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OF 699

NORTH-EASTERN BRITISH COLUMBIA

SUBSURFACE BIOSTRAT STUDIES

1. MIDDLE & EARLY UPPER DEVONIAN

Raasch and Associates

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1. MIDDLE & EARLY UPPER DEVONIAN

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Relationships, Devonian, Western
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NORTH-EASTERN BRITISH COLUMBIA

SUBSURFACE BIOSTRAT STUDIES

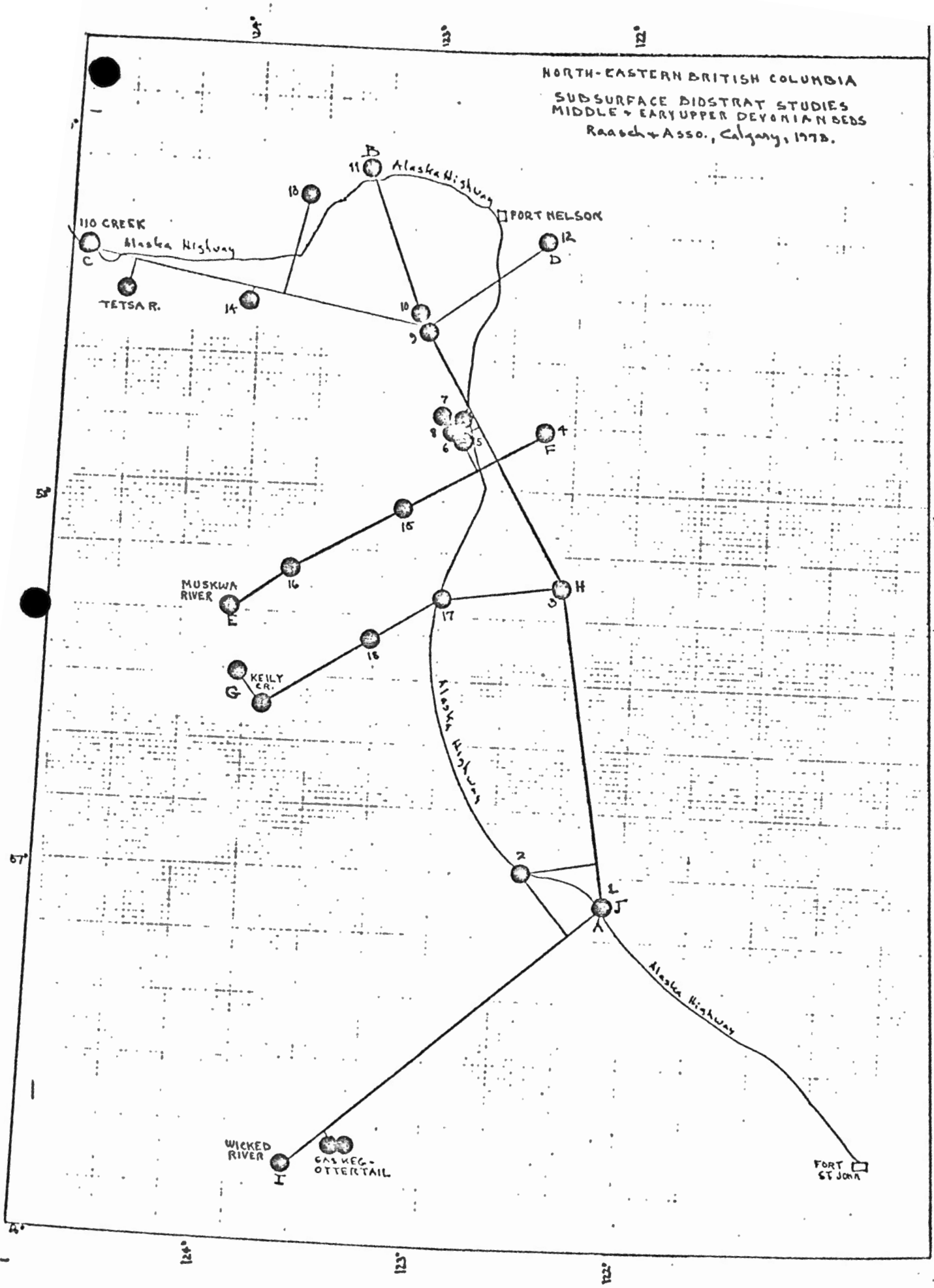
1. MIDDLE & EARLY UPPER DEVONIAN

OBJECTIVE OF INVESTIGATION

In the northeastern portion of British Columbia, a high degree of stratigraphic complexity exists in that economically important part of the Devonian section that lies above the Stone ("Chinchaga") Dolomite and beneath the Muskwa Shale. Correlations within this interval are difficult because of 1) the rapid lateral facies changes and 2) the presence of significant unconformities.

Therefore reliance for correlation on such purely physical criteria as lithologic similarity or E-log characteristics commonly proves unreliable if not misleading.

Recognizing that additional criteria are therefore needed, we have undertaken the examination of the cores of 16 wells, from 11 of which we were successful in securing fossils significant


NORTH-EASTERN BRITISH COLUMBIA
SUBSURFACE BIOSTRAT STUDIES
MIDDLE + EARY UPPER DEVONIAN BEDS
Raasch + Asso., Calgary, 1978.
Alaska Highway
PORT NELSON
110 CREEK
Alaska Highway
TETSA R.
MUSKWA RIVER
KEILY CR.
Alaska Highway
Alaska Highway
WICKED RIVER
GASKEG-OTTERTAIL
FORT ST JOHN
B
C
D
E
F
G
H
I
J
K
1
2
4
5
6
7
8
9
10
11
12
14
15
16
17
18

LIST OF WELLS

(numbers correspond to those on chart, facing page)

1. West Nat et al Highway b-31-I WA 1469
2. Sinclair Julienne Creek a-50-D WA 504
3. Cdn-Fina-Aluminex Trutch a-75-C WA 1397
4. Sinclair - Pac Klua Creek a-55-L WA 421
5. Altair et al Tenaka d-59-K, WA 1904
6. Phillips Tenaka No. 1 d-82-L WA 26
7. Pacific Tenaka b-7-C WA 2217
8. Pure-Pac Tenaka C-94-L WA 822
9. Pure-Pac Cheves c-5-A WA 892
10. Pure-Pac Klowee C-27-A WA 1231
11. West Coast - HB Valiant a-30-K WA 2753
12. Gulf States - Imp. Clarke Lk. c-94-L WA 397
13. Phillips-SR-West Can Kledo c-14-G WA-499
14. Pan Am Sheep Creek c-86-D WA 2150
15. Cdr-Pac Sinc Prophet d-21-B WA 1236
16. HB-Pan Am Muskwa a-6-G WA 553
17. Phillips Minaker a-25-D WA 494
18. Shell - HB Klingzut b-82-F WA 1845

(see also facing page and Appendix I)

for purposes of correlation.

The faunas involved were already familiar to us as a result of previous studies of the cores of 37 wells in the southern part of the District of Mackenzie (presented in our 3 volume report: "Slave Point Datum Project"; title currently revised to "Middle & Early Upper Devonian Correlations, Great Slave Lake to Fort Good Hope") and of outcrops in the front ranges from Peace River to Summit Lake (in connection with the report by W. B. Brady and G. O. Raasch, entitled "Peace River District, B. C.; Mid-Palaeozoic Outcrop Area").

Acknowledgments

We wish to express our appreciation to the British Columbia Department of Mines and Petroleum Resources, for permitting us to examine the cores and to collect and identify the fossils recovered. These latter remain in the possession of the Department.

We are happy to have had, in the preparation of this study,

the active co-operation of Canadian Stratigraphic Service, the use of their logs and facilities, as well as valuable advice in matters of interpretation, correlation, and nomenclature.

STRATIGRAPHIC PRINCIPLES

Stratigraphic Boundaries

Within a depositional complex like that in N. E. B. C., stratigraphic subdivision is affected by application of three different categories of stratigraphic boundary. These are:

Lithostratigraphic boundaries

Biostratigraphic boundaries

Tectostratigraphic boundaries

Lithostratigraphic boundaries delimit deposits of like lithologic character and similar lithofacies. They may, and commonly do, transgress time lines. Lithostratigraphic boundaries define the members, formations, and groups of conventional stratigraphic nomenclature.

Biostratigraphic boundaries delimit faunal zones and, when properly discriminated, constitute "penecontemporaneous" time-

lines. A faunal zone, as herein conceived, may and generally does involve several contemporaneous fauni-facies, It is defined more reliably on the basis of the combined ranges of a number of species than on the range of a designated index species.

Tectostratigraphic boundaries coincide with regional unconformities. These in turn involve some degree of crustal movement, either locally or eustatically; hence the prefix "tecto", a term not so-far defined in publication.

Lithostratigraphic boundaries may cross biostratigraphic boundaries, and conversely; but neither of these, properly discriminated, can cross a tectostratigraphic boundary.

Depositional Sequences and Discontinuties

Tectostratigraphic boundaries are the product of major regional unconformities. These in turn arise as a consequence of widespread ("eustatic") changes in sea level, with or without local regional tectonism, orogenic or epeirogenic. The ensuing

fall in sea-level and consequent emergence inaugurates a degree of subaerial erosion. Consequently, the succeeding marine transgression resulting from a rise in sea-level results in unconformable relations between the older and the younger strata. In stratigraphic terms, this establishes a major discontinuity in sedimentary accumulation.

Major Depositional Sequences

Between a pair of successive tectostratigraphic boundaries, on the other hand, the accumulation of sediments was essentially continuous, constituting a "major depositional sequence".

A major depositional sequence generally consists of a number of biostratigraphic zones (=time-stratigraphic units), each of which is bounded by a pair of biostratigraphic boundaries. A major depositional sequence is distinguished by the fact that the succession of zones comprising it is free from internal interruption.

In preparing regional paleogeographic maps, it is of fundamental importance that they deal with a single depositional sequence and that they do not involve any major discontinuities.

STRATIGRAPHIC ANALYSIS AND CORRELATION

Sequences and Discontinuities

In the region under consideration, the strata with which we are primarily concerned are interrupted by 1) the sub-Nahanni unconformity; 2) the sub-Watt Mountain unconformity; 3) the sub-Waterways hiatus, and 4) the sub-Muskwa unconformity. Each of these discontinuities extends far beyond the region; in fact, over much if not all of Western and Arctic Canada.

These four discontinuities define three significant sequences, one of Middle Devonian age, two of Early Upper Devonian age.

Sub-Nahanni Strata

In Outcrop

In the outcrop area of the Front Ranges west of the sub-surface

area under consideration, the Nahanni Formation is disconformably underlain by carbonates equivalent to the Landry/Arnica sequence of the region to northwest. According to our interpretations from field observations, the boundary between the Landry Limestone and the Arnica Dolomite is a lithofacies boundary, is commonly gradational, and is probably diachronic.

In the mountains immediately west of our subsurface area, the dolomite has been designated the Stone Formation (Taylor and MacKenzie, G. S. C. Bull. 186, 1970). The Landry equivalent has been lumped with the Nahanni and younger carbonates as the Dunedin Formation. Other than for gross mapping purposes, we object to this term since, as used in the Taylor/Mackenzie report, it includes a major regional unconformity.

The Landry equivalent disappears southward in the vicinity of Keily River. South of this, beds of Nahanni age rest directly on the Stone Dolomite.

Faunal Content

The Stone Formation lacks significant fossils, but the

Landry Formation carries the diagnostic giant ostracod, Moelleritia canadensis Copeland. This fossil and zone (our DLM 4 Zone) still farther north occurs low in the Gossage Formation. In equivalent beds it is wide-spread from the Alaska border across the Campbell Arch and into the Arctic Plains.

Locally micro-ostracods and possibly other microfauna may occur in the Landry equivalent (or "Lower Member" of the Dunedin). These are as yet unstudied. Farther north, equivalent beds bear the diagnostic "2-hole" crinoid ossicle Gasterocoma? bicaula Johnson & Lang.

In the Subsurface

Stone-equivalent strata persist apparently throughout the area studied, but in much of it, the dolomite is intercalated with anhyritic deposits. This is the case in the northern part of the area, involving the Pan Am Sheep Creek, Westcoast Valiant, and Gulf States-Imperial Clarke Lake wells, as well as the Tenaka district. On the other hand, evaporite deposits do not

appear in the more southerly area involving the Phillips Minaker and Shell Klingzut wells.

Landry-equivalent beds are restricted in their distribution to the northwest portion of the subsurface area. They reach a thickness of 115' in the Pan Am Sheep Creek well and a probable remnant of 40' in the HB-Pan Am Muskwa well.

Thus the Landry limestone evidently disappears eastward in the subsurface as it does southward in the mountains. Whether this process is a consequence of facies change or of pre-Nahanni removal by erosion is a moot point in the absence of faunas permitting a precise dating of the dolomite facies.

Nomenclature

On well-log correlations in which the Stone-equivalent beds are recognized they are generally referred to as "Chinchaga", less commonly as "Lower Elk Point". These terms, while not in fact incorrect, are imprecise.

The Chinchaga "Formation" of northern Alberta is in fact two formations, separated by a significant unconformity. We concur with Helen Belyea in regarding the Upper Chinchaga as an evaporitic equivalent to the Lower Hume/Lower Nahanni open marine facies. The Lower Chinchaga is much older, but its exact marine equivalents are as yet undetermined.

Lower Elk Point is a generic term relevant to the Alberta Basin; therefore is not only imprecise but geographically somewhat misplaced.

For the anhydritic beds which interfinger in the subsurface with Stone Dolomite, the term "Bear Rock" would be more precise as well as accurrate both in terms of time and of lithofacies character. Since the evaporitic beds are intricately interfingered with the dolomites, the combined term Stone/Bear Rock seems the most appropriate designation available.

The Stone Formation in age, lithologic character and direct

geographical continuity seems to be a junior synonym for the term Arnica. Therefore, our use of the term Stone is tentative and expedient, and we suggest its eventual abandonment.

The same may be said for what we term the "Lower Member" of the Dunedin Formation, for which the well established term Arnica is more appropriate.

Paleogeographic Considerations

The Stone Dolomite and its northward continuations in the Arnica and Gossage comprise a large "Bahamoid" carbonate bank between the evaporitic environment (Bear Rock, etc.) to the east and open marine environments to northwest (as part of the Cranswick and Michelle formations, etc.).

Relative to the succeeding Landry deposits, the *Moelleritia canadensis* assemblage is a restricted marine facies equivalent to the open-marine Cranswick Member of the Canyon Ranges and a part of the Blue Fiord Formation of the Arctic Islands.

Sequence A

Definition

The term Sequence A, we apply to the succession of strata lying above the sub-Nahanni Unconformity and below the Watt Mountain Unconformity.

Sub-Nahanni Unconformity

The youngest beds beneath the sub-Nahanni Unconformity are the Landry strata which carry the *Moelleritia canadensis* DLM4 fauna. The oldest fauna above the unconformity corresponds to Zone DLM9 of the Hume/Nahanni succession in the outcrop area to the west.

This leaves a gap, corresponding to the unconformity, of Zone DLM 5 through DLM 8.

This gap is filled in the Snake River-Royal Creek areas of east-central Yukon, where the DLM 4 fauna lies over 1000 feet

below Hume (Nahanni-equivalent) beds.

Nahanni Formation

The lowest stratigraphic unit of sequence A coincides with the Nahanni (=Lower Keg River) Formation. To northward, beds similar in age and lithology comprise the Hume Formation.

Where most fully developed (in the Snake River Area, Yukon), the Hume involves three faunal zones, our DLM 8, 9, and 10/11 zones. Eastward toward the Hume type area in the Mackenzie Valley the thickness is diminished by on-lap, and Zone DLM 8 is commonly missing.

Southward the Hume passes, with minor lithologic change, to the Nahanni Formation, which has yielded faunas of DLM 9 and DLM 10/11 age.

In Outcrop

In the British Columbia Rockies, the Nahanni Formation is

thickest northward (over 600' in the Summit Lake Area) thinning to under 100' in the Ottertail/Wicked River area. From Keily Creek south along the mountain front, the Nahanni equivalent is in a dolomite facies. It can be distinguished from the overlying Stringocephalus-bearing dolomites chiefly by it darker color, thinner bedding, and, of course, faunal content. In this facies expression, it might better be referred to as Lower Keg River.

Where the Nahanni is thick, it bears the DLM 9 fauna in its lower part and the DLM 10/11 fauna in its upper part. Where it is thin and in the Lower Keg River facies, only the DLM 10/11 fauna is present.

In the Subsurface

Where the Lower Keg River Formation is thin in the B. C. subsurface, it is easily overlooked. It may actually be missing in that portion of the area which includes the Shell Klingzut and Phillips Minaker wells. Elsewhere, that portion of the Nahanni present in the cores corresponds to the upper or DLM 10/11 zonal interval, except possibly in the thicker section in the Pan Am Sheep Creek well, where both zones may be present.

Time-Stratigraphic Subdivision

Faunal Content

The Hume/Lower Keg interval was cored in only one of the wells of our study. This is the Cdr-Pac-Sinc Prophet well, which hardly went deep enough to recover a substantial portion of the carbonate section.

The fauna recovered from the core, furthermore, is somewhat anomalous. The only significant fossil is *Atrypa aperanta*, the zone-fossil of the DLM 8 Zone. This zone, because of Hume/Nahanni transgressive onlap, is hardly to be expected this far southeast. Altogether, the interpretation regarding the Prophet well may be regarded as highly tentative.

Elsewhere, the beds of this interval establish their identity by lithologic correlation with sections in outcrop to the west and wells to the north (Arrowhead Area), where the Hume/Nahanni faunas are well-developed.

The faunal zones present in outcrops of the mountain region west of our area are two in number, namely the DLM 10/11 Zone of *Atrypa arctica/Utaratuia acucipicta* and the DLM 9 Zone of *Schuchertella adoceta*.

Paleogeographic Considerations

The Nahanni Formation is a shallow open-marine facies, the lower part of which passes eastward to an evaporitic facies, the Upper Chinchaga Formation.

The upper part of the Nahanni, coinciding with the DLM 10/11 Zone of *Atrypa arctica*, is one of the most widely extensive Devonian zones of North America.

It is the platform upon which the Upper Elk Point reef and bank deposits accumulated. The top of the formation and of its equivalents we regard as a time-line useful for isopach control, etc.

"Upper Elk Point Group"

Nomenclature

For the purposes of this report, we are defining the term "Upper Elk Point Group" to cover all beds lying above the Nahanni/Lower Keg River platform and below the Watt Mountain unconformity. Admittedly, this usage is unsatisfactory, but no alternative term is available to cover this interval.

The "Upper Elk Point Group" is remarkable for the fact that lateral facies change dominates vertical facies change, which is a reversal of the normal condition in the case of a sedimentary sequence. Three gross facies exist side by side, and commonly show an intricate pattern of distribution. These gross facies are 1) open-marine shales and limestones, 2) bank and reefoid carbonates, commonly dolomite, and 3) evaporites. Under these conditions, the problem of conventional stratigraphic nomenclature becomes abnormally complex.

Time-Stratigraphic Subdivision

The span of the "Upper Elk Point Group" corresponds to the span (biochron) of the brachiopod genus *Stringocephalus*.

A biostratigraphic study of the numerous species of this genus shows that they fall into three distinct biozones, which we have designated DLM 12, DLM 13, and DLM 14. However, the occurrence of *Stringocephalus* is primarily restricted to the reef and/or bank carbonate facies.

In descending order, the zones in this facies are as follows:

Zone DLM 14	Stringocephalus aleskanus Zone
Zone DLM 13	Stringocephalus axius Zone
Zone DLM 12	Stringocephalus sapiens Zone

Time-Stratigraphic/Rock Stratigraphic Relations

The DLM 12 Zone of *S. sapiens*, in the outcrop belt of the B. C. Rockies occurs in bank carbonates equivalent to the lower part of the Upper Keg River Formation. In the Great Slave Lake Region beds of equivalent age, but in a near-shore open marine facies correspond to the Middle Member of the Pine Point

Formation. Northward in the outcrop belt the Stringocephalus dolomite passes to deeper water dark shales designated Horn River and Hare Indian. These shales lack the Stringocephalus assemblage and are designated the Warrenella kirki facies of Zone DLM 12.

The DLM 13 Zone of S. axius, in the outcrop belt in the mountains occupies a position and lithofacies also presumed equivalent to the Upper Keg River. In the Norman Wells area these beds form the lower part of the Lower Ramparts Formation and rest upon Hare Indian shales of DLM 12 age.

In the Great Slave Lake area they are probably represented by the shales of the Upper Pine Point Member. Since these are known only from borings they have not as yet yielded any fauna.

The DLM 14 Zone of S. aleskanus is present not only in the B. C. mountain sections, but also in the Presqu'ile Formation of the Great Slave Lake Area and in the upper part of the Lower Ramparts Formation in the Norman Wells area. The open marine equivalent of the zone is as yet unknown.

In Outcrop

In the Front Range belt from the Peace River to Summit Lake, the Upper Keg River/Presqu'ile bank and/or reef dolomite bearing *Stringocephalus* extends from Peace River near Mt. Greene north to Keily River. In the south part of this belt, these Upper Keg River beds maintain a constant thickness of between 600' and 700'. The three faunal zones composing this interval also maintain a relatively constant thickness. This we interpret as a carbonate bank build-up.

Such is not the case farther north in the vicinity of Mt. Bertha, Redfern Lake, and Keily River, where both zonal and total thickness show a wide fluctuation from one locality to the next. This we interpret as an area of pinnacle-reef build-up. The cliffs along the south side of Keily River constitute the carbonate front.

From Keily River north to Prophet River, the reef/bank dolomite is replaced by open-marine limestones which nowhere are much over 100' thick. These carry a fauna similar to that of the Middle Pine Point near-shore open-marine facies.

phet River northward beyond Muncho Lake to the Cariboo
beds of Upper Elk Point age are missing or are present
remants of Horn River/Hare Indian affinity beneath the
kwa unconformity and above the Nahanni Platform top.

ve relations are described as if changes took place
ly in a north-south direction, whereas in fact the Front
raverse runs nearly parallel to the trend of facies
. Thus from Mt. Green on Peace River to the edge of the
te bank/reef build-up on Keily River is 100 miles.
ing west from Mt. Greene we find the carbonate bank edge
irs within ten miles so that the Muskwa rests upon the
at Hamlyn Creek near Wedge Peak. In this distance, Upper
nt beds are reduced from 700' at Mt. Green to zero at
Creek.

lear from the above that the principal component of
hange lies in an east-west not in a north-south direction.

Subsurface

The Presqu'ile/Upper Keg River carbonate front may be traced from the exposed escarpment on the south side of Keily River north-easterly to the Klingzut (18) and Minaker (17) wells, beyond which it assumes a northerly course west of the Tenaka area and of the Cheves (9) and Klowee wells. North and west of this line the Upper Keg River interval reduces as follows:

a) from 615' of dolomite in the Altair Tenaka well (5), to 15' in the Prophet Well (15) and 205' in the Muskwa Well (16). In both of these it is in the Middle Pine Point near-shore open-marine facies.

b) from 460' of dolomite in the Cheves Well (9) to 115' of Horn River/Hare Indian dark marly shale in the Sheep Creek Well (14).

c) going northerly and northwesterly from 450' of dolomite in the Cheves Well (9) to 272' of Hare Indian shale and marly shale in the Valiant Well (11), and to zero in the Kledo Well (13).

In the Clarke Lake area, the Upper Elk Point beds maintain an interval of 540' but only the upper 335' are in the bank/reef dolomite facies, whereas the remaining 205' are in the near-shore open-marine Middle Pine Point facies.

In the southeasternmost part of the area of our study, the bank carbonates appear to thin appreciably. This interpretation

is based on the presence of the DLM 12, Early Upper Keg, fossil Stringocephalus noctua Crickmay in the West Nat et al Highway Well (1) only 42' below the Watt Mountain sandstone. This hardly leaves room for deposits of DLM 13 and DLM 14 age, that is, of Presqu'ile or Late Upper Keg River age.

If this interpretation is valid (unfortunately, neither this well or the nearby Julienne Creek (2) were drilled through the Upper Elk Point interval), conditions here may be on trend with those of the Zama and Rainbow fields.

Paleogeographic Considerations

Painting of necessity with a rather broad brush, it would appear then that the carbonate bank and/or reef trend, which was first picked up in outcrop on Peace River, extends as a gross reefoid barrier northward through the mountains to Keily Creek, then northeastward in the sub-surface toward the Tenaka area, thence northward again through the area of the Cheves and Klowee wells, and finally, easterly to the Clarke Lake area.

Northward and westward of this barrier open-marine conditions prevailed and prospects for oil and gas accumulation are unfavorable. Behind the gross barrier-belt, back-reef conditions developed with complex relations between reefs and evaporates such as prevail in the Rainbow and Zama areas (see Hriskevich 1966, 1970; McCamis & Griffith 1967, 1968; Langton & Chin 1968 a & b).

Sequence B

Definition

The term Sequence B we apply to the succession of strata comprising the Beavertail of the Mackenzie Valley and its eastern equivalents, the Watt Mountain, Fort Vermilion, and Lower Slave Point Formations.

Sub-Watt Mountain Erosion Surface

The youngest deposits of Sequence A are those of the DLM 14 Presqu'ile and Lower Ramparts formations. Several well-cores studied in the southern part of the district of McKenzie (see our report "Middle-Early Upper Devonian Correlations, Great

Lake to Fort Good Hope") show a regolithic breccia in a matrix of waxy green geist-clay, which grades down into unweathered Presqu'ile Dolomite, a phenomenon indicative of pre-Watt Mountain subaerial erosion.

It is our interpretation that the variation in thickness of the "Upper Elk Point Group" is more the result of pre-Muskwa subaerial erosion than of depositional inequalities.

Watt Mountain Formation

General Consideration

The lithologic character of the Watt Mountain Formation changes laterally in response to the nature of the source material available upon the erosion surface encountered by the marine transgression. Thus lithologically it might be said that the only constant character of the formation is its inconstancy.

On the other hand, the electric log characteristics are as constant as they are conspicuous (see Canadian Stratigraphic Service Logs, appended).

In the Subsurface

In the southern part of the report area (I. e. in the vicinity of the Julienne Creek (2) and Highway b-36-I (1) wells), as in the outcrops at Wicked River and Ottertail Ridge to the west, the Watt Mountain is a sandstone, which becomes finer and more calcareous upward, as it grades to the overlying Beavertail/ Lower Slave Point. The underlying contact of the sandstone formation (as seen in outcrop) on the otherhand is clean-cut and undulating, with a relief of several inches.

In the remainder of the area, the Watt Mountain is marked by greenish-clays and shales, locally interbedded with marlstone, limestone, or dolomite. Details are not available in most cases, as the interval was cored in only two of the wells studied (Cheves (9) and Phillips Tenaka 1 (6)). The formation is thinner where in a shaly facies (max. 20') than where in a sandy facies (max. 123').

Beavertail-Slave Point Sucession

Relations in District of Mackenzie

The relation between the post-Watt Mountain strata of the Upper Mackenzie Valley, i. e. the Beavertail, Upper Ramparts and Kee Scarp (of Stelck, not Bassett) and of the Great Slave Lake Area, i. e. Fort Vermilion, Lower Slave Point, was the subject of a special study released as our report on the "Middle-Early Upper Devonian Correlations, Great Slave Lake to Fort Good Hope" (alternate title "Slave Point Datum Project").

Faunal Zones

The study showed the Beavertail to be a dark marlstone-shale facies containing two faunal zones, the lower of which we designated the DLM 15 Zone of *Cyrtina panda*, and the upper, the DFR 1 Zone of *Ponticeras*.

Facies Relations

In the Middle Mackenzie Region, the Beavertail Facies is replaced

by a thin-bedded limestone, the "Upper Ramparts Formation", which carries the same two-faunal zones.
The Kee Scarp reefs of the Norman Wells area are equivalent to the lower zone and possibly to the upper as well.

Traced eastward through cores in the subsurface, the upper faunal zone (DFR 1) occurs in the "Lower Member" of the Slave Point Formation, which is in a different, more restricted-marine facies with attendent change in fauna. These beds bear little other than the small emanuellid brachiopod Ladjia landesi Crickmay. This faunifacies is therefore termed the DFR 1 Zone of Ladjia landesi.

The Middle and Upper members of the Slave Point, on the other hand, appear to be facies-equivalent of the Lower Waterways and presumably to some part of the Beaverhill Lake. We do not include them in Sequence B.

In Outcrop

Strata belonging to Sequence B crop out in the Mountains from the Peace River only a limited distance north, as far as

Nabesche River headwaters. In the outcrop area, the rock is a succession of thin-bedded grey limestones, bearing the DLM 15 Cyrtina panda Fauna. Although that zone fossil is present, the brachiopod that is most abundant and ubiquitous is Emanuella caligatae Crickmay. These beds are commonly referred to as "the Slave Point of northeastern British Columbia". As indicated above, they are immediately pre-Slave Point but sequentially continuous with the lower part of that "formation".

At Ottertail Ridge, the DLM 15 fauna is overlain by calcareous "Besa River" shales with the DFR 1 Lower Slave Point fauna, but at Wicked River, it is overlain by beds carrying a DFR 2, Upper Slave Point fauna.

This suggests at least a minor non-sequence between the DFR 1 Zone and younger zones of Waterways equivalency.

In the Subsurface

In a more or less N-S trend, the Sequence B interval from the Julienne Creek (2) well to the Cheves (9) well varies from 425' to 480'. These figures are considered as representing close to the full depositional thickness of the sequence.

Within this interval, the DFR 1 fauna has been found from the top down to within 95' of the base. In the Altair Tenaka (5) well a fauna with Lower Beavertail, DLM 15 affinities was found at a lower elevation. This suggests that the lower 100' of the sequence within the report area may be of DLM 15 age.

Since separation of the zones is possible only on faunal evidence, it would seem expedient to refer to the entire interval as "Slave Point", as is in fact now being done by most of the industry.

Locally, within this interval, reefoid accumulations of dolomite developed, as at Clarke Lake (12) and in the Phillips Tenaka No. 1 (6) well. These reefs are contemporaneous with and analogous to the Kee Scarp (sensu Stelck) reefs of the Norman Wells area.

Paleogeography

The strata of Sequence B, both in outcrop and in the subsurface consist quite uniformly of lutitic, dark grey, thin-bedded limestone. The DLM 15 Zone is similar lithologically to the

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Paleogeography

The strata of Sequence B, both in outcrop and in the subs consist quite uniformly of lutitic, dark grey, thin limestone. The DLM 15 Zone is similar lithologicall

Upper Ramparts Limestone of the Fort Good Hope Area, as is the DFR 1 Zone. The latter however, has closer faunal affinity to the Lower Slave Point in being dominated by the brachiopod, Ladjia landesi, but in addition has a few Beavertail corals.

In summary the DLM 15 Zone is in a shallow water, open-marine facies, whereas the DFR 1 Zone is intermediate between the latter and the restricted-marine Lower Slave Point.

The DLM 15 Zone predominates in outcrop but thins toward the subsurface due to onlap factors. The succeeding DFR 1 Zone is thick in subsurface but thin to absent in the mountains, due presumably to post-cycle B (i. e. pre-Waterways) erosional beveling.

Paleogeomorphology

In surface and subsurface, the beds of Sequence B terminate northward and westward as a pre-Muskwa erosional edge. This edge closely follows the depositional edge of the reef/bank carbonates, which evidently was expressed topographically as

an escarpment which protected the younger beds. On average their erosional edge lies about 5 miles from the edge of the Presqu'ile/Upper Keg escarpment.

That the Beavertail/Lower Slave Point limits were caused by pre-Muskwa erosion rather than by non-deposition is attested by their reappearance in similar facies in the Upper Mackenzie River region of the District of Mackenzie.

Pre-Waterways Unconformity

The unconformity which separates the beds of Sequence B from the overlying Waterways/Beaverhill succession is physically inconspicous, and probably would be more properly referred to as a hiatus. The evidence for this hiatus is attested by the fact that in some localities (such as Wicked River) beds with a DFR 2 fauna rest directly on beds carrying a DLM 15 fauna; that is, DFR 1 beds are missing. The contact is marked by several inches of brown silty shale. It is further possible, that the hiatus is local and not general.

Sequence C

General Consideration

Sequence C corresponds to those rock units equivalent to the Waterways and Beaverhill successions.

Waterways Biozones

The interval occupied by the Waterways Formation (and presumably by its subsurface equivalent, the Beaverhill Lake Formation) involves three faunal zones, as follows:

DFR 4 Zone	Christina, Moberly, and Mildred Members
DFR 3 Zone	Calmut Member
DFR 2 Zone	Firebag Member

Of these, the Firebag Member, at least, seems to be a facies equivalent of the Middle and Upper Members of the Slave Point Formation of the region to the north.

In Outcrop

In the mountain belt, beds of Waterways equivalency crop out from Mt. Greene on Peace River north as far as Ottertail and Gas Keg ridges. In the latter area, the section extends as high as the upper part of the DFR 4 Zone of the Waterways at Ottertail and Gas Keg Ridges. The Waterways-equivalent beds are overlain by shales of the Muskwa Formation, with a sharp but apparently conformable contact.

In the Ottertail-Gas Keg area, the Waterways equivalent has a thickness in the neighborhood of 500 feet of calcareous shales and marlstones, with an open-marine fauni-facies. At Wicked River, the lower 60' of the interval is in a similar facies, whereas the remainder of the interval is occupied by a reef equivalent in age to the Swan Hills reefs of north central Alberta.

<u>In the Subsurface</u>

In most of the wells examined, the Muskwa Formation rests on older formations, but beds of Waterways-Beaverhill equivalency are present in four of the wells. Three of these are in the

Tenaka area, where the thickness ranges from 225' to 320'. In the Trutch well (3) a 100' remnant remains between the Muskwa and the Lower Slave Point.

Fauna

In two of the wells, Atrypas having a DFR affinity were found.

Muskwa Formation and Sub-Muskwa Unconformity

Definition

As used in the present report, the term "Muskwa" is synonymous with "Canol", as defined by Bassett (1961) for the District of the Mackenzie and Yukon. The Canol Formation is a non-calcareous, siliceous, highly fissile, hard, dark grey shale, which, on weathered surfaces, does not slake down to clay but to rusty chips and flakes. Faunally it yields little other than sponge spicules and conodonts, and these only rarely. The formation has a sharp lower contact, but grades upward by irregular increase in calcareous content and in silty bands,

to shales of the Imperial Formation. In "The Territories" the Canol Shale rests on beds as young as Beavertail (DFR 1) and Kee Scarp age, and as old as Silurian. At a number of localities it rests nonconformably on underlying strata, with an angle of divergence of as much as 10 degrees (see figs. 2, 3, & 10, of our report on "Middle-Early Upper Devonian Correlations, Great Slave Lake to Fort Good Hope").

In Outcrop

In the mountains to the west of the report area, the youngest rock unit beneath the pre-Muskwa unconformity is the DFR 4 Zone of the Waterways, probably equivalent to its Mildred Member. This relationship may be observed at Ottertail and Gas Keg ridges, etc.

In the Alberta Basin this same position is occupied by the Cooking Lake Formation, and it is logical to assume the latter to be equivalent to Canol/Muskwa. However, detailed faunal studies of cores in this region would have to be made to determine whether, in fact, the dark shale can be traced into the Cooking Lake dark marlstone. Obviously the shale can be

no older than Cooking Lake, but might be younger.

Northward, in the B. C. outcrop it rests on DFR 4 beds on Sikanni Chief headwaters east of the mountains, but east of Redfern Lake, and at Prophet River it rests on the Nahanni Fomation (DFR 10/11).

Beyond this to "The Territories" boundary, the shale continues essentially to lie on the Nahanni top, with occasional intervening remnants of Hare Indian dark, calcareous shale or Middle Pine Point argillaceous limestone, up to 50 feet thick, but generally much less. These strata bear tentaculitid and brachiopod faunas that identify them as belonging to the DLM 12 Zone. Locally goniatites of Middle Devonian, Givetian affinity also occur in these pre-Muskwa marlstones.

Among the localities which have yielded early Upper Devonian conodonts is that at 110-Creek (H. G. Bassett, personal communication).

The Canol/Muskwa shale, although widespread through northwestern

Canada, generally ranges from one to several hundred feet thick. The fact that it rests on pre-Muskwa deposits of widely different ages in different areas, combined with its demonstrably non-conformable relations in some outcrops, indicates extensive pre-Muskwa warping followed by erosional beveling sufficient to reduce the subcrop to a relatively plane surface before the Muskwa transgression.

In the Subsurface

Within the relatively limited area of the present report, the Muskwa Formation rests on a variety of formations and time-rock units, ranging in age from Waterways-equivalent DFR2 beds to Zone 10/11 of the Nahanni Formation (in the Kledo well, no. 13).

In a south to north direction, the Muskwa descends in the section to rest on DLM 12 beds in open-marine facies in the Valiant well (11), but the descent is much more rapid in an east to west direction in the northern part of the area, where it

descends from a DFR 2 position in the Altair Tenaka (5) well to rest on DLM 12, open-marine facies beds in the Muskwa well (16) of cross-section E-F; and in cross-section C-D, from a super-DFR 1 position in the Cheves (9) well to rest on DLM 10/11 beds in the Kledo well.

In both the outcrop and the subsurface areas of northeastern British Columbia, the shale section above the highest limestones was not extensively examined beyond noting the first appearance of black, non-calareous shale of Canol type. Q. R. Query (personal communication) has shown me logs of contiguous areas north and east of that covered by this report, in which two shales of Canol type are present. One of these closely follows the top of the limestone and/or marlstone sequence. The other, generally several hundred feet higher, maintains an essentially constant position relative to marker horizons above it in the Upper Devonian sequence.

This suggests that the shales designated "Muskwa" in the present report may not be altogether contemporaneous, although in all cases still Early Upper Devonian in age. This alternative

interpretation does not seriously alter the interpretation expressed above and on the cross-sections, but suggests that it may not be as simplistic as previously regarded.

SUMMARY

The Devonian succession under consideration in the present report, from the Lower Devonian Stone/Bear Rock beds to the Upper Devonian (Frasian) Muskwa Shale, involves three sequences and parts of two others.

It also incorporates two major regional unconformities, the sub-Nahanni unconformity and the sub-Muskwa unconformity, plus two minor unconformities or hiati, the sub-Watt Mountain and the sub-Waterways/Beaverhill.

Time lines most favorable for datum usage are the Nahanni top and the Beavertail/Lower Slave Point base, although the latter may be slightly diachronic.

The "Upper Elk Point" interval (as herein defined), although

consistent in comprising three faunal zones, is extremely variable in lithology as a result of rapid and complex lateral facies changes. In contrast, the Nahanni, and Beavertail/ Lower Slave Point are remarkably constant in lithofacies expression across the area.

An inherent error-creating factor in east-west correlation is the general lithologic similarity of the two sequences: 1) Stone Dolomite, Nahanni Limestone, Hare Indian/Middle Pine Point Shale, and 2) Presqu'ile Dolomite, Beavertail/Lower Slave Point limestone, Muskwa Shale. Thus in the more western and northern locations, where the Nahanni is the first limestone encountered, it may easily be misidentified as Beavertail/ Lower Slave Point Limestone. Similarly the underlying Stone Dolomite may be confused with the Presqu'ile/Upper Keg River Dolomite.

It is hoped that, with the assistance of the faunal evidence herein presented, future correlations may be fitted into the existing framework, with or without the aid of paleontologic evidence.

APPENDICES

Appendix I

Summary of Well Data

pp. 1 - 29

1. WEST NAT et al HIGHWAY b-~~31~~ 36-I
WA - 1469 94-B-16
Completed Feb. 11, 1965 T. D. 12,561'

CORE NO. 1 12206-12223' 17'/10'

Dark limestone full of spaghetti Amphipora, massive stroms. (mainly small Stachyodes?) and small brachiopods.

Fauna:
Ladjia landesi Crickmay
Coenites sp. "Trutch"
gastropod, low-spired

Age Determination:
GOR Zone DFR 1
Lower Slave Point Equivalent

CORE NO. 2 12485'-12525' 40'/29'

Dark dolostone, cryptocrystalline to fine crystalline with a few zones of aphanitic dolostone. Lower 5' is more argillaceous and basal 1' is massive, with filled vugs. Some zones near top have white crinoid ossicles and fossil trash.

Fauna:
Stringocephalus cf. noctua Crickmay

Age Determination:
GOR Zone DLM 12 to 14, most probably DLM 12. Upper Keg River Equivalent.

CORE NO. 3 12527-12561' 34'/19'

12527-40' generally similar to Core No. 2,but lamination is more conspicuous.
12540-44' is dolostone, medium grey, cryptocrystalline, dense, massive, with fossils.
Remainder is dolostone, more or less argillaceous, like portion of Core 2.

Stratigraphic Summary.
Lower Slave Point Eq. 12125-12410' 285'

Watt Mountain Sandstone	12410-12458'	48'
Upper Keg River Eq.	12458-12561' T. D.	103'+

2. SINCLAIR JULIENNE CREEK a-50-D
WA - 504 94-G-1
Completed Sept. 26, 1958 T. D. 13,734'

NO CORES

Stratigraphic Summary.

Lower Slave Point Eq.	12990-13452'	462'
Watt Mountain Sandstone	13452-13575'	123'
Upper Keg River Eq.	13575-13734' T. D.	159+

Note:
Correlations based on comparison with West Nat et al Highway b-31-I, which has fossiliferous cores.

3. CDN SUP-FINA-ALUMINEX TRUTCH a-75-C
WA - 1397 94-G-16
Completed Feb. 28, 1964 T. D. 9650'

CORE NO. 2 9076-9133' 57/57

Dark limestone, marly, stromatoporoidal, with Amphipora, Stachyodes (?), and massive types up to cabbage size. In lower part of core stroms encrust Coenites. Brachiopods fairly common, with large Atrypa in upper part of core.

9083-9089'

Fauna:
Atrypa cf. bentonensis Stainbrook

Age Determination:
Lower Waterways/Upper Slave Point Eq.

9099-9133

Fauna:
Ladjia landesi Crickmay
Atrypa cf. independensis Webster
Ambocoelia? sp.
Coenites sp. "Trutch"
? Grypophyllum mackenziense (Pedder)

Age Determination:
Lower Slave Point Equivalent

CORE NO. 3 9560-9580' 20/20

Dolostone, mostly light grey, some dark grey, with much sedimentary and dynamic breccia of Bear Rock type. Much white dolomite vein-filling.

Fauna:
none

Age Determination:
Stratigraphic and regional considerations would indicate this to be Presqu'ile/Upper Keg River, although on purely litholigic grounds it might equally well be Stone Formation.

Stratigraphic Summary.

U. Slave Point/L. Waterways Eq. 8995-9095'	100'
Lower Slave Point Equivalent 9095-9505'	410'
Watt Mountain? 9505-9515'	10'
Upper Keg River/Presqu'ile Equivalent 9515-9650'T. D.	135'

4. SINCLAIR-PACIFIC KLUA CREEK a-55-L
WA 421 94-J-1, A-55-L
Completed Mar. 15, 1959 T. D. 8614'

CORE NO. 1 8578-8614' 36/36

Alternation of limestone, dark, argillaceous, and dolostone, light medium grey. Zones with spaghetti Amphipora and massive stroms. to cobble size; small gastropods fairly common; few small to medium-sized brachiopods.

Fauna:
unidentifiable small to medium-sized brachiopods and small gastropods.

Age Determination:
Lower Slave Point Eq. on lithology and stratigraphic and regional considerations; fauna non-diagnostic.

Stratigraphic Summary.
Lower Slave Point Eq. 8198-8614' T. D. 414'+

5. ALTAIR ET AL TENAKA d-59-K
WA 1904 94-J-2, d-59-k
Completed May 2, 1966 T. D. 8830'

CORE NO. 1 7806-7831' 25/25

Limestone, argillaceous, black, aphanitic, highly fossiliferous, with massive branching stromatoporoids, brachiopods, slender corals, and gastropods.

Fauna:
Ladjia landesi Crickmay
Coenites sp. "Trutch"
Grypophyllum mackenziense (Pedder)

Age Determination:
GOR Zone DFR1
Lower Slave Point Equivalent

CORE NO. 2 7855-7915' 60/60

Upper half: limestone, interbedded dark, argillaceous, aphanitic with bioclastic fraction, and light-medium grey, finely crystalline, vaguely laminated, mostly unfossiliferous. Spaghetti Amphipora, massive stroms. to cobble-size, and thick-branched stroms. in zones, mainly in the dark limestone. Lower half mainly light to medium grey, interbedded dark Amphipora spaghetti-stone near bottom.
Upper 2' has strong pyrite and galena mineralization; and interstitial pyrite is disseminated for several feet down.

Fauna:

Ladjia landesi Crickmay
Coenites sp. "Trutch"

Age Determination:
GOR Zone DFR 1
Lower Slave Point Equivalent

CORE NO. 3 7915-7975' 60/60

Top 10' similar to bottom of Core No. 2. Remainder

limestone, dark, aphanitic, stromatoporoidal, with zones of Amphipora, cabbage stroms. & Stachyodes. Small cylindrical corals at 7925-26' with Coenites. 7958-68; tabular stroms., Amphipora, cabbage stroms., horn corals, crinoid ossicles, rare brachiopods;

Fauna:
Ladjia landesi Crickmay
Coenites sp. "Trutch"
Grypophyllum mackenziense (Pedder)

Age Determination:
GOR DFR-1
Lower Slave Point Equivalent.

CORE NO. 4 7975-8035' 60/60

To 8003'. Similar to Core 3, but less stromatoporoidal; gastropods, including bellerophont, murchisonid, and low-spired fairly common; also Coenites and small horn corals. Brachiopods common in a few narrow zones. 8006-16'. Dark limestone, roughly laminated in darker, more argillaceous & lighter, less argillaceous bands. No diagnostic fossils.
8016-35'. Limestone, dark grey, finely crystalline, rather massive, with zones of cobble stroms., scattered gastropods, etc. Grading downward to roughly laminated limestone, as in the 8006-16' interval.

Fauna:
Coenites sp. "Tenaka"
Coenites sp. "Trutch"
Emanuella aff. caligatae Crickmay
gastropods

Age Determination:
GOR DLM 15

CORE NO. 5 8209-8236' 27/27

Dolostone, upper part dark grey, finely crystalline, grading to light medium grey, uniform and compact. Some nodular-mottled structure and a few small patches of sedimentary breccia.

5'-15' above base are bands of what appear to be spaghetti *Amphipora*, but all organic structures have been obliterated.

Fauna:
see above

Age Determination:
Presumed Upper Keg River/Presqu'ile on basis of lithology and stratigraphic and regional considerations.

CORE NO. 6 8236-8268' 32/32

8236-8248', dolostone similar to preceding core, with much white calcite veining and dynamic breccia.
3248-3268', similar, with diminished dynamic features; laminated and medium brown-grey. No fossils observed.

Fauna & Age Determination
as in preceding core

Stratigraphic Summary.

Lower Slave Point Eq.	7800-7974'	174'
Lower Beavertail Eq.?	7974-8068'	94'
Watt Mountain Shale	8068-8085'	17'
Upper Keg River/Presqu'ile	8085-8775'	690'
Stone (?)	8775-8830' T. D.	55+'

6. PHILLIPS TENAKA NO. 1 d-82-L
WA 26 94-J-2, d-82-L
Completed Aug. 2, 1952 T. D. 9220'

CORE NO. 14 7512-7522' 20/8

Shale calcareous, grey green, with a few brachiopods.

Fauna:
Atrypa cf. *independensis* Webster

Age Determination:
Probably Lower Waterways Eq., GOR DFR2
Possibly Lower Slave Point Eq., GOR DFR1

CORE NO 15 8060-8070' 10/2.5

Marlstone, shaly, green grey to grey

Fauna:
No identifiable fossils

Age Determination:
Watt Mtn. on lithology and strat. position

Stratigraphic Summary

Lower Waterways Eq.?	7482-7745'	263'
Lower Slave Point Eq.	7745-7781'	36'
Swan Hills Reef	7781-8060'	279'
Watt Mountain	8060-8075'	15'
Upper Keg River/Presqu'ile	8075-8830'	755'
Stone	8830-9115?	285'

7. PACIFIC TENAKA b-7-C
WA 2217 — 94-J-7, b-7-C
Completed Dec. 26, 1967 — T. D. 7741

CORE NO. 1 7183-7208' — 25/18

Limestone, very dark, aphanitic, argillaceous, speckled with a white bioclastic fraction. Zones of tightly packed, irregular stroms. and of Amphipora; brachiopods locally common.

Fauna:
Ladjia landesi Crickmay
Atrypa cf. independensis Webster
Coenites sp. "Trutch"
Grypophyllum mackenziense (Pedder)
gastropod sp. "Tenaka" (low-spired)

Age Determination:
GOR Zone DFR 1
Lower Slave Point Equivalent

Stratigraphic Summary

Lower Slave Point Eq.	7080-7405'	325'
Watt Mountain Shale	7405-7418'	13'
Upper Keg River/Presqu'ile Eq.	7418-7741' T. D.	323+'

8. PURE-PACIFIC TENAKA c-94-L
WA 822 — 94-J-2, c-94-L
Completed Dec. 25, 1961 — T. D. 8472'

CORE NO. 1 7847-7851' — 4/4

Ls., black, aphanitic. Bedding planes slickensided

Fauna:
none

Age Determination:
Presumed Lower Slave Point on lithology and stratigraphic and regional considerations.

Stratigraphic Summary.

LOWER SLAVE POINT EQUIV. (incl. Lower Beavertail Eq?)	7834-8283'	449'
UPPER KEG RIVER/PRESQUILE	8283-8472' T. D.	169'

Note: intense slickensiding of the core suggests possibility of proximity to a fault zone.

9. PURE-PAC CHEVES c-5-A
WA 892 94-J-11, C-5-A
Completed Feb 26, 1962 T. D. 8596

CORE NO. I 7466-7524' 58/58

Dark argillaceous limestone, microcrystalline to aphanitic, predominantly an Amphipora spaghetti-stone, but also with vermicelli Amphipora, small diameter Stachyodes, massive stroms. to large cobble size, and Coenites encrusted by stroms. Small brachiopods at a few intervals. A few small gastropods.

Fossil-free zones commonly have "birdseyes" (canal-like vesicles with white calcite fill).

Some dynamic breccia and veining with sparry in-fill.

Fauna:
Ladjia landesi Crickmay
Coenites sp. "Trutch"
cf. Grypophyllum mackenziense (Pedder)

Age Determination:
GOR Zone DFR1
Lower Slave Point Equivalent

CORE NO. 2 7624-7682' 58/58

7624-47' similar to Core no. 1, but some zones are lighter to dark-medium grey. Fossils as in preceding.
7647-82' limestone becomes lighter, to medium brown-grey, non-argillaceous, and more massive. Stachyodes, spaghetti Amphipora, Coenites, massive stroms; a bed of cabbage near base.
Some darker interbeds like rock of Core no. 1, including "birdseye" zones.

Fauna:
Ladjia landesi Crickmay
Coenites sp. "Trutch"

Age Determination:
GOR Zone DFR 1
Lower Slave Point Equivalent.

CORE NO. 3 7924-7968' 44/44

top 6" shale, dark grey, non-calcareous, sub-fissile in three large chunks; possibly caved.

7924.5-7943.5' limestone, dark-medium brown-grey, rather massive, cryptocrystalline; a few darker bands. Veins of white calcite are conspicuous. Cabbage stroms. near base, overlain by beds with a nodular-Mottled structure. Stachyodes, Amphipora, massive stroms.

7943.5-7968', dolostone, light grey, finely crystalline, largely replaced by white dolomite mineralization; a few partially open large vugs. Top few inches are regolithic, in matrix of black marly dolostone. Contact with overlying limestone is irregular. 4' below contact is a 3.5' band of hard clay, with rounded, golf-ball-sized clasts; rock appears to have been plastic originally.

Fauna:
non-diagnostic

Age Determination:
GOR Zone DLM 15?
probably Lower Beavertail Equivalent

Stratigraphic Summary.

Lower Slave Point Eq.	7466-7850'	384'
?Lower Beavertail Eq.	7850-7943	93'
Watt Mt. clastics	7943-7951'	8'
Upper Keg River/Presqu'ile	7951-8410'	459'
?Nahanni Eq.	8410-8596 T. D.	186'+

10. PURE-PACIFIC KLOWEE c-37-A
WA 1231 94-J-11
Completed Mar. 1, 1963 T. D. 7921

CORE NO. 1 7847-7881' 34/33

Dolostone, medium grey, finely crystalline, extremely vuggy; vugs mainly filled with white dolomite.

Ghosts of Amphipora and Thamnopora seem to be present; the vugs may represent dissolved-out massive stroms..

Fauna:
nothing identifiable

Age Determination:
(On lithology and stratigraphic and regional considerations)
Upper Keg River/Presqu'ile.

Stratigraphic Summary.

Lower Slave Pt./Lower Beavertail	7798-7830'	32'
Watt Mountain Shale	7830-7835'	5'
Upper Keg River/Presqu'ile	7835-7921' T. D.	86'

11. WEST COAST - H. B. VALIANT d-30K
WA 2753 J-94-14
Completed Oct. 10, 1970 T. D. 8054'

CORE NO. 1 7664-7669' 5/5

CORE NO. 2 7675-7712' 37/37

Both cores: dolostone, dark grey, finely crystalline, dull; almost completely replaced by white dolomite mineralization, locally in "zebra stone" bands and other intricate patterns.

Fauna:
none

Age Determination:
Presumed Stone Formation on lithologic character and stratigraphic and regional considerations.

Stratigraphic Summary.

Nahanni Formation 7242-7594'	352'
Stone/Bear Rock Formation 7594-8025'	421'
basal sand 8025-8054' T. D.	

12. GULF STATES-IMP. CLARKE LAKE c-94-L
WA 397 94-J-9
Completed Feb. 6, 1959 T. D. 8039

CORE NOS. 3 to 9 6354-6511'

dolostone, light-medium to dark-medium grey, some intergranular porosity; extreme vuggy, mainly filled by white dolomite crystals.
Ghosts of stroms. in upper part, and of coarse-branching types in lower 5'.

Fauna:
nothing identifiable

Age Determination:
Presumed Slave Pt. reefy carbonate on lithologic character.

CORE NO. 10 6511-6530 19/18

6511-6513' dolostone like that above.
6513-6530' limestone, dark brown-grey, cryptocrystalline, compact. Largely composed of a coarse-branching strom. in place in original frame-building position with interstices filled by sparry calcite.

Fauna:
nothing diagnostic

CORE NO. 11 6532-6565' 33/26

similar limestone, mostly full of stroms., including massive types, spaghetti Amphipora, and the same coarse-branching type as in Core no. 10.

Fauna:
Alveolites sp. undet.
fistuliporoid bryozoa
Leiorhynchus sp. undet.
Schizophoria sp.
cephalopod fragment

Age Determination:
Fauna is non-diagnostic and unlike that normally occurring in the Lower Slave Point. It is tentatively placed in the Lower Beavertail.

Stratigraphic Summary.

Slave Point? Reefoid Carbonate	6355-6513'	158'
Lower Beavertail Equivalent	6513-6633'	120'
Watt Mountain Shale	6633-6650'	17'
Presquile Carbonate	6650-6995'	345'
Hare Indian/Middle Pine Point Facies	6995-7192'	197'
Nahanni Carbonate	7192-7300'	108'
Stone/Bear Rock Complex	7300-8030'	703'
Basal quartzite, etc.	8030-8039' T. D.	9'

13. PHILLIPS-SR-WEST CDN KLEDO c-14-G
WA 499 94-J-13
Completed July 23, 1960 T. D. 10,805

CORE NO. 1 9987-10,015' 28/22

9987-10,006' dolostone, dark; almost totally replaced by white dolomite mineralization; a few partly open vugs. 10,006-? begins above as steatic-appearing, calcareous, light grey phyllite, grading downward into, and interbedded with, microcrystalline compact dolostone.

CORE NO. 2 10,015-10,021' 6/?

Pieces only. Resembles lower part of Core no. 1

Fauna:
none

Age Determination:
Stone Formation on lithology and stratigraphic position.

Stratigraphic Summary.

Nahanni Formation	9647-9897'	250'
Stone Formation	9897-10474'	577'

14. PAN AM SHEEP CREEK c-86-D
WA-2150 94-J-12
Completed Nov. 20, 1967 T. D. 10,307

CORE NO. 2 8865-8887' 22/22

CORE NO. 3 8887-8919' 31/31

Both cores in Stone-type light grey dolostone, with moderate degree of mineralization and brecciation.

Fauna:
none

Age Determination:
Stone Formation
on basis of lithology and stratigraphic and regional considerations.

Stratigraphic Summary.

Nahanni Formation	8152-8625'	473'
Lower Dunedin (Landry)	8625-8745'	120'
Stone/Bear Rock	8745-10055'	1310'
Wokkpash?	10055'-10147'	92'

15. CDR-PAC-SINC-PROPHET d-21-B
WA 1236 94-J-3
Completed Mar. 8, 1962 T. D. 10272'

CORE NO. 1 10248-10272' 14/12

Limestone, dense, cryptocrystalline, with bands of sparse *Amphipora*; brachiopods common.

Fauna:
Atrypa aperanta Crickmay
Schizophoria sp.
Schuchertella sp.
Lingula sp. "Prophet"
Lingula sp. B

Age Determination:
GOR Zone DLM8
basal Nahanni

Stratigraphic Summary:
Nahanni Formation 10258-10272 144'

Fairly certain that this is slave pt, in spite of fossils
6" 19/04/78

16. HB-PAN AM MUSKWA a-6-G 94-6-13
WA 553 13-G-94
Completed: March 17, 1960 T. D. 3862

CORE NO. 1 2140-2190' 50/50?

Limestone, medium gray, massive, bioclastic; some portions nodular-mottled; with zones of more argillaceous, black, sooty limestone.

Fauna:
Atrypa perfimbriata Crickmay
Warrenella kirki (Merriam)
Warrenella cf. franklini (Meek)
Emanuella sublineata (Meek)
Devonoproductus cf. primus Crickmay
Chonetes sp. undet.
Schizophoria sp.
Spinatrypa sp.
Dechenella n. sp. "Muskwa"
Basidechenella? sp.
Thamnopora n. sp. "Muskwa"
Syringopora sp.
Alveolites sp. undet.
cf. Cyathophyllum kobehense Stumm
Atelophyllum? sp.
Stachyodes sp.
cephalopod, orthoconic, minute
crinoid ossicles

Age Determination:
GOR Zone DLM 12
Middle Pine Point Facies

CORE NO. 2 2541-2566' 25/25

2541-2543' dolostone, grey mottled, coarsely crystalline, marble-like lustre. 2543-2543.5' limestone, medium grey, dense, in pseudo-boudinage and collapse breccia, in matrix of hard grey green clay and sandy clay. 2543.5-2566' dolostone, light grey, very finely crystalline, dense, massive; shale parting at top.

Fauna:
none

Age Determination:
Stone Formation on lithology and stratigraphic position.

CORE NO. 3 2939-2964' 25/25?

Dolostone, light-medium grey, finely crystalline. Lower part somewhat mottled and vuggy; vugs open, crystal-lined "Birdseyes" in upper part.

Fauna:
none

Age Determination:
Stone Formation

CORE NO. 4 3007-3016' 9/7.5

Interbedded: sandstone and dark-medium grey dolostone, with zones of small vugs, largely calcite-filled.

Fauna:
none

Age Determination:
Probably Wokkpash Equivalent on basis of lithologic character plus stratigraphic and regional considerations.

Stratigraphic Summary.

Middle Pine Point Equivalent	2005-2210'	205'
Nahanni Formation	2210-2500'	290'
Stone Formation	2500-3000'	500'

17. PHILLIPS MINAKER a-25-D
WA 494 94-G-15
Completed July 9, 1960 T. D. 11,361

CORE NO. 1 9560-9603' 43/27.5

Dolostone, dark to very dark somewhat argillaceous; highly mineralized with much dolomite vug-filling. Dynamic brecciation and veining.

Abundant stroms, variously distributed and concentrated: cabbage stroms. spaghetti Amphipora, Stachyodes, and tabular forms.

Fauna:
see above

Age Determination:
see below

CORE NO. 2 9979-10016' 37/37

Dolostone, calcarenitic, light to dark medium grey; much altered.
"Initial" dips up to 75°; clasts common, mainly of dark dolostone, many large angular pieces in a "gefallen" situation. Presumed reef flank.

Much dynamic brecciation, mineralization (dolomite), veining, some micro-faulting.

Ghosts of massive stroms. (many replaced by dolomite mineralization), spaghetti Amphipora, crinoid ossicles; Atrypa sp. (1 at 9998').

Fauna:
as above

Age Determination:
see below

CORE NO. 3 10016-10048' 32/32

Dolostone similar to Core no. 2, but becomes darker; initial dips less steep, but with much evidence of "soft-rock" flowage; many large, angular, suspended clasts.

Dynamic effects decrease downward. Fossils as above but less numerous, plus Stringocephalus at 10017', 10020.5'.

Large lenses marcasite as metasomatic replacement of the dolostone.

Presumed reef-flank.

Fauna:
Stringocephalus sp. undet.

Age Determination:
Zones DLM12 through DLM14, equals Stringocephalus macrozone.

Note;
This and preceding cores appear to represent a stratigraphic unit equivalent to the Upper Keg River/Presqu'ile.

CORE NO. 4 10048-10093' 45/45

Dolostone similar to Core No. 3, but shows less flowage and dynamic effect.

A few stromatoporoid ghosts. Few small brachiopods; samples at 10054-63' proved unidentifiable.

Fauna:
nothing identifiable

Age Determination:
As above, on basis of lithologic continuity.

CORE NO. 5 10093-10141' 48/48

dolostone as above, but "initial" dips decreased to 0°-35°.

Thick-shelled gastropod (10093.5'); Amphipora spaghetti-stone (10104'); much-branched stroms. (top 10120').

10130-10136' shale, calcareous, black & dark marlstone grading to grey shale; in places minutely brecciated with white mineral matrix.

10136-10141' dolostone similar to that higher in core, with dark angular clasts, etc. Sharp upper contact. Small gastropods poorly preserved, but common near top.

Fauna:
see above

Age Determination:
see under Core No. 3 above.

CORE NO. 6 10141-10191' 50/49.5

10141-10145' dolostone like that immediately above.
10145-10147' sedimentary breccia with very large angular fragments, of several lithologies in random mix.

10147-10191' dolostone, grey, peppered by small white rhombs of secondary dolomite ("square crinoids"); shows "soft-rock" flowage, dynamic structures, and mineralization by marcasite and dolomite. A band of medium-grey shale is present from 10148-10151'.

Fauna:
None recovered

Age Determination:
above 10145' Upper Keg River/Presqu'ile on basis of lithologic continuity with the rock immediately above. 10145-10147', interformational conglomerate presumed basal to the preceding; 10148-10191' presumed Stone dol. equiv.

CORE NO. 7 10404-10439' 35 35

Dolostone, light to medium grey, some zones laminated; "initial" dips up to 35°.

Dynamic fracturing, with white calcite in-fill in veins and as breccia matrix; mineralization alteration less than in higher cores.

No fossils except possible Amphipora "ghosts".

CORE NO. 8 10439-10442' 3 3

Dolostone as in Core no. 7

No fossils

CORE NO. 9 10442-10474' 32 32

Dolostone as in Cores 7 and 8, interbedded with Bear Rock-type breccias; dips up to 45o.

Zones of "birdseyes" and possible Amphipora but no organic structures preserved.

Stratigraphic Summary:

Upper Keg River/Presqu'ile (reef)	9547-10147'	600'
Stone Dolomite	10147-10840'	653'

Note:
base of Upper Keg River/Presqu'ile placed at 10147' on core evidence. E-log evidence suggests base at 10170'.

SHELL - HB KLINGZUT b-82-F
WA 1845 94-G-11
Completed June 17, 1966 T. D. 11,462

Note:
no cores were taken. Stratigraphic summary is based on comparison with sample log of Phillips Minaker a-25-D and with outcrop sections to southwest.

Stratigraphic Summary.

Lower Beavertail Equivalent	9272-9417'	145'
Watt Mountain clastics	9417-9450'	33'
Upper Keg River/Presqu'ile	9450-10027'	577'
Stone Dolomite	10027-11073'	1046'

APPENDIX II. SUMMARY OF FAUNAL DATA

Foreword

Most of the fossils recovered from the cores and outcrops can be identified or closely compared with described species. It is not within the scope of the report to re-illustrate these species. Therefore we include a list of references in which illustration of them may be found. This list has been compiled on a basis of practicality and convenience, and is not to be taken as a full scientific documentation. Some references were omitted because of the difficulty in securing them; others because, in the practical sense, they amount to duplication.

Selected Paleo References

Caldwell, W. G. E., 1967, "Ambocoelid Brachiopods from the Middle Devonian Rocks of Northern Canada" in "International Symposium on the Devonian System, Vol. 11" D. H. Oswald, ed., Alta Soc. Petr. Geol., pub.

Copeland, M. J., 1962, "Canadian Fossil Ostracoda, Conchostraca, Eurypterida, and Phyllocarid , Geol. Surv. Canada, Bull 91.

Crickmay, C. H., 1950 "Some Devonian Spiriferidae from Alberta," Jour. Pal., Vol. 24, no. 2. pp. 219-225.

Crickmay, C. H., 1953, "New Spiriferidae from the Devonian of Western Canada", Imperial Oil Ltd., Calgary, pub.

Crickmay, C. H., 1954, "Paleontologic Correlations of Elk Point and Equivalents" in "Western Canada Sedimentary Basin", L. M. Clarke, ed., A. A. P. G. pub.

Crickmay, C. H., 1957, "Elucidation of Some Western Canadian Devonian Formations", Imperial Oil Ltd., Canada, pub.

Crickmay, C. H., Aug 1960, "The Older Devonian Faunas of the Northwest Territories", Imperial Oil Ltd., Calgary pub.

Crickmay, C. H. Sept. 1960 "Studies of the Western Canadian Stringocephalinae", Jour. Pal., vol. 34, no. 1

Crickmay, C. H., 1962, New Devonian Fossils from Western Canada', Imperial Oil Ltd., Calgary, pub.

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Crickmay, C. H., 1967, "The Method of Indivisible Aggregates in Studies of the Devonian", "Available at E. de Mille's Books, Calgary".

Crickmay, C. H., 1968, "Discoveries in the Devonian of Western Canada", "Available at Evelyn de Mille's Books, Calgary.

House, M. R , & Pedder, A. E. H., 1963,Devonian Goniatites and Stratigraphical Correlations in Western Canada", Palaeontology , Vol. 6, part 3.

Lenz, A. C., 1961, "Devonian Rugose Corals of the Lower Mackenzie Valley, Northwest Territories", in "Geology of the Arctic, Part I", G. O. Raasch, ed., Univ. of Toronto Press, pub.

McLaren, D. J., 1962, "Middle & Early Upper Rhynchonellid Brachiopods from Western Canada", Geol. Surv. Canada, Bull. 86.

Pedder, A. E. H., 1964, "Correlation of the Canadian Middle Devonian Hume and Nahanni Formations by Tetracorals", Palaeontology, Vol. 7, part 3.

Pedder, A. E. H., 1963, "Alaiophyllum mackenziense sp. nov., a Devonian Tetracoral from Canada", Palaeontology, Vol. 6 part 1.

Warren, P. S. & Stelck, C. R., 1956 "Devonian Faunas of Western Canada," Geol. Asso. Canada, Special Paper No. 1.

Warren, P. S. & Stelck, C. R., 1962 "Western Canadian Givetian", Jour. Alta Soc. Petr. Geol,, Vol. 10, no. 6

The above 20 references, all as yet, readily available we would recommend as a minimum reference library for identification of Devonian fossils from this part of the section and of the Country. All of them, moreover, include references to other sources of information relevant to the subject.

Available Illustrations of Relevant Fossils

Fossils listed below are in alphabetical order and references

at right refer to illustrations in readily available publications, as listed above. (Note, these are not necessarily the original descriptions of the species).

Alaiophyllum mackenziense (see Grypophyllum)

Atelophyllum fultum Lenz, 1961, p. 513, pl. 2, figs. 3, 13.

Atrypa aperanta Crickmay, Aug. 1960, p. 15, pl. 8, figs. 2-15.

Atrypa arctica Warren & Stelck, 1956, pl. 3, figs. 11-16.

Warren & Stelck, 1956, pl. 9, figs. 1-7 (as "A. aff. clarkei")

Crickmay, Aug. 1960, p. 15, pl. 8, figs. 16-22.

Atrypa bentonensis (as "A. cf. gigantea") Warren & Stelck, 1956 pl. 11, figs. 16-18.

Atrypa independensis Warren & Stelck, 1956, pl. 10, figs. 11-13.

Atrypa cf. independensis Warren & Stelck, 1956, pl. 10, figs 17-19, ibid, pl. 12, figs. 1-4.

Atrypa perfimbriata Warren & Stelck, 1956, pl. 6, figs 1-3 (as "Atrypa sp."), Crickmay, 1957, p. 13, pl. 1, figs 12-14.

"Cyathophyllum" kobchense Lenz, 1961, p. 503, pl. 1, figs 13-16.

Cystiphylloides? arcticus Lenz, 1961, p. 512, pl. 2, figs. 11-12 (as "C.? americanum arcticum")

Cystiphylloides kwangsiense Lenz, 1961, p. 512, pl. 1, fig. 23

Columnaria rhenana (see Dendrostella trigemme)

Dendrostella trigemme Pedder, 1964, p. 434, pl. 62, figs. 1-11. Lenz, 1961, p. 506, pl. 1, figs 5-10 (as "Columnaria rhenana"). Crickmay, 1962, p. 1, pl. 1, figs 3-4, (as "Iteophyllum virgatum").

Devonoproductus primus Crickmay, 1963, p. 24, pl. 5, fig. 16; pl. 14, figs 1-5.

Devonoproductus secundus Crickmay, 1963, p. 26, pl. 5, figs. 25-30; pl. 14, figs 23-26.

Disphyllum goldfussi Lenz, 1961, p. 501, pl. 1, figs. 11, 12.

Eleutherokomma jasperensis Warren & Stelck, 1956, pl. 14, figs. 5, 10-12. Crickmay, 1953, p. 4, pl. 2, figs 9-13.

Eleutherokomma killeri, Crickmay, 1953, p. 4, pl. 3, figs. 1-2, 10. Crickmay, 1950, p. 219, pl. 36, figs 4,5.

Emanuella caligatae Crickmay, 1967, p. 8, pl. 2, figs. 8-12; pl. 3, figs. 1-6.

Emanuella meristoides Warren & Stelck, 1956, pl. 4, figs. 22-24 (as"Ambocoelia meristoides"). Caldwell, 1967, p. 606, figs 7-9.

Emanuella sublineata Warren & Stelck, 1956, pl. IV, figs. 19-21 (as"Martinia? sublineata"). Caldwell, 1967, pp. 606-609, pl. 1, figs 10, 11.

Emanuella vernilis Crickmay, 1967, p. 8, pl. 2, figs 13-19. (equals Ladjia landesi)

Favosites cf. alpenensis Warren and Stelck, 1956, pl. 3, fig. 4.

Geranocephalus inopinus Crickmay, 1954, p. 157, pl. 1, figs. 1-12. Crickmay, 1968, p. 11, pl. 12, figs. 1-12

Grypophyllum mackenziense Pedder, A. E. H., 1963, pl. 19, p. 132 (as Alaiophyllum mackenziense).

Hadrorhynchia sandersoni Crickmay, 1963, p. 5, pl. 1, figs. 3-6; pl. 9, figs 1-7.

Hexagonaria furtiva Crickmay, Aug. 1960, p. 10, pl. 5, figs. 6-8.

Hexagonaria gemmifera Crickmay, Aug. 1960, p. 8, pl. 6, figs. 6-7.

Iteophyllum virgatum (see Dendrostella trigemme)

Ladjia landesi Crickmay, 1967, p. 9, pl. 2, figs 42-44; pl. 3, figs 22-24. (Note: same as Emanuella vernilis Crickmay 1967; difference in appearance is due to preservation of surface detail.

Ladogioides pax McLaren, 1962, p. 66, pl. 9, figs. 1-8; pl. 10, figs. 1-3.

Leiorhynchus castanea Warren and Stelck, 1956, pl. 9, figs. 12-16. McLaren, 1962, p. 83, pl. 14, figs. 2-7; pl. 15, figs. 1-11; pl. 16, fig. 1. (Note: includes L. hippocastanea).

Leiorhynchus hippocastanea Warren & Stelck, 1956, pl. 8, figs. 29-31. (as "Caryorhynchus castanea (Var.)") . Crickmay, Aug. 1960, p. 13, pl. 9, figs. 10-17. (as "Caryorhynchus hippocastanea")

Leiorhynchus rhabdotum Crickmay, 1963, p. 8, pl 1, figs. 18-21; pl. 8, figs. 7-12.

Leiorhynchus russelli McLaren, 1962, p. 95, pl. 17, figs 1-10.

Microplasma fongi Lenz, 1961, p. 511, pl. 1, figs 3,4.

Moelleritia canadensis Copeland, 1962, p. 4,pl.1, figures 3-17.

Ponticeras cf. tschernyschewi House, M. R. & Pedder, A. E. H, 1963, p. 516, pl. 70, figs. 5, 9, 10.

Schizophoria allani Warren & Stelck; 1956, pl.9, figs. 1-13.

Schizophoria athabascensis Warren & Stelck, 1956, pl. 11, figs. 1-3.

Schuchertella adoceta Warren & Stelck, 1956, pl. 1, figs 2-3 (as "Schuchertella nevadensis"). Crickmay, Aug. 1960, p. 18 pl. 10, figs. 10-17.

Sociophyllum glomerulatum Crickmay, 1962, p. 7, pl. 1, figs. 15; pl. 2, figs 6 & 7; pl. 4, figs 8,9. (as "Stringophyllum glomerulatum") Pedder, 1964, p. 445, pl. 69, figs. 1-13; pl. 70, figs. 1-12.

Stringocephalus aleskanus Crickmay, 1962, p. 12, pl.1, figs. 11; pl. 6, figs. 1-6; pl. 8, figs 4-7; pl 9, figs 1-3.

Crickmay 1968, p. 11, pl. 10, figs. 1-7.

Stringocephalus axius Crickmay, 1954, p. 158, pls. 2,3

Stringocephalus chasmognathus Crickmay, Sept. 1960, p. 885, pl. 114, figs. 5-7.

Stringocephalus giganteus Warren & Stelck, 1962, fig. 5, p. 284. (as "Geranocephalus cf. Stringocephalus giganteus").

Stringocephalus glaphyrus Crickmay, Sept. 1960, p. 882, pl. 113, figs. 1-8.

Stringocephalus noctua Crickmay, 1968, p. 10, pls. 8-9, figs. 14-17.

Stringocephalus sapiens Crickmay, Sept. 1960, p. 882, pl.13, figs 9-12; pl. 114, figs 1-4.

Utaratuia acucipicta Crickmay, Aug. 1960, p. 5, pl. 2, figs. 1-4.

Utaratuia laevigata Crickmay, Aug, 1960, p. 5, pl. 1, figs. 6-9.

Warrenella franklini Warren & Stelck, 1956, pl. 2, figs 1-3. (as "Martinia? franklini"); ditto pl. IV, figs. 9-12 (as "Martina? kirki var. occidentalus?")

Warrenella kirki Warren & Stelck, 1956, pl. 4, figs. 25-27 (as "Martinia? kirki").

Warrenella occidentalis Warren & Stelck, 1956, pl. 9, figs. 25-27 (as "*Martinia? occidentalis*"), Crickmay Aug., 1960, p.16, pl. 10, figs. 1-9 (as "*Warrenella timetea*"), Crickmay, 1962, p. 10, pl.1, figs. 8&9 (as "*Tingella timetea*") Crickmay, 1963, p.17, pl. 3, figs. 21-26; pl. 11, Figs. 14-18 (as "*Tingella timetea*").

APPENDIX III

STRATIGRAPHIC REFERENCES

General Stratigraphy

1. Griffin, D. L., 1967, "Devonian of northeastern British Columbia", International Symposium on the Devonian System, Vol. 1, pp. 803-826.

Note: in general we are in agreement with Griffin's stratigraphic interpretation and nomenclature. More specifically, his Otter Park appears to correspond to our Hare Indian/Horn River, except that we would not extend it as high as Slave Point equivalency. His Slave Point coincides with our Lower Beavertail/Lower Slave Point, but this difference may be regarded as minor. His Muskeg equals our Presqu'ile/Upper Keg River, the difference being merely nomenclatural. His use of Beaverhill corresponds to our Waterways, the two being almost certainly synonymous. Further minor discrepancies in nomenclature might be presented, but, overall, Griffin's regional picture and ours are in essential agreement. Particularly, we are gratified with his interpretation of the Muskwa and the pre-Muskwa unconformity, which coincides with ours (see his fig 1).

2. Gray, F. F., and Kassube, J. R., 1963, Geology and Stratigraphy of Clarke Lake Gas Field, northeastern British Columbia", American Asso. Petr. Geol. Bull,,Vol 47, no. 3, pp. 467-483.

Note: The only well in common with our study is that which we, following Canadian Stratigraphic Service, refer to as Gulf States-Imperial Clarke Lake c-94-L but which the authors along with the B. C. government designate as the West Nat-Imperial-Clarke Lake c-94-L. We do not agree closely with the above authors on the correlation of this well. However, there is agreement on the Muskwa and the top and bottom of the shale, 6995-7172' which they call Klua and which we identify with the Hare Indian and Horn River (Griffin's Otter Park).

3. Miscellaneous. Valuable comments on stratigraphy and bio-stratigraphy are also included in a number of the paleontologic references listed above. Among these we recommend:

Crickmay, 1957 (for Waterways Formation)

Crickmay, 1968, pp. 2-3

Crickmay, 1967, pp. 1-3 (especially relative to Slave Point and Waterways formations).

House & Pedder, 1963 (application of goniatite zonation to Devonian of Western Canada).

McLaren, 1962, pp. 3-16 (stratigraphic paleontology and zonal subdivision based on rhynchonellid brachiopods).

Pedder, A. E. H. 1963, pp. 132-133 (on fauna of the Kee Scarp Reef, Norman Wells).

Pedder, A. E. H., 1964, pp. 430-433 (on Hume, Nahanni, Headless correlations).

Warren & Stelck, 1956, (as the pioneer attempt at biostratigraphic subdivision of Western Canadian Devonian, and still a mine of information).

4. Crickmay, C. H., 1966, "Devonian Time in Western Canada" "available at E. deMille Books, Calgary".

The most comprehensive attempt at biostratigraphic zonation of Western Canadian Devonian, with which we agree in general, if not always in particular (as may be seen from the following Appendix IV).

ZONE NO.		TYPICAL OCCURRENCE	NORHEASTERN BRITISH COLUMBIA	CENTRAL MACKENZIE VALLEY	HAY RIVER GREAT SLAVE LAKE
DFA 5	Sinotectirostrum avellana	unnamed; N.W.T.	unfossiliferous in Besa River	present in Upper Imperial	
DFA 4	Gastrodetoechia utahensis	Costigan; Alta.		" "	
DFA 3	Evanescirostrum seversoni	Morro; Alta		" "	
DFA 2	Cyrtiopsis nahanniensis	unnamed; N.W.T.		" "	
DFA 1	Cyrtiopsis mimetes	Sassenach, Alta.		absent	
	MAJOR UNCONFORMITY				
DFR 12	"Vandergrachtella" scopulorum	Southesk, Alta	present in Besa River	present in Lower Imperial	
DFR 11	Cyrtospirifer whitneyi	Southesk, Alta.		present in Lower Imperial	Escarpment M., Alexandra, Grumbler
DFR 10	Cyrtospirifer placitus	Escarpment Member, Hay River			Hay River F.
DFR 9	Calvinaria albertensis	Mt. Hawk, Alta.			Hay River F.
DFR 8	Eleutherokomma reidfordi	Hay River F., Hay River			Hay River
DFR 7	Monlasmina bestl	Hay River F., Hay River	present in Besa River		Hay River
DFR 6	Eleutherokomma leducensis	Alta subsurface			
DFR 5	Warrenella catacostoma	Cooking Lake, Alta. subsurface	Canol (Musk		
	REGIONAL UNCONFORMITY				
DFR 4	Atrypa gregeri	Upper Waterways; N.E. Alta.	present in Besa River		Upper Waterways
DFR 3	Atrypa scutiformis	Calmut M., Waterways; N.E. Alta.	present in Besa River		Calmut Member, Waterways
DFR 2	Ladogioides pax	Firebag M., Waterways; N.E. Alta.	present in Besa River		Firebag M., Waterways; U. Slave Pt.
DFR 1	Ladjia landesi / Ponticeras	Lower Slave Pt. / U. Beavertail, N.W.T.	absent?	Upper Beavertail	Lower Slave Point, Ft Vermilion
DLM 15	Cyrtina "panda" / Grypophyllum mackenziense	Lower Beavertail; Mackenzie Valley	present in "Slave Point"	Lower Beavertail / Kee Scarp.	so-called "Slave Pt" of Deep Bay, etc.
	REGIONAL UNCONFORMITY		Watt Mountain Ss.		Watt Mt. (diachronic)
DLM 14	Stringocephalus aleskanus	Lower Ramparts, Mackenzie Valley	presnt in Dunedin	Lower Ramparts	Presqu'ile / Sulphur Pt.
DLM 13	Str. axius / Rensselandia	Lower Ramparts, Mackenzie Valley	present in Dunedin	Lower Ramparts	Upper Pine Point
DLM 12	Str. sapiens / Warrenella kirki	U. Keg River, N.E. B.C. / Hare Indian, N.W.T.	present in Dunedin / in Besa R.	Hare Indian	Middle Pine Point; Horn River
DLM 10/11	Atrypa arctica / Utaratuia acucipicta	U. Hume / U. Nahanni; N.W.T. / N.E. B.C.	present in Dunedin	Upper Hume	Lower Pine Pt.; Lonely Bay
DLM 9	Schuchertella adocota	L. Hume, Mackenzie Valley	present in Dunedin	Lower Hume	Upper Chinchaga
DLM 8	Atrypa aperanta	Basal Hume; E. Cen. Yukon	absent?	Basal Hume locally	
	MAJOR UNCONFORMITY				
DLM 7	Megakozlowskiella	Battleship Shale; E. Cen. Yukon	absent		
DLM 6	Spirinella collina	Cranswick; E. Cen. Yukon	absent		
DLM 5	Chonetes sp. DW105	" "	absent		
DLM 4	Spongonaria / Mölleritia	" ; E. Cen. Yukon / Gossage, N.W.T.	present in Dunedin		
	MAJOR UNCONFORMITY				
DLM 3	Carinatina	Michelle? E. Cen. Yukon	absent or unfossiferous		
DLM 2	Spirigerina / Monogr. yukonsis	Delorme, E. Cen. Yukon / Road R., N. Yukon			
DLM 1	Gypidula pelagica	Delorme, E. Cen. Yukon	fish in Muncho-McConnell		
SLL	Atrypella scheii	Delorme, E. Cen. Yukon	absent?		

FAUNAL ZONE - TIME - LITHOFACIES RELATIONSHIPS - DEVONIAN WESTERN CANADA

Raasch and Assoc. Ltd. 1971

APPENDIX IV

FAUNAL ZONES AND LITHO-STRAT EQUIVALENTS

General Consideration

The faunal zones involved in our present discussion range from the DLM 4 Zone of Spongonaria/Moelleritia below, to the DFR 5 Zone of Warrenella catacostoma above. A brief summary of the composition and stratigraphic relations of the zones follows.

DLM 4 Zone of Spongonaria/Moelleritia

The open-marine facies of this zone is developed only in the more northern regions, from east-central Yukon across the Arctic Islands. It is known as far south as north-central British Columbia but does not extend to the region of the report area.

It has a large fauna, especially of brachiopods, corals, and trilobites, for the most part undescribed. Among described forms are several species of the cerioid coral Spongonaria (see Crickmay, 1962, 1968), the pentamerid brachiopod Gypidula

recurrens (Meyer) (Geol. & Econ. Min of Canada, pl. IX) and the "two-holed" crinoid ossicle, Gasterocoma? bicaula Johnson & Lane (op. cit., pl. IX). In east central Yukon and the adjoining part of the District of Mackenzie, the assemblage occurs in the Cranswick Member of the Ogilvie Formation (see A. W. Norris, G. S. C. paper 66-39, p. 30); and in the Arctic, in the Blue Fiord Formation.

The restricted-marine facies equivalent to the preceding is the Moelleritia canadensis assemblage of the Landry Formation. In the Blackstone area of Yukon and in the Cranswick River area of west-central Mackenzie, the Moelleritia-bearing beds are interbedded with those bearing the Spongonaria open-marine fauna.

DLM 5 to DLM 7 Zones

In east-central Yukon and west-central Mackenzie, the top of the DLM 4 (Landry-equivalent) Zone lies more than 1600 feet below the Hume (DLM 8) basal contact. In the report area, on the other hand, DLM 4 beds directly underlie DLM 9 beds.

This gap, involving 4 faunal zones, emphasizes the magnitude of the break beneath Sequence A.

DLM 8 Zone of Atrypa aperanta

In line with the preceding, the DLM 8 Zone is presumably absent due to onlap in the report area. A possible exception is occurrence in CDR-Pac-Sinclair Prophet (15) well, which has been discussed in a previous portion of this report.

DLM 9 Zone of Schuchertella adoceta

Although the DLM 9 Zone was not recovered from wells in the subsurface area, the Nahanni thickness in a number of the wells suggests its presence. Unfortunately, this portion of the section was not cored in any of the wells.

In the surface area of the mountains to the west, on the other hand, at Mt. Helen and at Hamlyn Creek on Peace River, the DLM 9 Zone is shown to be present. These determinations are based on the presence of the zone fossil, *Schuchertella adoceta*, in the lower part of the Nahanni at Mt. Helen, and of the coral *Xystriphyllum hyperbolicum* Crickmay at Hamlyn Creek.

In some of the north-westerly wells in the subsurface area, but most particularly in the Pan Am Sheep Creek well (no. 14), where the Nahanni interval is 473 feet thick, Zone DLM 9 may be present. Unfortunately, this interval was not cored in any of the wells.

To the south and east, the limited Nahanni/Lower Keg thickness strongly suggests that the DLM 9 Zone has been lost by on-lap.

DLM 10/11 Zone of Atrypa arctica/Utaratuia acucipicta

In the Mackenzie Valley, where the DLM 10/11 is in a shallow-water open-marine facies, it bears a very rich fauna, of which the brachiopods, corals, and trilobites have, to date, received the major proportion of taxonomic attention.

From this facies, the following are extracted as being particularly diagnostic.

BRACHIOPODS:

Atrypa arctica Warren 1944

Spinatrypa andersonensis (Warren) 1944

Spinatrypa coriacea Crickmay 1960

"Carinatina" dysmorphostrata (Crickmay) 1960

Hysterolites compactus (Meek) 1867

Spinulicosta stainbrooki Crickmay 1960

CORALS:

Atelophyllum fultum Hill 1942

Radiastraea arachne Stumm 1937

Hexagonaria furtiva Crickmay 1960

Hexagonaria gemmifera Crickmay 1960

Hexagonaria arguta Crickmay 1960

Hexagonaria impedita Crickmay 1960

Utaratuia acucipicta Crickmay 1960

Cystiphylloides kwangsiense Yoh 1937

Cystiphylloides? arcticus (Meek) 1867

In the northeastern British Columbia mountains, the DLM 10/11 Zone is still in open marine facies, but the fauna is much sparser and suggests shoaling conditions. Farther south the beds

approach a reef/bank carbonate facies. These relationships are amply discussed in previous sections of this report.

DLM 12 Zone of Stringocephalus glaphyrus/Warrenella kirki

The lowest of the three zones which bear species of the brachiopod genus Stringocephalus is that which we designate the S. glaphyrus Zone. The presence of Stringocephalus is essentially limited to beds in a reef and/or bank carbonate facies. The equivalent open-marine facies is dominated by other brachiopods and designated the Warrenella kirki assemblage.

Stringocephalus-bearing carbonates in this age-brackett occur only in two areas: 1) in the British Columbia front ranges (see Brady and Raasch report, op. cit.) in beds presumably equivalent to the lower part of the Upper Keg River Formation; and 2) in Manitoba in the Winnipegosis Formation. Species of Stringocephalus occurring in this zone are S. ciconia Crickmay 1968, S. glaphyrus Crickmay 1960, S. noctua Crickmay 1968, and S. sapiens Crickmay, 1960.

The open-marine equivalent for Zone DLM 12 occurs in the Hare Indian and Horn River shales and in the Middle Member of the Pine Point Formation. The two former were deposited under rather strongly reducing conditions, so that the macrofauna is limited in variety, and consists mainly of three brachiopods, Warrenella kirki (Merriam), Leiorhynchus castanea (Meek), and Emanuella sublineata (Meek).

The same three brachiopods are common in the "Middle Member" of the Pine Point Formation, but this well-aerated facies bears a rich fauna in which the following described species are prominent:

BRACHIOPODS:

Atrypa perfimbriata Crickmay

Warrenella kirki (Merriam)

Warrenella franklini (Meek)

Leiorhynchus castanea (Meek)

Emanuella sublineata (Meek)

Productella verecunda Crickmay

Devonoproductus minimus Crickmay

Hadrorhynchia intermissa Crickmay

Rhyssochonetes cf. aurora (Hall)

DLM 13 Zone of Stringocephalus axius/Rensselandia

The middle zone of the Stringocephalus sequence is typically represented in the lower part of the Lower Ramparts Formation, as developed in the "Ramparts" of the Mackenzie River above Fort Good Hope. The fauna here is varied, but has largely been ignored except for the stringocephalids and certain corals. These are:

BRACHIOPODS:

Rensselandia laevis (Whiteaves)

Stringocephalus chasmognathus Crickmay

Stringocephalus axius Crickmay

Geranocephalus inopinus Crickmay

Emanuella sublineata (Meek)

CORALS:

Bethanyphyllum cf. robustum (Hall)

Cyathophyllum lonense Stumm

Siphonophrentis cf. gigantea (Lesuer)

In the report area, this zone is assumed to be present in the mid-portion of the Upper Keg River/Presqu'ile sequence. It is represented in the mountains to the west by several hundred feet of fossiliferous strata presumed euqivalent to the upper part of the Upper Keg River. The zone is definitely pre-Presqu'ile.

DLM 14 Zone of Stringocephalus aleskanus

The highest Stringocephalus-bearing zone is that represented by the upper part of the Lower Ramparts of Fort Good Hope and by the Presqu'ile of the Great Slave Lake region.

Most of the fauna of this zone remains unstudied but the following stringocephalids are present:

Stringocephalus aleskanus Crickmay

Stringocephalus (=? Geranocephalus) giganteus (Sowerby)

In addition, Emanuella sublineata persists into this zone. The horn corals Disphyllum goldfussi and Cyathophyllum? kobehense of Lenz are also present here, and Emanuella sublineata continues from below.

Open marine equivalents of Zones DLM 13 and DLM 14 are either unkown or (in the case of the Buffalo River Member of the Pine Point) unfossiliferous.

DLM 15 Zone of Cyrtina panda

The Beavertail (=Upper Ramparts) beds of the Mackenzie Valley involve two faunal zones which we have designated DLM 15 and DFR 1. The latter is time-equivalent to the "Lower Member" of the Slave Point Formation of the Great Slave Lake area, but the former is either absent there due to overlap or is represented by the Fort Vermilion evaporites.

The DLM 15 Zone corresponds to that which Warren and Stelck (1956) refer to as the "Cyrtina panda Zone." Whether the Cyrtina is the same as that described by Meek (1867) as Cyrtina panda may be open to question. Nevertheless, it is very distinct for its abnormally large size, which, with other characters, render it diagnostic for the zone. There is a rich additional fauna, which includes the following:

BRACHIOPODS:

Warrenella occidentalis (Merriam)

Emanuella caligatae Crickmay

Atrypa percrassa Crickmay

Leiorhynchus rhabdotum Crickmay

Spinatrypa mascula Stainbrook

Nervostrophia tulliensis (Hall)

Productella gulosi Crickmay

DFR 1 Zone of Ponticeras/Ladjia landesi

The upper beds of the Beavertail and of the equivalent Upper Ramparts in the Mackenzie Valley, have a different fauna from the DLM 15 fauna below. Most conspicuous is an abundance of the brachiopod Leiorhynchus hippocastanea Crickmay in limestones underlying and interbedded with dark shale bearing goniatites including Ponticeras tschernyschewi House. The ostracods, according to Braun, 1966, indicate affinity with the Slave Point Formation. More specifically we correlate it with the Lower Slave Point.

The small horn coral, "Alaiophyllum" (=Grypophyllum) mackenziense (Pedder) occurs in both the DLM 15 and DFR 1 zones, as well as in the reef at Kee Scarp, Norman Wells.

In the subsurface of the report area, the coral occurs associated with the Lower Slave Point brachipod, Ladjia landesi Crickmay. This brachiopod is considered to be synonymous with Emanuella vernilis Crickmay. The differences in surface character on which the distinction of the two "species" is based, varies according to preservation. Both occur abundantly in the Lower Member of the Slave Point south of Great Slave Lake.

DFR 2 Zone of Ladogioides pax

From previous studies, we have reached the tentative conclusion that the Upper (and probably also the Middle) Member of the Slave Point "Formation" is a facies equivalent of the Firebag and Peace Point members of the Waterways Formation. To this zone we have applied the designation DFR 2.

The DFR 2 Zone, as developed in the Firebag Member of the Waterways Formation, includes the following diagnostic brachiopods:

Atrypa cf. independensis Webster

Atrypa cf. littletonensis Fenton & Fenton

Cyrtina cf. missouriensis Swallow

Eleutherokomma impennis Crickmay

Ladogioides pax McLaren

DRF 3 Zone of Atrypa scutiformis

The zone which we designate as DFR 3 occupies the interval of the Calmut Member of the Waterways Formation in northeastern Alberta. In the Rockies, it occurs in the lower part of the Flume Formation in the more westerly ranges of the Canadian Rockies as far south as Mt. Devon and Fossil Mountain, Banff National Park.

Among brachiopods, the following are diagnostic of the zone:

Athyris occidentalis Whiteaves

Atrypa bentonensis Stainbrook

Atrypa scutiformis Stainbrook

Athabascia asmenistra Crickmay

Devonoproductus tertius Crickmay

Strophodonta cf. costata Owen

Strophodonta halli Cleland

Tylothyris cf. annae (Swallow)

DFR 4 Zone of Atrypa gregeri

The Zone of Atrypa gregeri in the Waterways comprises the Christina, Moberly, and Mildred members; and in the Front Ranges of the Rockies, the Flume and Maligne formations.

The fauna is rich and complex, and includes the following diagnostic brachiopods;

Allanella allani (Warren)

Allanella minutilla Crickmay

Atrypa gregeri Rowley (syn. A. clarkei Warren)

Atrypa pronis Stainbrook

Athyris randalia Stainbrook

Chonopectoides catamorphus Crickmay

Eleutherokomma hamiltonae Crickmay

Eleutherokomma jasperensis (Warren)

Eleutherokomma killeri Crickmay

Ladogioides kakwaensis (McLaren)

Cyrtina billingsi Meek

Leiorhynchus russelli McLaren

Eostrophalosia pedderi Crickmay

Leiorhynchus carya Crickmay

Devonoproductus secundus Crickmay

DFR 5 Zone of Warrenella catacostoma

Crickmay's Zone of Warrenella catacostoma corresponds to the Cooking Lake Formation of central Alberta. It is assumed that the Muskwa Shale of the project area corresponds in time to the Cooking Lake Formation and W. catacostoma Zone. However, we have not, so far, carried on studies in northern and central Alberta which might establish the suggested equivalencies.

For further studies on the Cooking Lake and its fauna, see the following:

Crickmay, C. H. 1961, "The Fauna of the Cooking Lake Formation", Jour., Alta, Soc. Petr. Geol., Vol. 9, no. 11, pp. 347-351.