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Date _____

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PRELIMINARY GEOLOGICAL REPORT

TRIAD OIL CO. LTD. PROJECT

UPPER MACKENZIE AREA, N.W.T.

Abstracted for
Geo-Science Data Index
Date

Prepared For

Triad Oil Co. Ltd.

October, 1957

J. C. SPROULE & ASSOCIATES
GEOLOGICAL & EXPLORATION CONSULTANTS

901 EIGHTH AVENUE WEST
CALGARY — ALBERTA

TELEPHONES
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AMHERST 2-4374

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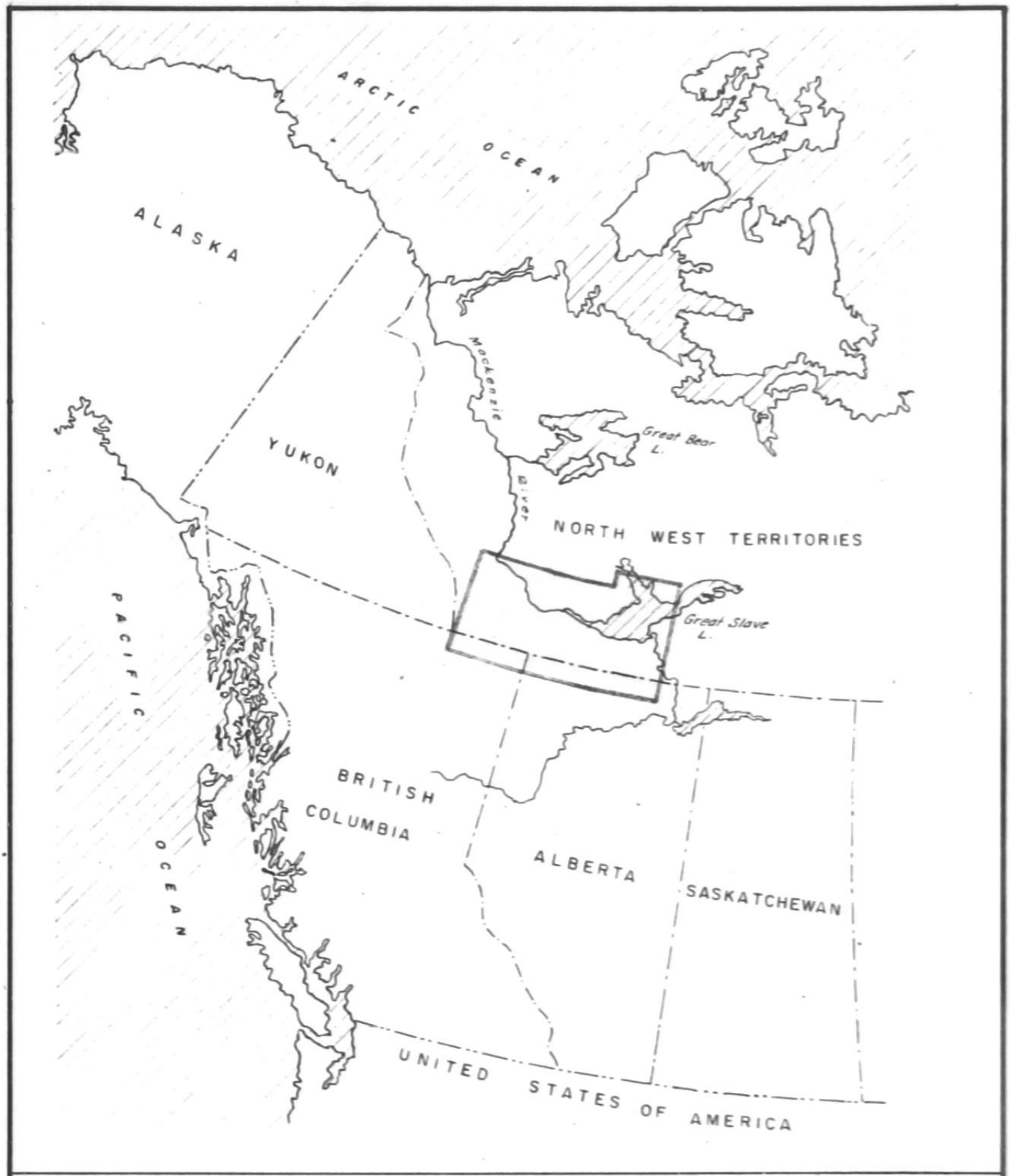

INDEX MAP

WESTERN CANADA

Area covered by report

J.C. SPROULE & ASSOCIATES, CALGARY

INDEX MAP

WESTERN CANADA

Area covered by report

J.C. SPROULE & ASSOCIATES, CALGARY

PRELIMINARY GEOLOGICAL REPORT

TRIAD OIL CO. LTD. PROJECT

UPPER MACKENZIE AREA, N.W.T.

PART I - REGIONAL SURVEY

INTRODUCTION

The present report contains the preliminary results of a geological survey conducted during the summer of 1957 by J. C. Sproule & Associates in the Upper Mackenzie area of the Northwest Territories at the request of Triad Oil Co. Ltd. The principal objective of this study is to indicate and evaluate conditions favourable for the accumulation of petroleum and natural gas within the lands held under Permit by Triad Oil Co. Ltd., in the vicinity of Trainor Lake, N.W.T. These Permits, numbered 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973 and 974, are situated between Longitude 120° to 120°45', Latitude 60° to 60°30', and between Longitude 119° 15' to 120°, Latitude 60° 20' to 60° 30'.

The geological evaluation of the area was to be carried out by varying means. The first approach was the undertaking of a field survey, mainly by helicopter in the Permit area itself. Partly as an aid to field work, but also as a separate method, a photogeological study was planned and carried out in this area. It was also decided, because of lack of outcrop in the immediate vicinity of the Permits, to expand the geological field investigation over a sizeable area, which reaches from the Nahanni and Liard Mountains in the west to Hay River and the shores of Great Slave Lake. To the south, scattered wells in northern Alberta have provided useful information, and to the north the study covered outcrops near North Nahanni River, Fort Simpson, the upper Mackenzie River and the north arm of Great Slave Lake. This larger area of interest, which may be called the Upper Mackenzie area, comprises the north part of the Alberta basin and the south part of the huge Mackenzie basin, which stretches to the Arctic Ocean.

The field work entailed reconnaissance trips by air and on the water along major streams and their tributaries. Outcrops near the few existing roads were examined, and in a number of places large exposures were measured in detail to gain an insight in the succession of strata and geological formations. In all outcrops a search was made for porous beds and for direct evidence of the presence of hydrocarbons.

The project was under supervision of R. deWit and G. K. Williams, and was carried out with the assistance of geologist N. Peterson, and student-assistant R. W. Turner. In addition to the geological personnel, the party consisted of a boatman-cook, H. Lindley, and the helicopter crews, pilots R. F. Ross and D. L. Sides, and engineers H. Smith and H. Lazaros.

Due to the extreme inaccessibility of the area, most transportation was by air. During the first month a Model G-1 owned by J. C. Sproule was used, but this machine was replaced by a Bell Model G-2 rented from General Helicopter, Santa Barbara, California, during the remainder of the season. Major camp moves, the distribution of fuel caches and, later, even geological reconnaissance trips were carried out by chartered airplane. Other means of transportation included trucks, a canoe, a rubber boat and rented river barges.

Field operations began in early June. The first base camp was established near Nahanni Butte(6), at the confluence of the South Nahanni and Liard Rivers. Two field parties, each consisting of two geologists, worked sections in the mountains and scouted the adjacent plains for outcrops.

The second base camp was located on the Liard River, near the mouth of Poplar River(11), for the period July 8 to July 16. This camp allowed study of a wide area, stretching from Fort Simpson(33), and the Martin Hills(14) to Deep Lake(16) and the Blackstone River(9).

After the middle of July the parties were divided and spread into different areas. G. K. Williams moved to Trainor Lake, while Peterson worked the wide vicinity of Fort Liard. DeWit and Turner proceeded to the North Nahanni River area(1) via Fort Simpson. The latter party moved on to Hay River in late July with the object of studying outcrops on Hay River(27) and near the Mackenzie Highway and the Mills Lake road(25). Work in the Hay River area was interrupted for a week, during which period Williams and deWit made a trip by helicopter to examine the "reef escarpments" between Kakisa Lake(21) and Deep Lake(16).

The field season was concluded with a reconnaissance of Great Slave Lake(28, 30, 31, 32), where oil seepages were examined near outcrops of Middle Devonian and older rocks.

Some time was devoted to the study of cores of wells drilled in the Northwest Territories and in northern Alberta. These cores are stored in the Department of Northern Affairs' core house at Hay River, at the Pine Point Concession of Consolidated Mining and Smelting Company, and at the Imperial Oil Ltd. core house in Peace River. Friendly co-operation of officials and personnel connected with the custody of these cores is gratefully acknowledged.

Owing to the vast number of scattered geological data that were collected during the field season of 1957, and also due to the complexity of geological problems peculiar to the borderland between the Alberta and Mackenzie basins, the final report on the geology will require further preparation.

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(6) Numbers following geographic names refer to localities marked on the enclosed geological map.

In the present report an attempt is made to summarize the main geological features of the Upper Mackenzie area and also to appraise in brief terms the oil and gas possibilities of the Trainor Lake Permits. It will be evident that the conclusions reached at present may be subject to revision in the light of further study of the data that were collected.

This preliminary report is illustrated by a regional geological map and four graphic stratigraphic sections.

GENERAL GEOLOGY AND STRATIGRAPHY

Geologically, the southern portion of the Northwest Territories occupies a central position between some of the major tectonic and stratigraphic features of Western Canada. The Upper Mackenzie area incorporates the north end of the Alberta basin, and it also forms part of the Mackenzie basin. These basins have certain similarities that have arisen from continent-wide movements of the earth's crust, but in many respects they contain a separate record of supply, modification, and removal of sediments during the course of geologic time. While the development of the Alberta basin is now reasonably well understood, the geology of the Mackenzie basin is by comparison almost unexplored and only very partially known.

Other major features, peculiar to the southern Territories are the sudden change in structure and direction of the disturbed mountain belt of Western Canada, and the southwest trending fault complex of the Canadian Shield near Great Slave Lake, which can be projected into the sedimentary area.

Many tectonic features of smaller magnitude, such as local basins and high arches or blocks of basement rock, must be inferred, or may be dimly discernable from certain observed facts.

In order to discuss the stratigraphy of this large and complex area it is divided into southwest, northwest and eastern portions. The southwest part includes the Trainor Lake Permit area and the wide vicinity north to South Nahanni and Liard Rivers. The northwest part includes the Nahanni Mountains and the area north of Liard River, while the eastern part lies east of Liard River and the Trainor Lake Permits.

Descriptions of the formations which are present in the various parts of the area studied, are summarized in the following tables:

Tables of Formations

The Southwest

System	Formation	Lithology	Thickness Feet
PLEISTOCENE		Boulder clay, gravel, sand	Varies
UPPER CRETACEOUS	Kootaneelee	Dark marine shale, salt and pepper sandstone, minor conglomerate	575+
	Fort Nelson	Upper member: Conglomerate and sandstone	250+
		Lower member: Sandstone, sandy shale, minor conglomerate	300±
LOWER CRETACEOUS	Lepine	Dark marine shale and sandy shale	2000±
	Scatter -Garbut (undifferentiated)	Fine-grained marine sandstone, sandy and silty shale, shale	850+
	Basal Cgl.	Chert and quartz pebble conglomerate, sandstone	0-100
		Unconformity	
PERMIAN -PENNSYLVANIAN	Unnamed	Chert zone; siliceous sandstone, bedded chert and shale	0-600
	Unnamed	Sandstone, with shaly bands, ironstone and a coal seam	0-3800
MISSISSIPPIAN	Rundle ?	Crinoidal limestone and shaly limestone	0-400
	Banff ?	Cherty and argillaceous limestone, calcareous shale and sandy shale	0-1200
	Exshaw ?	Black shale with ironstone concretions, non-calcareous	0-400
	Basal sand.	Sandstone and dark grey shale	0-500
UPPER DEVONIAN	Wabamun	Sandstone, silty limestone, shaly limestone and limestone	0-700

System	Formation	Lithology	Thickness Feet
	Winterburn	Limestone, silty limestone, siltstone and shale	500+
	Shale Unit	Greenish grey shale, with few limestone bands	2100-
		Unconformity	
MIDDLE DEVONIAN	Slave Point	Finely clastic brown limestone with petroliferous odour	400±
	Watt Mountain	Limestone breccia and green (residual) clay-shale	10-100
		Unconformity ?	
	Muskeg - Keg River	Limestone and dolomite, in part anhydritic	400-1000
	Chinchaga	Anhydrite and dolomite	200±
PRE-DEVONIAN ? (Age undetermined)	Red Beds	Varicoloured dolomite, sandstone, siltstone and shale; anhydrite	variable
PRECAMBRIAN		Igneous and metamorphic rock	

The Northwest

PLEISTOCENE		Boulder clay, gravel, sand	Varies
CRETACEOUS	Unnamed	Sandstone and shale, in part equivalent to Fort St. John group	0-200
		Unconformity	
UPPER DEVONIAN	Imperial	Sandstone, calcareous and maroon or grey silty shale	0-1200?
	Grumbler	Detrital limestone, biostromes, calcareous siltstone, grey and black shale, and sandstone	0-1000

System	Formation	Lithology	Thickness Feet
	Fort Creek	Greenish grey shales, partly changing into black shales in the extreme northwest. Incorporates the "Simpson shale", and is in part an equivalent of Ireton and Beaverhill Lake	1000-2000
	Beavertail	Dark grey argillaceous limestone in extreme northwest	0-20 ?
		Unconformity	
MIDDLE DEVONIAN	Ramparts	Limestone, in part organic	0-800
UNDETERMINED	Bear Rock ?	Dolomite breccia	200±
	Lone Mountain	Alternating light and dark dolomites	1700
		Unconformity	
SILURIAN or ORDOVICIAN	"Ronning"	Dolomite and sandstone	1000
CAMBRIAN ?	Unnamed	Reddish and buff sandy dolomites, dolomitic sandstone and siliceous shales	0-575
PRECAMBRIAN		Igneous and metamorphic rocks	
		The East	
PLEISTOCENE		Boulder clay, gravel, sand	50-300
CRETACEOUS		Dark grey, marine shale	1,000
		Unconformity	
UPPER DEVONIAN	Trout River	Limestone, silty, cream, granular	0-300

System	Formation	Lithology	Thickness Feet
	Winterburn	Limestone, silty limestone, siltstone and shale	500+
	Shale Unit	Greenish grey shale, with few limestone bands	2100-
		Unconformity	
MIDDLE DEVONIAN	Slave Point	Finely clastic brown limestone with petroliferous odour	400±
	Watt Mountain	Limestone breccia and green (residual) clay-shale	10-100
		Unconformity ?	
	Muskeg - Keg River	Limestone and dolomite, in part anhydritic	400-1000
	Chinchaga	Anhydrite and dolomite	200±
PRE-DEVONIAN ? (Age undetermined)	Red Beds	Varicoloured dolomite, sandstone, siltstone and shale; anhydrite	variable
PRECAMBRIAN		Igneous and metamorphic rock	
		The Northwest	
PLEISTOCENE		Boulder clay, gravel, sand	Varies
CRETACEOUS	Unnamed	Sandstone and shale, in part equivalent to Fort St. John group	0-200
		Unconformity	
UPPER DEVONIAN	Imperial	Sandstone, calcareous and maroon or grey silty shale	0-1200?
	Grumbler	Detrital limestone, biostromes, calcareous siltstone, grey and black shale, and sandstone	0-1000

System	Formation	Lithology	Thickness Feet
	Fort Creek	Greenish grey shales, partly changing into black shales in the extreme northwest. Incorporates the "Simpson shale", and is in part an equivalent of Ireton and Beaverhill Lake	1000-2000
	Beavertail	Dark grey argillaceous limestone in extreme northwest	0-20 ?
		Unconformity	
MIDDLE DEVONIAN	Ramparts	Limestone, in part organic	0-800
UNDETERMINED	Bear Rock ?	Dolomite breccia	200±
	Lone Mountain	Alternating light and dark dolomites	1700
		Unconformity	
SILURIAN or ORDOVICIAN	"Ronning"	Dolomite and sandstone	1000
CAMBRIAN ?	Unnamed	Reddish and buff sandy dolomites, dolomitic sandstone and siliceous shales	0-575
PRECAMBRIAN		Igneous and metamorphic rocks	
		The East	
PLEISTOCENE		Boulder clay, gravel, sand	50-300
CRETACEOUS		Dark grey, marine shale	1,000
		Unconformity	
UPPER DEVONIAN	Trout River	Limestone, silty, cream, granular	0-300

System	Formation	Lithology	Thickness Feet
	Grumbler	Reef limestone and dolomite, detrital limestone, silty limestone, silty shale and shale, partly reddish stained	0-1000
	Alexandra	Limestone, cream, cryptocrystalline and biostromal limestone and dolomite	100
	Hay River	Greenish grey shale, with sandstone and silty limestone, and biostromal limestone near the top	0-2250
		Unconformity	
	Slave Point	Finely clastic brown limestone with petroliferous odour	200±
	Watt Mtn.	Breccia of Limestone or dolomite, green (residual?) clay-shale	0-50
		Unconformity	
	Presqu'ile	Dolomite, brown, crystalline, in part reefal	300±
	Pine Point	Limestone, brown, finely crystalline	0-500
		Unconformity	
SILURIAN or ORDOVICIAN		Dolomite, shale, red beds	0-600
PRECAMBRIAN		Igneous and metamorphic rock	

Description of Formations

The Southwest

The geology and stratigraphy of the vicinity of the Trainor Lake

Permits are included in the formation descriptions for the Southwest part of the report area. The oldest rocks found in outcrops in the southwest portion of the Upper Mackenzie area are of Upper Devonian age. Some information regarding older formations is derived from the wells that were drilled in northern Alberta and in the Northwest Territories. Cambrian, Ordovician and Silurian strata that are found in the mountains to the west do not occur in the subsurface of the Plains of northern Alberta.

Precambrian

Crystalline rocks of Precambrian age outcrop on the south shore of Great Slave Lake about 10 miles east of the mouth of Slave River, where they occur at lake elevation of 513 feet above sea-level. From this location the Precambrian surface dips in southwesterly direction, and lies at a depth of 4,000 to 5,000 feet below sea-level in the area of the Trainor Lake Permits.

"Granite Wash"

The Precambrian is generally overlain by red beds of variable age, thickness and composition. These may contain sandstone, carbonates, evaporites, shale and breccia, which together make up the so-called "Granite Wash".

Chinchaga Formation

The Middle Devonian Chinchaga formation forms a dolomite and evaporite unit at the base of the Devonian sequence. Sandstone is frequently found at the base of the formation, but in some places poorly sorted quartzose sandstone occurs at the top. Thickness of the formation varies from 100 to 200 feet.

Keg River and Muskeg Formations

The Keg River and Muskeg formations of Middle Devonian age are readily separated in the subsurface of northern Alberta. The Muskeg formation generally contains abundant salt or anhydrite, together with limestone and dolomite, and it overlies the Keg River formation of similar lithology. However, in northwest Alberta, the two formations consist largely of dolomite, and their distinction as separate units becomes increasingly difficult. Still farther north the upper portion of the combined carbonate units changes to limestone and may be continuous with the "Ramparts" formation of Nahanni Mountains and of the central Mackenzie Basin. Thus, the porous dolomites of the Muskeg, and particularly those of the Keg River formation, appear to change laterally into dense limestone. This change takes place to the north in up-dip direction and, consequently, it may effect favorable conditions for the accumulation of hydrocarbons in these formations in the southern Territories. The combined thickness of the two formations probably varies from 400 to 700 feet in our area of interest.

Watt Mountain Formation

The Watt Mountain formation is widely recognized in northern Alberta. It consists of siltstone, shale, dolomite, and partly of breccia. The unit is

relatively thin, 10 to 150 feet, and probably represents widespread uplift, or withdrawal of the sea towards the end of Elk Point time. Little evidence of this event is found in the Northwest Territories, possibly because of continued submergence of the Mackenzie basin.

Slave Point Formation

The Slave Point formation is here tentatively placed in the Middle Devonian, but several authors consider it as the basal part of the Upper Devonian on the basis of faunal interpretation. The formation has a remarkably uniform lithology in northern Alberta and the southern Territories, where it consists of finely clastic brown limestone. Almost without exception the limestone emits a strong petroliferous odour when it is struck with a hammer, and oil-staining can be noticed in most cores that have been recovered from this unit, but porosity is generally invisible or very poor. The Slave Point carries a poor fauna of algal(?) balls, Amphipora and poorly preserved brachiopods. However, the nature of the rock suggests that locally the clastic limestones could be associated with reefs, which under favorable circumstances might offer better porosity and suitable conditions for the forming of oil or gas reservoirs.

The thickness of the Slave Point is estimated at 400 feet, but erosion seems to have caused a certain relief on top of the formation. Since no evidence of the Slave Point was found in the extreme northwest portion of the area under discussion it is inferred that the formation is absent in the Mackenzie basin, or that it is equivalent to a deposit which is dissimilar to the limestone unit of northern Alberta.

Upper Devonian Shale Unit

The Shale Unit of northern Alberta and the southern Territories is a continuation of the widespread green shales in the south. It is equivalent to the Woodbend group and the Beaverhill Lake formation of central Alberta. The Unit consists of a monotonous series, 2,000 feet thick, of greenish grey shales with minor limestone bands, which are found in outcrop north of Liard River and near Fort Simpson on the Mackenzie River.

The upper part of the Shale Unit appears to be silty to the north. It is assumed that Liard Rapids(12) are caused by silty beds belonging to the Shale Unit.

Winterburn Group

Rightly or wrongly, the name Winterburn is carried north from central Alberta. This group is characterized in the southwestern map-area by its marked silt content, and by biostromes and associated clastic limestone sediments. The dolomitic and calcareous siltstones reflect widespread shallow marine conditions during deposition, and are characterized by numerous ripple marks and worm tubes. Southwest-trending shoal reefs or reefoid beds up to 40 feet thick may be encountered in places even as far south as the Alberta border, but in general these organic beds seem to be more numerous and better developed to the north and northeast.

A low, but prominent escarpment of outcropping limestone between Blackstone River and Poplar River may represent the top of the same group.

Wabamun Group

This unit is present in most of the area, but it has been eroded north and east of the truncation limits of the Mississippian. In the area under discussion the Wabamun group consists of shaly limestone and silty clastic limestone. West of the Nahanni Mountains(7) it contains more sand, and here it possibly grades into the sandy and shaly Imperial formation of the Mackenzie basin.

Where the group is fully developed its thickness is estimated at 700 feet. No encouraging evidence of porosity or of the presence of hydrocarbons was found in cores or in the sparse outcrops of the Wabamun.

Mississippian

Mississippian strata of the Plains of northern Alberta and of the southern Territories are strongly eroded. The eastern truncation limit is almost parallel to the Rocky Mountains from Lesser Slave Lake on to the north, but ultimately it curves sharply west towards Nahanni Butte. Most of the Triad Permits are probably still underlain by a remnant of the Mississippian.

An excellent exposure of the Mississippian was examined in the mountains near Jackfish Gap(7), some 30 miles west of Nahanni Butte. Here an almost complete succession of Mississippian shales, sandstones and limestones is present to an aggregate thickness of 2,500 feet. A graphic log of this section, Figure III, is enclosed. On the Table of Formations an attempt has been made to compare the stratigraphy of the Jackfish Gap Mississippian beds with the more familiar succession of Alberta.

The names Rundle, Banff and Exshaw are tentatively applied to an upper limestone series of encrinites and minor shale, a series of shaly and cherty limestones and calcareous shales, and to a black shale series.

The "Exshaw" of Jackfish Gap is lithologically quite similar to the type section of the Exshaw formation near Bow Valley, but it is considerably thicker. It is underlain by a thick series of basal sands, silts and dark shales that are tentatively placed in the Mississippian, mainly because the aspect of the sand is somewhat different from the underlying typical clean quartzose Devonian silts. The contact between the Devonian sands and those of possible Mississippian age is relatively sharp, but it does not bear signs of an unconformity.

Drastic truncation of the Mississippian strata (and also of Permian and Pennsylvanian) is evident within a short distance to the east of the mountains. But the basal sands, which may continue north into the semi-continental Mississippian of the Mackenzie basin, also seem to disappear in an eastward direction. The middle portion of the Jackfish Gap section may be traced into the Plains. Two Mississippian outcrops were found on Petitot River, one of these was located near the Bovie Lake fault(8). Field data and meagre well information

suggest that the Mississippian of the subsurface may be largely composed of shale, with some shaly and cherty limestone, and minor semi-continental sandy beds. However, within the vast unexplored area the unsuspected local development of encrinites and of porous dolomites near the eroded surface may still be found.

Permian and Pennsylvanian

A series of quartzose sandstones, with some intercalated shale, overlies the Mississippian in the mountains. These sandstones are of continental origin and contain some coal. They reach an aggregate thickness of almost 4,000 feet and are overlain by 600 feet of cherty beds. This succession is believed to be Permian and Pennsylvanian in age. The rate of truncation in an eastward direction must be considerable. A last outcrop is found near Liard River, some 20 miles downstream from Fort Liard. The sandstones, which would constitute an excellent reservoir for oil or natural gas, have not been reported in the subsurface of the Plains east of the disturbed belt. The occurrence is probably limited to the mountains and possibly to the immediate vicinity to the east.

Cretaceous

Cretaceous formations that were observed in outcrop near Fort Liard are listed and briefly described in the Table of Formations. Well logs and core data suggest that the Cretaceous sandstones wedge out rapidly towards the east. It is almost certain that oil and gas fields will be found in the Cretaceous, but at present the lack of data makes the Cretaceous unattractive as a prime objective in the search for oil. Initial exploration of the Cretaceous will be accessory to concerted efforts applied to other objectives, until such time when a pattern can be discerned in thickness and areal distribution of the Cretaceous sands.

The Northwest

A radical change in lithology, thickness and distribution of various systems and formations can be noticed in the northwest part of the Upper Mackenzie area, as compared with the more familiar stratigraphy to the south and east. Great thicknesses of pre-Devonian beds are found in the Nahanni Mountains. These older beds can be divided into lithologic units, but in most places their age is in doubt. Organic remains are relatively scarce and, in general, poorly preserved. Published faunal data are tentative and controversial, leaving much room for different interpretation. Much the same comment applies also to the Devonian in this area.

A thick succession of dolomite beds, overlain by dolomite breccia, separates limestone of Middle Devonian age from definitely pre-Devonian rocks. Some authors have considered the dolomites as Silurian and described them under various names. However, the faunal evidence is inconclusive, and because of the

presence of unsorted quartz sandstone at the base of the dolomites the latter are considered in this report as possibly Devonian in age.

The massive coralliferous limestone series of Middle Devonian age has been correlated with the Ramparts formation of the Norman Wells area. No evidence was found of the Slave Point formation; instead, the Beavertail limestone of the Mackenzie basin forms the base of the Upper Devonian.

The Upper Devonian has a greater thickness here than in the Alberta basin. It comprises a substantial proportion of dark grey and black shales. In the field the Upper Devonian is characterized by subdued topography and lack of good exposures.

Precambrian

Precambrian igneous rocks underlie the sedimentary beds in the area, but they are not exposed and have not been encountered in wells.

Cambrian

Some 10 miles south of Little Doctor Lake(2), at a locality that is sometimes called Red Rock Pass(3), the outer east-facing cliff of the Nahanni Mountains exhibits a succession of orange and grey-coloured beds which are thought to belong to the Cambrian system. This section comprises orange, brown, reddish, greenish and grey layers of quartzite and silty dolomite, with shaly beds in the upper part. The exposed thickness of the red beds is nearly 600 feet. On the basis of colour they may be compared with the Macdougal group of the Fort Norman area in the north.

The upper shaly part could possibly be of Ordovician age.

Silurian or Ordovician

The Cambrian red beds are overlain by a thousand feet of dark grey dolomite layers which in places contain a profusion of specimens of the coral Halysites. This coral, which is most abundant in the lower part of the section, indicates late Ordovician or Silurian age. The upper portion of the dolomite sequence contains several sandstone beds. The Halysites beds show fair vuggy and intercrystalline porosity on the weathered rock surface.

The name Ronning has been loosely applied to this group of sediments on our Table of Formations.

Lone Mountain

A thick succession of bedded dolomites overlies the previously described Silurian or Ordovician strata. These dolomites have been referred to in the past as the Lone Mountain formation. The lithology consists of alternating light grey and dark grey crystalline dolomite beds which are poorly fossiliferous, but otherwise they resemble the Upper Devonian Fairholme dolomite of the southern Rocky Mountains.

In places some intercrystalline porosity was noticed on the weathered surface.

Bear Rock Formation (?)

This lithologic unit consists largely of brecciated dolomite. The upper limit of the unit is well defined at the base of a limestone series, but downward it grades into unbroken dolomite beds. Part of the brecciation may be due to collapse after the removal of evaporite beds which originally impregnated the rock. Most of the space between the angular fragments is tightly cemented by white secondary dolomite, but in places small vugs can be noticed on the weathered surface.

The thickness of the Bear Rock must be variable. In the Nahanni Mountains(2-4) the formation is some 200 feet thick, but it has been reported that similar breccias, which are associated with gypsum, reach 1,600 feet at Mount Cap near Wrigley, N.W.T.

Ramparts Formation

The Ramparts formation consists largely of limestone which is in part so rich in corals and stromatoporoids that it could be called "reefal." The formation caps the Nahanni range; it may be correlated to the east with part of the Middle Devonian in the subsurface.

Beavertail Formation

This formation was encountered in only one single outcrop located in a narrow valley which joins North Nahanni River(1). The unit consists of dark grey argillaceous limestone that contains an abundance of characteristic large brachiopods. The contact between the Beavertail and the underlying Ramparts limestone was obscured by talus, but the presence of an unconformity is suspected at this stratigraphic position.

The contact with the overlying Upper Devonian black shales was inaccessible but visible from a short distance. The succession appeared to be conformable. The formation is tentatively considered to represent the base of the Upper Devonian. The exposed thickness of the Beavertail at this outcrop is 10 feet.

Fort Creek Formation

Greenish grey shales, resembling those of the Shale Unit of Northern Alberta, were found on Liard River near the mouth of Birch(10) and Matou Rivers. Similar outcrops were encountered to the north on a tributary of Martin River(13) and near Fort Simpson on Mackenzie River(33).

The name "Simpson Shale" has long been used for light grey shales outcropping near Fort Simpson, and it was also applied to basal green and black shales of northern Alberta and the Hay River area. It is now generally agreed that the name serves no practical stratigraphic purpose.

On Blackstone River(9) some Upper Devonian black shale is found, but the stratigraphic position of these outcrops cannot be determined at present. The occurrence of black shale in the Plains is significant because it provides some data to establish a line of demarcation between the southern "green shale basin" and a "black shale basin" to the north and west.

In the mountains the Upper Devonian is largely obscured by vegetation, but scattered outcrops such as occur on Nahanni Butte(6), west of Grainger Canyon(4), near North Nahanni River(1), and near Army Camp Lake(1), contain a large proportion of dark grey and black shales. Partial sections of the Upper Devonian can best be pieced together in the valley of North Nahanni River where they were first described by G. S. Hume. It would appear that the greenish grey-coloured "Shale Unit" of Alberta consists here almost entirely of black shale and silty shale with an aggregate thickness of 1,000 to 2,000 feet. This succession of black shale is closely related to the Fort Creek formation of the Fort Norman area.

"Grumbler Formation"

The Grumbler formation is recognized in the area between Hay River and Kakisa River. It would appear that the lower part of the Grumbler grades into greenish-grey shale to the west of Kakisa Lake. The upper part of this formation can be traced to Liard River in outcrops of siltstone and shale which form the Liard Rapids(12).

A succession of hard organic and detrital limestones, 40 to 50 feet in thickness, forms the top of the Grumbler formation. These reefs and "reefoid" limestones form a long escarpment south of Mackenzie River and east of Liard River, which is an important landmark in this region.

The name "Grumbler" is also used in this report to designate an interval in the Upper Devonian of the northwest which is perhaps not the exact equivalent of the Grumbler, but it occupies a similar position in the stratigraphic column and it contains elements of the same lithology and fauna. At Army Camp Lake(1), north of the North Nahanni River, this interval is almost completely exposed. It consists of cyclic dark grey and greenish grey silty shales and sandstones. On Root River these beds incorporate a bioherm, according to G. S. Hume. Total thickness of the Grumbler of Army Camp Lake is estimated at 1,000 feet.

Imperial Formation

The Imperial formation is here interpreted as an approximate time equivalent of the Wabamun group. It consists of sandstone and maroon or grey silty shale near North Nahanni River. Near Grainger Canyon(4) in the Nahanni Mountains 460 feet of hard black siliceous shales may form part of the Imperial formation.

BARNSCLIFFE
LINEN BOND

Cretaceous

A Cretaceous outcrop was found at the foot of the Nahanni Mountains near Grainger Canyon[4]. Beds in this exposure are overturned and belong to the Fort St. John group. The Martin Hills[14], located north of Liard River represent a large erosion remnant of Cretaceous strata. The hills are largely covered by vegetation, but one section was examined and described containing salt and pepper sandstone, silty shale and grey shale with a total thickness of 100 feet. The only organic remains found in this locality were some small brown sporangia. It is, therefore, impossible to determine the exact stratigraphic position of these Cretaceous beds at this time.

The East

The stratigraphy of the eastern Mackenzie area is closely related to that of the southwest part. A new feature is the increase of silt and limestone within the upper part of the Devonian "Shale Unit." All strata rise gradually from the vicinity of Trainor Lake to the east and northeast. In the same direction roughly concentric zones of consecutively older beds form the eroded bedrock surface which, in places, shows through the cover of glacial drift.

Precambrian

Precambrian igneous rocks occur at the surface around the eastern part of Great Slave Lake. To the west they have been encountered in several bore holes at the base of the overlying sediments.

Silurian or Ordovician

Little information is available regarding the pre-Devonian strata that are known to occur in the vicinity of Great Slave Lake. The pre-Devonian succession is probably thin or altogether absent southwest of Hay River.

The Precambrian is overlain by yellowish to grey, poorly sorted basal sandstone. The basal sandstone is exposed in a 25-foot section on Old Fort Island[32] which lies on the west side of Great Slave Lake. This sandstone is poorly consolidated and very porous. A striking angular unconformity within the sands occupies the centre of the exposure. It is our belief that the unconformity is caused by slumping during deposition and not by tectonic movement.

More than 500 feet of red beds, containing dolomite and anhydrite, overlie the basal sandstone in the Imperial Windy Point deep test[28]. A possible equivalent of at least part of the red beds was observed at Red Rock Point, north of Windy Point. This section consists of 37 feet of rusty sandstone, siltstone and greenish grey shale.

Farther north, the pre-Devonian sands and shales are overlain by finely vuggy dolomite with a thickness of 17 feet at a locality 12 miles north of Old Fort Island. This dolomite forms a flat rock surface in a huge area that ter-

EARNSCLIFFE

minates in an escarpment, roughly parallel to the west shore of Great Slave Lake and Marian Lake. The dolomite contains poorly preserved fossils which have been determined as Silurian in age by some, but as Ordovician by others.

Pine Point Formation

The Pine Point limestone forms the basal portion of the Middle Devonian. Exposures of this formation were examined near Fort Resolution[31], and in several places near Dawson Landing[30], where fossiliferous brown, possibly bituminous, limestones are found in small outcrops.

The Pine Point formation has been penetrated in some wells, particularly in the eastern group of core holes that were drilled in the Pine Point[29] concession of Consolidated Mining and Smelting Co.

Little information is available at this time regarding the character of the base of the Pine Point. The top of the formation is chosen at the base of the overlying Presqu'ile dolomite, but it would appear that the stratigraphic position of the contact varies because the two formations laterally grade into one another.

Presqu'ile Formation

The Presqu'ile dolomite is exposed along the shores of Great Slave Lake near Presqu'ile Point, Windy Point[28], and at Sulphur Bay. It is also found at the surface in the Pine Point concession[29], and many bore holes have penetrated the formation, or its equivalents the Muskeg and Keg River, in the Territories and northern Alberta.

The dolomites are in part possibly of detrital nature, but certainly they incorporate also unstratified reefs in which vague outlines of colonial corals can still be recognised despite intensive recrystallization. Vuggy porosity is common, and oil seepages of dark brown oil dripping from the vugs and fissures of the rock can be observed at many places near Windy Point[28].

The top of the formation is characterized by bright green clay which occurs in the form of vug-fillings and thin irregular layers within 10 or 20 feet below the top of the dolomite. This clay may suggest leaching of the surface of the Presqu'ile prior to deposition of the overlying beds.

The thickness of the Presqu'ile formation may reach 600 feet.

Watt Mountain Formation

The Watt Mountain formation of northern Alberta has been discussed previously in connection with the southwest part of the Upper Mackenzie area. Near Hay River it is indistinct and efforts to trace the Watt Mountain in outcrops or cores into this area were thus far unsuccessful, but it can be recognized on electric logs. The "Amco shale" of the Pine Point Concession[29], which occurs in the basal Slave Point, has been regarded by some authors as a Watt Mountain equivalent, but this correlation is questionable.

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J. C. SPROULE & ASSOCIATES

Slave Point Formation

The remarks concerning this formation, that were made in discussing the southwest part of the Upper Mackenzie area, are also applicable to the eastern part. The Slave Point was examined in outcrop near Windy Point[28] and in the cores of several wells. Total thickness in the eastern area is estimated at less than 300 feet.

Hay River Formation

The Hay River formation consists mainly of greenish grey shale with a few thin limestone bands. Near the top, siltstone, silty limestone and biostromal beds are found that may be grouped as the Louise Falls member (See Figure VI). The Hay River formation is well exposed on Hay River, where most beds may be traced for some distance.

Two siltstone units were found in the Louise Falls member. The upper one, forming the top of the Hay River formation, is 10 to 15 feet thick; it remains remarkably uniform and can be recognized in the sub-surface as far south as the Imperial Yates River well. The lower siltstone unit is more than 20 feet thick near the junction of the Mackenzie Highway with the Mills Lake Road, but five miles to the south it wedges out entirely.

Several biostromal beds were found ranging in composition from pure limestone to dolomite. Slight porosity in these biostromes is not uncommon, particularly in the more dolomitized types. Their lateral extent seems to vary considerably; some can be traced many miles, but others are small and have more the character of bioherms. Maximum thickness of organic beds observed on Hay River is 15 feet.

Alexandra Formation

The Alexandra formation consists of 100 feet of light coloured crypto-crystalline limestone on Hay River. In this locality the limestone has a clastic character and it incorporates a biostromal unit near the base. The formation forms an escarpment which may be traced to the northwest. In places it incorporates organic limestone and dolomite sections more than 40 feet thick. To the west and northwest of Kakisa River the organic and detrital limestones appear to grade into shale.

The Alexandra formation may correlate with part of the "Shale Unit" of northern Alberta. Top and bottom of the formation are arbitrarily chosen within transitional boundary zones.

Grumbler Formation

The Grumbler formation is partially exposed on Hay River[27] and it can be followed intermittently to the west as far as Blackstone River[9]. The formation consists of clastic limestone units, reefs and a large proportion of

silty and shaly beds. Many of the outcrops on Hay River are stained with maroon colouring. The most interesting of the smaller units are the reefs, some of which are of the bioherma1 type while others are vaguely bedded and partially clastic. It was noticed that the bioherms are almost invariably overlain by bedded encrinites or crinoidal limestones. Possibly the isolated encrinite beds that are exposed along the Hay River may be associated with reef beds. Reef units are most numerous in the lower part of the Grumbler from Hay River to the vicinity of Kakisa Lake(24). Farther west reefs are more prominent in the upper Grumbler (See Figure II). They form prominent escarpments south and west of Kakisa Lake(20, 22) and individual reefs reach a thickness of approximately 50 feet. West of Redknife River(18) reefal beds occur only in the top of the Grumbler formation.

It would appear from surficial evidence that in successively younger beds the broad reef lenses are shifted from east to west. The individual lenses may be elongated in a southwest direction.

The reefs show varying amounts of dolomitization and porosity. Some reef outcrops south of the Hills Lake road(25) have been reported showing coarsely crystalline dolomite with excellent porosity. Organic dolomite lenses of this type, if properly sealed, would constitute good reservoirs for hydrocarbons.

In a westerly direction the lower Grumbler reefs appear to change progressively into silty limestone and shales. To the west, the base of the Grumbler formation, as originally defined on Hay River, cannot be identified because the lower limestone members show lateral transition into the thickened Upper Devonian Shale Unit.

The thickness of the Grumbler formation in the area between Hay River and Kakisa Lake is estimated at 1,000 to 1,100 feet, of which the lower 800 to 900-foot interval may be partly exposed on Hay River.

Trout River Formation

The Trout River formation is equivalent to the Calmar, Graminia, and basal Wabamun of Alberta. It consists of cream-coloured silty limestone and sandstone. Outcrops are not plentiful, but are encountered on Kakisa River near Tathlina Lake(22), near the Briggs Rabbit Lake deep test locations(19), on Trout River(17), and on Beep Lake(16).

The boundary between the Trout River and the underlying Grumbler formation is marked by a major change in fauna which can be noticed in the field without much difficulty.

Maximum thickness of the Trout River in the subsurface is estimated at 300 feet. The formation is overlain by silty and shaly limestone of the Wabamun, which was possibly seen at one outcrop on Trout River.

Cretaceous

Undifferentiated dark grey shales of Lower (?) Cretaceous age are found in the Cameron Hills(26). Good exposures are few in number. The thickness of the section may be roughly estimated at 1,000 feet.

REGIONAL STRUCTURE

The northwest-trending structural monocline of Alberta terminates in the Upper Mackenzie area where the strike swings from northwest to west. The change in strike is illustrated in some detail by contours on top of the Alexandra formation (Figure II), near Hay River. It is our belief that structure on the Alexandra formation is further complicated by southwest-trending faults, but concrete evidence is lacking. It is known, however, that the system of southwest faults at the east arm of Great Slave Lake has been active far into the sedimentary area.

Direct evidence of faulting was noticed on Reef Creek near the Mills Lake road[25]. Here, biostromal dolomites and limestones are cut by three or four small northwest-striking normal faults with maximum displacement of 30 or 40 feet. The position of part of the Heart Lake reef escarpment may be determined by these faults, but otherwise no further evidence could be found of faulting beyond the Reef Creek exposure.

Major tectonic disturbance has obviously taken place in the mountains west of the Upper Mackenzie area during the Laramide orogeny. The position of the mountain front has shifted to the east as compared with the trend of the Rocky Mountains in Alberta and British Columbia. A structural front of strongly folded and faulted Mesozoic formations is not present, except for a rudiment of overturned Cretaceous beds in front of the Nahanni Mountains near Grainger Canyon[4]. Instead, the almost undisturbed sediments of the Plains seem to reach to the mountains. Here and there large faults are present east of the mountains, such as the Bovie Lake fault[8] which is orientated in north-south direction.

The Nahanni and Liard Mountains must represent an old structural hinge line. The sudden increase in thickness to the west of the pre-Devonian and of Mississippian, Pennsylvanian and Permian strata indicates at least two major periods of down-buckling, one possibly at the beginning of the Devonian, and the other at the end of Paleozoic time. It would appear that approximately the same line of weakness in the earth's crust near the Nahanni Mountains formed the borderline for structurally stable and unstable areas during three major periods of tectonic activity. Probably this hinge line forms part of the boundary between the Alberta and Mackenzie basins.

OIL AND GAS POSSIBILITIES

The main potential oil and gas reservoirs of the Upper Mackenzie area are briefly reviewed.

Cretaceous

The majority of the thick sandstone units of the Fort Liard area seems to wedge out within a relatively short distance to the east. Some sands may form wedge-edges in shale as far east as Trainor Lake, and up-dip migration into

silty and shaly beds. Many of the outcrops on Hay River are stained with maroon colouring. The most interesting of the smaller units are the reefs, some of which are of the bioherm type while others are vaguely bedded and partially clastic. It was noticed that the bioherms are almost invariably overlain by bedded encrinites or crinoidal limestones. Possibly the isolated encrinite beds that are exposed along the Hay River may be associated with reef beds. Reef units are most numerous in the lower part of the Grumbler from Hay River to the vicinity of Kakisa Lake[24]. Farther west reefs are more prominent in the upper Grumbler (See Figure II). They form prominent escarpments south and west of Kakisa Lake[20, 22] and individual reefs reach a thickness of approximately 50 feet. West of Redknife River[18] reefal beds occur only in the top of the Grumbler formation.

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these sands would cause the accumulation of oil or gas. Present information regarding the distribution and character of these sands is insufficient. It is suggested that the Cretaceous objectives should be regarded as secondary targets in the course of an exploration program.

Permian or Pennsylvanian

The porous Permian or Pennsylvanian sandstones would provide an excellent reservoir under suitable conditions of sealing. Due to erosion these beds do not extend far beyond the Mountains into the Plains. It is impossible to predict the position of the truncation limit, but it is certain that the sand unit does not reach the Trainor Lake area.

Mississippian

The Mississippian of the Liard Mountains is largely composed of tight shaly beds. Sands within the Mississippian may form reservoirs in the Plains, and in places secondary porosity near the old erosion surface may also have produced reservoir conditions. Sparse well data give the impression that the lime content of the lower beds does not increase to the west, as happens in Alberta.

Although Mississippian strata may be present in a large part of the Trainor Lake Permits, their significance as potential reservoirs is regarded as negligible.

Upper Devonian

Most of the Upper Devonian consists of tight limestone, silty limestone and shale. It is possible that porous reef reservoirs will be found near Trainor Lake in the stratigraphic equivalent of the Grumbler formation. Present geophysical methods are inadequate to detect reef bodies of this type, and well control is too limited to use the facies approach. It does not seem possible to locate reefs similar to those near Kakisa Lake by direct means. They form, therefore, an objective of secondary importance.

The proximity of a "green shale basin" to a "black shale basin" in the Upper Devonian to the northwest suggests the possible presence of a chain of reef complexes, similar to those of the Leduc-Rimbey trend of central Alberta, which separate the shale units of different colour. Beds with a facies similar to Beaverhill Lake and Cooking Lake have not been observed in the Northwest Territories, and consequently the parallel between the two areas is not complete.

Slave Point

Most of the cores taken in the Slave Point formation have a strong petroliferous odour, and many are stained with oil, but the limestone is generally tight and visible porosity is rare. Shows of gas and high gravity oil have been reported. The Slave Point merits close attention in every well that will be drilled in the Upper Mackenzie area. Unsuspected topographically high remnants on top of the eroded surface of the formation, fractured or dolomitised zones and local reefs within the Slave Point may have caused oil or gas accumulation.

Presqu'ile-Muskeg-Keg River

The Middle Devonian dolomites form the most promising reservoir in the Upper Mackenzie area. In many places these dolomites show excellent vuggy porosity. The suspected transition into limestone to the north may have caused large up-dip porosity traps. Favourable indications of the presence of oil are particularly plentiful in the general Hay River area where oil seepages are known and oil-stained cores have been recovered from several wells. In this area, good reservoirs may be found associated with faulting. The discovery well in the Rabbit Lake area is reported to yield gas at the rate of 17 MMcf per day from the Middle Devonian.

Pre-Devonian

Porous beds in pre-Devonian carbonates were observed in the northwest and northeast parts of the Upper Mackenzie area, but no evidence, direct or indirect, points to conditions favourable for the accumulation of hydrocarbons in these strata.

"Granite Wash" possibilities are difficult to assess because of lack of data. Seismic prospecting may assist in the search for basement topography and faulting which may have influenced the accumulation of basal detrital beds. Particularly, the porous basal sand that was found in outcrop at old Fort Island on Great Slave Lake would, under certain conditions, form a desirable reservoir in the subsurface.

SUMMARY AND RECOMMENDATIONS

The regional geological study which has been made indicates that 6,000 to 7,000 feet of sedimentary rocks, including several formations prospective for oil and gas, may be present in the Trainor Lake area where Triad Oil Co. Ltd. hold approximately 759,224 acres under permit. Relatively few deep tests have been drilled in the Upper Mackenzie area, but the incidence of oil and gas shows is high in these wells. The occurrence of gas and oil seeps in the Great Slave Lake area is further evidence of the prospectiveness of the area.

The porous reef dolomites of the Presqu'ile, the Muskeg and the Keg River formations of Middle Devonian age are regarded as the prime objectives in the search for oil and gas in the Upper Mackenzie area. Secondary objectives are basal Paleozoic sands and the reef developments in the Upper Devonian. Possibilities of the Cretaceous are uncertain, and the Permo-Pennsylvanian and Mississippian prospects are restricted to the southwest part of the area studied.

The lack of bedrock outcrops in the immediate area of the Trainor Lake Permits makes it impossible to deduce the local subsurface structure, although photogeologic evidence may indicate the presence of deep-seated faulting. At present, geological data are also inadequate to specify the location of stratigraphic traps. In the exploration of the selected area it is recommended that the next step towards evaluation should be the location of faults or local doming

which may form suitable traps for hydrocarbons. This may be achieved with the aid of structure test or geophysical methods, preferably seismic work. Either of these methods of exploration would of necessity have to be conducted in the winter season because of the inaccessibility of most of the area during the summer months.

R. deWit

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S.R.L. Harding, P.Eng.

PART II - PHOTOGEOLOGICAL AND FIELD SURVEY OF TRAINOR LAKE PERMITS

INTRODUCTION

Twelve Petroleum and Natural Gas Permits including approximately 759,224 acres are held in the Trainor Lake area of the Northwest Territories by Triad Oil Co. Ltd. The Permits are situated between Longitude 120° to 120° 45', Latitude 60° to 60° 30', and between Longitude 119° 15' to 120°, Latitude 60° 20' to 60° 30'.

A field camp was moved into the Trainor Lake area by chartered Norseman airplane for the period July 24th to 31st, 1957. Field studies were made with assistance of a Model 47 G-2 Bell helicopter contracted from General Helicopter, of Santa Barbara, California. Field crew included G.K. Williams, geologist, and D.L. Sides and H. Lazaros, helicopter pilot and engineer, respectively.

From the Trainor Lake base camp the area was flown systematically to check for outcrop on every stream, hill or other likely spot. As not a single outcrop was found within, or even near, the area, the survey mainly contributed information on the physiography of the terrain. The locations of existing seismic lines were also plotted. The photo-mosaic with all field data plotted will be submitted with the final report when it is completed.

PHYSIOGRAPHY

The Trainor Lake area is situated within the vast muskeg country of northern Alberta, northeastern British Columbia and the Northwest Territories. Low relief, poor drainage, numerous small lakes and extensive muskeg areas are the dominant characteristics of the terrain.

The effects of the last glaciation are everywhere in evidence. A layer of boulder clay, which must be at least 100 feet thick, covers the entire country. The sluggish streams have not cut through the drift to bedrock. In places, good sections of glacial till are exposed by stream cuts. The best exposures are sandy cutbanks in fluted moraine on the Kakisa River. On other streams, clay till with few boulders is exposed.

In places where the drift is thick, especially on topographic highs, the till is moulded into long, narrow ridges and troughs. The development of these features is not fully understood, but they must be related to the formation of drumlins, as in places they grade into each other. Glacial fluting, the term used to describe these ridges, is most pronounced along the west bank of the Kakisa River, and is less well developed on the hills south of Trainor Lake. Relief from the tops of the ridges to the bottoms of the troughs is generally no more than 30 to 40 feet. The direction of the fluting, which is assumed to be the direction of ice movement, is about 30° west of south.

Another glacial feature is the occurrence of many esker-type gravel or sand ridges arranged in small crosses or other geometric forms. These are referred to as "ice crack moraines." It is believed that they originated by sedimentation in cracks developed in stagnant ice. This pattern is well developed east of Trainor Lake, both east and west of the Kakisa River. The small sand ridges are generally less than 15 feet high and usually have scattered bleached boulders on their surface. Because of their sandy composition they generally support a growth of healthy pine and thus the geometric pattern stands out clearly among low spruce swamps and open muskeg. Similar low patterns of pine or spruce in muskeg suggest that many of these ice crack deposits have been nearly buried by muskeg since the time of glaciation.

Two hills, in the area south of Trainor Lake, rise about 400 feet above the Plains. They slope fairly steeply to the north, but are gently inclined to the southwest. As seen from a distance their profiles suggest that they may be the topographic expression of very gently south-dipping bedrock. These hills, together with others near Trout Lake, seem to form parts of a common dip-slope that may indicate the presence of an underlying widespread resistant bed. Round Mountain, which lies north of Trainor Lake, also has a gently south-dipping surface with a steep north front. The form of this feature could be controlled by a stratigraphically lower resistant bed, although no outcrops were observed.

Permafrost is widespread. Where water collects, in lakes, ponds or open muskegs, there is apparently no permafrost. On higher ground, the ice is usually found within a foot of the surface. On the aerial photographs, the areas of permafrost show dark and the unfrozen low areas a lighter color.

GENERAL GEOLOGY

No bedrock outcrops were found in or near the Trainor Lake area. From regional geology, however, we know that Cretaceous strata must form the near-surface bedrock. By relating the Cretaceous stratigraphy of the Fort Liard area to the topography in the vicinity of Trainor Lake it is possible to make some assumptions.

Round Mountain probably is underlain by the lowest resistant Cretaceous unit, which would be equivalent to the Scatter formation; a marine sandy shale or sandstone. The hills south of Trainor Lake may represent the next higher resistant unit, presumably Upper Cretaceous Fort Nelson (Dunvegan) formation. If this interpretation is correct the northern portion of the area is underlain by the soft marine shale of the upper part of the Fort St. John group. The hills south of Trainor Lake contain Upper Cretaceous strata.

The stratigraphic sequence and description of the formations in the subsurface have been discussed in Part I of this report.

STRUCTURAL GEOLOGY

As no bedrock outcrops were found in the area, the following comments are based on field observation of the topography and on the study of air photographs.

The regional strike of the Cretaceous strata is indicated to be approximately 20° north of west and the regional dip to the southwest, probably about 50 feet per mile.

On the photo mosaics several lineal features have been marked that are also shown on the map (Figure II). These lineations are parallel to the direction of Pleistocene ice movements and may be caused by glaciation, but they also coincide with the known trend of basement faulting near Great Slave Lake. It is probable that some of these lineal features reflect the presence of basement faults. Such faults or fault zones can significantly influence the subsequent sedimentation and structure, particularly in regard to the localization of sand and reef development.

G.K. Williams, P.Eng.

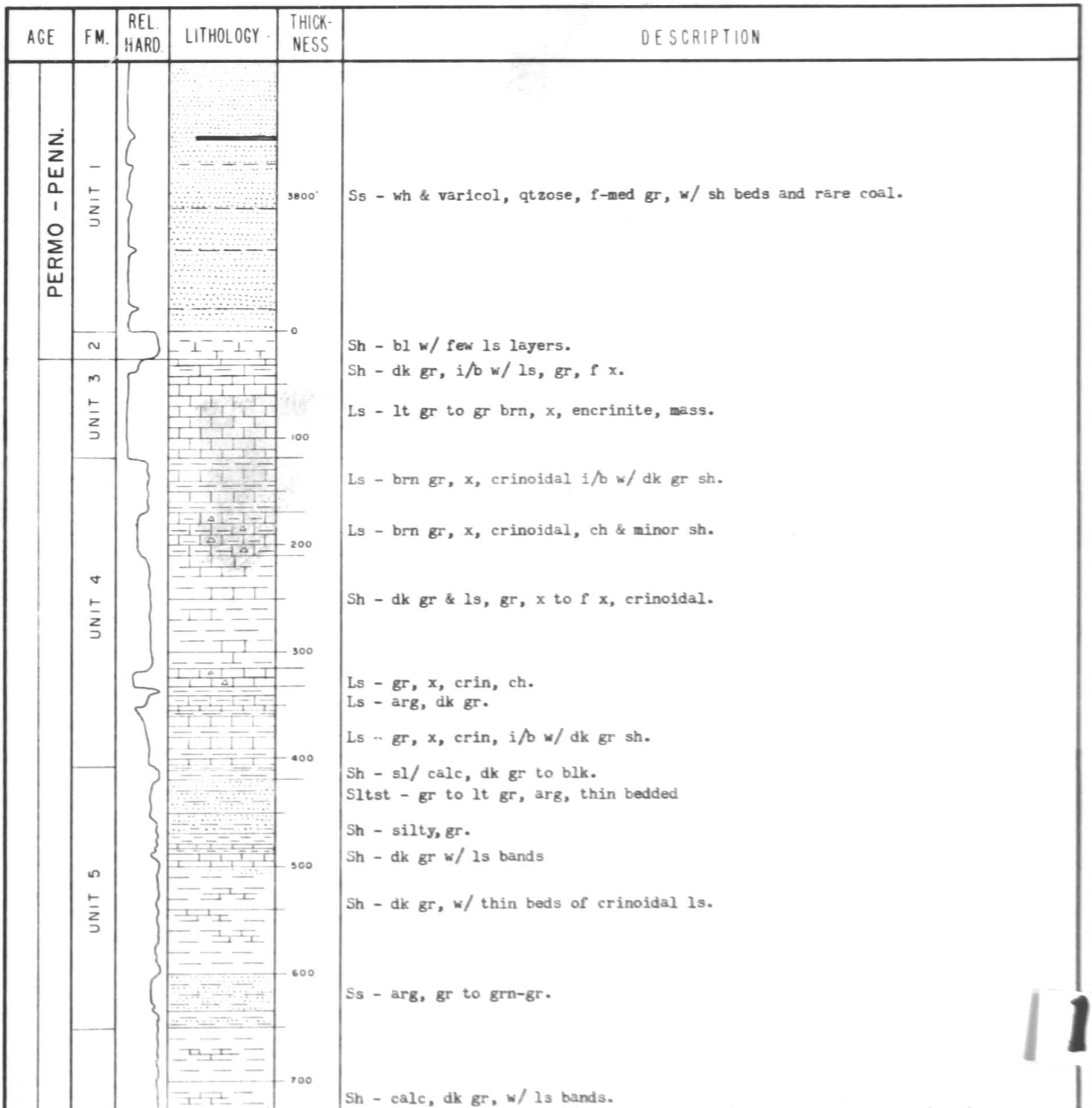
S.R.L. Harding, P.Eng.

901 - 8th Ave. West,
Calgary, Alberta,
October 18, 1957

STRATIGRAPHIC SECTION NO. 7

JACKFISH GAP

NORTHWEST TERRITORIES



PALEOZOIC

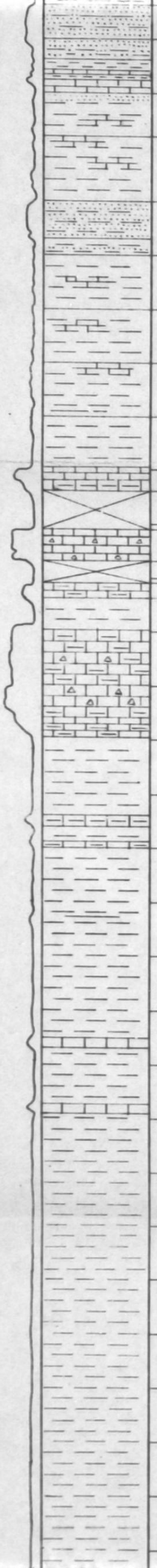
MISSISSIPPIAN

UNIT 5

UNIT 6

UNIT 7

UNIT 8



Sh - sl/ calc, dk gr to blk.

Sltst - gr to lt gr, arg, thin bedded

Sh - silty, gr.

Sh - dk gr w/ ls bands

Sh - dk gr, w/ thin beds of crinoidal ls.

Ss - arg, gr to grn-gr.

Sh - calc, dk gr, w/ ls bands.

Ls - arg, brn gr, crinoidal.

Ls - brn, gr, f x, ch.

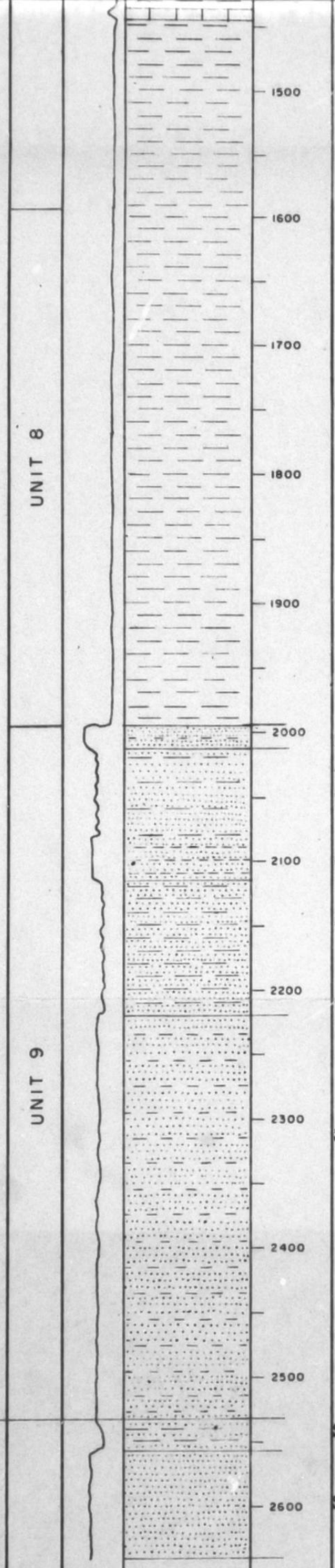
Ls - arg & sh.

Sh - calc, dk gr.

Ls - brn & gr, x, crinoidal & sh, dk gr.

Sh - dk gr w/ occasional ls bands

Sh - blk w/ ironstone conc.



Sh - blk w/ ironstone conc.

Ss & Sltst - brn gr, sl/ arg.

Sh - dk gr, i/b w/ ss.

Ss - dk gr, f g, silty & arg.

Sh - dk gr, silty thin bedded.

Ss - mudstone & arg, sltst - dk gr, f g.

Sh - gr & dk gr, w/ silty bands.

Ss - lt gr, qtzose, f g.

3 of 3

FIGURE-III

J.C. SPROULE & ASSOCIATES, CALGARY

STRATIGRAPHIC SECTION NO. 27

HAY RIVER

NORTHWEST TERRITORIES

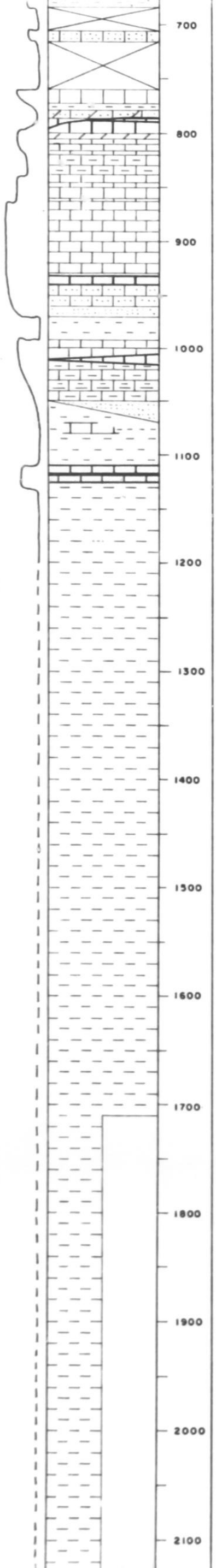
AGE	FM.	REL. HARD	LITHOLOGY	THICKNESS	DESCRIPTION
	GRUMBLER FORMATION			0	Ls - sl/ silty & arg, lt brn, f x, brachiopods.
					Ls - sl/ silty, lt brn, f x, brachiopods.
				100	Ls - biostromal, sl/ dol, lt gr, x, v fossiliferous, ppp.
					Ls - v silty, lt brn, f x, brachiopods, corals.
					Ls - lt brn & red, finely bioclastic, thin bedded, brachiopods.
				200	Ls - cream, crypto x, small vugs.
				300	
				400	
				500	
				600	Ls - cream, crypto x, vuggy zones, massive.
					Ls - biostromal, stromatoporoids, corals.
				700	Sh - dol, silty, maroon.
					Sltst & silty ls - maroon, fossiliferous.
					Ls - buff & red, f x, hard.
					Sh - maroon
					Ls - dol, silty, arg, maroon, v fossiliferous.
				800	Ls - bioherm, corals.
					Dol - brn, x, ls - buff.
					Ls - arg, buff & maroon, crinoidal.
					Ls - buff to lt brn, f x, mottled.
	XANDRA FM.			900	Ls - cream, crypto x, massive.

PALEOZOIC

UPPER DEVONIAN

HAY RIVER FORMATION

ALEXANDRA F.M.



Sh - dol, silty, maroon.

Sltst & silty ls - maroon, fossiliferous.

Ls - buff & red, f x, hard.
Sh - maroon
Ls - dol, silty, arg, maroon, v fossiliferous.
Ls - bioherm, corals.
Dol - brn, x, ls - buff.
Ls - arg, buff & maroon, crinoidal.

Ls - buff to lt brn, f x, mottled.

Ls - cream, crypto x, massive.

Ls - biostromal, dol, corals, stromatoporoids.
Ls - silty, lt brn, f x, nodular.
Sltst - grey, cross bedded.
Sh - grn-gr.

Ls - arg, lt gr-brn, f x, in part sh.

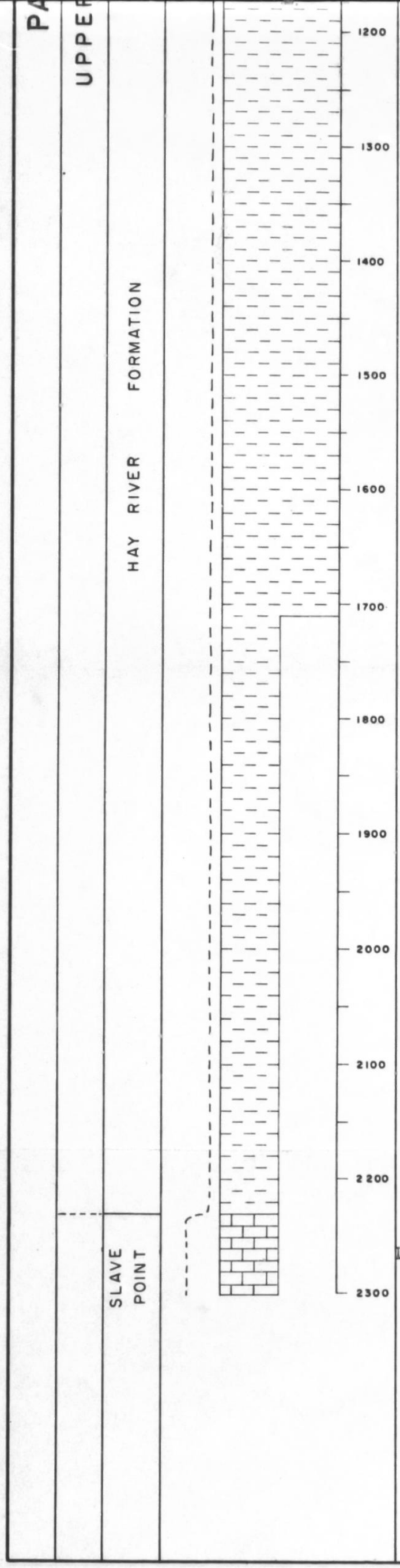
Sltst - dol.

Sh - grn and maroon.

Ls & dol - x, biostromal, v fossiliferous.

Sh - grn-gr sl/ calc to non-calc.

2 of



Ls - brn, f x, clastic.

3 of 3

FIGURE - VI

J. C. SPROULE & ASSOCIATES, CALGARY

STRATIGRAPHIC SECTION NO. 4

GRAINGER RIVER

NORTHWEST TERRITORIES

AGE	FM.	REL. HARD	LITHOLOGY	THICK-NESS	DESCRIPTION
PALEOZOIC — MIDDLE DEVONIAN	"RAMPARTS"				Ls - dk gr, dense to f x, calc & qtz veining thin bedded.
				100	Dol ls - dk gr, dense to f x, in part arg ls, minor ch.
				200	
				300	
				400	Dol ls - blk, dense, cal veining, tracery, ch fossil fragments, massive.
				500	Ls - dk gr, dense, i/b arg ls, ch fossil fragments.
					Ls - as above.
				600	Dol - wh, c x, mot lt gr, vuggy.
					Ls - blk, dense, thin bedded.
				700	Ls - as above.
					Banded dol - dk gr, c x, secondary dol, minor breccia.
					Banded dol - as above.
				800	Banded dol - as above.
	BEAR ROCK			900	
					Dol breccia - blk angular dol in wh x matrix, thick bedded.

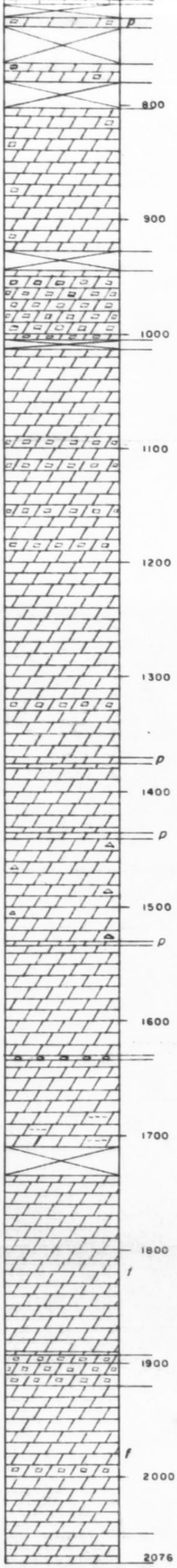
1

PALEOZ

MIDDLE DEVONIAN OR SILURIAN

BEAR ROCK

LONE MOUNTAIN ?



Ls - as above.

Banded dol - dk gr, c x, secondary dol, minor breccia.

Banded dol - as above.

Banded dol - as above.

Dol breccia - blk angular dol in wh x matrix, thick bedded.

Banded dol - gr, dense to f x, dol veining, minor i/b dol breccia.

Vuggy dol - dk gr, c x, bedded secondary dol.

Banded dol - as above.

Vuggy dol - as above.

Banded dol - as above. Minor brn ch.

Vuggy dol - as above.

Banded dol - as above. Minor pink dol.

Cgl - rounded lt gr dol pebbles in dk gr dol matrix

Banded dol - as above. Sl/ silty in lower part.

Banded dol - dk gr to blk, dense to f x, geodal dol, thick bedded.

Dol breccia - as above. Dol geodes and veining.

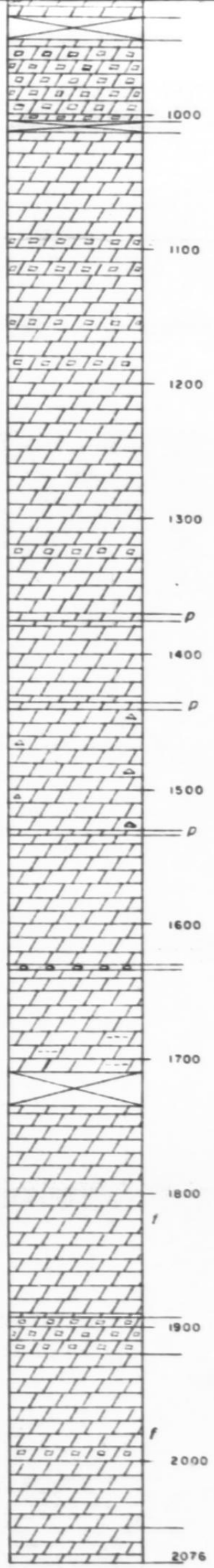
Banded dol as above. Minor dol breccia.

Dol - buff gr, dense, dol veining, thin to thick bedded.

2 of

MIDDLE DEVONIAN OR SILURIAN

LONE MOUNTAIN ?



Dol breccia - blk angular dol in wh x matrix, thick bedded.

Banded dol - gr, dense to f x, dol veining, minor i/b dol breccia.

Vuggy dol - dk gr, c x, bedded secondary dol.

Banded dol - as above.

Vuggy dol - as above.

Banded dol - as above. Minor brn ch.

Vuggy dol - as above.

Banded dol - as above. Minor pink dol.

Cgl - rounded lt gr dol pebbles in dk gr dol matrix

Banded dol - as above. Sl/ silty in lower part.

Banded dol - dk gr to blk, dense to f x, geodal dol, thick bedded.

Dol breccia - as above. Dol geodes and veining.

Banded dol as above. Minor dol breccia.

Dol - buff gr, dense, dol veining, thin to thick bedded.

3 of 3

FIGURE-X

J.C. SPROULE & ASSOCIATES, CALGARY

STRATIGRAPHIC SECTION NO. 2

LITTLE DOCTOR LAKE-NAHANNI RANGE

NORTHWEST TERRITORIES

AGE	FM.	REL. HARD	LITHOLOGY	THICKNESS	DESCRIPTION
U. DEV.	FORT CR.				
MIDDLE DEVONIAN	RAMPARTS			0	Sh - blk, thin, platy, hard.
					Ls - gr, c x, highly fossiliferous, nodular, massive.
				f	Ls - dk gr, f x, biostromal, massive.
				100	Dol ls - dk gr to brn gr, f x to x, biostromal, massive.
				f	Ls - dk gr, f x, minor dol ls & calc dol at top.
				200	
				f	Ls - gr, f x, nodular, massive.
					Ls - dk gr, f x, dk brn dol mot.
				f	
				300	
				f	Ls - dk gr, f x, massive.
					Ls - dk gr, f x, minor dol mot, massive.
				400	Arg ls - dk gr, f x, thin, platy, nodular.
					Ls - gr to dk gr, f x, minor dol mot, nodular.
					Ls - dk gr, f x, ch nodules, vertical qtz fissures.
				f	Ls - gr, f x, minor dol mot, stromatoporoids.
				500	Ls - dk gr, f x, biostromal near base, nodular, massive.
				f	
				600	Ls - grey & brn gr, f x, minor dol mot, massive.
					Ls - dk gr, f x, minor dol mot, i/b sh, nodular in part, partly covered.
				f	Dol - brn gr, x to c x, secondary dol.
				f	Ls - gr, f x, arg in part, nodular.
				700	
				f	
				800	Dol - gr brn & wh, c x, vuggy.
					Ls - dk gr, f x, arg in part, pyritic.
	ROCK"			f	Dol breccia - dk gr, c x, abundant secondary dol, minor calc dol, minor lst, vuggy, p in part.

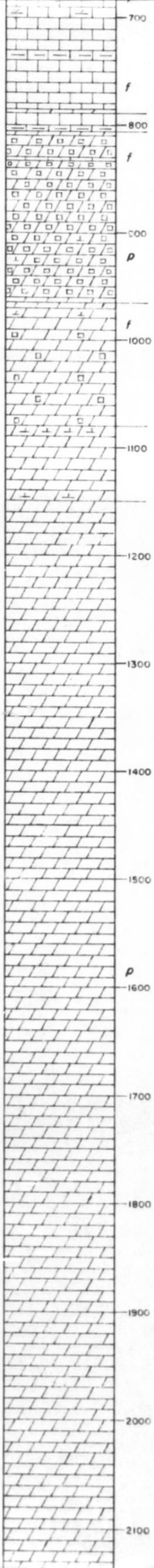
1

PALEOZOIC

MIDDLE DEVONIAN OR SILURIAN

LONE MOUNTAIN?

"BEAR ROCK"



Dol - gr brn & wh, c x, vuggy.

Ls - dk gr, f x, arg in part, pyritic.

Dol breccia - dk gr, c x, abundant secondary dol, minor calc dol, minor lst, vuggy, p in part.

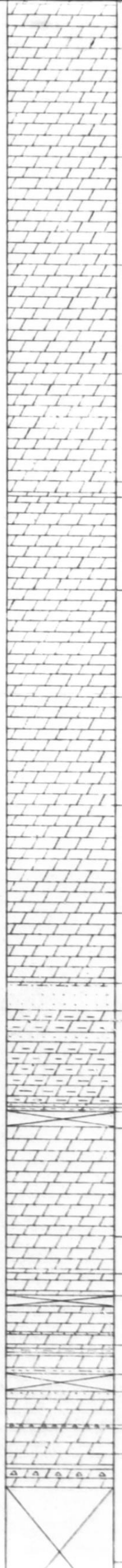
Dol - dk gr, x, minor secondary dol, minor breccia, minor vugs, massive.

Dol - lt gr, c x, f x near top, secondary calcite, minor vugs.

Dol - dk gr & gr, x to f x, minor fossiliferous zones, vuggy near top, thick bedded to massive.

MIDDLE

LONE MOUNTAIN



Dol - lt gr to buff gr, f x to dense, massive to thick bedded.

Ss - gr-wh, f to m g, poorly sorted, poorly bedded, dolomitic at top.

Dol - dk gr, f x, arg, thin ss bed.

Ss - gr, f to m g.
Sltst - lt gr, dense, dol.

Dol - gr, micro x to f x, finely vuggy.

SILURIAN

RONNING ?

Dol - lt gr to blk, f x.

Dol - gr to dk gr, f x, thin ss bed, thick bedded to massive.

Dol - gr to dk gr, arg and sdy in part.
Sltst - lt gr, i/b dk gr sh.

Dol - gr, x, sdy near top.
Ch - lt brn gr, stromatoporoids.

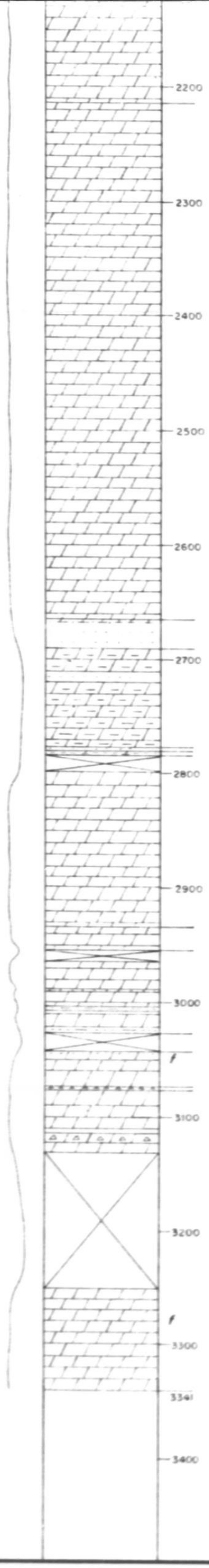
Dol - gr, f x, rubbly.

Dol - abundant brn ch.
Dol - gr, x, m bedded.

3 of

SILURIAN

RONNING?



Dol - lt gr to buff gr, f x to dense, massive to thick bedded.

Ss - gr-wh, f to m g, poorly sorted, poorly bedded, dolomitic at top.
Dol - dk gr, f x, arg, thin ss bed.

Ss - gr, f to m g.
Sltst - lt gr, dense, dol.
Dol - gr, micro x to f x, finely vuggy.

Dol - lt gr to blk, f x.

Dol - gr to dk gr, f x, thin ss bed, thick bedded to massive.

Dol - gr to dk gr, arg and sdy in part.
Sltst - lt gr, i/b dk gr sh.

Dol - gr, x, sdy near top.
Ch - lt brn gr, stromatoporoids.
Dol - gr, f x, rubbly.

Dol - abundant brn ch.
Dol - gr, x, m bedded.

Dol - gr, x, small vugs, m bedded.

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J.C. SPROULE & ASSOCIATES, CALGARY

FIGURE-IV

LITHOLOGICAL CONVENTIONS

Limestone

Dolomite

Shale

Siltstone

Sandstone

Conglomerate

Quartzite

Coal

Covered Section

Calcareous

Dolomitic

Carbonaceous

f Fossil

Concretion

Chert

P Porosity

Breccia

EXHIBIT 4

SUMMARY OF GEOLOGICAL INTERPRETATION

o f

AERIAL PHOTOGRAPHY

a n d

PLANIMETRIC MAPS
(Scale: 1" to 1 mile)

TROUT LAKE AREA, N.W.T.

b y

A. G. Walle

for

Triad Oil Co. Ltd.

Toronto, Canada June, 1956

Resources Survey Division

The Photographic Survey Corporation Limited

GEOLOGICAL INTERPRETATION OF AERIAL PHOTOGRAPHY
TROUT LAKE AREA, NORTHWEST TERRITORIES

INTRODUCTION

In March 1956, Triad Oil Co. Ltd. contracted the Photographic Survey Corporation to carry out a geological interpretation of aerial photography covering the Crown Reservation area east of Trout Lake and just north of the Alberta border in the Northwest Territories. Approximately 1,250 square miles are included. The area lies within the following topographic sheets: 95-A-1, 2, 7, 8, and 85-D-5, and 6. The interpretation was accomplished by the Resources Survey Division of the Photographic Survey Corporation Limited.

BASE MAPS AND PHOTOGRAPHY

The Photography used for this study was taken by the R.C.A.F. and is at a scale of 3,333 feet to the inch. The interpretation was marked on the individual prints and the information transferred to the base maps by Sketchmaster. The base maps were produced by Photographic Survey and are at a scale of one mile to the inch.

GENERAL GEOLOGY

There is no published geological information concerning the area. This is undoubtedly because of the paucity of outcrop and the heavy mantle of glacial deposits covering the region. However, some general ideas concerning the probable geology can be inferred by extrapolation from surrounding areas. The interpreted area is probably underlain by marine and non-marine sediments of Cretaceous age. Some Devonian sediments may also be present. The regional strike is probably about east-west with a southerly dip.

APPLICABILITY OF THE PHOTOGRAPHIC INTERPRETATION

The amount of information to be gained from the study of aerial

photography in such an area is somewhat limited. The main function of the interpretation is (a) to identify outcrop occurrences, and (b) to delineate features of possible structural significance.

Nowhere in the surveyed area could outcrop be positively interpreted. If any exposures are present they will be small in a real extent. The scale of the photography and its generally poor quality make the interpretation of small outcrops difficult. However, in a few places it appears from the form of the surface topography that bedrock is near surface and may possibly outcrop. Such places have been presented on the map as possible outcrop areas.

Since there are no extensive bedrock exposures, the only structural features which may be observed will be subsurface structures which are reflected in the covering glacial drift. Unfortunately the surface form of the glacial deposits tends to mask features of subsurface origin. A number of linear features which may represent subsurface faulting or jointing have been delineated. The attempt has been made to ignore linear features which are caused by glaciation, but it is inevitable that some such linears have been included.

CONCLUSIONS

Careful stereoscopic examination of the aerial photography yielded disappointingly little geological information. The most important conclusion to be drawn from the study is a negative one, namely, that there is little likelihood of outcrop occurring throughout most of the area.

Possible outcrop sites were interpreted in three localities:

(1) South and southeast of Tetcho Lake;

(2) Northeast of Trainor Lake; a n d

(3) Near the centre of the west boundary of Twp. 127, Rge. 15.

It is unlikely that outcrop will be found elsewhere. The major streams were closely examined but over most of the area the drift cover appears thick and the streams do not cut bedrock. A cursory glance at the photography of surrounding areas suggests that more outcrop may be found outside the boundaries of the interpreted section.

Many linear features were delineated but no important conclusions could be drawn from the pattern of the linears. Until more geological information is acquired, little structural interpretation can be done.

EXHIBIT 5

STATUTORY DECLARATION

CANADA PROVINCE OF ALBERTA TO WIT:	IN THE MATTER OF the Territorial Oil and Gas Regulations and the application of Triad Oil Co. Ltd. for refund of performance deposits pursuant to Section 25 of the said Regulations:

I, Michael Hartman Finnell of the City of Calgary in the Province of Alberta, Secretary-Treasurer, DO SOLEMNLY DECLARE:

1. THAT I am the Secretary-Treasurer of Triad Oil Co. Ltd. and as such have personal knowledge of the matters hereinafter set forth.

2. THAT the statements and information contained in the application to the Chief, Mining and Lands Division, to which this Declaration is attached, are true and correct in substance and in fact, to the best of my knowledge, information and belief.

And I make this solemn declaration conscientiously believing the same to be true, and knowing it is of the same force and effect as if made under oath, and by virtue of The Canada Evidence Act.

Declared at Calgary in the Province of Alberta, this 23rd day of October, A. D. 1957 before me:

A Commissioner of Oaths in and for the Province of Alberta

Airborne Magnetometer Survey
Permits 963 to 974, Northwest Territories

This airborne magnetic survey was flown and compiled by Aeromagnetic Surveys Limited during the months of November, 1956 to January, 1957. The survey covered an area of approximately 1,200 square miles including Permits Nos. 963 to 974 in the Northwest Territories. This area is situated between latitudes 60° 00' and 60° 29' N and longitudes 119° 00' and 60° 29' N and longitudes 119° 16' and 120° 46' W.

The survey was made using a twin engined aircraft based at Fort St. John, British Columbia. The survey was monitored using a ground magnetometer of the flux gate type, which was operated at the flying base. A mean flight altitude was maintained above the terrain of 1,000 to 1,500 feet. The positioning of the record was accomplished using a 35 mm. camera synchronized with the magnetic record.

The records measure the earth's total magnetic field with a minimum noise level from extraneous sources. This does not exceed plus or minus 1.5 gamma. The resolution of the instrument is such that variations of field intensity of 2.5 gamma or less will be readable.

Two total magnetic maps are being submitted, which show the variation of the total magnetic force in gamma with a scale of 1 inch to 1 mile. The contour interval is 10 gamma with a mean flight line spacing of 1½ miles and a datum altitude above sea level of 3,500 feet. The fiducial points are circled and labelled with their numerical sequence, while the inflection points are checked along the light of flight. The flight lines are numbered consecutively

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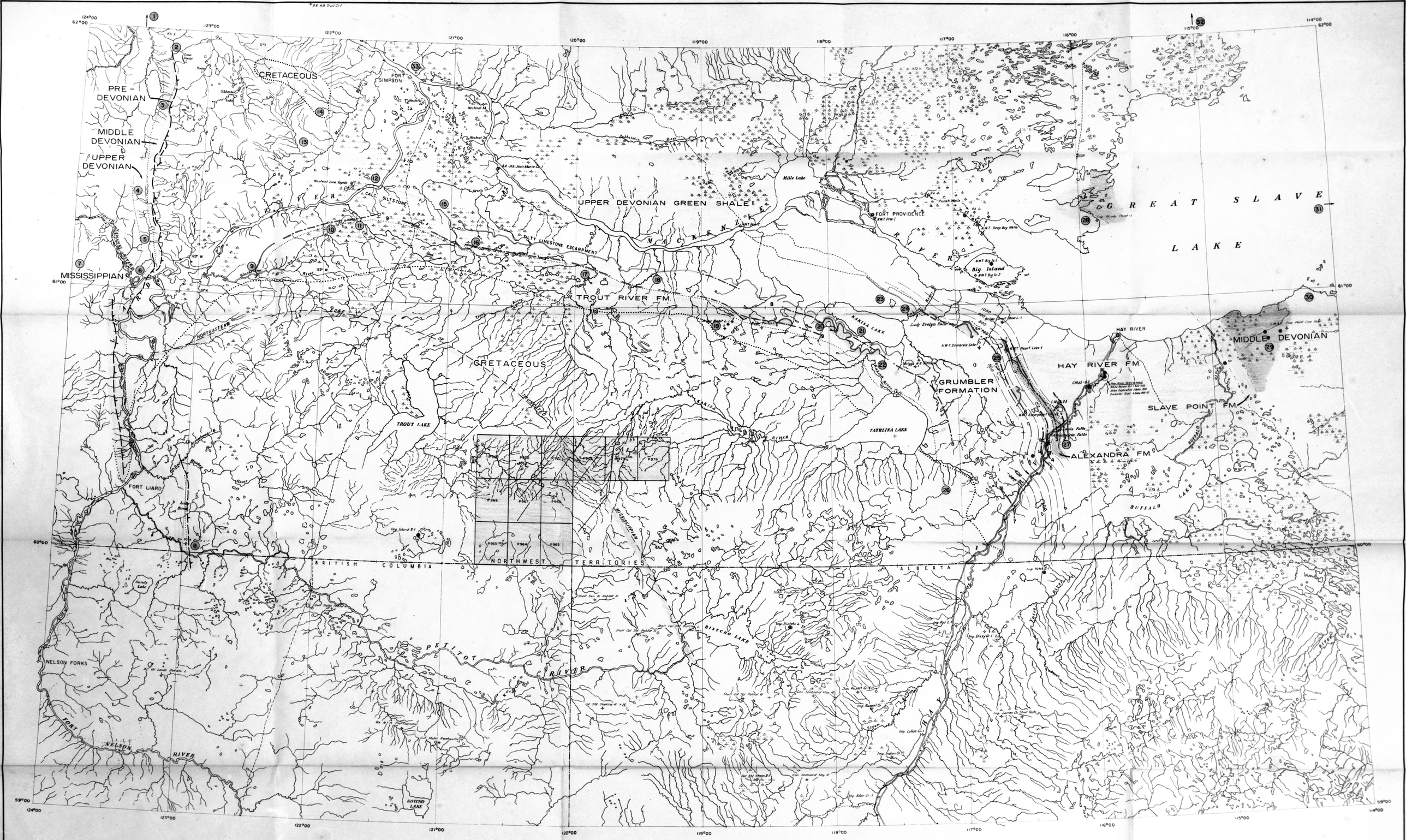
from the top to the bottom of the map from 2 to 24. The variable spacing between surveyed lines has been kept to a minimum and the east to west flight lines have been adjusted for diurnal variation by the use of north to south control lines spaced at approximately 6 mile intervals.

T C Richards

T. C. Richards
Chief Geophysicist

October 1, 1957.



Location or Drilling Well
Gas Well
Abandoned Well
Wells - Cores & Samples Examined
P & N.G. Permit

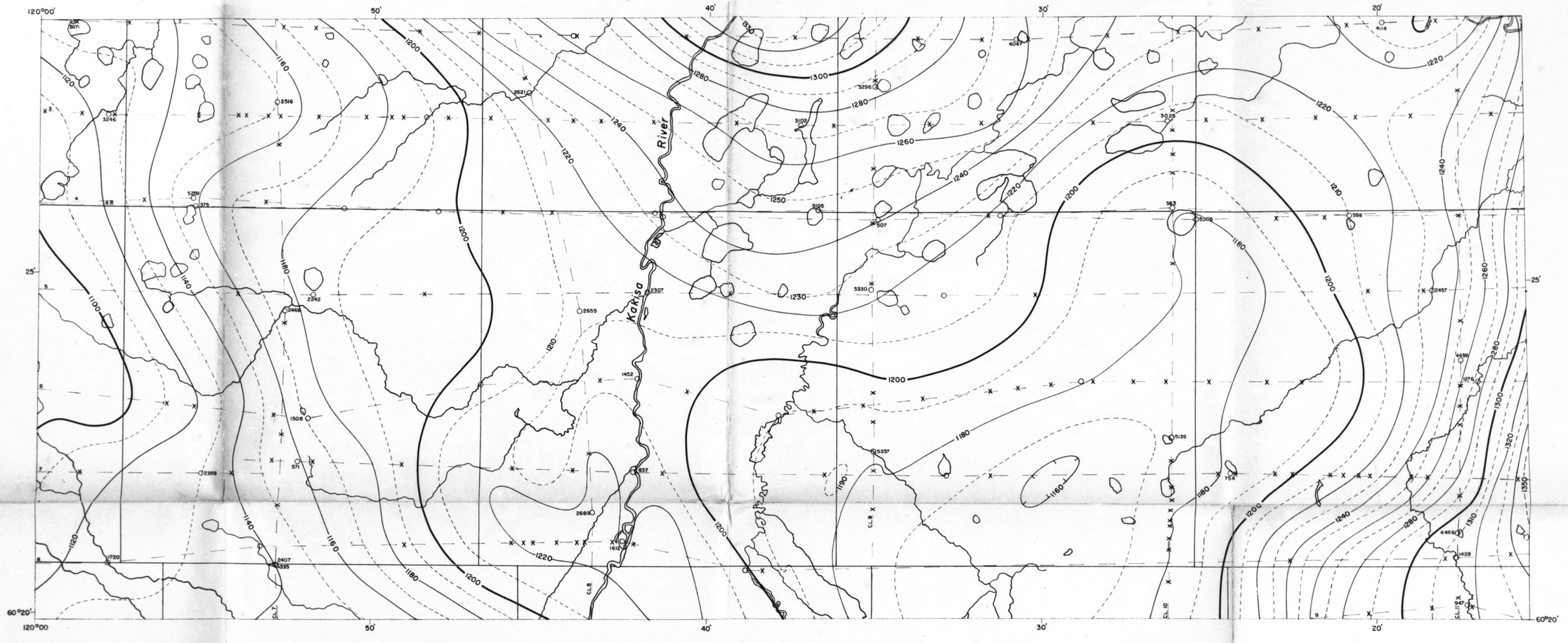
Geological Formation Contact
Geological Formation Contact (Indefinite)
Fault
Contours on Alexandra Fm.
Grumbler Reef & Reefoid Outcrop Edges
Grumbler Silty Limestone Outcrops
Number of Outcrop Area
Lineal Features
Direction of Glaciation

MESOZOIC
CRETACEOUS
PALEOZOIC
MISSISSIPPIAN
UPPER DEVONIAN
Trout River Fm.
Grumbler Fm.
Alexandra Fm.
Shale Unit
MIDDLE DEVONIAN
Slave Point Fm.
Presqu'ile Fm.
PRE-DEVONIAN

MAP OF
MAIN GEOLOGICAL FEATURES
LIARD RIVER - GREAT SLAVE LAKE AREA
B.C. - ALTA. - N.W.T.

Scale 1" = 8 miles

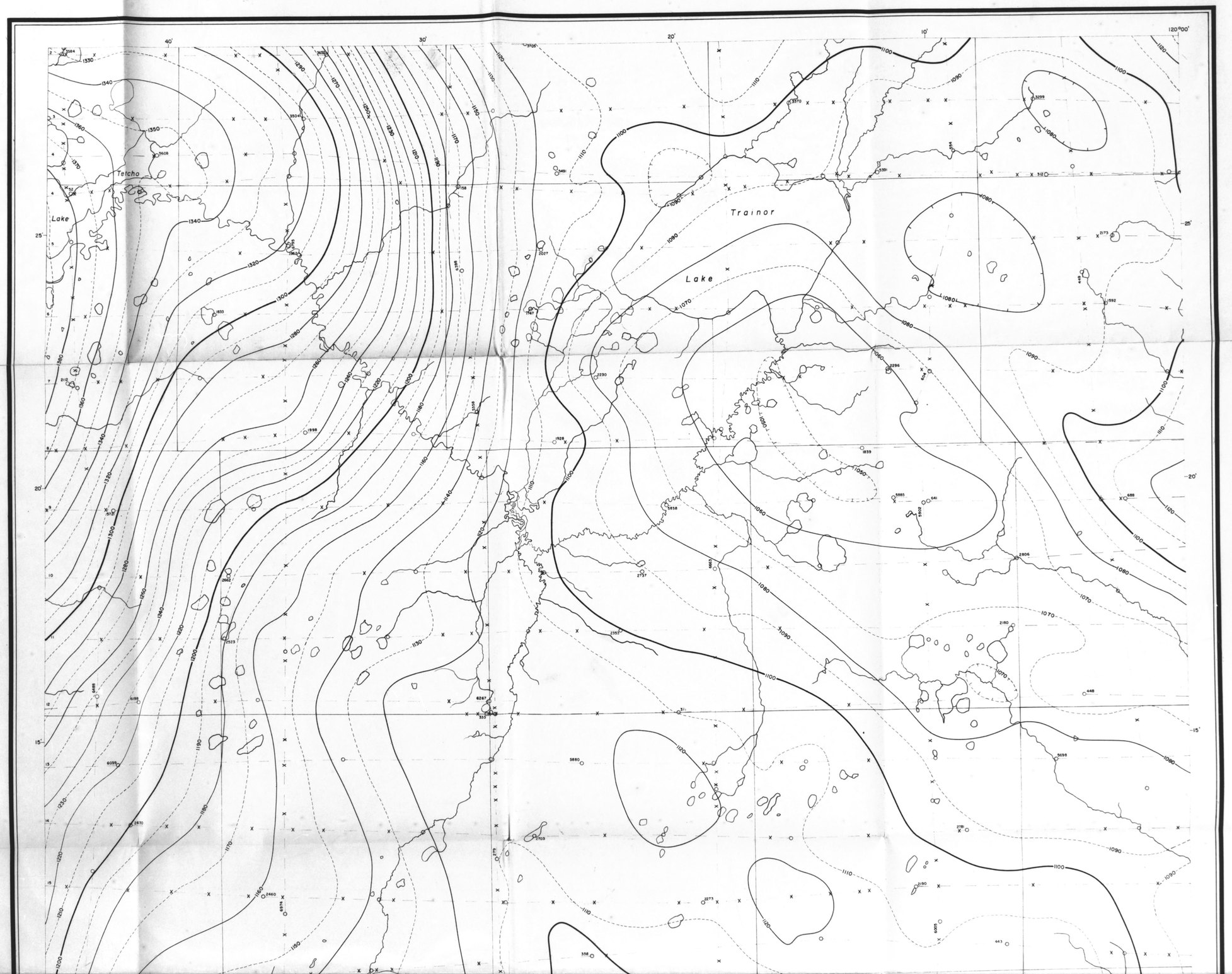
J.C. SPROULE & ASSOCIATES LTD.



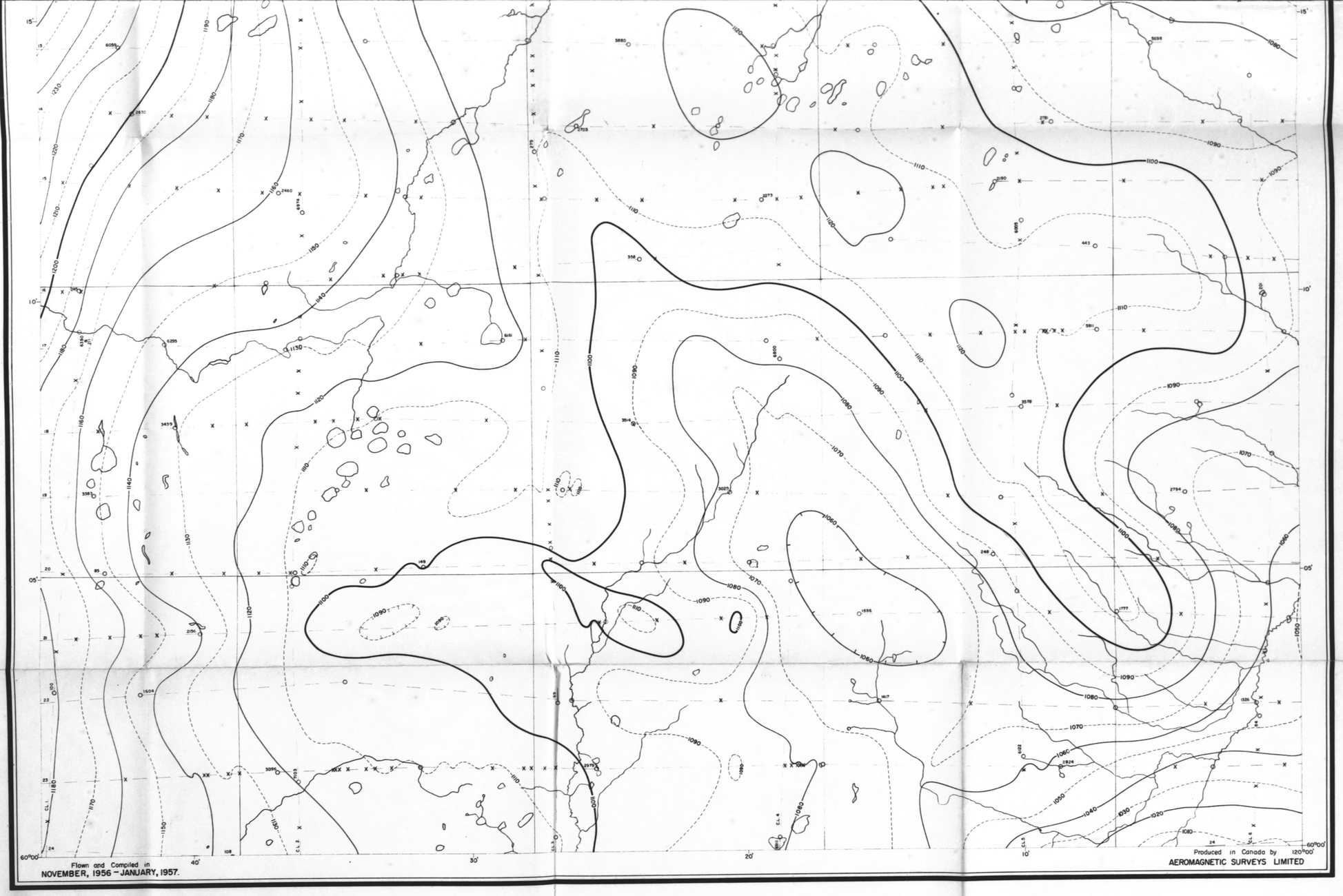
Flown and Compiled in
NOVEMBER, 1956 - JANUARY, 1957.

Produced in Canada by
AEROMAGNETIC SURVEYS LIMITED

TRIAD OIL COMPANY LIMITED
AIRBORNE MAGNETOMETER SURVEY



1 OF 2

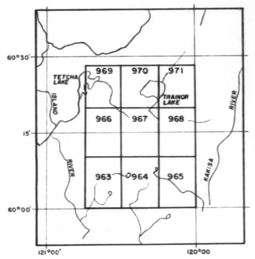


CONTOUR INTERVAL ..... 10 GAMMA
MEAN FLIGHT LINE SPACING ..... 1½ MILES
ALTITUDE ABOVE SEA LEVEL ..... 3500 FEET
500 GAMMA CONTOUR
100 GAMMA CONTOUR
20 GAMMA CONTOUR
10 GAMMA CONTOUR
MAGNETIC LOW
FIDUCIAL POINTS 3690
FLIGHT LINES ..... 2 TO 24
INFLECTION POINTS

PERMITS Nº 963-964-965-966-967-968-969-970-971
NORTHWEST TERRITORIES

SCALE

1 inch to 1 Mile



2 of 2

G.P. 947/1