-65-K
Location: a-65-K/94-P-9
Status: abandoned
K.B. 1,544 T.D. 6,913 Completed: March, 1961
Slave Point core: 5,446-5,506
Slave Point top: 5,427 Base: 5,700

Two main rock types are recognizable in this interval. The first is a medium brownish grey limestone, dense to aphanitic in texture, which is unresolved at x 30 of the stereoscopic microscope. There is little evidence of carbonaceous material on the etched surface of the rock. The colour and dense texture of this limestone suggest that it is a micrite. In some places limestone of a similar colour is made up of closely compacted allochems which are surrounded by thin films of carbonaceous material.

The second rock type is dark brownish grey in colour and contains visible carbonaceous material. In many places this darker rock is made up of fine grained allochems, medium brownish grey in colour, which are separated from each other by a dark carbonaceous matrix.

In the upper two-thirds of the cored interval the lighter coloured limestone makes up about 30 to 35 per cent of the rock and occurs as irregular inclusions (often of clot-like form) in the darker limestone. These inclusions vary a great deal in size, ranging from several millimeters across up to many centimeters in diameter. In some instances the lighter material occupies the full width of the core (3.5 inches).

In the lower third of the cored interval the lighter rock type becomes dominant and makes up most of the core. In places the micritic rock contains small vein-like inclusions, usually less than 1 centimeter in length, of sparry calcite and/or carbonaceous material.

Biogenic material is not common in this Slave Point section. However, occasional ramose, nodular, and massive stromatoporoids occur in parts of the core.

Phillips Minaker a-25-D
Location: a-25-D/94-G-15
Status: abandoned
K.B. 2,582 T.D. 11,361 Completed: July, 1960
Slave Point core: 9,560-9,603 (Recovery: 27.5 feet)
Slave Point top: 9,548 Base: 9,950

The cored interval consists largely of dolomite, medium dark grey to dark grey, mainly finely crystalline but grading in parts to medium crystalline. This dark dolomite is associated with white coarsely crystalline dolomite and calcite. About 10 per cent of the rock consists of the lighter coloured material.

The light phase occurs in parts as approximately horizontal bands which reach up to 5 millimeters in thickness. In some instances these bands are very thin and less than the width of the core in lateral extent. Some of the light coloured dolomite and calcite occurs as irregularly shaped inclusions up to several centimeters in diameter. These inclusions sometimes contain a central cavity. Veins of white calcite and dolomite also occur in the rock. No preferred occurrence of the light coloured dolomite as opposed to the similarly coloured calcite was noted.

In parts the dolomitized remains of structures that appear to be Amphipora are present in the rock. The coenostea are recrystallized and consist of very light grey medium to coarsely crystalline dolomite.

Parts of the core are fissile in a plane approximately horizontal. A residue test carried out on some of the fissile material indicates that it contains a considerable quantity of argillaceous and silty material.

There are indications of brecciation in parts of the rock, with blocks of the darker dolomite being separated by thin veins of the light phase. It is possible that this material is in reality a pseudo-breccia.

In places the dolomite is vuggy. The vugs rarely reach more than 3 centimeters across. They are lined with coarse to extremely coarsely crystalline dolomite. Carbonaceous material and quartz crystals occur in the vugs.

Pure Pac Cheves c-5-A
Location: c-5-A/94-J-11
Status: abandoned
K.B. 1,776 T.D. 8,596 Completed: February, 1962
Slave Point core: 7,466-7,524; 7,624-7,682 (Recovery: 55 feet)
Slave Point top: 7,466 Base: 7,940

FIRST SLAVE POINT CORE: 7,466-7,524. This interval consists of brownish black calcilutite with abundant Amphipora, 2 to 4 millimeters in diameter. Other types of stromatoporoids are also present but in lesser amounts. The matrix rock is unresolved at x 30 under the stereoscopic microscope. The calcilutite varies from extremely carbonaceous to moderately carbonaceous, except in the lower 12 to 15 feet of the interval where it is only slightly carbonaceous. Occasional carbonaceous partings occur in the rock. Calcite veining is evident in places. The limestone shows minor dolomitization in some intervals.

The rock of the lower 15 feet (7,509-7,524) of the interval differs somewhat from that above. It contains less carbonaceous material and in places the rock is composed of fine to medium grained intraclasts which are usually merged together to produce a rock of fairly uniform texture; in some cases, however, sparry calcite fills the interstitial spaces. Sparry calcite also occurs as small discrete patches. This material often fills small spaces parallel to the bedding; in other cases no obvious pattern of distribution can be recognized. A distinctive fissile fracture, approximately horizontal, is evident in this interval; it does not appear to be related to any obvious structures or constituents of the rock. Amphipora occurs in moderate amounts in these limestones. The fissile character also occurs in other parts of the core but it is not as pronounced as in the lower 15 feet of the interval.

SECOND SLAVE POINT CORE: 7,624-7,682. The calcilutite of this Slave Point core is brownish grey to brownish black in colour and in general is unresolved at x 30 magnification. There is less evidence of carbonaceous material in the rock than in the case of the upper core. Occasional carbonaceous stylolitic breaks occur. Minor fine to medium grained intrasparites, brownish grey in colour, are present in this section. However, they rarely reach a stage of clear development. Ramose stromatoporoids including Amphipora occur sporadically. Thamnopora is also present in places.

Inclusions of sparry calcite occur occasionally in the rock. They take the form either of elongated inclusions, usually approximately parallel to the bedding, which reach up to 1 centimeter or more in length and are usually less than 1 millimeter in thickness, or the sparry calcite may occur as irregular patches usually less than 2 to 3 millimeters in maximum dimension. The former type of inclusion is often associated with rocks showing intraclast structure.

Some of the limestones possess the fissile character noted between 7,509 and 7,524 feet in the upper core.

Sohio C&E Ekwan a-55-G
Location: a-55-G/94-I-10
Status: Gas well in the Mississippian
K.B. 1,239 T.D. 6,050 Completed: February, 1962
Slave Point core: 5,831-5,865
Slave Point top: 5,740 Base: not penetrated

The core consists of dark brownish grey to dark grey calcilutite; the total interval contains moderate amounts of biogenic material. In the upper 10 feet Amphipora is common; the coenostea are usually 2 to 3 millimeters in diameter. At approximately 22.5 feet from the top of the core a 10-inch zone contains abundant ramose stromatoporoids (including Amphipora). Nodular stromatoporoids and Thamnopora also occur in this zone. There are sporadic occurrences of Amphipora and nodular stromatoporoids throughout the rest of the core. The calcilutite is carbonaceous to a varying extent, and numerous carbonaceous, stylolitic breaks are present in the core. Calcite veining occurs throughout much of the rock.

Texaco NFA Nig Creek a-79-B (1)
Location: a-79-B/94-H-4
Status: Gas well in the Triassic
K.B. 2,984 T.D. 11,999 Completed: February, 1954
Slave Point core: 11,110-11,130 (Recovery: 14 feet);
11,135-11,150 (Recovery: 12 feet)
Slave Point top: 10,930 Base: 11,215

FIRST SLAVE POINT CORE: 11,110-11,130. Dark grey to greyish black calcilutites make up the major part of this interval. The calcilutite is dense to aphanitic in texture. Abundant ramose stromatoporoids including Amphipora are present in the rock. Nodular stromatoporoids and Thamnopora also occur. Occasional brachiopods are present in parts of the interval.

In the upper 5 feet of this cored section the limestones are partially altered to dark grey, fine to medium crystalline dolomite. It is mainly the matrix rock that is affected by dolomitization; the biogenic material remains unaltered.

SECOND SLAVE POINT CORE: 11,135-11,150. This interval is composed of dark grey to greyish black calcilutites, uniformly dense in texture. Amphipora occurs sporadically in the calcilutite. In parts of the rock small, often elongated inclusions of sparry calcite are present. They vary from 1 millimeter to 5 millimeters in length.

In the upper part of the core very small tube-like structures occur. They range up to 2 millimeters in length and are about 0.1 millimeter in width. The structures show numerous closely spaced cross partitions arranged at right angles to the main axis.

Texaco NFA N Tsea d-47-C
Location: d-47-C/94-P-12
Status: abandoned
K.B. 1,924 T.D. 8,320 Completed: February, 1962
Slave Point core: 6,875-7,116 (Recovery: 236 feet)
Slave Point top: 6,860 Base: 7,116

UPPER INTERVAL: 6,875-7,081. The core of this interval provides a good section in rocks that appear in part to be true micrites. The micrites are medium brownish grey to brownish grey in colour and are aphanitic in texture. In places they contain ostracode tests (approximately 0.5 millimeter in maximum dimension). In other parts of the rock small, round, thick-walled structures occur, 100-150 microns in diameter which *have a core of clear calcite. In general the micrite contains few of the larger biogenic* fragments, but occasional stromatoporoid coenostea are present. The light coloured micrites make up 50 to 60 per cent of this cored interval.

The micrite is associated with a dark brownish grey to dark grey, carbonaceous calcilutite, which is only poorly resolved under high power of the stereoscopic microscope (x 30). There are occasional suggestions of sparry calcite in the rock and thus it may grade in parts to a sparite. This darker rock occurs most abundantly in the upper quarter (approximately 6,875-6,925) of the interval under discussion.

The dark calcilutite contains more of the larger biogenic constituents than the lighter coloured micrites. Large ramose stromatoporoids are present. Massive stromatoporoids, nodular stromatoporoids, and Amphipora also occur. Thamnopora is seen in places and brachiopod shells are occasionally encountered.

The lighter coloured micrite and the dark calcilutite are commonly interbedded on a small scale; frequently stringers and clots of the lighter coloured material pass into the dark material. In some instances there are inclusions of the dark material in the light material.

The light or dark rock type may occur over intervals of up to several feet to the exclusion of the other type. On the other hand the two rock types may be intermixed over intervals of up to several feet. In places the light coloured rock occurs as turbulent "clots" in a matrix of the dark calcilutite. These "clots" reach 4 to 5 centimeters across.

Where considerable intervals are made up of the lighter material it is often crossed, approximately horizontally, by thin veins of darker carbonaceous material. In places these veins are highly irregular and appear to cross the bedding.

Incipient dolomitization occurs in places and is seen most frequently in the dark rock type. Dolomitization in this cored interval is only of minor importance.

LOWER INTERVAL: 7,081-7,116. At 7,081 a limestone breccia occurs which consists of rounded fragments of brownish grey micrite, 1 millimeter to 3 centimeters across, set in a matrix of very light grey, dense, argillaceous limestone. When the breccia is etched the light grey matrix material stands above the included limestone fragments, presumably because the etching process removes the calcium carbonate from the matrix and leaves a thin crust of unaffected argillaceous material on the rock. Below the brecciated zone, in the interval 7,082-7,086, this distinctive very light grey limestone occurs as irregular inclusions, up to several centimeters across, in the surrounding brownish grey limestones.

The lowermost section, 7,086 - 7,116, of this Slave Point core consists of brownish grey and medium brownish grey micrites which are interbedded with increasing amounts of dark brownish grey and dark grey calcilutites towards the base of the interval. These rocks are almost devoid of the larger biogenic (stromatoporoid) material.

Texaco NFA Townsoitoi d-44-C
Location: d-44-C/94-I-10
Status: abandoned
K.B. 1,314 T.D. 6,959 Completed: March, 1962
Slave Point core: 5,903-5,923.5 (The interval 5,923.5-5,952 was also cored but no recovery was obtained.)
Slave Point top: 5,890 Base: 6,190

The core consists of dark brownish grey to brownish black calcilutite containing moderate to abundant amounts of biogenic material. The rock is very carbonaceous in parts. The biogenic material consists mainly of nodular stromatoporoids and ramose stromatoporoids including Amphipora. In the upper 10 feet of the core there are numerous occurrences of small cylindrical structures which may be derived from crinoids. These structures reach a maximum dimension of about 8 millimeters; they often show a central canal or cavity. Small shell fragments, usually less than 5 millimeters in length, are also distributed sporadically through the rock; they are replaced in many cases by whitish translucent calcite. The limestones show minor incipient dolomitization in places.

Most of the calcilutites of this section are unresolved at x 30 under the stereoscopic microscope. However, there are indications that in places the calcilutite grades to a rock made up of fine to medium grained allochems of irregular shape which are either closely compacted or associated in a micritic matrix.

Texaco NFA Tsea b-68-K
Location: b-68-K/94-P-5
Status: Gas well in Slave Point Formation
K.B. 2,070 T.D. 7,110 Completed: March, 1961
Slave Point core: 6,876-6,900 (Recovery: 22.4 feet)
Slave Point top: 6,875 Base: not penetrated

This core consists of the white and grey dolomite. The dark phase is medium dark grey in colour and varies from fine to medium crystalline in texture. The medium crystalline grades often show intercrystalline carbonaceous material. The finely crystalline dolomite is mostly uniformly pigmented and discrete particles of carbonaceous matter cannot be seen. In some parts of the core a very finely disseminated yellow mineral (sulphur ?) occurs interstitially in the medium crystalline dolomite.

The white dolomite of this core is coarse to very coarsely crystalline. It occurs in lesser amounts than the dark dolomite and gives rise to the banded, clotted, and microinclusion textures. In the first, thin bands of the white dolomite 2 to 3 millimeters across, often with a medial cavity, cross the dark phase at a slight angle to the horizontal, but in rare cases they are inclined at 30 degrees from the horizontal. In parts the bands show an undulating form. Thicker bands reaching up to 1 centimeter across are present in parts. In the clotted texture seen in this core "clots" of white dolomite with vague outlines and varying from 0.5 to 8 centimeters across are distributed in the dark dolomite. The microinclusion texture is illustrated in Plate XI. Small inclusions of the white dolomite, usually less than 5 millimeters across are disseminated in a matrix of the dark dolomite.

Vugs are common in this core. They vary from 0.5 centimeter across to the full width of the core (3.5 inches). The vugs are lined with coarse to very coarsely crystalline white dolomite together with quartz crystals. Dark carbonaceous material often occurs in the vugs. Many of the vugs are elongated in form; others have a rounded outline.

Texaco NFA Walrus b-86-L
Location: b-86-L/94-I-16
Status: Gas well in the Mississippian
K.B. 1,753 T.D. 6,501 Completed: March, 1962
Beaverhill Lake core: 5,779-5,788.5 (Recovery: 8.5 feet)
Beaverhill Lake top: 5,775 Base: 5,805

The interval consists of medium grey to medium dark grey, non-calcareous to very calcareous shale. The shale tends to break into blocks rather than thin plates. Moderate amounts of very finely disseminated pyrite occur in parts; 5 feet from the top of the core a 2-inch zone contains abundant pyrite; it occurs in aggregates with crystals up to 1.5 millimeters across. In some places the rock contains very small fragments of brownish black chitinous material. These range up to approximately 1 millimeter in length.

Dark grey to dark brownish grey argillaceous limestone occurs in the interval 5,785-5,786. The limestone contains much broken and fragmented biogenic material. It also contains larger, more complete, but poorly preserved brachiopod shells. Interbedded with the limestone is a medium dark grey, non-calcareous shale containing small chitinous brachiopod valves.

TGT Tooga Lake c-27-K
Location: c-27-K/94-P-2
Status: abandoned
K.B. 2,103 T.D. 6,725 Completed: February, 1961
Slave Point core: 6,319-6,504
Slave Point top: 6,270 Base: 6,610

UPPER INTERVAL: 6,319-6,429. This interval of Slave Point core consists of brownish grey to dark brownish grey calcilutite, very fine grained to dense in texture. Carbonaceous material is moderately abundant in the rock; some of it occurs in stylolitic partings. In places the calcilutites grade into rock which shows suggestions of intrasparite texture.

Biogenic material occurs abundantly in some sections of the core. It consists mainly of small Amphipora (approximately 2 to 3 millimeters in diameter) but also includes other ramose forms and nodular and massive stromatoporoids. Thamnopora is abundant over the interval 6,404-6,429; it also occurs sporadically in other parts of the core. Occasionally brachiopod shells occur in the core; in some cases they are replaced by light coloured translucent calcite.

LOWER INTERVAL: 6,429-6,504. The rock of this interval consists of brownish grey to dark brownish grey stromatoporoid-bearing calcilutite, which grades in several places into fairly well developed fine to medium grained intrasparites. The lighter coloured rock (brownish grey) is dominant in the lower 35 to 40 feet. There are suggestions in parts of the core of intramicrites. The intraclasts of the latter tend to be angular in outline and to merge into the matrix. It should be noted, however, that the intraclast rocks form only a minor element in the total lithology.

Carbonaceous material occurs in only moderate amounts. Biogenic material is common in some intervals. Amphipora and nodular stromatoporoids occur over restricted intervals usually about 1 to 2 feet in thickness and containing mainly either one type or the other. Idiostromatidae, other than Amphipora, and Thamnopora also occur in the rock.

West Nat et al Clarke b-70-I
Location: b-70-I/94-J-10
Status: Gas well in Slave Point Formation
K.B. 1,309 T.D. 6,422 Completed: January, 1961
Slave Point core: 6,260-6,284 (Recovery: 21.5 feet)
Slave Point top: 6,205 Base: not penetrated

The cored interval consists of vuggy white and grey dolomite. The main types of texture represented are the clotted, banded, and macroinclusion. In some sections of the core white coarsely crystalline dolomite is very abundant; in one 7-inch section it makes up 75 per cent of the rock.

The vugs in the rock range in size from less than 1 centimeter across up to the full width of the core (3.5 inches). Black carbonaceous material occurs in the vugs and also in fissures in the rock. In places the carbonaceous material contains disseminated crystals of dolomite which fall into the fine size class.

Thin, irregular inclusions and interbeds of dark grey carbonaceous shale occur in places. Some of the shale is slightly calcareous, in other places it shows a greasy lustre.

West Nat et al Clarke c-78-I
Location: c-78-I/94-J-10
Status: Gas well in Slave Point Formation
K.B. 1,295 T.D. 6,533 Completed: February, 1960
Slave Point core: 6,183-6,199 (Recovery: 1 foot)
Slave Point top: 6,152 Base: not penetrated

The recovery for this interval is very poor; only 1 foot of rock represents the cored section. The recovered material consists of rounded fragments of the white and grey dolomite. The texture of the rock is difficult to ascertain because of the fragmentary condition, but the clotted texture can be recognized in places. Some areas of the dark phase of the rock appear to be argillaceous. The dolomite contains vugs in parts. The very poor recovery from this interval suggests that the original rock was extremely vuggy.

West Nat et al Clarke c-47-J
Location: c-47-J/94-J-10
Status: Gas well in Slave Point Formation
K.B. 1,343 T.D. 6,957 Completed: January, 1957
Slave Point core: 6,550-6,572 (Recovery: 16 feet)
Slave Point top: 6,510 Base: 6,750

The recovered material consists largely of white and grey dolomite which is moderately vuggy. Over the total interval the light coloured phase is abundant and it makes up 60 to 65 per cent of the recovered material. Some intervals, reaching up to 7 inches in thickness consist almost entirely of white dolomite. The following textures of the white and grey dolomite were observed: banded, clotted, and pseudo-brecciated. In the latter blocks of the dark dolomite occur in a matrix of the lighter phase and the reverse relationship is also developed. In places the darker coloured dolomite is cut by veins of white, coarse to very coarsely crystalline dolomite.

Carbonaceous material occurs both between the crystals of the dark phase of white and grey dolomite and also in the vugs. Pyrite occurs in parts of the rock.

West Nat et al Evie d-14-F
Location: d-14-F/94-J-15
Status: abandoned
K.B. 1,728 T.D. 7,925 Completed: December, 1961
Slave Point core: 6,902-6,960
Slave Point top: 6,610 Base: 6,985

This Slave Point core is composed mainly of biosparrudites. The rock grades in parts to a biosparite with allochems in the arenaceous size class. Stromatoporoids constitute the main biogenic component; much of the material is fragmented and thus its original form cannot be recognized. However, ramose stromatoporoids are well represented and in addition many of the fragments are probably derived from nodular and massive forms. Over substantial intervals of the core this biogenic material is distributed in a matrix of sparry calcite, which grades in parts to dense, finely crystalline calcite.

Much of the stromatoporoid material has undergone recrystallization to dense biogenic calcite, light brownish grey in colour. Accompanying the recrystallization process there has been a redistribution of the carbonaceous material with a tendency for it to become aggregated in certain areas of the fragments or to be extruded almost completely from the biogenic material.

In the lower half of this Slave Point core medium brownish grey limestones occur which possess a more uniform texture than the biosparrudites. There is much fine carbonaceous banding in these rocks; usually it is approximately horizontal. Microscopic examination reveals that the rocks are composed in part of closely compacted biogenic material, which passes into a rock made up of fine to coarse grained allochems (intraclasts or fossil fragments). Interstitial sparry calcite may fill the spaces between the allochems but in some areas they are merged together to form a limestone of micritic appearance.

West Nat et al Evie Lake b-89-E
Location: b-89-E/94-J-15
Status: abandoned
K.B. 1,943 T.D. 8,240 Completed: September, 1960
Slave Point core: 6,634-6,679; 6,730-6,780; 6,840-6,890 (Recovery: 45 feet)
Slave Point top: 6,555 Base: 6,930

FIRST SLAVE POINT CORE: 6,634-6,679. The upper 35 feet of this core is made up largely of fragmented stromatoporoids. Over most of the interval the biogenic material is closely compacted with a matrix consisting of sparry calcite or more rarely finely crystalline to aphanitic calcite. In some intervals the biogenic components are dispersed in a matrix of dark grey calcilutite. The lower 10 feet of the core consists mainly of dark grey calcilutite which contains relatively small amounts of biogenic material.

The dark grey calcilutite thus forms a rock in its own right and also occurs as the matrix in rocks composed largely of stromatoporoid fragments. The calcilutite contains abundant carbonaceous material which imparts the dark colour.

The stromatoporoid material in the core is mainly in a fragmented condition and most of it appears to be derived from large ramose types (coenostea 0.5 to 1 centimeter in diameter), but in addition fragments of small ramose and nodular stromatoporoids are present. Thamnopora and occasional large brachiopods reaching 3 centimeters across also occur.

SECOND SLAVE POINT CORE: 6,730-6,780. The dominant lithological type represented in this core is the stromatoporoid biosparite. The biogenic fragments vary in size from the fine arenaceous size grade up to diameters in excess of 2 centimeters. The larger fragments in some cases are recrystallized to brownish grey dense biogenic calcite with the accompanying redistribution of contained carbonaceous material. The fine to medium grained biosparites are often dark grey in colour and close examination is necessary to establish the fact that the rock is a biosparite.

A certain amount of size sorting of the biogenic material is evident and biosparites with fragments in the fine to medium arenaceous size grades occur in places as beds from 6 inches to 1 foot in thickness. Other sections of the core consist of more poorly sorted biosparrudites.

In places indications of bedding can be seen in the fine to coarse grained biosparites; in the observed cases it is approximately horizontal.

Stromatoporoids are the most common organic structures preserved in the core and it appears that amongst these forms the large ramose types are dominant. However, much of the material is fragmented and its original nature is difficult to establish. Massive stromatoporoids occur occasionally; Amphipora was not recognized with certainty but this form may occur as recrystallized fragments.

Brachiopods occur in parts of the core and gasteropods are occasionally encountered. Thamnopora is another member of the faunal assemblage.

The colour of the rocks of this cored section varies between dark grey and light to medium brownish grey. The amount of carbonaceous material present in the rock and the way it is distributed between the biogenic fragments and the matrix are the main factors which influence the colour of the rock.

In some parts of the lower section of this core limestones that appear to be true micrites are developed. They are light brownish grey in colour and they contain varying amounts of biogenic material.

THIRD SLAVE POINT CORE: 6,840-6,890. The third Slave Point core continues the pattern seen in the second core. The lower core consists mainly of stromatoporoid biosparites, the fragments of which range in size from very fine to coarse grained and up into the rudaceous size class, the latter embracing the large stromatoporoid fragments. Much of the stromatoporoid material is fragmented but large ramose types together with nodular forms which reach a maximum dimension of 2 to 3 centimeters can be recognized. There are occasional massive stromatoporoids, many centimeters in maximum dimension, and laminar types are also present.

As in the case of the preceding core the way in which the carbonaceous material is distributed is a most important factor in determining the colour of the rock.

In the lower 5 feet and also over restricted intervals in other parts of the core a uniform, light brownish grey, aphanitic limestone occurs. Some of this material may be dense biogenic calcite derived from the recrystallization of algal or stromatoporoid material. Again, parts of it may be a true micrite and there is evidence in places that the rock was originally an intrasparite which has subsequently undergone recrystallization to form a dense aphanitic limestone. Veins of carbonaceous materiel cross this light coloured rock in the lower 5 feet of the core.

West Nat Imp Clarke Lake c-8-D
Location: c-8-D/94-J-16
Status: Gas well in Slave Point Formation
K.B. 1,380 T.D. 6,650* Completed: December, 1959
Slave Point core: 6,307-6,330* (Recovery: 14 feet);
6,343-6,366* (Recovery: 6 feet);
6,436-6,468* (Recovery: 3 feet)
Slave Point top: 6,270* Base: not penetrated

FIRST SLAVE POINT CORE: 6,307-6,330. The recovery for this interval is 14 feet. The core consists of white and grey dolomite showing the clotted, macroinclusion, nebulous and pseudo-brecciated textures. Veins of white dolomite usually about 2 to 3 millimeters in width cross the core in places. The rock is vuggy. Some of the vugs attain a width of 3 to 4 centimeters. Carbonaceous material is often present in the vugs. Occasional carbonaceous breaks (stylolites ?) are developed in the rock. Some sections of the core, up to 12 centimeters in length, consist of coarsely to very coarsely crystalline dolomite with abundant carbonaceous material between the crystals. A foot of core at the base of the interval consists of brownish grey, fine to medium crystalline dolomite showing the microinclusion texture. The inclusions are distributed in such a way that they give rise to turbulent structures within the rock. This lower section of brownish dolomite appears to be argillaceous.

SECOND SLAVE POINT CORE: 6,343-6,366. Only 6 feet of core was recovered from this interval. The upper 2 feet consist of carbonaceous, dolomitic, argillaceous material, greyish black in colour. Vugs are present in the rock and they contain carbonaceous material. The lower 4 feet of the core is made up of vuggy white and grey dolomite. There are indications of brecciation in this dolomite. Dark carbonaceous material and small amounts of sphalerite occur in fissures in the rock.

THIRD SLAVE POINT CORE: 6,436-6,468. Only 3 feet of rock was recovered over this interval. Most of the recovered material consists of greyish black, carbonaceous shale. The rock shows the development of irregular partings which exhibit a "greasy" surface. Brown coloured score marks are produced when the shale is scratched with a steel needle.

Also present in the recovered material is an 8-inch section of the white and grey dolomite showing pseudo-brecciated texture. The dolomite contains argillaceous inclusions and is pyritic in parts.

The evidence suggests that these three Slave Point cores come from an area very close to the facies front. The vuggy nature of the rock indicated by the poor recovery, and the presence of abundant argillaceous and carbonaceous material support this interpretation.

*Inclined hole, figures quoted are true vertical depths.

West Nat Imp Clarke Lake b-78-J
Location: b-78-J/94-J-9
Status: Gas well in Slave Point Formation
K.B. 1,309 T.D. 6,520 Completed: March, 1961
Slave Point core: 6,205-6,243; 6,271-6,331; 6,435-6,491
Slave Point top: 6,205 Base: not penetrated

The following remarks refer to all three cored sections, except as indicated.

The limestone of these cores contains abundant stromatoporoid material both in a fragmented and a more complete form. The upper two intervals contain a higher proportion of biogenic material than the lower interval. Most of the stromatoporoid material is derived from massive, nodular, laminar, and large ramose types; Amphipora occurs only in relatively subordinate amounts.

There is a considerable diversity of size and shape amongst the stromatoporoid fragments; some are obviously derived from ramose types, others are more angular in outline and these vary from 1 to 2 centimeters in maximum dimension. Other, more complete stromatoporoid coenostea, are much larger.

The stromatoporoid material is mainly medium brownish grey in colour; it grades to light brownish grey in parts. The stromatoporoid fragments are frequently altered to very finely crystalline calcite (dense biogenic calcite).

The matrix in which this biogenic material is dispersed consists of a dark brownish grey to dark grey calcilutite. Under the microscope this rock is seen to pass in parts to an intraclast rock, in which the intraclasts are in the fine to medium arenaceous size class and are set in a matrix of carbonaceous, micritic calcite or more rarely sparry calcite.

In the upper part of the lowermost core (6,435-6,491) clearly developed biosparites occur in subordinate amounts. They consist of stromatoporoid coenostea, both large ramose and nodular types, compacted together in a sparry calcite matrix.

In the lower part of the same core (6,435-6,491) there are intervals which are relatively free of stromatoporoid material and dark grey and dark brownish grey colours are prominent. The rock appears to be a calcilutite-biosparite-intrasparite assemblage in which the allochems of the sparites are in the fine to medium arenaceous size class.

West Nat Imp Clarke Lake d-91-L
Location: d-91-L/94-J-9
Status: Gas well in Slave Point Formation
K.B. 1,366 T.D. 6,550 Completed: March, 1960
Slave Point core: 6,291-6,303; 6,456-6,499
Slave Point top: 6,290 Base: not penetratea

FIRST SLAVE POINT CORE: 6,291-6,303. This core consists to a large extent of stromatoporoid material. Massive stromatoporoids, large ramose stromatoporoids, Amphipora, and fragments of these types are all present. Much of the biogenic material is recrystallized to brownish grey dense biogenic calcite. In parts of the core the organic material is closely compacted and in some areas minor interstitial sparry calcite is present; in other parts of the core the biogenic components are dispersed in a brownish grey micritic matrix which also contains fine to coarse, angular allochems and ostracode shells.

Carbonaceous material is present and it is often restricted to a fissure pattern which crosses the recrystallized stromatoporoid material; in a smaller number of instances it surrounds the outer border of the biogenic fragments. The larger stromatoporoids tend to show areas in which the carbonaceous material is aggregated, and other areas which are relatively free of this material.

In summary, it can be said that the core consists mainly of closely compacted stromatoporoid material together with stromatoporoid biomicrites.

SECOND SLAVE POINT CORE: 6,456-6,499. The cored section consists of an upper limestone interval (6,456-6,461), a central section of limestones and dolomites (6,461-6,487), and a lower interval consisting of limestone (6,487-6,499).

The upper and lower limestone sections are similar to those described for the first Slave Point core. The limestone of the upper interval is dark grey in colour whilst that of the lower interval is brownish grey in colour. Both sections contain considerable amounts of stromatoporoid material (massive, large ramose types, and Amphipora are represented). The biogenic material is either closely compacted or dispersed in a matrix of dark grey or brownish grey micrite. Recrystallization has produced a rock of dense uniform texture. The limestone shows incipient dolomitization.

The central interval (6,461-6,487) consists of an alternating series of limestones and dolomites. The limestones are mostly dark grey in colour and appear to consist largely of fragments of biogenic material.

Some of the dolomites of the central interval are of the white and grey type (see page 24) and show microinclusion, macroinclusion, and nebulous textures. They appear to be derived from stromatoporoid-bearing calcilutites which carried moderate to abundant amounts of biogenic material--the latter giving rise to the light phase and the dark calcilutite to the dark phase of the dolomites. These dolomites are vuggy in parts; the vugs vary from less than 1 centimeter in maximum dimension up to 3 to 4 centimeters.

Limestones showing partial dolomitization are present in the section and in these rocks the biogenic fragments are altered to white coarsely crystalline dolomite whilst the matrix limestone shows disseminated crystals of dolomite in the medium to coarse size grades.

West Nat Imp Clarke Lake c-94-L
Location: c-94-L/94-J-9
Status: Gas well in Slave Point Formation
K.B. 1,372 T.D. 8,039 Completed: February, 1959
Slave Point core: 6,355-6,383 (Recovery: 17.5 feet);
6,401-6,565 (Recovery: 141.6 feet)
Slave Point top: 6,355 Base: 6,700

FIRST SLAVE POINT CORE: 6,355-6,383. The core consists mainly of white and grey dolomite. The clotted, nebulous, and microinclusion textures (see pages 24 and 25) are developed. Some intervals consist of medium grey, medium crystalline dolomite. Small vugs are developed throughout the cored section. They are lined with coarse to very coarsely crystalline dolomite and vary from a few millimeters to several centimeters in maximum dimension. Quartz crystals and carbonaceous material occur in the vugs. Intercrystalline porosity is developed in addition to the vuggy porosity.

SECOND SLAVE POINT CORE: 6,401-6,565. This cored interval can readily be divided into two parts: an upper part (6,401-6,513) consisting of dolomite and a lower part (6,513-6,565) consisting mainly of limestone.

The dolomite section (6,401-6,513) consists for the most part of the white and grey dolomite although some sections of the core, reaching up to 15 centimeters in length, are made up of white coarsely crystalline dolomite. The following textures can be recognized in the white and grey dolomite: microinclusion, macroinclusion, nebulous, clotted, and pseudo-brecciated. For the interval as a whole the white dolomite makes up about 35 per cent of the core and the darker, usually matrix-forming dolomite, represents about 65 per cent of the core.

The darker dolomite is medium light grey to medium grey in colour and medium to coarsely crystalline in texture; the medium crystalline types are the most common. Intercrystalline carbonaceous material occurs in this medium and coarsely crystalline dolomite.

The light coloured phase of the white and grey dolomite in the core is coarse to very coarsely crystalline in texture. Vugs are common in this phase and they range from less than 1 centimeter across up to several centimeters in diameter. They are lined with very coarse crystals of dolomite; quartz crystals also occur in the vugs. Carbonaceous material is frequently present between the crystals of the vug lining.

In addition to the vuggy porosity intercrystalline porosity is developed in places between the crystals of the dark phase of the white and grey dolomite.

As noted above the section 6,513-6,565 of this core consists largely of limestones. These form a complex group of carbonates which are difficult to interpret because of the poor condition of the core and the tendency for original textures to be lost by recrystallization.

Medium brownish grey to brownish grey intrasparites (possibly biosparites) occur which show fine to coarse grained allochems. They appear to grade in parts to a rock with little evidence of allochems and these may be "welded" intramicrites or possibly true micrites.

In other parts of the core brownish grey biomicrites are developed. The vague forms of large biogenic fragments can be seen embedded in the biomicrites and some of the micrites (?).

There is evidence that a considerable number of massive stromatoporoids occur in the core which in some cases have sparry calcite infilling cavities in the structure; large ramose forms are also present.

Some intervals of the core probably consisted almost entirely of large ramose stromatoporoids set in a matrix of sparry calcite. In a few instances this rock type is clearly developed (see Plate IX) but more often recrystallization of the stromatoporoids to dense biogenic calcite and an apparent deformation (compression) of the rock have obscured its original nature.

Incipient dolomitization occurs in parts of the limestone section. The dolomite crystals are either disseminated more or less evenly through the rock or isolated in small patches. The secondary dolomite is medium and coarsely crystalline in texture. In some of the more clearly developed biogenic rocks the dolomitization is restricted to matrix material lying between the biogenic fragments. Authigenic quartz prisms occur commonly in some of the micrites (?) and biomicrites of this limestone interval.

West Nat Kotcho a-9-F
Location: a-9-F/94-P-3
Status: abandoned
K.B. 2,191 T.D. 6,966 Completed: March, 1961
Muskwa core: 6,636-6,656 (Recovery: 20 feet)
Muskwa top: 6,585 Base: 6,656

The Muskwa Formation of this core consists of greyish black, nor-calcareous to slightly calcareous shale, which shows brown coloured score marks when scratched with a steel needle. The rock is moderately pyritic in parts. In the lower 2 feet of the core chitinous brachiopods are very common. Authigenic barite occurs in the shale; it is normally restricted to narrow zones which may reach a thickness of 2.5 inches. Seven of these zones are present in the cored interval.

At the base of this core the dark shales lie above the Slave Point Limestone. A short unbroken section of core 2.5 feet from the base of this interval shows a contact between 0.15 inch of shale and 1.5 inches of biomicrite containing crinoid fragments and stromatoporoid material. The contact is sharp, undulating and approximately horizontal. Below this thin limestone the lithology passes back to shale and at the base of the cored shale interval another short unbroken section of core appears to represent the contact with the Slave Point Formation. In this case a sharp contact is preserved between 0.25 inch of shale and 1 inch of Slave Point Limestone.

The above description indicates that the contact between the Slave Point and overlying shales is not a simple, sharp contact between a limestone unit and a shale unit. However, it should be borne in mind that in a well such as the present one, situated close to the facies front, the Slave Point may in fact be overlain by a thin section of the Otter Park Shale which in turn would be overlain by the Muskwa Formation. This could readily account for the minor interbedding of limestone and shale observed near the contact.

Slave Point core: 6,656-6,693 (Recovery: 33 feet)
Slave Point top: 6,656 Base: 6,820

The Upper 15 feet of this interval is made up largely of fragmented stromatoporoids. The fragments range in maximum dimension from almost 2 inches across (diameter of core) down to particles which fall into the arenaceous size class. The fragments are either compacted together or disseminated in a matrix of calcilutite which appears to be argillaceous in places. Some parts of the section consist mainly of calcilutite. The limestone of this upper interval varies from brownish grey to light brownish grey in colour. Much of the stromatoporoid material in the rock is recrystallized to dense biogenic calcite.

The biogenic rocks of the upper 15 feet grade down in the lower part of the core to brownish grey to dark brownish grey limestones, dense in texture, in which moderate amounts of stromatoporoid material are present. These rocks contain finely disseminated carbonaceous material in places.

INDEX

Plate I. Dark stromatoporoid-bearing calcilutite with only minor amounts of biogenic material. x 2/3. From the well, BA Shell Klua b-49-F (94-J-9) at 6,524 feet. Photograph of cut and etched core sample.*

Plate II. Dark stromatoporoid-bearing calcilutite with moderate amounts of encrusting stromatoporoids and brachiopod fragments. x 4/5. From BA Shell Klua b-49-F (94-J-9) at 6,520 feet. Photograph of cut and etched core sample.

*The coin used as a scale in Plates I to XX is 1.9 centimeters in diameter.

Plate I.

Plate II.

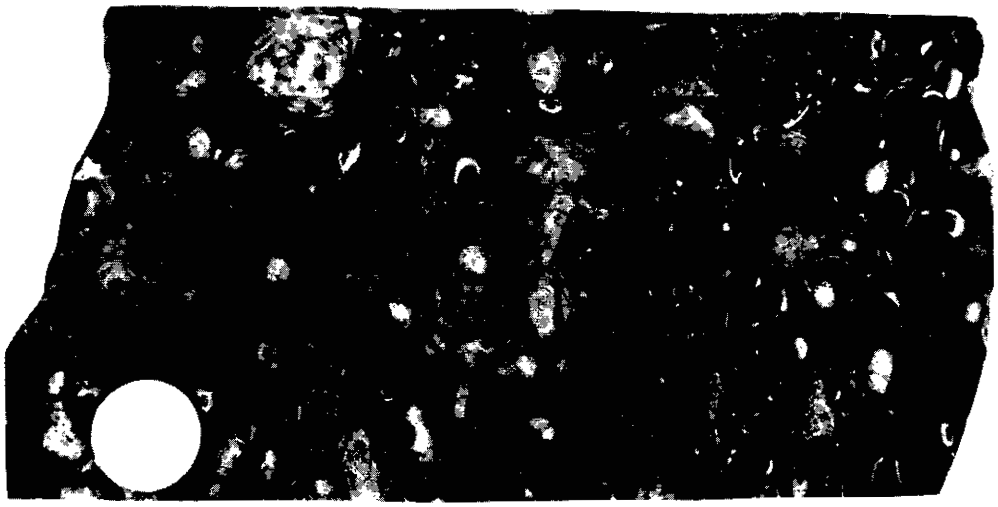

Plate III. Dark stromatoporoid-bearing calcilutite with moderate amounts of biogenic material (Amphipora most common type) showing well developed nodular stromatoporoids. x 3/5. From the well, Imp Fontas d-37-B (94-I-7) at 6,459 feet. Photograph of cut and etched core sample.

Plate IV. Dark stromatoporoid-bearing calcilutite containing abundant Thamnopora and ramose stromatoporoids. Natural size. From the well, BA Shell Klua b-49-F (94-J-9) at 6,512 feet. Photograph of cut and etched core sample.

Plate III.

Plate IV.

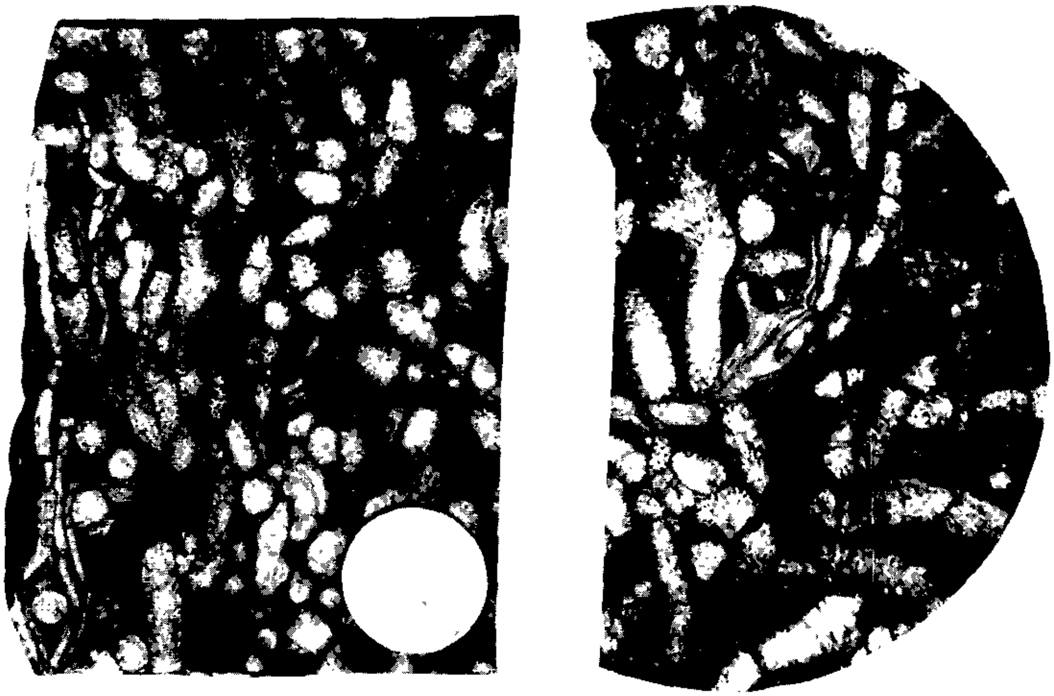

Plate V. Dark stromatoporoid-bearing calcilutite with abundant laminar and ramose stromatoporoids. x 4/5. From the well, BA Shell Klua b-49-F (94-J-9) at 6,507 feet. Photograph of cut and etched core sample.

Plate VI. Part of massive stromatoporoid from the well, BA Shell Klua b-49-F (94-J-9) at 6,478 feet. x 3/5. This specimen occupies a continuous 22-inch section of the core. Photograph of cut and etched surface of core sample.

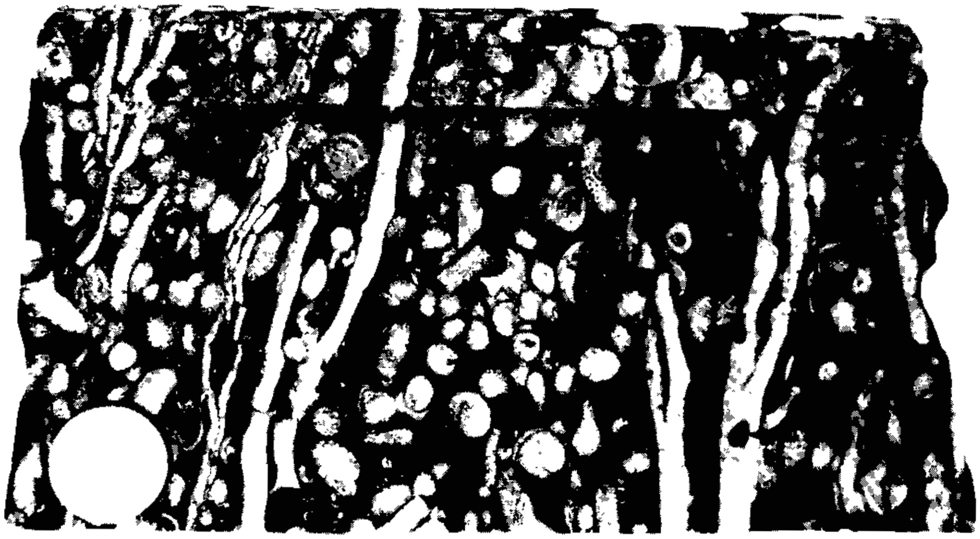

Plate V.

Plate VI.

Plate VII. Limestone from the facies front. Poorly sorted stromatoporoid biosparite from West Nat et al Evie Lake b-89-E (94-J-15) at 6,777 feet. Natural size. Rock consists mainly of poorly sorted stromatoporoid fragments partly recrystallized to dense biogenic calcite, set in a matrix of sparry calcite and dense calcite. Note large brachiopod shell at left. Dark carbonaceous material occurring in fissures in the recrystallized stromatoporoid fragments can be seen at lower left of photograph. Photograph of cut and etched core sample.

Plate VIII. Limestone from the facies front. Sorted stromatoporoid biosparite from West Nat et al Evie Lake b-89-E (94-J-15) at 6,861 feet. Natural size. Most of the stromatoporoid fragments have undergone recrystallization to dense biogenic calcite. Dark rings of carbonaceous material surround many of the fragments. The dark band which crosses the lower half of the specimen contains biogenic fragments which are smaller than those in other parts of the rock. Photograph of cut and etched core sample.

Plate IX. Limestone from the facies front. Stromatoporoid biosparrudite from West Nat Imp Clarke Lake c-94-L (94-J-9) at 6,523 feet. x 4/5. Rounded fragments of ramose stromatoporoids are set in a matrix of sparry calcite. Photograph of cut and etched core sample.

Plate X. Limestone from the facies front. Stromatoporoid biomicrudite from West Nat Imp Clarke Lake c-94-L (94-J-9) at 6,539 feet. Approximately natural size. Ramose and nodular stromatoporoids are closely packed in a micritic matrix. Photograph of cut and etched core sample.

Plate VII.

Plate VIII.

Plate IX.

Plate X.

Plate XI. The white and grey dolomite--microinclusion texture. x 5/6. From Texaco NFA Tsea b-68-K (94-P-5) at 6,881 feet. Photograph of cut core surface.

Plate XII. The white and grey dolomite--macroinclusion texture. x 3/4. From West Nat Imp Clarke Lake d-91-L (94-J-9) at 6,463 feet. Photograph of cut core surface.

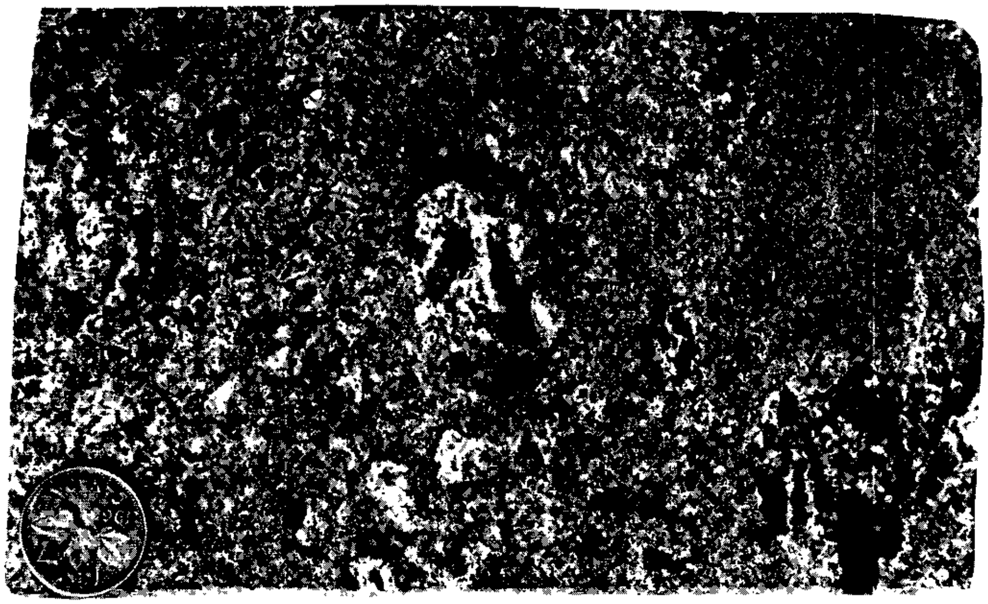

Plate XI.

Plate XII.

Plate XIII. The white and grey dolomite--banded texture. Approximately natural size. Details of location and depth not available at time of publication. Photograph of core sample.

Plate XIV. The white and grey dolomite--right side of photograph shows the clotted texture. Approximately natural size. From West Nat Imp Clarke Lake c-94-L (94-J-9) at 6,480 feet. Photograph of cut core surface.

Plate XIII.

Plate XIV.

Plate XV. The white and grey dolomite--left side of photograph shows the nebulous texture. Natural size. From West Nat Imp Clarke Lake c-94-L (94-J-9) at 6,472 feet. Photograph of cut core surface.

Plate XVI. The white and grey dolomite--pseudo-brecciated texture. x 5/6. From West Nat Imp Clarke Lake c-94-L (94-J-9) at 6,467 feet. Photograph of cut core surface.

Plate XV.

Plate XVI.

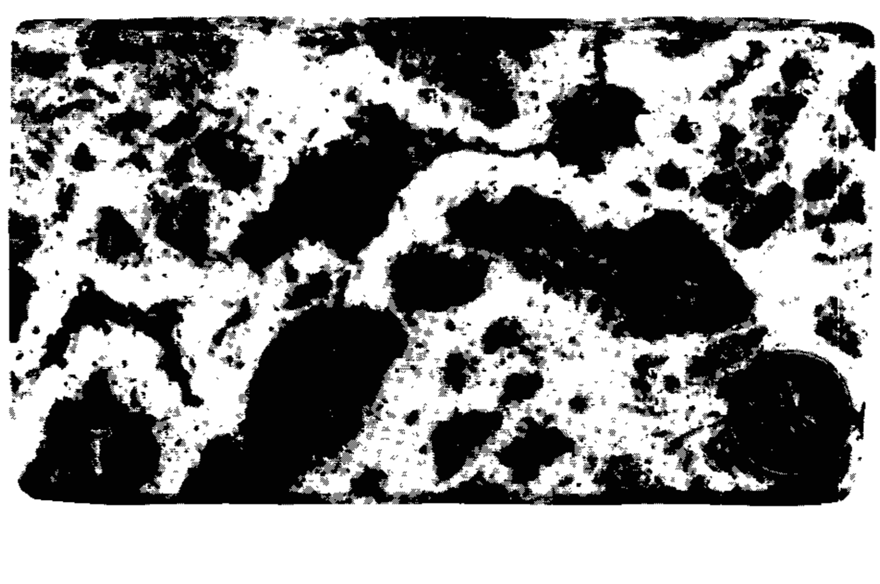

Plate XVII. Dark stromatoporoid-bearing calcilutite from Pure Pac Cheves c-5-A (94-J-11) at 7,507 feet. Thin section in transmitted unpolarized light. x 15. Amphipora coenosteum at right of photograph; cross section of ostracode at lower centre. Note presence of dark bodies 0.06 to 0.2 millimeter in diameter.

Plate XVIII. Intrasparite from HB Imperial Union Paddy a-49-B (1) (94-H-16) at 7,986 feet. Thin section in transmitted unpolarized light. x 11.5. Irregularly shaped intraclasts, mainly 0.1 to 0.5 millimeter in diameter are set in a matrix of sparry calcite. Oölites and superficial oölites are also common in the rock.

Plate XIX. Calcarenite showing cross sections of ostracodes and Calcisphaera from HB Imp Union Gutah a-99-K (94-H-10) at 8,081 feet. x 13. Photograph of etched surface. The peripheral spines of several specimens of Calcisphaera can be seen in the lower left-hand quarter of the photograph.

Plate XX. Foraminifera and brachiopod biosparite from HB Imp Union Gutah a-99-K (94-H-10) at 8,102 feet. Thin section in transmitted unpolarized light. x 8.5. Photograph shows cross section of several foraminifera and numerous brachiopod shell fragments. The matrix material is sparry calcite.

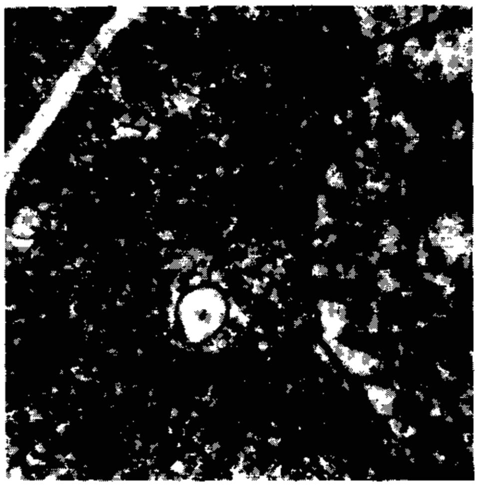

Plate XVII.

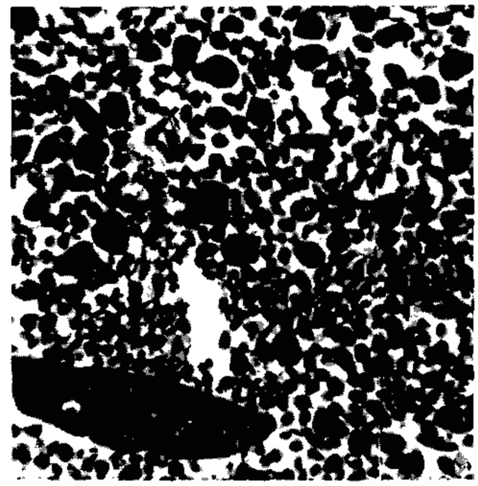

Plate XVIII.

Plate XIX.

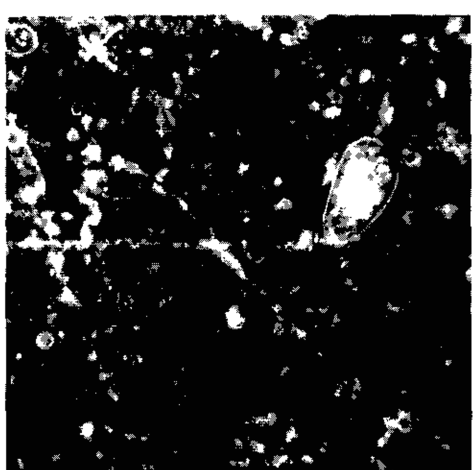

Plate XX.

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APPENDIX III - MAP SHOWING LOCATION OF WELLS USED IN STUDY AND THE DISTRIBUTION OF SLAVE POINT FORMATION.

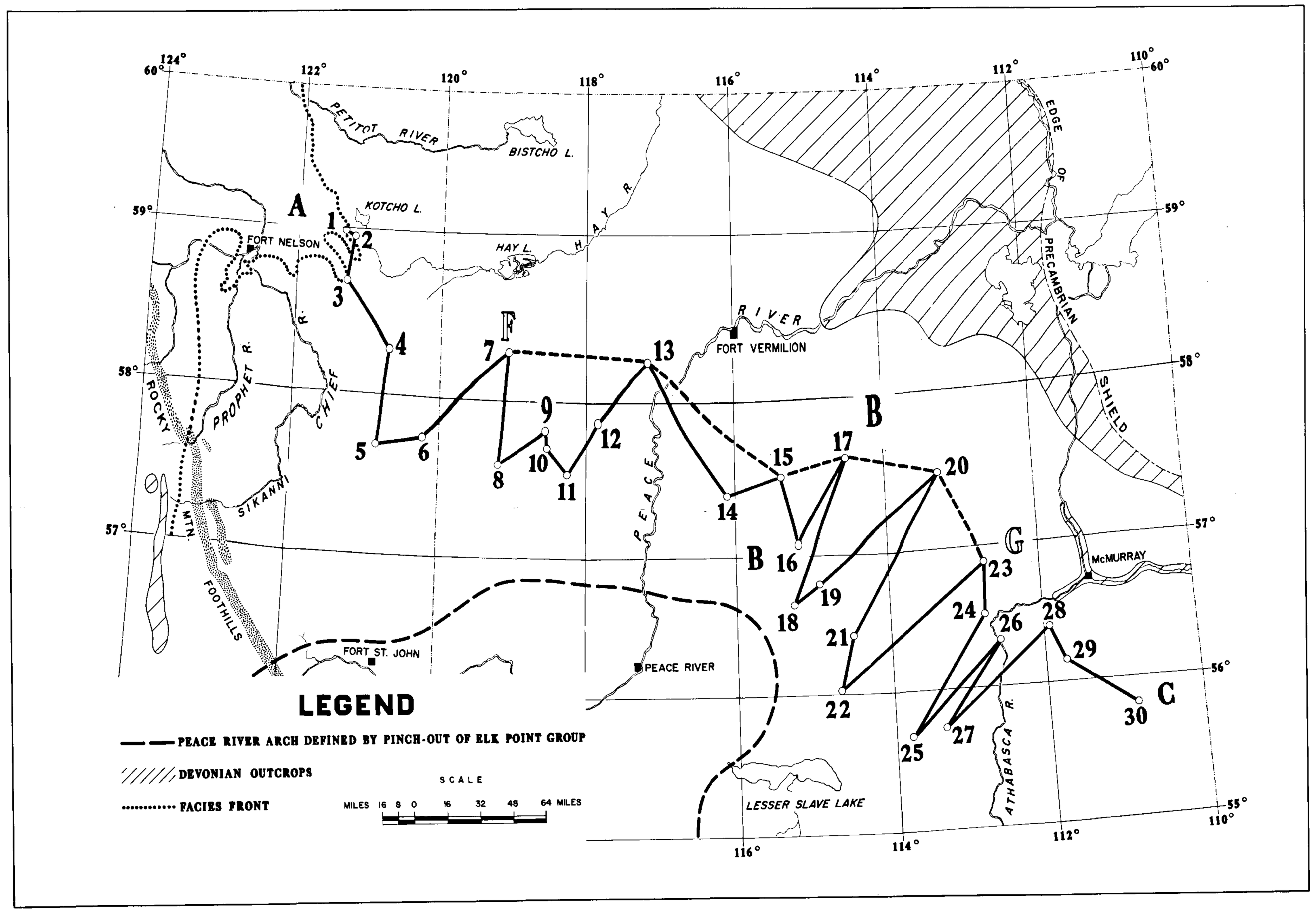

FIGURE 5 -- INDEX MAP -- showing lines of Section ABC and Section FG.

To accompany Bulletin 50. "The Slave Point, Beaverhill Lake and Muskwa Formations in Northeastern British Columbia". 1964.

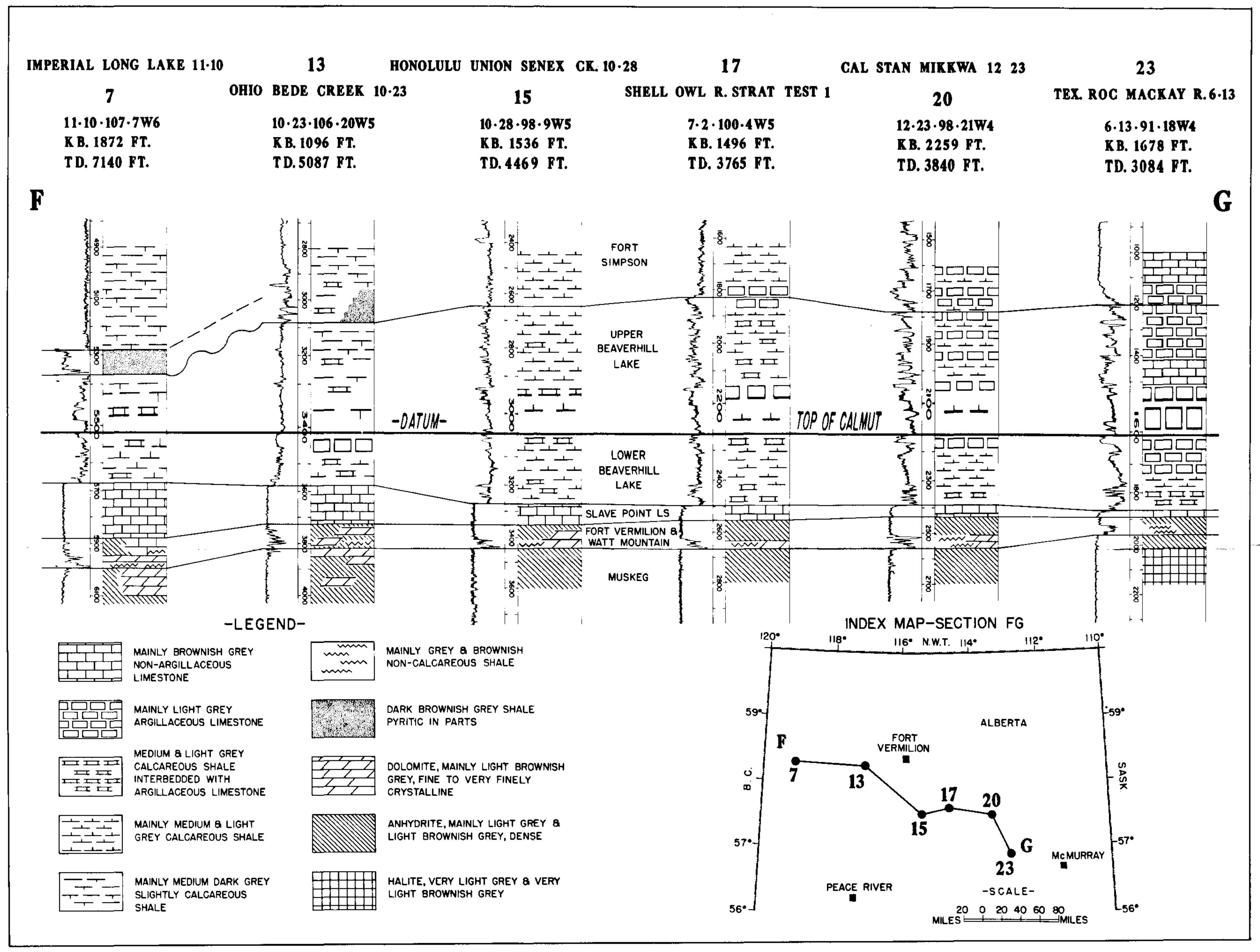

FIGURE 7 -- Cross section FG showing the lithology over the Muskwa - Beaverhill Lake - Slave Point interval in selected wells from Section ABC. Depths in feet shown on well logs.

FIGURE 6 -- Cross section ABC. The section traces the Slave Point, Beaverhill Lake and Muskwa Formations between the Kotcho Lake area of northeastern British Columbia and eastern Alberta. The section is based on Gamma Ray Neutron and Gamma Ray Sonic Logs. Depths in feet shown on well logs.

#50 (2)