GREAT PLAINS DEVELOPMENT COMPANY OF CANADA, LTD.

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Parcel 1 of 3

PHOTOGEOLOGIC EVALUATION

OF THE

PEEL BASIN AREA

NORTHWEST TERRITORIES AND YUKON

Prepared by

GEOPHOTO SERVICES, LTD.

Calgary, Alberta.

1964

LIST OF ILLUSTRATIONS

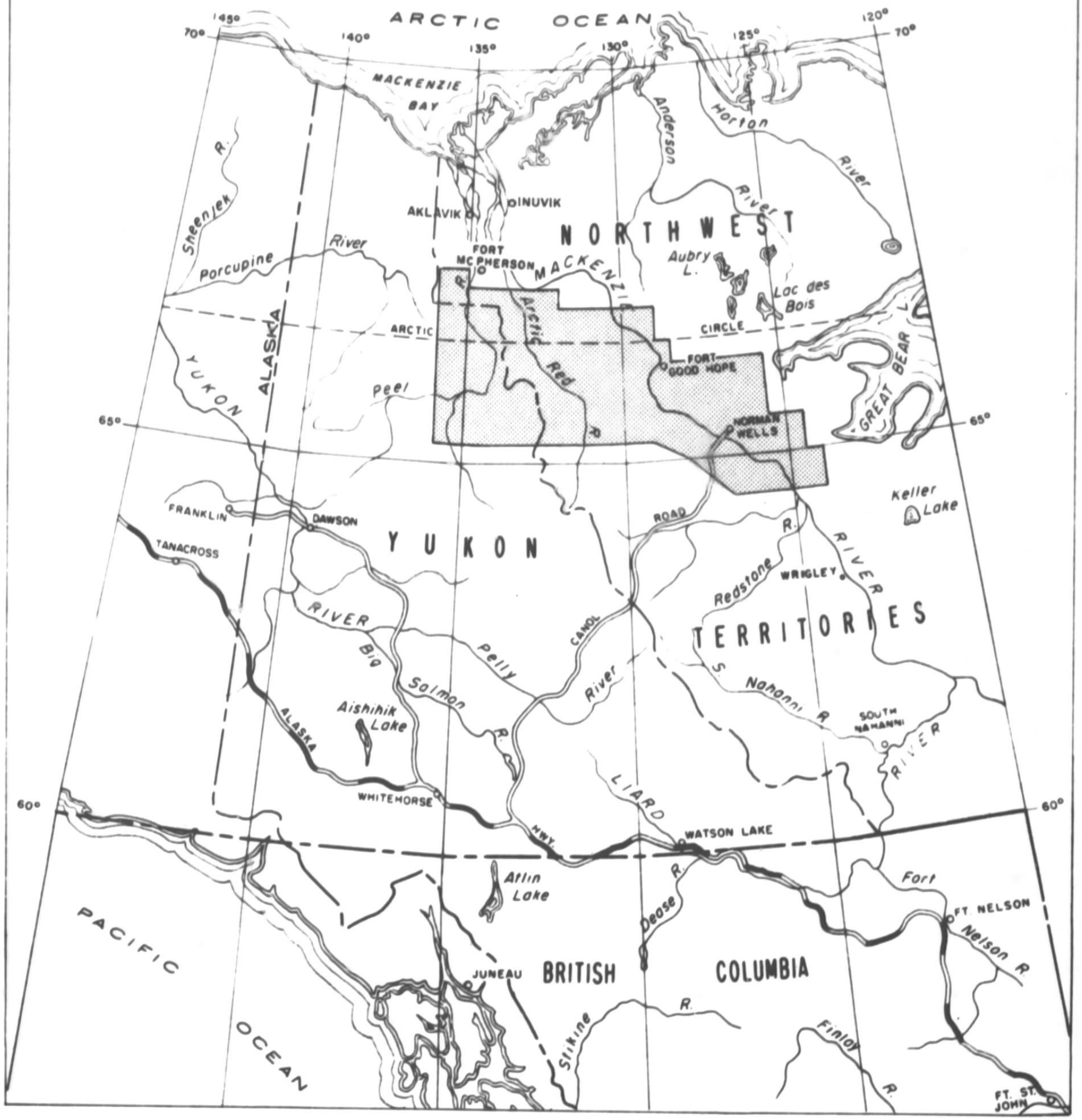

Plate 1

REGIONAL LOCATION MAP

SCALE: 1 inch = 125 miles approx.

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INTRODUCTION

The series of maps and illustrations which accompany this report presents the results of a photogeologic evaluation of an area of 41,070 square miles, located along the northern front of the Canadian Cordillera in the western part of the Northwest Territories, and including a part of the northern Yukon. The regional location of the project area, and its relation to territorial boundaries, towns and major streams is shown on Plate 1. This photogeologic study was undertaken by Geophoto in order to present a series of coordinated and uniform geologic maps of this prospective area. This evaluation is one of a series of such studies, which cover a large part of the sedimentary basin of Western Canada.

This evaluation is based on a study of the air photographs and available geologic literature, and reflects Geophoto's ten years of photogeologic and field experience in northern Canada. Field observations in the western part of the project area were made available to Geophoto by a major oil company, and these observations are incorporated in the photogeologic maps and in this report. Much of the available geologic literature dates back to the Canol Project (circa 1944), and is herein interpreted in terms of the more recent formational terminology and dating. A selected bibliography is appended to this report; all references to the bibliography are by author and date.

TOPOGRAPHY AND ACCESSIBILITY

Plates 2a and 2b are World Aeronautical Charts at a scale of 1:1,000,000, on which the project area is outlined. A pronounced change in the physiography of the Canadian Cordillera occurs at approximately the 60th parallel. South of this parallel, the familiar terrain of the Canadian Rockies and their Foothills may be traced southwards for a distance of almost 1,000 miles to the U.S. border. At the 60th parallel, the Rocky Mountains and their Foothills disappear as a topographic unit, and are replaced in a right-hand en echelon manner by the Mackenzie Mountains, and associated foreland ranges which are collectively known as the Franklin Mountains. The low lying areas occurring between the eastern front of the Mackenzie Mountains and the Franklin Mountains are known as the Mackenzie Plain. The southern boundary of the project area is the 60th parallel, and the project area includes the eastern front of the Mackenzie Mountains, a large portion of the Mackenzie Plains, and a large portion of the Franklin Mountains. The Franklin Mountains form an elongate arcuate belt merging with the Mackenzie Mountains to the south at approximately the 60th parallel, and merging with them again some distance to the north, north of the project boundary. In the intervening area, the maximum separation between the Mackenzie front and the outermost range of the Franklin Mountains is approximately 80 miles. To the south, where the Mackenzie and Franklin merge, the definition between the two mountain systems is not clear and the region has been termed the Liard Plateau. In this area, for the purposes of

this report, the Liard Range is considered to be part of the Franklin Mountains System, whereas the Labiche Range is considered to mark the easternmost range of the Mackenzie Mountains System.

Bostock (1948) divided the Mackenzie Mountains into two parts: an easternmost portion which he termed the Canyon Ranges, and a westerly portion which he termed the Backbone Ranges. The project area includes a small part of the Canyon Ranges.

Within the project area maximum elevation is attained in the southern part of the Mackenzie Mountains (Liard Plateau), where in the vicinity of the Nahanni River elevations of 6, 200 feet are reported. The Franklin Mountains are somewhat lower with average elevations of approximately 3, 000 feet, attaining a maximum elevation of 5, 200 feet in the Nahanni Range. The intervening Mackenzie Plain lies at an average elevation of less than 2, 000 feet, and at some places descends to less than 1, 000 feet elevation. In general, the mountainous areas are relatively free of vegetation, and form bold rocky terrain. The lowlands are poorly drained, and support numerous lakes and extensive muskeg deposits. In general, the lowlands are densely covered with small trees and bush which seriously impede ground travel.

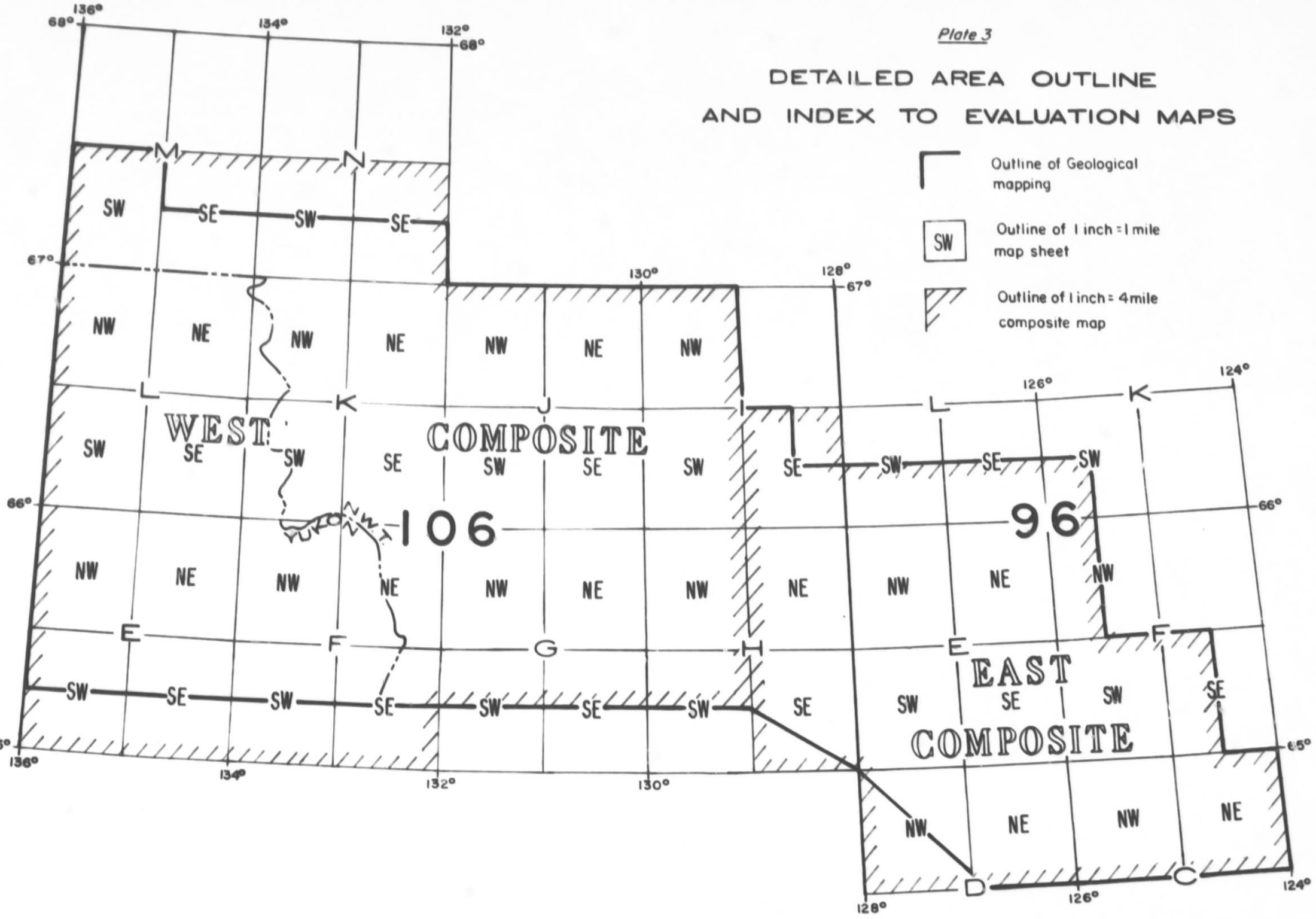
The Mackenzie River area is served by Pacific Western Air Lines with regular scheduled service to Fort Simpson (east of the project area) and Wrigley (north of the project area). During the summer months a considerable amount of freight is moved by barge down the Liard and Mackenzie Rivers.

Winter tractor roads can easily be constructed through most of the low lying areas of the project, and many such roads have been built to service seismic and drilling operations.

Geologic field operations in this region are usually conducted with the aid of helicopters during the short summer field season. Field parties usually operate out of base camps established with float equipped aircraft on the larger lakes and rivers.

Plate 3

DETAILED AREA OUTLINE AND INDEX TO EVALUATION MAPS



GEOPHOTO SERVICES LTD.

SCALE: 1 INCH TO 40 MILES

PHOTOGRAPHY AND MAP COMPILATION

The air photography used for this photogeologic evaluation was obtained from the Royal Canadian Air Force, and is at a scale ranging from 1:35,000 to 1:40,000. This photography was flown during the period 1949 to 1954 with a camera equipped with a six-inch focal length lens. This photography is not of high quality, but, in general, is suitable for a regional evaluation of this type.

The set of evaluation maps covering this area consists of 49 individual map sheets prepared at a scale of 1 mile to 1 inch; these maps are identified by number and letter according to the Canadian National Topographic System. Each of the map sheets covers an area of 30 minutes of latitude by 1 degree of longitude, and forms one quadrant of a National Topographic System letter designated area. The locations of these 49 map sheets are shown on Plate 3, Detailed Area Outline and Index to Evaluation Maps.

Geologic detail was annotated directly on alternate air photos by geologists while viewing the photographs stereoscopically. The geologic detail was then transferred from the air photos to a Permascale planimetric base by means of a Map-O-Graph, a projection-type instrument providing a method of making rapid scale changes, thereby accomodating air photographs of different scales. The base maps were constructed by inking a polyconic projection at the designated scale of 1:63,360 on Permascale film. Streams and cultural features were inked to these bases from planimetric maps issued by the Map Distribution Office, Dept. of Mines and Technical Surveys, Ottawa, Ontario.

All topographic, cultural and hydrographic details were compared with the air photographs and corrected where necessary.

Two composite geologic maps at a scale of 4 miles to 1 inch were produced by photographically reducing the 49 evaluation maps, splicing together the film negatives, and making blue line prints directly from the negatives. The east composite map includes the area east of 129°00' west longitude, and the west composite map includes the area west of 129°00' west longitude.

Plate 4

REGIONAL STRUCTURE

Plutonic Rocks

140° 138° 136° 134° 132° 130° 128° 126° 124° 122°

70° 69° 68° 67° 66° 65° 64° 63°

AMUNDSEN GULF

BRITISH MTNS

BARN MTNS. UPLIFT

OLD CROW BASIN

ARCTIC COASTAL BASIN

AKLAVIK

RIVER

DAVE LORD HILLS ARCH

PORCUPINE

BELL

EAGLE PLAIN RIVER BASIN

RICHARDSON MTNS

ESKIMO LAKES

KUGALUK RIVER

INUVIK

INUVIK UPLIFT

ANDERSON RIVER

ANDERSON HOMOCLINE

PRECAMBRIAN SHIELD

HORNADAY R.

HORTON R.

COLVILLE MONOCLINE

CARNWATH

IROQUOIS R.

FORT McPHERSON

ARCTIC RED RIVER

PROJECT BOUNDARY

ARCTIC

PEEL BASIN

ONTARATUE

RED RIVER

MACKENZIE

HARE INDIAN

FORT GOOD HOPE

GREAT BEAR LAKE

BEAR RIVER

FRANKLIN

MAHONY LAKE

GREAT BEAR LAKE

NORMAN WELLS

CENTRAL OGILVIE MTNS. UPLIFT

BONNET PLUME MTNS. UPLIFT

SELWYN TRENCH

MACKENZIE MOUNTAIN RIVER

FT. NORMAN

MACKENZIE

SOUTHERN OGILVIE MTNS. UPLIFT

N.W.T. YUKON

KEELE RIVER

PLAIN RIVER

MOUNTAINS UPLIFT

INTERIOR PLATEAUS

STEWART

MAYO

RIVER

SELWYN MOUNTAINS

MOUNTAINS

REDSTONE

WRIGLEY

BASIN

UPLIFT

ROOT RIVER

MACMILLAN

PELLY R.

TINTINA TRENCH

GEOPHOTO SERVICES LTD.

SCALE: 1 INCH TO 60 MILES

REGIONAL GEOLOGY

The eastern margin of the Cordilleran System of Western Canada trends in a general northwesterly direction from the Canadian-United States border to the project area, a distance of over 1200 miles. One major break occurs at about the 60th parallel, where the Mackenzie Mountains and the Rocky Mountains are offset in a right-hand en echelon manner. In the western part of the project area another major break occurs where the Richardson Mountains trend obliquely across the western limits of the Mackenzie Mountains. The Richardson Mountains appear to be a structural and depositional link between the Cordilleran System and the Brooks Range-British Mountains System. A small part of the Brooks Range-British Mountains System may be seen in the northwestern part of Plate 4. West of the area of Plate 4 the Brooks Range-British Mountains System trends westerly across northern Alaska for a distance of over 500 miles. The Cordilleran System trends southwesterly across Alaska, forming the "Pacific Mountain System" (Gates and Gryc, 1963). In Alaska the two mountain systems are separated by a medium stable area of intermontane plateaus. A brief description of the more important structural features shown on Plate 4 is given in the following paragraphs.

Peel Basin, Inuvik Uplift, Anderson Homocline, Colville Monocline

The Peel Basin is a low-lying, relatively undeformed region exposing mainly Cretaceous and Upper Devonian clastic rock. The Peel Basin is surrounded by uplifts, except to the north, where it is separated from the coastal

areas by a broad, poorly defined, westerly plunging arch in Paleozoic strata. The Inuvik Uplift appears to be a small fault block, exposing a southerly dipping section of Cambrian, Ordovician, Silurian, and Devonian rock. The Anderson Homocline marks a northerly dipping downwarp, north of which Cretaceous rocks are exposed.

The axial position of the Peel Basin lies close to the northern front of the Mackenzie Mountains, and the basin is decidedly asymmetric, with a sharply upturned south flank and a gently dipping and broad north flank. The Cretaceous section appears thicker on the south flank of the basin, indicating a southerly source.

The structure of the Colville Monocline is imperfectly known; it apparently represents a zone of steeper than average dips in the Paleozoic carbonate strata dipping westerly off the Precambrian Shield. The Colville Monocline is probably faulted at some places along its eastern edge. The boundary between the Colville Monocline and the Franklin Mountains Uplift marks a distinct change in structural grain.

Franklin Mountains Uplift

The Franklin Mountains Uplift is formed by an arcuate series of block faulted foreland ranges, which expose Lower Paleozoic carbonate rock. These foreland ranges first develop at about the 130th meridian, swing southeasterly in a broad arc, and again merge with the Mackenzie Mountains to the southeast of the area of Plate 4. Martin (1963) has suggested that the faults

bounding the ranges of the Franklin Mountains are splays from a zone of separation at the Archeozoic-Proterozoic boundary.

Mackenzie Plain Basin

The Mackenzie Plain Basin is an intermontane structural basin, lying between the Franklin and Mackenzie Mountains. Surface exposures in the Mackenzie Plain Basin are mainly Cretaceous and Upper Devonian, with a considerable amount of Tertiary cover. The Mackenzie Plain Basin is segmented by outlying fault blocks of the Franklin Mountains System. Broad low-amplitude folds are present in the surface strata of the basin.

Mackenzie Mountains Uplift

The front of the Mackenzie Mountains is marked by an abrupt upwarp and exposure of the lower Paleozoic carbonate section. At many places the mountain front is faulted at the surface, and a subsurface fault may be inferred at most places. Rocks exposed in the Mackenzies are mainly Paleozoic, with the Proterozoic exposed at some localities. The Mackenzies are folded, the degree of deformation being greater to the southwest. Plutonic rocks are not reported from the Mackenzies, although small dykes and sills are present. The Mackenzies are bounded on the southwest by a trench-like zone, part of which has been named the Selwyn Trench (Haites, 1960). To the northwest this trench trends into the fault zones on the east flank of the Richardson Mountains.

Selwyn Mountains and Interior Plateaus

Data concerning the structure and stratigraphy of the Selwyn Mountains and Interior Plateaus are not abundant. One very obvious characteristic of this

area is the abundance of plutonic rock, mostly of acid composition, and believed to be of Mesozoic age. The sedimentary rocks are of Proterozoic and Paleozoic age; it is presumed that the Paleozoics are mainly of an eugeosynclinal facies, and distinct from the carbonate facies mapped in the project area in the Mackenzie and Franklin Mountains. This structural unit is bounded on the southwest by the Tintina Trench, a northerly extension of the Rocky Mountain Trench.

Richardson-Bonnet Plume Mountains Uplift, Barn Mountains & British Mountains

The Richardson Mountains trend across the western part of the project area, and marks a northerly excursion of the early Paleozoic eugeosyncline obliquely across the miogeosyncline. Rocks exposed in this uplift are characterized by a great thickness of lower Paleozoic (pre-Upper Devonian) graptolitic shale and siltstone. In the northwestern part of the Mackenzie Mountains a minor amount of interbedding is noted between this eugeosynclinal facies and the early Paleozoic carbonate sequence of the northern Mackenzies. Similar, but more extensive, intercalations of the two facies are noted to the west, in the Central Ogilvie Mountains. This linear early Paleozoic depositional trough was probably fault-controlled, and may have had a northerly connection with a depositional trough in the site of the present British-Barn Mountains trend, where somewhat similar rocks are exposed. This area is now mantled by Jurassic and Lower Cretaceous rocks of the Arctic Coastal Basin.

The Richardson, Barn, and British Mountains were deformed in

mid-Devonian time, and thick sections of Upper Devonian and Mississippian clastic rock collected in bounding foredeeps. There is also evidence of late Paleozoic deformation in this mobile zone. The southern boundary of the Richardson-Bonnet Plume Mountains Uplift, as shown on Plate 4, is questionable.

Dave Lord Hills Arch

This unusual northeasterly trending arch exposes lower Paleozoic carbonate rock, and marks the north flank of the Eagle Plain Cretaceous Basin. This arch is bounded by faults, which trend for short distances northeasterly into the Cretaceous fill of the Arctic Coastal Basin. Unusual transverse structures in the Arctic Coastal Basin suggest a northeasterly extrapolation of the southerly bounding fault of the Dave Lord Hills Arch. Other obvious features along this trend are the Inuvik Uplift and the Anderson Homocline. The Dave Lord Hills Arch gives evidence of at least two episodes of Paleozoic deformation, apparently synchronous with deformation in the Richardson Mountains.

Arctic Coastal Basin

The Arctic Coastal Basin, as herein defined, marks the limits of Jurassic and lower Lower Cretaceous (pre-Albian) rock. A great thickness of these and younger strata are found on the north slope of Alaska, and form a prominent embayment into northern Canada to the east of the British Mountains and west of the Mackenzie Delta. A linear tongue of these strata extends down the east flank of the Richardson Mountains. The oldest Cretaceous strata in the Eagle Plain and Peel Basins are Albian. The Arctic Coastal Basin is severely

to moderately deformed in its southerly parts, and gently folded in its northerly parts. It is possible that the Cretaceous strata north of the Anderson Homocline may indicate a northeasterly extension of the Arctic Coastal Basin.

Eagle Plain Basin

The intermontane Eagle Plain Cretaceous Basin exposes a considerable thickness of Lower and Upper Cretaceous strata in gentle northerly trending folds. Pre-Albian Mesozoic strata, such as are found in the Arctic Coastal Basin, are not present in the Eagle Plain Basin.

Central and Southern Ogilvie Mountains Uplift

The southern edge of the Eagle Plain Basin is marked by the abrupt upwarp of the Central Ogilvie Mountains, which exposes Paleozoic rocks in a series of fairly broad folds. The northern front of the Southern Ogilvies is another abrupt flexure, which brings up Proterozoic rock. There is probably no great contrast between the Southern Ogilvies and the Selwyn Mountains.

MAP UNITS – EAST

QUATERNARY	Surficial deposits	Q	
TERTIARY	Nonmarine clastic rock	Tu	
UPPER CRETACEOUS	East Fork		K
	Little Bear —LB—		
LOWER & UPPER CRETACEOUS	Slater River		
LOWER CRETACEOUS	San Sault	Kl	
UPPER DEVONIAN	Imperial —JR—	Di	Dum
MIDDLE DEVONIAN	Canol	Dc	
	Kee Scarp —KS—	Dks	Dchi
	Hare Indian	Dhi	
	Hume —H—	Dh	Dhbr
LOWER (?) DEVONIAN	Bear Rock	Dbr	Dh-SOr
SILURIAN - ORDOVICIAN	Ronning	SOr	
CAMBRIAN	Saline River	€srmc	MacDougal Group, €
	Mt. Cap		
	Mt. Clark	€mc	
PRECAMBRIAN	Katherine	p€	

KEY HORIZONS

—LB— Base of Little Bear
—JR— Base of Jungle Ridge limestone
—KS— Base of Kee Scarp
—H— Base of Hume

NOTE: The Imperial map unit (Di) includes only the upper sandy portion of the Imperial Fm. The lower shaly portion of the Imperial Fm. is mapped with the Canol Fm.

MAP UNITS - CENTRAL

QUATERNARY	Surficial deposits	Q		
U. CRETACEOUS	Sandstone, minor shale	Ku	K	
L. CRETACEOUS	Albian shale, with basal sandstone unit	Kl	K	
MISSISSIPPIAN & U. DEVONIAN	Imperial sandstone, includes Mississippian strata to west	MDi	Di	Du — Imperial shale and sandstone, may include minor Canol shale
U. & M. DEVONIAN	Imperial shale, and Canol shale	Dc		Dum — Imperial and Canol, may include Hare Indian
M. DEVONIAN	Kee Scarp (Dks) and possible western equivalent (Dmc)	Dmc	Dks	Dchi — Canol and Hare Indian shale
	Hare Indian, shale, minor limestone	Dhi		
	Hume, limestone	Dh		Dml, Dhbr, Dh-SOr
L. (?) DEVONIAN	Bear Rock (Dbr), and westerly equivalent limestone (Dl)	Dl	Dbr	Dml, Dhbr
ORDOVICIAN & SILURIAN	Carbonate rock, Ronning (SOr) and westerly equivalents (SO)	SO	SOr	Dh-SOr
CAMBRIAN	Macdougal Group	€	€p€	
PRECAMBRIAN	Katherine Group	p€	€p€	

IGNEOUS ROCKS

CAMBRIAN (?)	Diabose sills and dikes	

Plate 6

MAP UNITS - WEST

QUATERNARY	Surficial deposits	Q
QUATERNARY AND TERTIARY	Non-marine sediments and glacial debris	QT
L. CRETACEOUS	Albian shale	Kl
	Pre-Albian sandstone, shale and siltstone	Kl_1
JURASSIC-CRETACEOUS	Sandstone, minor shale	KJ
UPPER TRIASSIC	Limestone, shale	Ŧ
CARBONIFEROUS	Limestone, shale	C
MISSISSIPPIAN AND U. DEVONIAN	Sandstone, shale, may include some M. Devonian shale	MDu
M. DEVONIAN	Canol - type black shale	Dc
L. & M. DEVONIAN	Carbonate rock	Dmc
	Shale, zones of pinnacle reefs in Knorr Range, may include some Silurian shale	Dmls
L. DEVONIAN (?) AND SILURIAN	Graptolitic shale and siltstone, minor limestone	DIS
ORDOVICIAN	Argillaceous limestone	O
CAMBRIAN	Sandstone, siltstone and shale	€
	Limestone, exposed at apex of Richardson Mountains	€ls
PRECAMBRIAN & CAMBRIAN	Macdougal and Katherine Groups	€p€

- Dm — Mainly carbonate rock, minor shale
- DmSO — Mainly carbonate rock, minor shale
- SO — Mainly carbonate rock, some shale
- SO€ — Carbonate rock, shale, siltstone, sandstone

STRATIGRAPHY

The rocks exposed in the project area range from the Precambrian to the Recent, with all of the geologic systems represented, except possibly the Permian.

Rocks exposed in the Peel and Mackenzie Plain Basins are almost entirely of Late Devonian or Cretaceous age. The Mackenzie and Franklin Mountain Uplifts expose strata ranging from the Precambrian through the Middle Devonian. The Permo-Carboniferous and lower Mesozoic strata are confined to the Richardson Mountains area.

The lower Paleozoic strata in the Mackenzie and Franklin Mountains were deposited in a miogeosynclinal environment on the northeastern margin of the Cordilleran geosyncline. At this time the Richardson Mountains area was a rapidly subsiding linear zone, in which a great thickness of eugeosynclinal type sediments was deposited. Deformation occurred in Late Devonian time. and the basin configuration was changed. The Richardson's were uplifted, and thick clastic sections were deposited in bounding foredeeps. It is very likely that the Selwyns were deformed at this time. There is some evidence of uplift in the Richardsons near the close of the Paleozoic. The upper Paleozoic and lower Mesozoic section is thickest in the foredeeps bounding the Richardson Mountains Uplift, and thins easterly in the Peel and Mackenzie Plain Basins.

In the following pages the details of each recognized stratigraphic unit are presented in a series of "stratigraphic data sheets". Details of lith-

Plate 8 (from Douglas, Norris, Thorsteinsson and Tozer, 1963)

PERIOD AND STAGE			INTERIOR PLAINS (Southern)				LIARD PLATEAU		MACKENZIE MOUNTAINS				FRANKLIN MOUNTAINS			MACKENZIE MTNS	INTERIOR PLAINS (Northern)	
			1 SLAVE R.	2 GREAT SLAVE L.	3 LAMARTRE-HORN R'e	4 TROUT L.	5 EASTERN	6 SOUTH-WESTERN	7 SUNBLOOD RANGE	8 FUNERAL RANGE	9 NAHANNI PLATEAU	10 WHITTAKER-REDSTONE RANGES	11 NAHANNI-CAMBELL RANGES	12 McCONNELL RANGE	13 NORMAN WELLS	14 CARCAJOU-MOUNTAIN RIVERS	15 LOWER MACKENZIE R.	16 ANDERSON-HORNADAY R'e 17
Overlying					Cretaceous	Mississippian	Mississippian	Carboniferous			Mississippian		Mississippian ?		Cretaceous	Cretaceous	Cretaceous	Cretaceous
DEVONIAN	Upper	Famennian				KOTCHO	Shale (may include representatives of Middle Devonian to Mississippian formations)	Shale (may include representatives of Middle Devonian to Mississippian formations)			Shale / Sandstone	Shale Siltstone Limestone	Shale Sandstone ? / Shale Limestone / Sandstone		IMPERIAL	IMPERIAL	IMPERIAL	
						TETCHO												
						TROUT R.												
		Frasnian		KAKISA		KAKISA							Sandstone / Shale / Limestone					
				REDKNIFE		REDKNIFE / JEAN-MARIE						Sandstone ?						
				TATHLINA		FORT SIMPSON					FORT SIMPSON	FORT SIMPSON	FORT SIMPSON					
				TWIN FALLS														
				ALEXANDRA														
				ESCARPMENT														
				HAY RIVER	FORT SIMPSON													
	Middle	Givetian	SLAVE PT.	SLAVE PT.	La	SLAVE PT.									CANOL / KEE SCARP	CANOL		
			NYARLING	WATT MTN.	HORN RIVER	WATT MTN.									HARE INDIAN	HARE INDIAN	Shale	Shale
				SULPHUR PT. / PRESQU'ILE		SULPHUR POINT												
			LITTLE BUFFALO FALLS	PINE POINT	LONELY BAY	PINE POINT	NAHANNI			NAHANNI	NAHANNI	NAHANNI	NAHANNI	NAHANNI	HUME	HUME	HUME	Shale Limestone
							HEADLEES	?	HEADLEES	HEADLEES	HEADLEES	HEADLEES	HEADLEES					
		Eifelian	CHINCHAGA	CHINCHAGA	CHINCHAGA	CHINCHAGA	MANETOE	MANZTOE ?	MANETOE	FUNERAL	MANETOE / FUNERAL	LANDRY / ARNICA	MANETOE / LANDRY / ARNICA	BEAR ROCK	BEAR ROCK	BEAR ROCK	Limestone / Dolomite	Limestone / BEAR ROCK
			Salt	Salt			ARNICA	ARNICA	ARNICA	ARNICA	ARNICA							
DEVONIAN OR SILURIAN											BOMBRE / Dolomite	BOMBRE / CAMBELL / DELORME	Dolomite ?			RONNING	Dolomite	Dolomite
SILURIAN					CHEDA-BUCTO			Limestone Shale Conglomerate ?	Limestone Shale	Limestone Shale Sandstone ?		WHITTAKER		MT KINDLE / FRANKLIN MTN.	MT KINDLE / FRANKLIN MTN.			
ORDOVICIAN				MIRAGE POINT	LAMARTRE ? / MAZENOD ?				Shale Dolomite Limestone				Dolomite					
?					OLD FORT I. ?				BUNBLOOD	BUNBLOOD ?		BUNBLOOD	? Dolomite Sandstone ?	SALINE R. / MT CAP / MT CLARK / LONE LAND / Shale Sandstone Dolomite	SALINE R. / MT CAP	MacDOUGAL / KATHERINE		Shale Gypsum Sandstone ?
CAMBRIAN									Sandstone Dolomite Shale ?			Dolomite Sandstone ?						
PRECAMBRIAN			Igneous and metamorphic rocks	Sedimentary Igneous and metamorphic rocks	Igneous and metamorphic rocks	Sedimentary Igneous and metamorphic rocks			Argillites									

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CORRELATION OF DEVONIAN AND OLDER PALAEOZOIC ROCKS OF DISTRICT OF MACKENZIE

Plate 9 (from Douglas, Norris, Thorsteinsson and Tozer, 1963)

Period		CAMPBELL UPLIFT 32	RICHARDSON MTNS. TRAIL RIVER 33	RICHARDSON MTNS. NORTHERN 34	WEST KEELE AND OLD CROW RGES. 35	OGILVIE MTNS. PORCUPINE R. 36	OGILVIE MTNS. BLACKSTONE R. 37	WERNECKE MTNS. WIND RIVER 38	NORTHERN MACKENZIE MOUNTAINS KNORR RANGE 39	NORTHERN MACKENZIE MOUNTAINS SNAKE RIVER 40	NORTHERN MACKENZIE MOUNTAINS CRANSWICK R. 41
Overlying			Carboniferous	Penn.		Mississippian	Mississippian	Tertiary		Mississippian	Lower Cretaceous
DEVONIAN	Upper		IMPERIAL				IMPERIAL	IMPERIAL		IMPERIAL	IMPERIAL
	Middle	Limestone Dolomite	Shale	Limestone		Limestone	Shale Limestone	Shale	Shale	Shale Limestone Dolomite	Shale Limestone Limestone
	Lower				?		? Shale ?	?	?		
SILURIAN		Dolomite	ROAD RIVER Shale	Limestone	Limestone	Dolomite	ROAD RIVER	ROAD RIVER	Shale Limestone	Dolomite Limestone	Dolomite
ORDOVICIAN			Limestone	Limestone Dolomite		Dolomite	Dolomite	Limestone Dolomite	Limestone Dolomite	Dolomite	Dolomite
CAMBRIAN		Dolomite Siltstone	Siltstone Limestone	Dolomite Mudstone		MACDOUGAL	MACDOUGAL	MACDOUGAL		Conglomerate Hematite MACDOUGAL KATHERINE	MACDOUGAL KATHERINE
PRECAMBRIAN			Phyllite		TINDIR	TINDIR	Phyllite	Phyllite	Slate	Phyllite	Phyllite

GEOPHOTO SERVICES LTD.

CORRELATION OF DEVONIAN AND OLDER PALAEOZOIC ROCKS OF NORTHERN YUKON

Plate 10 (from Douglas, Norris, Thorsteinsson and Tozer, 1963)

PERIOD		PETITOT RIVER 42	LIARD PLATEAU 43	PEEL CANYON 44	OGILVIE MTNS 45	NORTHERN RICHARDSON MTNS 46	BRITISH MTNS 47	NORTHEAST MELVILLE ISLAND 48	NORTHEAST MELVILLE ISLAND 49	GRINNELL PENINSULA 50	ELLESMERE I BLIND FIORD 51	AXEL HEIBERG I WHITSUNDAY BAY 52	ELLESMERE ISLAND NORTH OF CANYON FIORD 53	ELLESMERE ISLAND NORTH OF CANYON FIORD 54	ELLESMERE ISLAND BLAA MTN 55	NORTHERN AXEL HEIBERG I 56
Overlying		L. Cretaceous	L. Cretaceous	L. Cretaceous	Triassic	Jurassic	Pre-Jurassic Sandstone	Triassic	Triassic		Triassic	Triassic	Triassic	Triassic	Triassic	Triassic
PERMIAN	Upper	FANTASQUE	FANTASQUE		TAHKANDIT			ASSISTANCE	ASSISTANCE	ASSISTANCE	Chert Shale Siltstone	—?—	ASSISTANCE	ASSIS-TANCE	Siltstone Shale	Red sandstone / Chert / Basalt
	Lower			Sandstone	Calcarenite Shale	Siltstone Sandstone Limestone	?		SABINE BAY / BELCHER CHANNEL	BELCHER CHANNEL	BELCHER CHANNEL	Siltstone Shale Sandstone	SABINE BAY / Siltstone Sandstone / Anhydrite	SABINE BAY / BELCHER CHANNEL	Siltstone Shale Limestone	Limestone
PENNSYLVANIAN	Upper		Upper								Limestone Siltstone		Limestone	Limestone / CANYON FIORD	Reef Limestone	
	Middle		MATTSON	Calcarenite	Calcarenite		Shale	CANYON FIORD	CANYON FIORD							
	Lower		Middle		—?— Limestone Shale —?— Shale							Anhydrite Gypsum			Anhydrite Gypsum	Anhydrite Gypsum
MISSISSIPPIAN	Upper	MATTSON	Lower	? Limestone Shale	Limestone Shale									Lower Palaeozoic		Sandstone Coal
	Middle	FLETT	FLETT													
	Lower	BANFF	CLAUSEN / YOHIN				—?— Lisburne limestone —?— Kyak shale									
		EXSHAW	? Upper Devonian													
Underlying		KOTCHO		IMPERIAL	IMPERIAL ?	IMPERIAL	Precambrian NERUOKPUK	L and M Palaeozoic	L and M Palaeozoic	CORNWALLIS						

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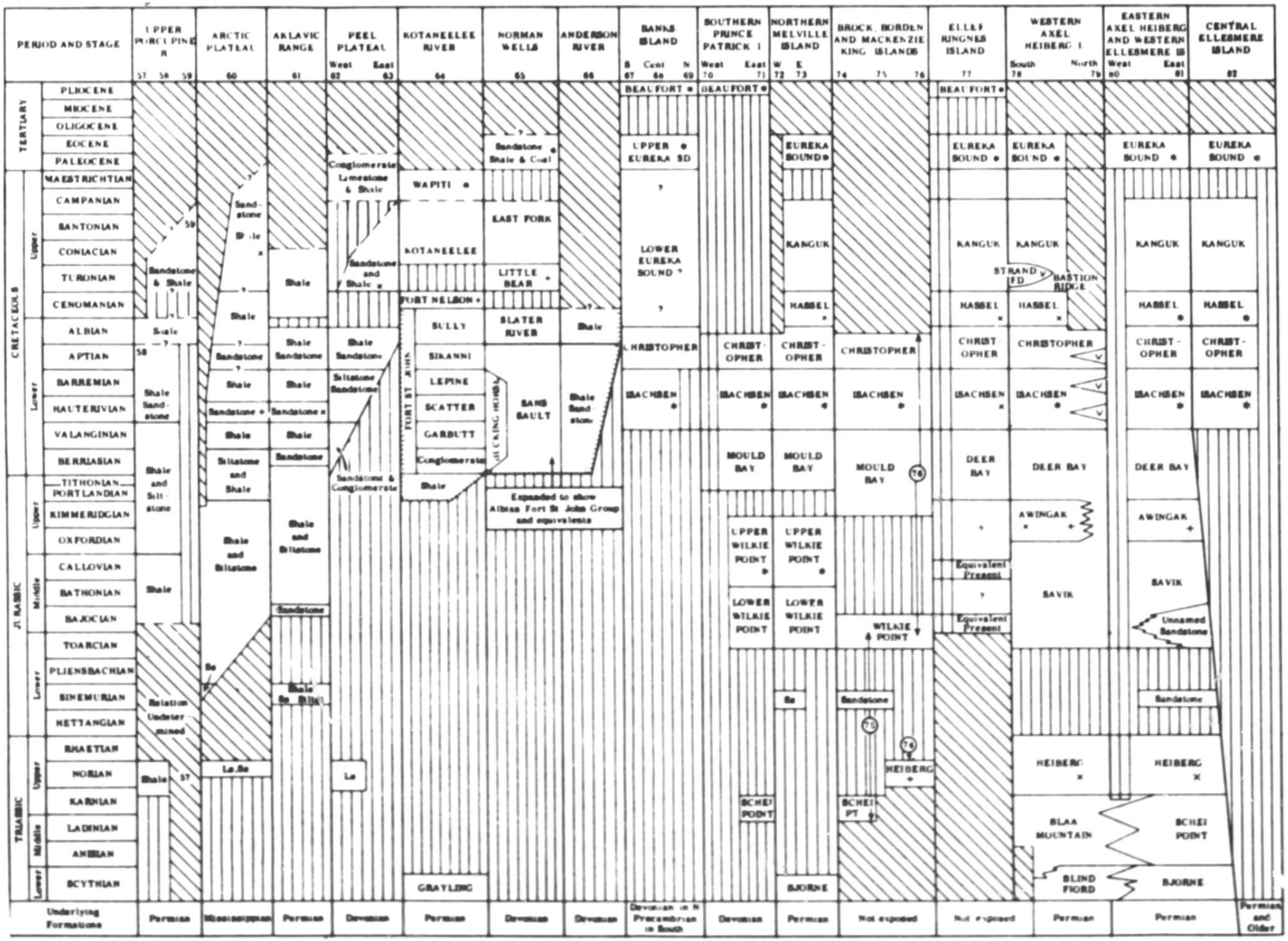
CORRELATION OF CARBONIFEROUS AND PERMIAN ROCKS OF NORTHERN CANADA

Plate II (from Douglas, Norris, Thorsteinsson and Tozer, 1963)



Basalt V Entirely Nonmarine • Dominantly Nonmarine × Partly Nonmarine + Remaining formations are Marine

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CORRELATION OF MESOZOIC ROCKS OF NORTHERN CANADA

ology and thickness are derived from published sources, from the photogeologic study, and from field observations supplied to Geophoto by a major oil company (see Introduction).

Several stratigraphic illustrations are included to facilitate the presentation of stratigraphic details. Plates 5, 6, and 7 are reproduced from the legend of the accompanying photogeologic maps, and show the map units used in the photogeologic study. Plates 8, 9, 10, and 11 are correlation charts reproduced from Douglas et. al. (1963), and show the relation of the stratigraphic units of the project area to the stratigraphic units of other areas in northern Canada. Plates 12 through 16 are columnar sections, at the scale of one inch equals 200 feet. Some of these sections were field measured, others were measured with photogrammetric instruments. Plate 17 is a stratigraphic panel diagram, which correlates stratigraphic sections in the project area.

PROTEROZOIC ROCKS

Type Locality

Proterozoic strata exposed within the project area can presumably all be referred to the Katherine Group, the type locality of which is in the vicinity of Katherine Creek, in map area 96D/NW. This group was named by Link in 1921 (Hume, 1954).

Distribution

Proterozoic strata are extensively exposed in the Mackenzie Mountains in the southern part of the project area.

Mapping Methods

East of the 129th meridian the Precambrian-Cambrian unconformity is visible on the air photographs, and the Precambrian strata are separately mapped with the symbol pЄ. West of the 129th meridian, the Precambrian-Cambrian contact cannot be readily detected on the air photographs, and in this area all Precambrian strata are mapped with the overlying Cambrian rocks as the map unit ЄpЄ.

Lithology and Thickness

Nauss (1944) reports that at the crest of Macdougal anticline, in the vicinity of Dodo Creek (map area 96D/NW), 450 feet of interbedded quartzite and black platy shale of the Katherine Group are exposed. Nauss reports that the upper 75 feet of this group contains petroliferous limestone and sandy limestone. Large outcrop areas of Katherine Group are mapped in the western part of the Mackenzie Mountains and in the Knorr Range (map area 106E/SE) by Norris et. al. (1963). Norris does not report an exposed thickness of the Katherine Group in this region, or a lithology, except to note that it is composed primarily of non-metamorphic rocks of a clastic nature.

Contacts

The lower contact of the Katherine Group is not exposed within the project area. The upper contact of the Katherine Group is an unconformity, either sub-Cambrian or sub-Ronning. At some places this unconformity is a distinct angular unconformity; at other localities, particularly in the Knorr Range, no angular discordance is apparent.

Age

The Proterozoic age of the Katherine Group is based upon its lithology and stratigraphic position. At some places the group is overlain by Middle or Upper Cambrian strata of the Macdougal Group. It appears possible that the Katherine Group may include Lower Cambrian rocks.

Correlation

Late Precambrian sedimentary rock is widespread in the eastern part of the Cordillera of Western Canada. Approximately 130 miles west of the project area, along the International Border, the slightly metamorphosed strata of the Tindir Group are believed to be an approximate equivalent of the Katherine Group.

CAMBRIAN MACDOUGAL GROUP

Type Locality

The type locality of the Macdougal Group is in the upper reaches of the Macdougal River at Dodo Canyon. It was named by T. A. Link in 1921 (Hume, 1954).

Distribution

Within the project area rocks of the Macdougal Group are irregularly distributed in the Mackenzie Mountains, and a very large area of Cambrian rocks, that are probably Macdougal equivalents, is exposed in the core of the Richardson Mountains in the western part of the project. The distribution of the Macdougal Group under the Peel Plateau is unknown; the regional cross-sections show the postulated distribution of the Macdougal in the project area.

Mapping Methods

East of the 129th meridian the Macdougal Group can be recognized on the air photos and is mapped with the symbol Є. West of the 129th meridian, in the Mackenzie Mountains, the Macdougal cannot be separated from the underlying rocks of the Katherine Group, and the two units are mapped together with the symbol ЄpЄ. To the northwest, in the Richardson Mountains, probable Macdougal equivalents are mapped with symbol Є. At the structurally highest part of the Richardson Mountains a limestone unit is exposed which may be a lower member of the Macdougal Group. This limestone unit is mapped with the symbol Єls.

Lithology and Thickness

In 1944, Nauss examined the type locality of the Macdougal Formation and measured 1, 195 feet of section which he divided into six formational units. These formational names have not been widely used. Nauss' section is as follows:

Dodo Formation	50 ft.	Dark-gray limestone.
	50 ft.	Greenish-gray and chocolate covered shale.
Sanguine Gypsum	400 ft.	Soft reddish weathering gray sandy mudstone, and gypsum.

Clemis Formation	150 ft.	Black platy shale.
	40 ft.	Slate colored limestone, and interbedded black shale.
	38 ft.	Green silty shale.
Alder Sandstone	88 ft.	Blocky rusty weathering hard sandstone, with interbeds of black shale.
Echo Canyon Limestone	200 ft.	Hard ridge-forming limestone.
Dead End Shale	15 ft.	Green shale.
	14 ft.	Red shale.
	20 ft.	Interbedded red and green calcareous shale.
	130 ft.	Chocolate colored calcareous shale.
	1, 195 ft.	Total Thickness

In the extreme western part of the project area, in the Richardson Mountains, a limited amount of field control and published information is available regarding the lithology and thickness of probable Macdougal equivalents. In the structurally highest part of the Richardson Mountains, at approximately 66° 10' N, 135° 45'W, a moderately large outcrop of Cambrian limestone is indicated with the symbol €ls. This lime stone unit may be a lower member of the Macdougal Group. Norris, et. al. (1963), report that at least 1, 200 feet of limestone is exposed in this locality, and that the unit contains Early Cambrian fossils. This limestone unit is composed of light-gray to light-brown medium-crystalline fairly massive beds. Overlying the limestone unit is a photo-estimated 5, 000 to 6, 000 feet of siltstone, sandstone, and shale, which crops out extensively in this part of the Richardson Mountains. No fossils have been reported from this succession of clastic rocks, but it is presumed to be of Cambrian age, and an equivalent of the Macdougal Group.

In the Snake River area, near the southern project boundary, a unit of conglomeratic mudstone occurs between the Macdougal Group and the overlying Ronning Group (Norris, et. al., 1963). This unit has a

local distribution and wedges-out northerly. A thin wedge-edge of this unit is present in the mapped area, and is included in the €p€ map unit. South of the mapped area this unit attains a maximum thickness of about 4,000 feet. Norris et. al. (1963) assign this unit to the Upper Cambrian Series. This mudstone unit is notable in that it contains a zone of siliceous hematite which ranges up to several hundred feet thick. The deposits are being developed by the Crest Exploration Company.

Contacts

In the Mackenzie Mountains the contact between the Precambrian Katherine Group and the overlying Cambrian Macdougal Group is a distinct angular unconformity. In the Richardson Mountains the base of the Macdougal Group is not exposed. The upper contact of the Macdougal Group in the Mackenzie Mountains is also a distinct angular unconformity. This relationship is extremely well displayed on the flanks of the Cambrian anticline in map area 106H/SE. It will be noted at this locality that the section of Macdougal rock exposed on the northeast flank of the anticline is considerably thinner than that exposed to the southwest. This rapid northeasterly thinning of the Macdougal is a result of bevelling below the sub-Ronning unconformity. In the Richardson Mountains the contact between the Cambrian (Macdougal?) strata and the overlying Ordovician argillaceous limestone unit is transitional. This contact is well exposed in the vicinity of the Trail and Road Rivers, where the upper part of the Macdougal becomes argillaceous and calcareous, and grades transitionally into the overlying limestone unit which bears Ordovician fauna.

Age

At the type locality the Macdougal Group carries a fauna indicative of Middle and Late Cambrian age. The Lower Cambrian limestone unit exposed in the Richardson Mountains is apparently the oldest Cambrian rock within the project area, and perhaps should not be included as a member of the Macdougal Group.

Correlation

The Macdougal Group grades laterally to the southeast into the Mt. Clark, Mt. Cap, and Saline River Formations of the Mackenzie Plain area.

CAMBRIAN MT. CLARK, MT. CAP, AND SALINE RIVER FORMATIONS

Type localities of the three above named formational units are in the Mackenzie Plain area, south of the area of the present project. These three rock units apparently grade northwesterly into the previously described Cambrian Macdougal Group. In the extreme southern and southeastern part of the mapped area a few rock exposures are present where the Mackenzie Plain Cambrian terminology is used. The Mt. Clark Formation is mapped with the symbol Cmc, whereas the Mt. Cap and Saline River Formations, which cannot be separated on the air photos, are mapped with the symbol Csrmc.

The Mt. Clark Formation is a sandstone unit several hundred feet in thickness, consisting of fine-grained white cross-bedded quartzose sandstone. A very small exposure of this unit is mapped in the southwestern part of map area 96D/NE.

The Mt. Cap Formation is a soft olive-green shale, and the overlying Saline River Formation is composed of red and green gypsiferous shale, and salt. Together these two formations form a recessive map unit, approximately 500 to 600 feet thick. Exposures of this unit are mapped in the McConnell Range.

ORDOVICIAN MAP UNIT

Distribution and Mapping Methods

In the western part of the project area, on the east flank of the Richardson Mountains, a thick sequence of argillaceous limestone is identified as Ordovician and is shown on the accompanying photogeologic maps with the symbol O. This map unit apparently forms the lower part of the Road River Formation as described by Jackson and Lenz (1962). This unit, however, is a distinct lithologic unit, has a widespread distribution within the Richardson Mountains, and is probably deserving of separate formational status.

Lithology and Thickness

Field reconnaissance along the Road River indicates that the Ordovician map unit consists of at least 6,000 feet of argillaceous limestone with interbedded calcareous shale. At this locality the upper portion of the map unit is faulted against younger rocks, and total thickness of the unit is unknown. A short distance to the north the unit is present in normal contact with overlying and underlying strata, and photogeologic observations suggest that the 6,000 foot figure is close to the maximum thickness.

Contacts

The lower contact of the Ordovician map unit is transitional with the underlying shale and siltstone of the Cambrian map unit. The upper contact has not been field observed; photogeologic studies indicate the contact is probably conformable and transitional.

Age

Along the Road River the Ordovician map unit contains a zone of Dictyonema which is believed to be indicative of an Ordovician age. The detailed palaeontologic work of Jackson and Lenz indicates an abundance of Ordovician fauna in this part of the section.

Correlation

A very thick section of argillaceous graptolitic strata of Ordovician, Silurian, and probable Early Devonian age exists in the vicinity of the Richardson Mountains. To the east and to the west this argil-

laceous section grades laterally into thinner carbonate equivalents. The contacts as mapped in the photogeologic evaluation are based on lithology rather than time boundaries. It is very likely that the Ordovician map unit may include only Ordovician strata at some localities, and at other localities include Ordovician and Silurian strata. The exact relationship between the argillaceous and graptolitic section of the Richardson Mountains and the predominately carbonate section of the Mackenzie Mountains is not clearly established. The Ordovician map unit of the Richardson Mountains is believed to be equivalent to some part of the Ordovician and Silurian carbonate map unit of the Mackenzie Mountains. It is noted that along the Snake River, in map area 106F/SW, graptolitic shales are interbedded with the dolomites of the lower part of the Ordovician and Silurian map unit.

SILURIAN AND LOWER DEVONIAN MAP UNIT

Distribution and Mapping Methods

In the vicinity of the Richardson Mountains a thick section of argillaceous and graptolitic strata is mapped with the symbol DlS. This section, in general, is recessive in outcrop, and its distribution can be fairly readily recognized on the air photos. Here again it is noted that the boundaries of this map unit are based primarily on lithology and the resultant morphology of the outcrop area. Because of the rapid facies changes in this area the Silurian and Lower Devonian map unit may at some places include Ordovician or Middle Devonian strata.

Lithology and Thickness

Along the Road River the DlS map unit consists of approximately 5,000 feet of black graptolitic siltstone and shale, and black and green chert. At this locality the lower part of the map unit is in fault contact with the underlying Ordovician map unit, and the total thickness may be somewhat greater. Farther south, in the vicinity of Prongs Creek (map area 106E/SW), the DlS map unit is photo-estimated to be 2,000 feet thick. At Margery anticline (map area 106E/NE) the DlS map unit is photo-estimated to be 1,200 feet thick, with the base not exposed. Exposures of the DlS map unit on the north plunge of Margery anticline consist of approximately 600 feet of very argillaceous buff-weathering limestone, underlain by approximately 600 feet of dark-gray fissile graptolitic shale. It is interesting to note that on the south plunge of Margery anticline, only 2 miles farther south, the DlS map unit is composed primarily of carbonate rock. The facies boundary between these two equivalent sections is well expressed in the topography, and is shown on the accompanying maps as a zig-zag line.

Contacts

In the central part of the Richardson Mountains the contact between the DlS unit and the underlying Ordovician argillaceous limestone appears to be conformable and probably transitional. At Prongs Creek the DlS unit rests with a sharp contact on massive carbonate rock which is reported by Raasch (1960) to be entirely of Ordovician age. The base of the unit is not exposed at Margery anticline. Along the Road River the DlS map unit is overlain by a few hundred feet of

limestone carrying Middle Devonian fauna. The contact is sharp, but there is no evidence of angular discordance. A few miles farther south, along the Trail River, the DlS map unit is directly overlain by black siliceous shales of the Middle Devonian Canol Formation. On the Trail River this contact is marked by a one foot zone of red weathering argillaceous material, which may represent an erosional unconformity. At Prongs Creek the DlS unit is overlain transitionally by argillaceous limestone and interbedded shale of Middle Devonian age. At Margery Creek the DlS map unit is overlain by 120 feet of limestone breccia containing Middle Devonian fossils. A similar limestone breccia overlies the DlS map unit along the Peel River (map area 106E/NE).

Age

The DlS map unit corresponds to the upper part of the Road River Formation as defined by Jackson and Lenz (1962). The Ordovician-Silurian boundary as established by Jackson and Lenz does not correspond with any specific lithologic boundary, but falls within a shale section. Therefore, it appears probable that the DlS map unit, as mapped along the Road River, probably includes, at its base, some Ordovician strata. At Prongs Creek Raasch (1960) reports Silurian fauna within 120 feet of the base of the DlS unit. At this locality the shales of the DlS unit are underlain by massive carbonate rocks which Raasch assigns a tentative Late Ordovician age.

Similar strata farther west in the Ogilvie Mountains are reported by Norris, et. al. (1963) to range from Late Silurian to Early Devonian. Insofar as the axial part of the early Paleozoic graptolitic shale basin appears to have been in the vicinity of the Richardson Mountains, it appears reasonable to assume that Early Devonian strata were deposited in the Richardson region. For this reason the map unit herein described is assigned an age range which includes the Early Devonian. It is emphasized that the DlS map unit is a morphologic unit which includes shale and siltstone, and outcrops in a distinctive valley-forming belt. Because of the rapid facies changes in this area the age of the sequence is probably not constant from place to place, and the unit may include strata both older and younger than the assigned age. The assigned age of Silurian and Early Devonian is believed to cover the age range of the greater part of the interval.

Correlation

The argillaceous strata of the DlS unit grade laterally, both to the east and west, into carbonate rock.

LOWER AND MIDDLE DEVONIAN SHALE UNIT

The Lower and Middle Devonian shale unit (Dmls) outcrops as a distinctive valley-former on the east flank of the Knorr Range in map area 106E/SE. At this locality the Dmls map unit consists of approximately 1, 200 feet of calcareous shale and siltstone. The Dlms map unit is lithologically similar to, and unquestionably a lateral equivalent of, the previously described DlS map unit. At this locality, however, faunal evidence indicates that the interval does not contain Silurian strata, hence a different map symbol is used.

At this locality, on the east flank of the Knorr Range, an interesting development of pinnacle reefs is present in the Dlms map unit. These reefs occur as discrete masses within the surrounding shale and siltstone, and range from 20 to 50 feet in diameter. These reefs eroded as distinct pinnacles which rise above the surrounding siltstone and shale, and are readily visible on the air photographs and in the field. The pinnacle reefs are shown on the accompanying photogeologic maps as a series of distinct oval shapes within the Dlms map unit.

On the east flank of the Knorr Range the Dmls map unit is underlain with apparent conformity by silty carbonate rock which carries a Silurian fauna, and is overlain by argillaceous limestone of late Middle Devonian (post-Hume) age.

ORDOVICIAN AND SILURIAN RONNING GROUP, AND ORDOVICIAN AND SILURIAN MAP UNIT

Type Locality

The type locality of the Ronning Group is at Mt. Ronning in the Mackenzie Mountains, where T. A. Link, while in the employment of Imperial Oil Limited, first applied the name Mt. Ronning Formation. Hume (1954) raised the Ronning to a group status and noted that it is equivalent to the Franklin Mountain and Mt. Kindle Formations of the Franklin Mountains area.

Distribution and Mapping Methods

The contact between the two formations which compose the Ronning Group is not visible on the air photographs, and on the accompanying photogeologic maps the Ronning Group is shown as a single map unit with the symbol SOr. The Ronning Group is mapped in the Franklin Mountains, and in the Mackenzie Mountains as far west as approximately the 131st parallel. West of this parallel the equivalent strata are mapped simply as SO. Because of the great distance from the type locality at Mt. Ronning, it was not felt advisable to extend the use of the term "Ronning Group" west of the 131st parallel. Where the Mackenzie and Richardson Mountains intersect, at approximately the 134th meridian, facies changes occur and much of the SO map unit grades northwesterly into a shale unit. Outcrops of massive carbonate in the vicinity of the Bonnet Plume Basin are mapped as a part of the SO carbonate unit, although it is realized that because of lateral facies changes these rocks may be mainly of Ordovician age.

At some localities, the carbonate rocks of the SOr and SO map units cannot be separated on the air photographs from the overlying Devonian carbonate rocks, and combined mapping units are used.

Lithology and Thickness

The Ronning Group and equivalent strata along the front of the Mackenzie Mountains and in the Franklin Mountains are typically dolomite, light to dark-gray, occasionally tan, hard, siliceous, and cherty at some localities. At some places it has been noted in the field that the Ronning may be conveniently divided into two divisions. The basis for this division is an upward change from cherty to non-cherty dolomite, with a corresponding change from a dark-gray to a light-gray color. Although this division is not sharp, it can be located within

100 feet or so in any one section, and can be observed at most localities between the 130th and 134th meridians. It is possible that this two-fold division may exist east of the 130th meridian and may ultimately grade southeasterly into the contact between the Franklin Mountain and Mr. Kindle Formations.

Thicknesses of the Ronning Formation and equivalent strata within the project area are as follows:

Carcajou River (map area 96D/NW)	1, 830 ft. (Nauss, 1944)
Imperial River (map area 106H/SE	1, 240 ft. (Laudon, 1943)
Lemming anticline (map area 106F/SE):	
Upper Ronning	1, 800 ft.
Lower Ronning	2, 000 ft.
Snake River (map area 106F/SW):	
Upper Ronning	2, 950 ft.
Lower Ronning	1, 900 ft.

It will be noted from the above figures that the Ronning and equivalent strata show a great increase in thickness in a westerly direction. The nature of this thickening is not fully understood, but in the western areas where the Ronning is divided into two parts, it appears that the thickening is confined to the upper part.

At the most westerly localities, such as at the Snake River, interbeds of limestone were noted in the dolomites of the lower part of the Ronning Group.

Contacts

The lower contact of the Ronning Group is an angular unconformity. Where this formation overlies the Macdougal Group (as at Cambrian anticline in map area 106H/SE), it can be demonstrated that the unconformity cuts down-section in a northerly direction. Farther west, along the main front of the northern Mackenzie Mountains, similar details cannot be noted on the air photographs; however, Norris, et. al. (1963) map a similar relationship. In this area, along the front of the mountains, the Ronning Group rests on the Precambrian Katherine Group. A few miles to the south, on the south flank of the frontal fold of the Mackenzie Mountains, the Macdougal Group intervenes between the Ronning and Katherine Groups.

The upper contact of the Ronning Group is believed to be an unconformity in the eastern part of the project area, but to the west, where a thicker section is present, this contact may be conformable.

Age

There is little specific information available on the age of the Ronning Group in this region, except that it embraces Ordovician and Silurian strata. The unconformity at the base of the Ronning Group is tentatively dated as mid-Ordovician on regional considerations. It appears quite possible, however, that at westerly localities Lower Ordovician strata may be present. Norris, et. al. (1963) imply that at western localities these strata may include Upper Cambrian rock.

LOWER(?) DEVONIAN BEAR ROCK FORMATION, AND EQUIVALENT LIMESTONE STRATA

Type Locality

The type locality of the Bear Rock Formation is along the Mackenzie River at Bear Rock in map area 96C/NW (Hume and Link, 1945). West and southwest of the type locality the breccias of the Bear Rock Formation grade laterally into limestone strata.

Distribution and Mapping Methods

Within the project area the Bear Rock Formation is widely distributed in the Franklin Mountains, and where it can be recognized on the air photographs is mapped with the symbol Dbr. At some localities it is necessary to group the Bear Rock with other strata in a broader age range map unit. In the Mackenzie Mountains the Bear Rock Formation can be recognized as far west as approximately the 129th meridian. West of this locality equivalent strata do not have typical Bear Rock lithology, and are mapped simply as Lower(?) Devonian (Dl). At some places the Lower(?) Devonian strata must be grouped with either overlying or underlying strata in broader map units. Still farther west, in the vicinity of the Richardson Mountains, the Lower(?) Devonian limestone strata grade into an argillaceous section which has been described.

Lithology and Thickness

At the type locality the Bear Rock comprises some 250 feet of poorly bedded brecciated limestone and dolomite. It has been suggested that these breccias are collapse breccias resulting from the solution of associated evaporites (Bassett, 1960). To the west the Bear Rock grades into slightly argillaceous limestones, which typically outcrop in light-gray and dark-gray bands approximately 50 to 100 feet thick. These banded limestones form a good photogeologic map unit at some places.

Reported thicknesses of the Bear Rock and equivalent strata are as follows:

Carcajou River (map area 96D/NE)	400 ft. of breccia (Nauss, 1944)
Imperial River (map area 106H/SE)	400 ft. of breccia (Laudon, 1943)
Lemming anticline (map area 106F/SE)	1, 100 ft. banded limestone

Contacts

The lower contact of the Bear Rock Formation is everywhere sharp, and may represent an unconformity. The upper contact of the Bear Rock Formation is thought by Bassett (1960) to be also unconformable. To the west the contact of the banded limestones with the underlying Ronning is sharp and probably disconformable. The upper contact of the banded unit becomes progressively less distinct to the west, and in the vicinity of the Snake River the banded unit cannot be satisfactorily separated from the overlying Middle Devonian limestone.

Age

The age of the Bear Rock Formation has been the subject of much study and several conflicting opinions have been brought forth. Bassett (1960) states "The age of the greater part, if not all, of the Bear Rock Formation can only be Early Devonian".

Correlation

The relationship of the Lower(?) Devonian banded limestones to the argillaceous strata of the Richardson mobile belt has been discussed. In the southern Mackenzie Mountains, south of the project area, the Bear Rock grades westerly into carbonate rock of the Arnica-Funeral-Manetoe-Landry sequence.

MIDDLE DEVONIAN HUME FORMATION

Type Locality

The term "Hume Formation" was proposed in 1960 by Bassett for the succession of Middle Devonian limestone and, in places, shale, which overlies the Bear Rock Formation and underlies the Hare Indian Formation. The type locality of the Hume Formation is where the east branch of the Hume River intersects the front of the Mackenzie Mountains in map area 106H/SW.

Distribution and Mapping Methods

The Hume Formation is widely distributed within the project area in the Franklin and Mackenzie Mountains. At most places it forms a distinct photogeologic unit which is mapped with the symbol Dh. At other places it is included with other strata in map units with a broader age range. The Hume is recognized along the front of the Mackenzie Mountains as far west as approximately the 133rd meridian. West of this area the Hume is difficult to identify, both in the field and on the air photographs, as it becomes lithologically similar to the underlying Lower(?) Devonian limestone. Still farther west, in the Richardson Mountains area, Hume equivalents are largely absent; a few rather unusual outcrops are mapped.

Lithology and Thickness

The Hume Formation thickens in a southwesterly direction in the project area, and ranges in thickness from approximately 300 feet in the Franklin Mountains to over 900 feet on the north flank of Lemming anticline in map area 106F/SE (see plate 14). At the type locality Bassett (1960) describes the Hume as follows:

30 ft.	Limestone, medium-gray, finely-crystalline, thin- to medium-bedded, very fossiliferous.
15 ft.	Shaly limestone, and calcareous shale, very fossiliferous.
90 ft.	Limestone, light-gray, finely-crystalline, very fossiliferous.
240 ft.	Limestone, argillaceous, brownish-gray to medium-gray, finely-crystalline.
25 ft.	Limestone, medium-gray, finely-crystalline.
400 ft.	Total Thickness

At more westerly locations, such as Lemming anticline, the Hume Formation contains very little argillaceous material, and is a dark-gray micro-crystalline fairly massive limestone unit, with some shale interbeds and fossils near the top.

West of the 134th meridian several isolated outcrops of Middle Devonian limestone are tentatively identified as Hume. At Margery anticline (map area 106E/NE) the previously described DlS argillaceous unit is overlain by 120 feet of limestone breccia, which carries Middle Devonian fossils. On the accompanying maps this limestone breccia is tentatively identified as the Hume Formation. Farther to the northwest, where the Peel River intersects the Road River fault zone (map area 106E/NW), a similar breccia, approximately 120 feet thick, rests on the DlS unit, and is overlain by black shales which are believed to be of the Canol Formation. Farther noth, along the Road River (map area 106L/NW), the DlS argillaceous shale unit is overlain by approximately 200 feet of crinoidal limestone which carries Middle Devonian fauna. These limestones are overlain by 200 feet of calcareous shale, which is tentatively assigned to the Middle Devonian Hare Indian Formation. At the Road River locality the Middle Devonian limestone and the overlying shale section is indicated on the accompanying photogeologic maps as Middle Devonian (Dm).

Contacts

In the Franklin Mountains and in the more easterly parts of the Mackenzie Mountains the contact between the Bear Rock Formation and the overlying Hume is sharp and probably disconformable. To the west, in the vicinity of the Snake River, the contact is less sharp, and in this region may be transitional. Still farther west, in the Richardson Mountains area, the previously described limestone breccia and crinoidal limestone rest with a sharp contact on the underlying argillaceous rocks of the DlS map unit. In the Franklin Mountains, and eastern part of the Mackenzie Mountains, the contact between the Hume Formation and the overlying Hare Indian Formation is fairly sharp, but gives some evidence of being transitional. In the Richardson Mountains the contact between the Middle Devonian limestone section and the underlying DlS strata is sharp. At the Road River the limestone is overlain by calcareous shale, presumably of the Hare Indian Formation, which is, in turn, sharply overlain by siliceous shale of the Canol Formation. A few miles farther south, at the Trail River, the Canol rests directly on the DlS unit, having overlapped the Dm section.

Age

Abundant fossil material in the Hume Formation indicates an early Middle Devonian age.

Correlation

The Hume Formation appears to be a direct lateral and time equivalent of the Nahanni Formation of the southern Franklin Mountains area. Prior to 1960 the Hume Formation was commonly referred to as the "lower limestone member of the Ramparts Formation". This terminology has been largely abandoned because of a history of inaccurate useage.

MIDDLE DEVONIAN HARE INDIAN FORMATION

Type Locality

The lower end of the Ramparts gorge of the Mackenzie River in map area 106I/SE (Kindle and Bosworth, 1921).

Distribution and Mapping Methods

The Hare Indian Formation is widely present in the Franklin Mountains and the Mackenzie Mountains. To the west, in the Richardson Mountains, a few isolated occurrences of strata that are presumably part of the Hare Indian Formation are present.

Where recessive beds of the Hare Indian Formation are overlain by the resistant Kee Scarp Formation the Hare Indian can be mapped on the air photographs, and is indicated with the symbol Dhi. At other localities the Hare Indian is included in broader map units.

Lithology and Thickness

Bassett (1960) reports that north of 65° 20' north latitude the Hare Indian is characteristically a greenish-gray calcareous shale with interbeds of argillaceous limestone. South of this latitude, however, the shales are characteristically dark-gray and only slightly calcareous.

Throughout the Franklin Mountains and the eastern part of the Mackenzie Mountains the Hare Indian Formation has an average thickness of 500 to 600 feet. Farther west, along the front of the Mackenzie Mountains, in the Snake River region, approximately 1, 200 feet of calcareous shale of the Hare Indian Formation is present. In the Richardson Mountains trend several somewhat unusual occurrences of Middle Devonian shale and limestone are referred to the Hare Indian Formation. On the north plunge of Margery anticline (map area 106E/NE), approximately 2, 100 feet of strata is tentatively mapped as Hare Indian Formation. This section consists of a basal 1, 600 foot interval of fairly resistant argillaceous limestone and calcareous shale, overlain by approximately 1, 500 feet of typical greenish-gray very calcareous Hare Indian type shale. Farther north, along the Road River, approximately 200 feet of calcareous shale is present and tentatively assigned to the Hare Indian Formation.

Contacts

Throughout the Franklin Mountains and the Mackenzie Mountains both

the upper and lower contacts of the Hare Indian Formation appear to be slightly transitional, and probably somewhat diachronous in the Richardson Mountains trend. The upper contact of the Hare Indian is a fairly distinct angular unconformity. This angular unconformity may be observed on the north plunge of Margery anticline, along Margery Creek, where an angular discordance of perhaps 5° exists between the Hare Indian and the overlying Canol Formation. The relationship of the Canol Formation to the underlying Middle Devonian strata along the Road and Trail Rivers has been described in the previous stratigraphic data sheet.

Age

The Hare Indian Formation is abundantly fossiliferous and its Middle Devonian age is well established.

Correlation

It would appear that the Hare Indian Formation is correlative with a part of the Horn River Formation of the southern Franklin Mountains area.

MIDDLE DEVONIAN KEE SCARP FORMATION, AND WESTERLY EQUIVALENT

Type Locality

The term "Kee Scarp" was applied by Canol geologists to limestones exposed at Kee Scarp, 6 miles east of Norman Wells (map area 96E/SE).

Distribution and Mapping Methods

The Kee Scarp Formation is a reefoid limestone development which grades laterally into equivalent shale strata, thus having a somewhat irregular distribution and thickness. The Kee Scarp is widely developed in the Franklin Mountains and along the north front of the Mackenzie Mountains as far west as the 130th meridian, where it apparently grades into shale in a westerly direction. Farther west, in the vicinity of the Snake River, another limestone is developed at approximately the same stratigraphic level as the Kee Scarp. The more or less continuous outcrops of the Kee Scarp Formation in the Franklin Mountains and the eastern part of the Mackenzie Mountains form a readily identifiable photogeologic unit, which is mapped with the symbol Dks. The western development of reefoid limestone in the vicinity of Snake River is mapped as Middle Devonian carbonate rock (Dmc).

Lithology and Thickness

Bassett (1960) recognizes a two-fold division of the Kee Scarp Formation in the eastern part of the project area. In this region the lower limestone beds of the Kee Scarp are brownish-gray, commonly argillaceous, interbedded with shale, and are characterized by a prolific Stringocephalus fauna. The upper Kee Scarp limestones are light-gray, commonly poorly bedded, and at many localities are composed mainly of branching corals and stromatoporoids. In the Franklin Mountains and the eastern part of the Mackenzie Mountains the Kee Scarp ranges in thickness from a wedge-edge to a maximum of approximately 800 feet.

In the western part of the Mackenzie Mountains, in the vicinity of Snake River, there is a development of a reefoid limestone which is presumed to be a more-or-less lateral equivalent of the Kee Scarp Formation. At the Snake River this limestone unit is approximately 500 feet thick, and consists of buff weathering finely-crystalline

argillaceous limestone that is abundantly fossiliferous. Farther west, on the east flank of the Knorr Range, this limestone unit is 1,300 feet thick. These rapid thickness changes are the result of lateral gradation between the reefoid limestone and the Hare Indian shale.

Contacts

The lower contact of the Kee Scarp Formation and equivalent strata is transitional and diachronous. The upper contact is transitional at some places, but may become unconformable to the west.

Age

The Kee Scarp Formation is abundantly fossiliferous and is dated by Bassett (1960) as late Middle Devonian. The presumed Kee Scarp equivalents in the Snake River area carry Middle Devonian fossils; the exact age relationship of this unit with the Kee Scarp Formation is unknown.

Correlation

Bassett (1960) reports that the lower Kee Scarp can be correlated with the dolomites exposed at Presqu'il Point, Great Slave Lake. The upper Kee Scarp beds may be correlated with the Slave Point Formation of northeastern British Columbia.

MIDDLE(?) DEVONIAN CANOL FORMATION

Type Locality

In 1960 Bassett proposed the term "Canol Formation" for the black shale unit which, at most places, directly overlies the Kee Scarp Formation. The type locality of the Canol Formation is on the northwest side of Powell Creek at the Mackenzie Mountain front (map area 106H/NE).

Distribution and Mapping Methods

The Canol Formation is widely distributed within the project area, and equivalents are recognized in the Richardson Mountains trend. At most places in the Franklin Mountains and the eastern part of the Mackenzie Mountains, where the Kee Scarp Formation is present, the basal contact of the Canol Formation can be recognized and mapped on the air photos. Where the Kee Scarp Formation is absent, the Canol Formation cannot be separated on the air photographs from the underlying Hare Indian Formation, and the two rock units are included within a single map unit. The Canol Formation is overlain by distinctly different shales of the lower part of the Upper Devonian Imperial Formation. This contact is readily identifiable where exposed in the field, but, as the two units have a similar topographic expression, the contact is not recognizable on the air photographs at all localities in the project area. East of the 134th meridian the map unit which includes the Canol Formation, either separately or in combination with the Hare Indian Formation also includes the lower shales of the Imperial Formation. West of the 134th meridian the Canol Formation becomes thicker and more resistant, and in this region there is little difficulty in mapping Canol Formation only as the separate map unit. This mapping technique is indicated on the legends of the accompanying photogeologic maps (see Plates 5 and 6).

Lithology and Thickness

At the type locality, at Powell Creek, Bassett (1960) reports the following section of Canol Formation:

75 ft. Shale, dark-gray to black, weathers greenish yellowish and rusty brown, soft to very hard, predominantly non-calcareous; lower one-quarter is mudstone, upper three-quarters very fissile.

This description of the Canol Formation is fairly representative of exposures in the Franklin Mountains and the eastern part of the Mackenzie Mountains, although the thickness varies considerably depending upon the build-up of the underlying Kee Scarp Formation. Maximum recorded thickness of the Canol Formation in this region is 400 feet at the southeastern edge of the Norman Wells field. West of the type locality, along the front of the Mackenzie Mountains, the Canol Formation is at all localities involved in structural complications which preclude accurate thickness determination. It appears obvious, however, that the Canol Formation thickens rapidly in this direction. On the north flank of Margery anticline, along Margery Creek (map area 106E/NE), over 900 feet of the Canol Formation is exposed. In this region the Canol consists of black hard platy siliceous lithographic mudstone, intercalated with similar but fissile shale. The entire sequence is non-calcareous and covered with a surface stain of iron oxide and efflorescence of alum minerals. Marcasite nodules are common in these black shales and mudstones. Farther north, along the Road and Trail Rivers, the Canol Formation is approximately 1,000 feet thick and is composed of black hard siliceous mudstone, which closely resembles black chert. At all localities the Canol Formation is characterized by abundant staining of reddish-brown iron oxide. At some places the iron oxide imparts a reddish-brown color to streams flowing over outcrops of the Canol Formation.

Contacts

In the central and eastern part of the project area the contact of the Canol Formation with the underlying Middle Devonian strata is presumably conformable and transitional. In the Richardson Mountains trend, however, this contact appears to be an angular unconformity. Along Margery Creek (map area 106E/NE) the contact is well exposed, and a dip divergence of approximately 5° exists between Canol Formation and the underlying Hare Indian shale. Farther to the northwest, in the vicinity of the Road and Trail Rivers, the Canol Formation apparently overlaps some 400 feet of Middle Devonian strata in a distance of several miles. The contact of the Canol Formation with the overlying soft silty shales of the Imperial Formation is extremely sharp, and presumably represents a disconformity.

Age

The Canol Formation is relatively unfossiliferous and its age has not been well established. Insofar as the Canol Formation appears to be

more closely related to the underlying Middle Devonian strata than to the overlying Upper Devonian strata, it is herein tentatively placed in the Middle Devonian Series.

Correlation

Prior to the publication of Bassett's work in 1960 the Canol Formation was commonly referred to as the lower part of the "Fort Creek" Formation. The upper part of the "Fort Creek" Formation comprised the silty shales of the lower part of the Imperial Formation. To the southeast the Canol Formation probably grades into some part of the Horn River-Fort Simpson sequence, and into the lower part of the Besa River Formation.

UPPER DEVONIAN MAP UNIT

In the northern part of the Peel Basin a considerable expanse of Upper Devonian strata is shown on the accompanying photogeologic maps with the symbol Du. These strata are composed of shale and silstone, with minor sandstone beds, and are a northerly equivalent of the Imperial Formation (as redefined by Bassett, 1960) At some places this map unit may include beds of the Canol Formation. The Du map unit is overlain with angular unconformity by Cretaceous rock.

UPPER DEVONIAN AND MISSISSIPPIAN IMPERIAL FORMATION

Definition

The Imperial Formation was originally defined by Hume and Link (1945) as a predominantly sandstone section transitionally overlying shales which were then referred to the upper part of the "Fort Creek" Formation. In 1960, Bassett redefined the Imperial Formation to include both the upper sandstone section and the underlying shale section.

Distribution and Mapping Methods

The Imperial Formation occurs throughout the project area, and shows a tremendous increase in thickness in the vicinity of the Richardson Mountains. To the east the lower shaly portion of the Imperial Formation cannot be separated on the air photographs from the underlying shales of the Canol Formation, and as noted in a previous data sheet, the shales are mapped as part of the Canol Formation. The upper sandy portion of the Imperial Formation is a good photogeologic map unit and comprises the Imperial map unit of the accompanying photogeologic maps. Thus, the Imperial to the east, as shown on the accompanying maps, conforms to the original definition of the Imperial Formation, and not to the Imperial as redefined by Bassett (1960). In the Franklin Mountains the Imperial Formation is apparently entirely of Devonian age, and is shown on the accompanying maps with the symbol Di. To the west the Imperial Formation thickens and ranges up-section to include Mississippian strata. An arbitrary change in mapping symbols is made at approximately the 133rd meridian; west of this meridian the Imperial is mapped as MDi. Still farther west, on the east flank of the Richardson Mountains, Imperial equivalents are mapped in a different manner. In this area the hard siliceous mudstone of the Canol Formation is overlain by approximately 7,000 feet of Upper Devonian and Mississippian strata, which grades transitionally upward from interbedded shale and siltstone to sandstone and conglomerate. This entire sequence is mapped with the symbol MDu At some places a key horizon is mapped which separates the predominantly shale-siltstone section from the predominantly sandstone-conglomerate section. This key horizon is indicated on the accompanying maps with the symbol SS, indicating the base of the sandstone sequence.

It will be noted that in the Franklin and Mackenzie Mountains the

Imperial map unit includes only the upper sandy portion of the redefined Imperial Formation, whereas on the east flank of the Richardson Mountains the MDu map unit represents a tremendously thickened section stratigraphically equivalent to all of the redefined Imperial Formation.

Lithology and Thickness

At the type locality along the Imperial River the redefined Imperial Formation consists of a basal section of approximately 360 feet of gray silty shale, overlain transitionally by approximately 2,000 feet of greenish-gray siltstone and sandstone with intercalated light- to medium-gray shale. The top of the Imperial Formation is marked by an erosional unconformity, and considerable lateral variations in the thickness of the formation are noted. At most places along the northern front of the Mackenzie Mountains the Imperial is poorly exposed, and the basal portion is involved in structural complications which preclude accurate thickness measurements. On the east fork of the Cranswick River (see Plate 13) a poorly exposed reconnaissance section indicates a thickness of approximately 3,400 feet of Imperial Formation, composed principally of shale with an uppermost unit of approximately 200 feet of sandstone. It should be noted again, that only the upper sandstone unit is shown on the accompanying photogeologic maps as the Imperial Formation. Farther west at Imperial Ridge, in map area 106F/NW (see Plate 16), the uppermost sandy portion of the Imperial Formation is approximately 2,000 feet thick, and composed of alterations of silty sandstone and shale with zones of clean quartzose sandstone. The underlying shaly portion of the Imperial is not exposed at this locality, and its thickness is unknown. To the northwest, on the east flank of the Richardson Mountains along the Road River, the MDu unit is about 7,000 feet thick, and grades upward transitionally from a shale-siltstone sequence into a sandstone-conglomerate sequence. Still farther north, on the north plunge of the Richardson Mountains (map area 106M/SW), the uppermost sandy portion of the MDu map unit is approximately 7,000 feet thick, and has a lithology similar to that described at the Imperial Ridge section. The lower shaly portion of the MDu map unit was not examined at this locality, but it is evident that the map unit in total is over 10,000 feet thick. It is presumed that a considerable portion of the MDu map unit in the vicinity of the Richardson Mountains is of Mississippian age.

Contacts

In the Franklin Mountains, and along the north front of the Mackenzie

Mountains, the redefined Imperial Formation overlies the Middle(?) Devonian Canol Formation with a sharp contact, which is presumed to be a disconformity. In the same general area the Imperial is unconformably overlain by Lower Cretaceous rock. In the Richardson Mountains trend contact relations are not too clear. Along the Road and Trail Rivers the MDu map unit overlies the Canol Formation with a sharp but apparently conformable contact. Farther north, on the north plunge of the Richardson Mountains, the MDu map unit overlies probable Silurian rock. A similar relationship is mapped in the Illtyd Range in map area 106E/SW. In the northern part of the Richardson Mountains (map area 106M/SW) a very prominent angular unconformity exists between the MDu map unit and the overlying Mesozoic strata. Thus, an unconformity of regional extent exists at the top of the Imperial throughout the Peel and Mackenzie Plain Basins.

Age

In the eastern part of the project area the Late Devonian age of the Imperial Formation is well established. To the west a thickened Imperial section includes Mississippian strata (Bassett, 1960; Norris, et. al., 1963).

CARBONIFEROUS MAP UNIT

In the extreme southwestern part of the project area a small part of the Ogilvie Mountains are mapped. In this area a Carboniferous map unit is present which is not found elsewhere in the project area. This unit rests with apparent conformity on the MDu map unit; the upper contact of the Carboniferous unit is not exposed. Photogeologic studies and the published map of Norris, et. al. (1963) indicate that this Carboniferous section consists of interbedded limestone and shale, and probably ranges through part of the Mississippian and Pennsylvanian Systems. At least 2,500 feet of this unit is exposed on the east flank of the Deception syncline in map area 106E/NW.

UPPER TRIASSIC ROCKS

A few isolated outcrops of Upper Triassic strata are present on the east flank of the Richardson Mountains, a few miles north of the Peel River, and are mapped with the symbol TR. These Triassic strata form a resistant cap on a series of low-lying hills, and are composed of argillaceous to sandy cream-colored limestone, with some intercalated shale. It is estimated that not more than 50 to 100 feet of Triassic rock are present. The Triassic strata rest on clastic rock of the MDu map unit; the contact has not been examined but is presumed to be an unconformity. Fossils recovered from these strata have been assigned a Late Triassic age (Norris, et. al., 1963).

The above described occurrences of Triassic strata are the only known occurrences within the project area. It is presumed, however, that the Jurassic and Lower Cretaceous (KJ) map unit mapped in the northeastern part of the project area may include some Triassic strata in its lower parts.

JURASSIC AND LOWER CRETACEOUS ROCKS OF NORTHERN RICHARDSON MOUNTAINS

Distribution and Mapping Methods

In the northwestern part of the project area, on the east flank and north plunge of the Richardson Mountains, a sequence of Jurassic and Lower Cretaceous strata is present which is not found elsewhere in the project area, but apparently represents a southerly embayment of the Arctic Coastal Basin (see Plate 4). Jeletzky (1958, 1960a, 1960b) has done a considerable amount of field work in this area, and has divided the Mesozoic section into several informal units. Jeletzky's terminology is, however, inadequate for photogeologic mapping, as he has apparently given names with lithologic connotations to time stratigraphic units. For example, Jeletzky notes that his "upper shale-siltstone division" is composed mainly of sandstone south of the Rat River. The rapid facies changes in this area, coupled with the highly mantled nature of the outcrops, preclude photogeologic mapping of the many divisions reported by Jeletzky. It is possible, however, to divide the section into two distinct map units. The lowermost portion of this Jurassic and Lower Cretaceous section is composed of sandstone and conglomerate, and forms resistant topography. This part of the Mesozoic section is shown on the accompanying maps with the symbol KJ. The overlying strata are, for the most part, recessive in outcrop and are mapped with the symbol Kl_1. At a few localities stratigraphic breaks can be observed for short distances on the air photographs which correspond to the contacts between some of Jeletzky's informal divisions. Where these breaks can be observed on the air photographs, they are indicated on the accompanying maps as key horizons with an appropriate note.

Lithology and Thickness

On the north branch of the Vittrekwa River (map area 106M/SW) the KJ map unit is approximately 1,000 feet thick, and consists of two distinct parts. The lower part is a sequence of maroon-colored shale and siltstone with abundant plant remains. These red beds carry pelecypods which are dated as Jurassic. Overlying the red beds is 200 to 300 feet of glauconitic quartzose sandstone, presumably of Early Cretaceous age. A few miles farther south on another branch of the Vittrekwa River (map area 106L/NW), the KJ unit consists mainly of boulder conglomerate. Still farther south, near Bernard Creek (map area 106L/NW), the KJ unit is composed of buff-colored sandstone and pebble conglomerate with abundant plant remains and

small seams of carbonaceous matter. Overlying the KJ unit, throughout the northeastern part of the project area, is several thousand feet of shale and siltstone, with at least one zone of 50 to 100 feet of sandstone. Unconformably overlying the shale-siltstone sequence is 200 to 300 feet of quartzose sandstone. This sandstone is one of the best marker beds in this part of the section, and has been termed the "upper sandstone division" by Jeletzky. In the photogeologic evaluation, the top of the "upper sandstone division" is the upper contact of the Kl_1 map unit. It is estimated that as much as 4,000 feet of Kl_1 map unit is exposed along the tributaries of the Vittrekwa River.

Contacts

The contact between KJ map unit and the underlying sandstone of the MDu map unit is a distinct angular unconformity. This angular relationship can be readily recognized on the air photographs, and is particularly evident at the north plunge of the Richardson Mountains at approximately 67°12'N, 135°55'W. It is very probable that other unconformities exist within the KJ map unit, but these cannot be recognized on the air photographs. The contact between the KJ map unit and the overlying shale and siltstone of the Kl_1 map unit is apparently conformable. The uppermost sandstone member of the Kl_1 map unit rests with great angular discordance on older strata. Near the mouth of Stony Creek, at Shiltee Rock, this "upper sandstone division" rests on Upper Devonian shale and siltstone. To the west a wedge of Lower Cretaceous strata intervenes between these two rock types, and in the upper reaches of Stony Creek the "upper sandstone division" is separated from the Upper Devonian shale and siltstone by at least four to five thousand feet of Mesozoic strata, plus an additional several thousand feet of Imperial type sandstone. This eastern overlap of some 7,000 to 8,000 feet of section occurs in a distance of approximately 20 miles. This relationship is illustrated on geologic cross-section No. 5 (see Plate 25). To the south the shale and siltstone of the Kl_1 map unit apparently wedge-out just south of the Caribou River, but the contact cannot be observed on the air photographs. This southerly wedge-out is indicated on the accompanying geologic maps in a diagrammatic manner; the exact location of the wedge-out is unknown. The "upper sandstone division" of the Kl_1 map unit is overlain with apparent conformity by the shale and siltstone of the Kl map unit.

Age

The Jurassic and Early (pre-Albian) Cretaceous age of the strata

herein described has been well established by Jeletzky. It should be noted that the widespread Cretaceous rocks in the Peel Basin and the Mackenzie Basin are apparently all of Albian and later age. Pre-Albian rocks are confined to the north plunge and east flank of the Richardson Mountains, and apparently represent a southerly embayment of the Arctic Coastal Basin. Several small outcrops of Upper Triassic strata have been described on the southeast flank of the Richardson Mountains. It is very likely that the KJ map unit may contain other unrecognized Triassic strata at some localities. Knipping (1960) has noted extensive exposures of Permian and Pennsylvanian rock resting with angular unconformity on Mississippian and Upper Devonian rock in the northern part of the Richardson Mountains, slightly to the west of the project area. Similar strata are not known within the confines of the project area, but it is entirely possible that the KJ map unit may also include some Pennsylvanian and Permian rock.

Correlation

With the exception of the "upper sandstone division" of the Kl_1 map unit all of the strata herein described have no known correlatives to the southeast along the eastern front of the Canadian Cordillera in northern Canada. To the northwest, however, equivalent strata are widespread in the Arctic Coastal Basin and on the north slope of Alaska. The "upper sandstone division" of the Kl_1 map unit is widespread through the Peel Plateau, and forms the basal member of the Cretaceous sequence in that area. This sandstone unit is probably correlative with a part of the Sans Sault Group.

Remarks

It should be noted that west of approximately the 135th meridian the "upper sandstone division" is mapped as the upper member of the Kl_1 map unit, whereas east of approximately the 135th meridian, this same sandstone forms the basal portion of the Kl map unit. Exposures of this sandstone unit are not clearly enough expressed on the air photographs to map the unit separately, and the above described mapping procedure was adopted.

CRETACEOUS STRATA OF THE PEEL BASIN

Distribution and Mapping Methods

The greater portion of the Peel Basin exposes Cretaceous rock of Early and Late Cretaceous age. The Upper Cretaceous rock is exposed along the axial portion of the basin, parallel and close to the northern front of the Mackenzie Mountains. The Lower Cretaceous rock is mapped as Kl, the Upper Cretaceous rock is mapped as Ku.

Lithology and Thickness

McKinnon (1944) traversed the Arctic Red River in the central portion of the Peel Basin and divided the Cretaceous section into three parts which he termed, in ascending order, Units A, B, and C. McKinnon's section is as follows:

Unit C	900 ft.	Massive sandstone beds, alternating with sandy shale.
Unit B	1,500 ft.	Dark gray fissile shale, with minor sandstone beds.
Unit A	500 ft.	Sandstone, massive, fine-grained, conglomeratic.

McKinnon's Units A and B comprise the Kl map unit of this evaluation, and McKinnon's Unit C forms the Ku map unit. The lithology and thickness reported by McKinnon is believed to be representative for the Peel Basin, but insofar as these units are at most places heavily mantled and poorly exposed, considerable variations in thickness could occur.

Contacts

The basal arenaceous portion of the Cretaceous sequence of the Peel Basin rests with angular unconformity on older strata. Along the northern front of the Mackenzie Mountains the Cretaceous rests on Mississippian or Upper Devonian strata. To the northwest, on the east flank of the Richardson Mountains, the angular unconformity at the base of the "upper sandstone division" has been described in the preceding data sheet. To the north the Kl rests unconformably on Devonian rock. There are no obvious unconformities within the Cretaceous section, although Douglas et. al. (1963) indicate an angular unconformity at the base of Unit C.

Age

In the vicinity of the Richardson Mountain Jeletzky dated his "upper sandstone division" mainly as Aptian. It is presumed that this dating holds for the basal sandstone of the Lower Cretaceous sequence of the Peel Basin area, although it is realized that this unit is probably time transgressive and younger in an easterly direction. The overlying shale unit (McKinnon's Unit B) is apparently mainly of Albian age, although Douglas, et. al. (1963) indicate that the upper part of this unit is of Cenomanian age (Late Cretaceous). The overlying sandstone and shale of McKinnon's Unit C is dated as Turonian by Douglas, et. al. (1963).

Correlation

The Cretaceous Units A and B of the Peel Basin appear to be direct lithologic equivalents of Jeletzky's "upper sandstone division" and "Albian shale-siltstone division". To the east of the Mackenzie Basin area the Units A and B apparently grade into the Sans Sault Group and Slater River Formation, and the Unit C into the Little Bear and East Fork Formations.

CRETACEOUS STRATA OF THE MACKENZIE PLAIN BASIN

East of the 129th meridian there are several structural basins lying between the uplifted ranges of the Franklin Mountains and the Mackenzie Mountains, in which an extensive cover of Cretaceous strata is present. The Canol geologists adopted a four-fold subdivision of the Cretaceous rock which is, in descending order, the East Fork Formation, the Little Bear Formation, the Slater River Formation, and the Sans Sault Group. The contacts between these formations are, for the most part, not visible on the air photographs, and the entire Cretaceous sequence is shown with the symbol K on the accompanying photogeologic maps. At a few localities the base of the moderately resistant Little Bear Formation is visible on the air photographs, and is indicated as a key horizon labeled LB.

Lithology and Thickness

East Fork Formation

The East Fork Formation was named by Stewart (1945) for exposures along the East Fork of the Little Bear River. At this locality the formation consists of approximately 850 feet of gray marine shale. Stewart notes that the East Fork Formation has a limited distribution, and is not found south of the Little Bear River.

Little Bear Formation

The Little Bear Formation was named by Stewart (1945) for exposures along the Little Bear River. At the type locality the formation consists of 780 feet of sandstone, conglomerate, sandy shale, and coal. The formation is partly non-marine.

Slater River Formation

Stewart (1945) applied the term Slater River Formation to a section of approximately 1,000 feet of black shale with numerous ironstone concretions and occasional sandstone beds, exposed along the Mackenzie River below the mouth of Little Bear River, and on the Mountain River. Other Canol geologists have reported thicknesses of 1,400 to 1,500 feet for the Slater River Formation.

Sans Sault Group

The Sans Sault Group was named by Stewart (1945) for exposures in the vicinity of Sans Sault Rapids of the Mackenzie River. Stewart noted

that the fullest development of the formation is along the Mountain River, where the stream cuts across the Imperial Range. At this latter locality the Sans Sault Group is 3, 850 feet thick, and consists of shale, sandy shale, sandstone, and occasional conglomerate layers.

Contacts

The contact of the Sans Sault Group with the pre-Cretaceous strata is an erosional unconformity; in most places the Sans Sault Group rests on rocks of Late Devonian age. The contact between the Sans Sault Group and Slater River Formation is transitional, and was placed by Stuart at the base of the lowermost bentonite bed of the Slater River Formation. Douglas, et. al. (1963) indicate that the contact between the Slater River and the overlying Little Bear River Formation is an unconformity which progressively cuts down-section to the southeast. It was noted during the photogeologic mapping that in the southern part of the project area a key horizon identified as the base of the Little Bear Formation occurs only a short interval above the Middle Devonian Hume Formation. It is presumed that in this area the Little Bear Formation has overlapped a large part of the underlying Cretaceous strata, and at some places may lap on the Devonian.

Age

The Cretaceous rock of the Mackenzie Basin area is believed to be mainly Albian or later age. The exact position of the Lower-Upper Cretaceous boundary is unknown, and is presumed to be in the upper part of the Slater River Formation. The Little Bear and East Fork Formations are entirely of Late Cretaceous age.

Correlation

The Sans Sault and Slater River Formations are believed to be thickened easterly equivalents of the Cretaceous Units A and B of the Peel Basin area. The Little Bear and East Fork Formations are lateral equivalents of the Cretaceous Unit C of the Peel Basin area. To the south the Sans Sault and Slater River Formations are believed to grade into the Fort St. John Group of northeastern British Columbia.

TERTIARY NON-MARINE STRATA

In the southeastern part of the project area a considerable expanse of non-marine Tertiary deposits are present in the low-lying area between the McConnell Range and the Norman Kay Ranges. These strata appear to have been deposited in a local basin, and are shown on the accompanying photogeologic maps with the symbol Tu. In the vicinity of the Little Bear River Hart (1944) reports 1,600 feet of Tertiary strata, consisting of soft coarse carbonaceous sand, gravel, conglomerate, shale, and lignite. These Tertiary strata rest unconformably on older strata, at some places transgressing on strata as old as Cambrian. In general, it appears that the Tertiary strata overlie a somewhat irregularly shaped structural high in the underlying Paleozoic rocks. It would appear, from available outcrops around the margin of the Tertiary basin, that the upper Paleozoic and Mesozoic section in this region is very thin, and that at most places the Tertiary strata directly overlie Middle Devonian or older carbonate rock.

TERTIARY AND QUATERNARY MAP UNIT

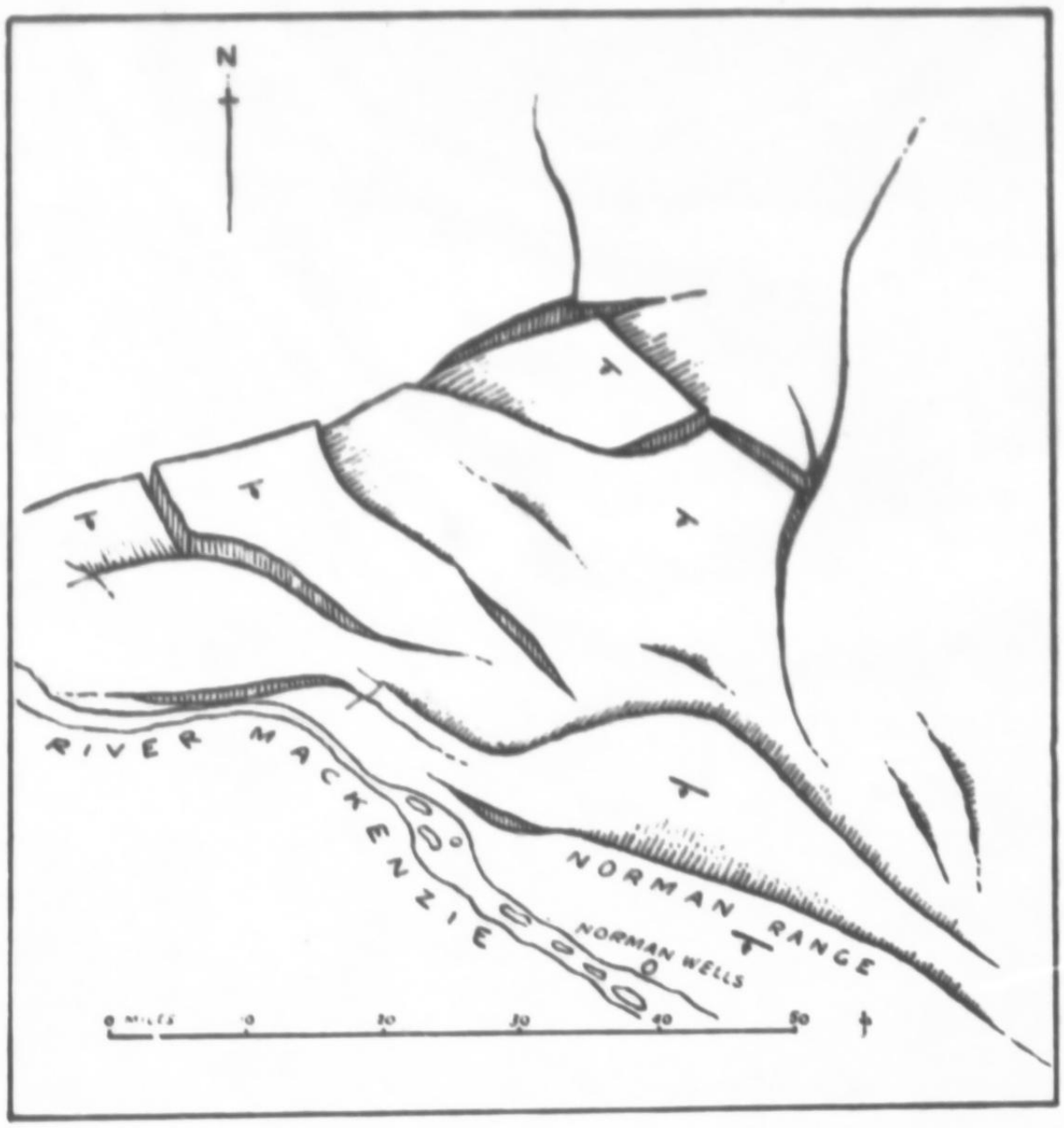
The Bonnet Plume Basin in the southwestern part of the project area is a relatively small basin of non-marine Tertiary deposition. In this region, because of the extensive glacial mantle, the Tertiary and Quaternary rocks cannot be divided on the air photographs, and are mapped as a single unit labeled QT.

The Bonnet Plume Basin is much like the previously described Tertiary Basin in the Mackenzie Plain area, in that it apparently overlies a structurally high area in the older rocks. Around the flanks of the Bonnet Plume Basin Tertiary strata rest on rock as old as Cambrian. Stelck (1944) reports over 1,000 feet of Tertiary strata in the Bonnet Plume Basin, consisting of gravel, sand, shale, and lignite. These Tertiary strata are sharply upturned at some places around the flank of the Bonnet Plume Basin, but, in general, are undeformed and flat-lying.

IGNEOUS ROCKS

Diabase sills and dykes are present in the Mackenzie Mountains in the Precambrian and Cambrian (ЄpЄ) map unit. The sills cannot be readily distinguished from sedimentary beds on the air photographs, and are not mapped. A northwesterly trending dyke, at least four miles long, is mapped in map area 106G/SE.

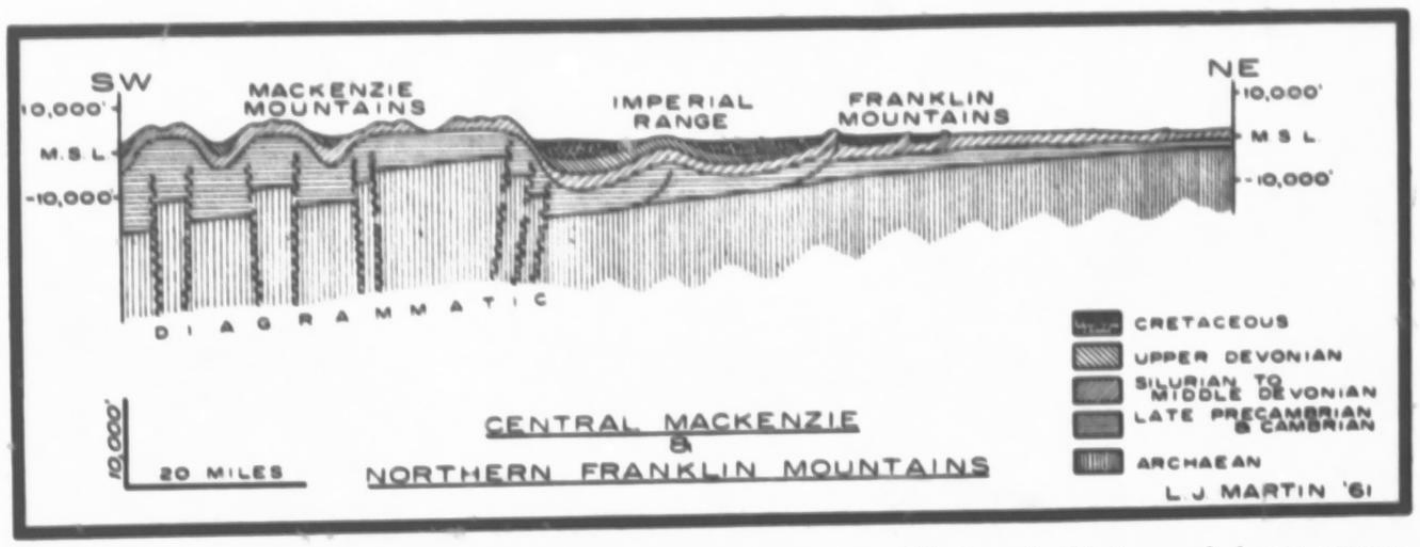
The age of these igneous rocks is not definitely established; they appear to cut rocks no younger than the Macdougal Group, and are tentatively dated as Cambrian.



Generalized diagrammatic interpretation of faulting in crystalline basement in foreland corner north of Norman Wells, N.W.T.

Plate 18

FROM GOODMAN, 1951



Cross section through northern Franklin Mountains, Mackenzie Plain, and front ranges of Mackenzie Mountains.

Plate 19

FROM MARTIN, 1963

STRUCTURAL GEOLOGY

The mapped area includes parts of several major structural provinces. The gross features of these structural provinces and their relations to adjoining structural provinces are described in a proceding part of this report under the heading of "Regional Geology". In the following pages the more local structural conditions are described.

Franklin Mountains Uplift

The Franklin Mountains are a series of faulted and folded foreland ranges which occur north and east of the main front of the Mackenzie Mountains. Much of the eastern part of the project area lies in the Franklin Mountains Uplift. Two contrasting theories have been advanced to explain the structure of the Franklin Mountains. In 1951 A. J. Goodman suggested that the Franklin Mountains are a series of tilted basement fault blocks. He theorized that the sedimentary cover overlying the basement surface responded to stress in a varying fashion, depending upon its composition, thickness, and overlying load. Thus, this sedimentary cover is at some places faulted and at other places folded. Plate 18 is a structural diagram reproduced from Goodman which shows the postulated fault system on the basement surface. It will be noted that many of these faults reverse their dip separation along strike. Goodman infers that these faults on the basement surface are high-angle reverse faults, and it is obvious that the dip of the fault plane must be near vertical in order to effect this lateral change in stratigraphic throw. The fault system outlined by Goodman

corresponds in general detail to the fault system revealed by this photogeologic interpretation, and Goodman's concepts were used in the construction of the geologic cross-sections which accompany this report. More recently Martin (1963) suggested that the faults which bound the individual uplifted ranges are splays from a zone of separation at the Archeozoic-Proterozoic boundary, or from a zone of separation in a Cambrian evaporite section. Figure 19, reproduced from Martin, illustrates these concepts. It is suggested that Goodman's explanation more nearly fits the observed surface structure. It is difficult to understand how movement of the sedimentary section on a zone of separation would produce the observed fault system, particularly the abrupt changes in the strike of the major faults and the change in dip separation along the trace of the faults.

Most of the anticlines within the Franklin Mountains Uplift are sharply folded and are associated with faults, whereas the synclines are relatively broad. Associated with the Franklin Mountains Uplift in the eastern part of the project area is a small part of a rather large structural feature which is herein termed the Colville Monocline. The limits of this monocline are shown on Plate 4, and the feature has been described in "Regional Geology". Within the project area the Colville Monocline is represented by a broad northerly trending moderately dipping area of Ordovician and Silurian carbonate rock. The outlines of the Colville Monocline are also indicated in Goodman's diagram (see Plate 18) by the two northerly trending fault traces in the northern part of the diagram.

In the southeastern part of the project area there is an extensive region of Tertiary outcrop. Around the flanks of this region the Tertiary strata are observed to transgress rock as old as Cambrian (just south of the project boundary) and it is possible that the Tertiary rocks conceal a structurally high area of Paleozoic rock. If this idea is correct, the Paleozoic surface underneath the Tertiary cover may represent a southerly extension of the Colville Monocline.

Mackenzie Plain Basin

The Mackenzie Plain Basin, as herein defined, is the low lying area of Upper Devonian and Cretaceous strata between the Franklin Mountains Uplift and the eastern front of the Mackenzie Mountains Uplift. The limits of this basin are shown on Plate 4. A part of the Mackenzie Basin is included within the confines of the project area. The photogeologic interpretation indicates several relatively broad folds within the mapped portion of the Mackenzie Plain Basin. It is suggested that the surface structure of these folds is fairly representative of the shape and extent of the folds in the subsurface. It is possible that some of these folds are associated with deep-seated faults, but it is doubtful that these faults are of the magnitude of the faults in the Franklin Mountains Uplift or Mackenzie Mountains Uplift.

Mackenzie Mountains Uplift

The abrupt upwarp which marks the northern and eastern front of the Mackenzie Mountains within the project area is believed to almost certainly rep-

resent a fault zone at the basement surface, although the surface strata are not obviously faulted at most places. Immediately south of the front of the Mackenzie Mountains a series of broad anticlinal folds is present, mostly exposing Cambrian or Precambrian strata at their crest. It is likely that these folds are localized over upthrust and downdropped basement blocks. The cross-section prepared by Martin (see Plate 19) probably very closely represents the structure of the Mackenzie Mountains Uplift. In the eastern part of the project area the predominant structural grain of the Mackenzie Mountains is, as would be expected, parallel to the mountain front. To the west, however, a northwesterly fault trend becomes progressively more prominent, and ultimately merges with the northerly trending Richardson Mountains Uplift.

Richardson Mountains Uplift

The western part of the project area is dominated by the northerly trending Richardson Mountains Uplift. In this region the stratigraphic section indicates an eventful geologic history with extremes of subsidence and elevation. This northerly trending mobile zone has been an important structural unit as far back in geologic time as at least the Cambrian, and possibly the Precambrian. The eastern margin of the Richardson Mountains Uplift is formed by a series of major high angle faults. These faults are believed to be primarily high-angle reverse faults, although Jeletzky (1960a, 1960b) believes that these faults have a considerable amount of right lateral separation. The Richardson Mountains are probably bounded on their western flanks by a similar fault zone, although

the photogeologic study did not extend far enough west to map the details of this fault zone. The interior structure of the Richardson Mountains is that of a broad moderately folded anticlinorium. The uplift plunges northerly from approximately 66° 10'N., 135° 50'W. where Lower Cambrian limestone is exposed. South of this region the uplift plunges southerly toward the Bonnet Plume Basin, where a structural saddle is concealed by Tertiary rock.

Peel Basin

The Peel Basin is a broad area of gently to moderately deformed Cretaceous strata lying west of the Franklin Mountains, north of the Mackenzie Mountains, and east of the Richardson Mountains. To the north of the project area, the Peel Basin is bounded by a broad gentle arch in Upper Devonian strata. The Peel Plateau Basin is decidedly asymmetric, and the axial portion of the basin, exposing Upper Cretaceous strata, lies to the south near the northern front of the Mackenzie Mountains. Structural trends within the Peel Basin have a generally west to northwesterly direction. The northwesterly direction is more pronounced near the northwesterly trending Richardson Mountains. Most parts of the Peel Plateau Basin are mantled by glacial deposits, and there is very little direct evidence of surface structure except in areas adjacent to the bounding uplifts. The geomorphic study, however, has indicated a number of northeasterly and northwesterly trending lineaments, some of which are interpreted as fault zones. The stream pattern in this region gives some evidence of broad folds, and these postulated folds are shown on the accompanying maps.

Geologic Cross-Sections

Geologic cross-sections constructed at the scale of one inch to one mile are included as Plates 20 through 28 of this report. The geologic cross-sections are shown on the individual one inch to one mile map sheets. In addition, the geologic cross-sections are photographically reduced to the scale of one inch equals four miles, and are shown on the margins of the composite maps of the same scale.

Structure Data Sheets

The remaining part of this discussion on structural geology is presented as a series of structure data sheets, each one of which discusses the salient features of an individual anticline. Only those anticlines which are judged to have some possible economic significance are described by means of structure data sheets. In order to facilitate the reading of the structure data sheets, each structure data sheet is numbered, and the corresponding structure is numbered and named on Plate 29, Generalized Geologic Map and Index to Structure Data Sheets. Plate 29 is a compilation of all the individual one inch to one mile sheets, and shows the generalized distribution of gross rock units, and the major geologic structure. A certain amount of interpretation is involved in the material presented on Plate 29; many minor structural features are not shown and connections are postulated between major structural features. Plate 29 also shows the lines of geologic cross-section.

The anticlinal structures described on the following structure data

sheets are believed to have economic potential. This does not imply, however, that non-anticlinal traps do not exist. There is abundant evidence suggesting conditions favorable for stratigraphic accumulations, and fault traps could be present at some localities.

STRUCTURE DATA SHEET 1

NAME: Slater Anticline

TYPE: Broad gently folded elongate closed anticline

TREND: Northwesterly

AXIS MAPPED: FROM: 64°53'N., 125°52'W.
TO: 65°11'N., 126°55'W.

APPROXIMATE LENGTH: 38 Miles.

MAP SHEETS: 96C/NW
96D/NE
96E/SE

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Questionable Upper Devonian Imperial Formation

SURFACE CLOSURE: Poorly defined

APPROXIMATE POSITION OF APEX: 64°57'N., 126°23'W.

REMARKS

The central part of this anticlinal structure lies in an area that is topographically higher than the surrounding region and possibly represents an outcrop of the Upper Devonian Imperial Formation. If this interpretation of the topography is correct, the anticline has an appreciable area of structural closure with the apex being located in the topographically high area. It is possible, however, that this high ground exposes only Cretaceous strata. The remaining part of this anticline is mapped through a region of highly mantled Cretaceous strata and structural control for the existence of this anticline is very sparse. The anticline is based mainly on field observed and published dips along the Little Bear River and along Loon Creek.

The shape and extent of this anticlinal structure is highly questionable, and should be verified by field work. A dry and abandoned test Imperial Loon Creek No. 1 is located in the extreme northwestern part of this anticlinal structure.

STRUCTURE DATA SHEET 2

NAME: Carrot Anticline

TYPE: Broad gently folded closed anticline

TREND: Northwesterly

AXIS MAPPED: FROM: 65°12'N., 127°58'W.
TO: 65°15'N., 128°12'W.

APPROXIMATE LENGTH: 7 Miles. MAP SHEETS: 106H/SE
96E/SW

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Upper Devonian Imperial Formation

SURFACE CLOSURE: Very well defined

APPROXIMATE POSITION OF APEX: 65°12'N., 128°05'W.

REMARKS

This well defined anticlinal feature is untested. The structure lies near the center of a narrow synclinal trough between the main front of the Mackenzie Mountains and the Imperial Range.

STRUCTURE DATA SHEET 3

NAME: Whirlpool Anticline

TYPE: Broad gently folded closed anticline

TREND: Northeasterly

AXIS MAPPED: FROM: 65°31'N., 129°24'W.
TO: 65°32'N., 129°10'W.

APPROXIMATE LENGTH: 7 Miles. MAP SHEET: 106H/NW

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Upper Devonian
Imperial Formation reported exposed along the crest of this anticline along the Mackenzie River.

SURFACE CLOSURE: Moderately well defined

APPROXIMATE POSITION OF APEX: 65°31.5'N., 129°19'W.

REMARKS

The southerly flank of this anticline appears to be in part faulted. A short fault segment approximately 1 mile long is mapped on the south flank of this anticline near the Mackenzie River.

A few miles to the northwest of the Whirlpool anticline two short plunging anticlines are mapped on the upthrown side of an inferred northwesterly trending fault. The folds in this region together with the fault may create small areas of possible fault closure.

STRUCTURE DATA SHEET 4

NAME: Arctic Red Anticline

TYPE: Elongate gently folded closed anticline

TREND: Westerly

AXIS MAPPED: FROM: 65°39'N., 129°38'W.
TO: 65°36'N , 131°20'W.

APPROXIMATE LENGTH: 50 Miles.

MAP SHEETS: 106H/NW
106G/NE
106G/NW

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Lower Cretaceous

SURFACE CLOSURE: Poorly defined

APPROXIMATE POSITION OF APEX: Indeterminate

REMARKS

Westerly plunge on this anticlinal structure is poorly defined and closure, if present, is in the westerly part of the structure. A structural saddle exists in the central part of the anticline. To the east the axis is terminated by a northwesterly trending lineament believed to represent a fault trace.

STRUCTURE DATA SHEET 5

NAME: Ontaratue Anomaly

TYPE: Broad gently folded geomorphic anomaly

TREND: Northwesterly

AXIS MAPPED: FROM: 66°26'N., 129°49'W.
TO: 66°43'N., 130°36'W.

APPROXIMATE LENGTH: 30 Miles.

MAP SHEETS: 106I/NW
106I/SW
106J/NE

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Lower Cretaceous

SURFACE CLOSURE: None apparent

REMARKS

This geomorphic anomaly is outlined by curved drainage segments, which are believed to be strike-controlled.

STRUCTURE DATA SHEET 6

NAME: Beaver Anomaly

TYPE: Elongate gently folded geomorphic anomaly

TREND: Southeasterly

AXIS MAPPED: FROM: 66°47'N., 133°51'W.
TO: 66°20'N., 132°10'W.

APPROXIMATE LENGTH: 55 Miles.

MAP SHEETS: 106K/NW
106K/NE
106K/SE

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Lower Cretaceous

SURFACE CLOSURE: None apparent

REMARKS

This geomorphic anomaly is based on curved drainage segments which appear to be structurally controlled and indicate a southeasterly plunging anticlinal axis. The Atlantic Columbian Carbon Arctic Circle Ontaratue No. H-34 dry and abandoned exploratory test is located approximately 4 miles north of the extreme southeastern part of this postulated structure. This test drilled to a total depth of 13,370 feet, and is rumored to have drilled several thousand feet of Cambrian strata.

STRUCTURE DATA SHEET 7

NAME: Sainville Anomaly

TYPE: Broad elongate southeasterly plunging geomorphic anomaly

TREND: Southeasterly

AXIS MAPPED: FROM: 66°13'N., 133°34'W.
TO: 66°00'N., 132°21'W.

APPROXIMATE LENGTH: 37 Miles.

MAP SHEETS: 106K/SW
106K/SE

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Lower Cretaceous

SURFACE CLOSURE: None apparent

REMARKS

This geomorphic anomaly is based on curved drainage segments which are believed to be strike-controlled, and indicate a southeasterly plunging anticline.

STRUCTURE DATA SHEET 8

NAME: Trevor Anticline

TYPE: Northerly to northeasterly plunging broad gently folded anticline

TREND: Northerly to northeasterly

AXIS MAPPED: FROM: 65°33'N., 134°03'W.
TO: 65°51'N., 133°43'W.

APPROXIMATE LENGTH: 23 Miles.

MAP SHEETS: 106E/NE
106F/NW

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Lower Cretaceous

SURFACE CLOSURE: None apparent

REMARKS

This anticline is situated in the extreme southwestern part of the Peel Basin in an area where reef development may be expected in the lower Paleozoic section. To the south, this anticline is terminated against a fault zone.

STRUCTURE DATA SHEET 9

NAME: Big Bend Anticline

TYPE: Broad moderately folded elongate closed anticline

TREND: Westerly to northwesterly

AXIS MAPPED: FROM: 65°54'N., 133°05'W.
TO: 65°57'N., 133°26'W.

APPROXIMATE LENGTH: 10 Miles. MAP SHEET: 106F/NW

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Lower Cretaceous

SURFACE CLOSURE: Moderately well defined

APPROXIMATE POSITION OF APEX: Indeterminate

REMARKS

Field measured dips along the Snake River confirm the presence of this anticline and structural closure. The large bend of the Snake River in this region appears to be structurally controlled and related to the Big Bend anticline. This structure occurs in the southwestern part of the Peel Plateau Basin in a position favorable for the development of reefs in the lower Paleozoic section.

STRUCTURE DATA SHEET 10

NAME: Cariboo Lake Anticline

TYPE: Elongate gently folded closed anticline

TREND: Northwesterly

AXIS MAPPED: FROM: 65°57'N., 134°34'W.
TO: 66°30'N., 135°13'W.

APPROXIMATE LENGTH: 45 Miles.

MAP SHEETS: 106L/SW
106L/SE
106E/NE

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Middle Devonian
Canol Formation

SURFACE CLOSURE: Moderately well defined

APPROXIMATE POSITION OF APEX: 66°13'N., 134°48'W.

REMARKS

This anticline lies in the western part of the Peel Basin near the east flank of the Richardson Mountains. It is presumed that the lower Paleozoic section in this region may contain reefs which would make suitable petroleum reservoirs.

STRUCTURE DATA SHEET 11

NAME: Vittrekwa Anticline

TYPE: E ongate moderately folded southerly plunging anticline

TREND: Southerly

AXIS MAPPED: FROM: 67°12'N., 135°36'W.
TO: 67°02'N., 135°32'W.

APPROXIMATE LENGTH: 11 Miles. MAP SHEET: 106M/SW

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Lower Cretaceous (pre-Albian)

SURFACE CLOSURE: None apparent

REMARKS

The southerly part of this anticline is exceptionally well defined by field measured dips along the North Branch Creek and the Vittrekwa River. To the north the position of the anticlinal axis is defined by widely scattered dips and the axis appears to pass northerly into a fault zone.

STRUCTURE DATA SHEET 12

NAME: Elk Anticline

TYPE: Elongate moderately folded closed anticline

TREND: Northerly

AXIS MAPPED: FROM: 67° 10'N., 135° 43'W.
TO: 67° 14'N., 135° 46'W.

APPROXIMATE LENGTH: 5 Miles. MAP SHEET: 106M/SW

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Jurassic and Lower Cretaceous Map Unit

SURFACE CLOSURE: Very well defined

APPROXIMATE POSITION OF APEX: 67° 12'N., 135° 44'W.

STRUCTURE DATA SHEET 13

NAME: Toughenough Anticline

TYPE: Elongate moderately to steeply folded faulted anticline

TREND: Northerly

AXIS MAPPED: FROM: 67°25'N., 135°49'W.
TO: 67°30'N., 135°49'W. (project boundary)

APPROXIMATE LENGTH: 6 Miles. MAP SHEET: 106M/SW

OLDEST ROCKS EXPOSED ON CREST OF FOLD: Jurassic and Lower Cretaceous Map Unit

SURFACE CLOSURE: Well defined

APPROXIMATE POSITION OF APEX: Indeterminate

REMARKS

This anticline is bounded on its east flank by a high angle up-to-the-west reverse fault. To the north, this anticline presumably extends for some distance beyond the project boundary. To the south, the previously described fault trends obliquely across the crestal part of the anticline and terminates the crestal line.

PETROLEUM

The Norman Wells Oil Field, which is the only producing oil field in the Northwest Territories, is located within the project area. There are many reported oil and gas seeps in this region, and the reported lithology of the stratigraphic section suggests the widespread occurrence of sedimentary rocks suitable for the generation and entrapment of petroleum.

Norman Wells Oil Field

The Norman Wells Oil Field is located in the northern part of the Mackenzie Plain Basin in a homoclinal structure on the southwest flank of the Norman Range. Production is obtained from the Middle Devonian Kee Scarp reefoid limestone at a depth of 1,400-1,700 feet. The porous upper part of the limestone member shales-out up-dip, thereby providing the necessary trap for the accumulation of oil. The lower non-petroliferous part of the Kee Scarp crops out on the flank of the Norman Range. Within the Norman Wells field the oil-saturated part of the reef ranges up to 400 feet thick. Current production (1963) from the Norman Wells field is about 500,000 barrels a year. The field was originally located by drilling on seepages. Oil and gas seepages and indications of bituminous material are found throughout the project area, usually in association with Devonian rock.

Exploratory Drilling

Prior to 1947 twenty-four exploratory wells were drilled in the project area outside of the boundaries of the Norman Wells Oil Field. All of these tests

were unsuccessful. Four of the tests were drilled in the years 1921-1922, and the remainder were drilled during the war years as a part of the Canol Project. The reader is referred to Stewart (1945) and Hume (1954) for a summary of this drilling activity. In recent years The Atlantic Refining Company (and associated companies) has drilled several shallow tests to evaluate its large "Glacier Block" in the Peel Basin. This company recently drilled a deep unsuccessful test to a total depth of 13, 370 feet. This test, known as the Atlantic-Columbia Carbon Arctic Circle Ontaratue H-34, is located in the central part of the Peel Basin. In 1960 the Richfield Oil Corporation drilled two unsuccessful tests in the northern part of the Peel Basin, just north of the project area.

Reservoirs and Traps

The Kee Scarp Formation, which is the producing zone at the Norman Wells Oil Field, is subject to abrupt lateral changes, and the oil entrapment at Norman Wells is controlled by an up-dip shale-out of the porous zone. It appears very likely that similar conditions may be present elsewhere on the flanks of the upthrust ranges of the Franklin Mountains.

In the eastern and central parts of the project area the stratigraphic section contains zones of porous and permeable strata which could provide reservoirs for the accumulation of petroleum in favorable structural conditions. Perhaps the most widespread of these favorable zones is the Lower(?) Devonian Bear Rock Formation. At some places zones of porosity are present in the upper part of the Hume Formation, and within the upper part of the Ronning Group. The Imperial Formation contains some zones of good porosity (see

Plate 16), but in general is quite silty except at the more westerly localities. Very porous sandstones are present in the upper part of the Cambrian-Precambrian section along the front of the Mackenzie Mountains, and it is not impossible that these beds could provide a petroleum reservoir under the Peel Basin.

Numerous facies changes occur in the sedimentary section in the western part of the project area where the Ordovician, Silurian, and Lower(?) and Middle Devonian section grades westerly into an argillaceous section, with the concurrent development of reefoid facies in the interface region. A reefoid-type limestone unit occurs in the section at the approximate stratigraphic position of the Kee Scarp Formation, and in the Knorr Range pinnacle reefs are present in a shale unit of Lower(?) and Middle Devonian age. It is suggested that in the western part of the Peel Basin there is an excellent possibility for the discovery of reef-type hydrocarbon accumulation in the Ordovician and Silurian sections, and more particularly in the Middle Devonian. It is believed that a regional unconformity exists in this area near the top of the Middle Devonian, which may enhance the possibility of a discovery. The southeasterly trending Peel lineament in map area 106L/NE, and a southerly extension of this line, could possibly mark a hinge line separating the westerly argillaceous facies from the easterly carbonate facies.

In the extreme northwestern part of the mapped area a deep trough of Mesozoic clastic rock is present on the east flank of the Richardson Mountains. These Mesozoic rocks are several thousand feet thick and consist mainly of

marine shale and siltstone, with interbedded sandstone. This section is truncated easterly by an angular unconformity, and appears to offer attractive possibilities for hydrocarbon accumulation.

SUMMARY AND CONCLUSIONS

This report presents the results of a photogeologic evaluation of a 40,070 square mile area of northern Canada, which includes the Peel Basin, the northern part of the Mackenzie Plain Basin, and parts of surrounding areas. Accompanying the report are 49 photogeologic map sheets at a scale of 1 inch equals 1 mile. In addition, the photogeologic mapping is presented at the reduced scale of 1 inch equals 4 miles on two composite maps. The report incorporates all pertinent published and unpublished information available to Geophoto, and is illustrated by a series of stratigraphic and structural diagrams.

The project area includes parts of five major provinces which are:

The Mackenzie Mountains Uplift

The Mackenzie Plain Basin

The Franklin Mountains Uplift

The Peel Basin

The Richardson Mountains Uplift

A small portion of the Mackenzie Mountains is present in the extreme southeastern part of the project area. This uplift is bounded on the north by an abrupt downwarp. Rocks exposed in the Mackenzie Mountains are principally carbonate and clastic strata of Middle Devonian and older age. These rocks are folded into a series of relatively broad folds. A part of the Franklin Mountains Uplift is present in the eastern half of the project area. This uplift is formed by a series of upthrust foreland ranges which collectively form an arcuate

pattern northeast of the Mackenzie Mountain front. These upthrust ranges expose Middle Devonian and older strata. The Mackenzie Plain Basin is a low-lying area between the Mackenzie Mountains and the Franklin Mountains where Upper Devonian and later clastic rock is deformed into a series of broad gentle folds.

Part of the Richardson Mountains Uplift is mapped in the extreme western part of the project area. The Richardson Mountains Uplift is a large anticlinorium bounded on its east flank by a prominent fault zone. Rocks exposed in the Richardson Mountains include a thick section of lower Paleozoic argillaceous strata and late Paleozoic clastic rock.

The Peel Basin, which comprises the major part of the project area, is bounded on the west by the Richardson Mountains, on the south by the Mackenzie Mountains, and on the east by the Franklin Mountains. To the north the Peel Basin is bound by the poorly defined, broad, westerly plunging arch in Paleozoic strata. The greater part of this arch lies to the north of the project area. Rocks exposed in the Peel Basin are mainly of Cretaceous age. The axial portion of the Peel Basin lies to the south, parallel and close to the front of the Mackenzie Mountains. In this region the Cretaceous strata of the Peel Basin are moderately deformed by folds. North of the axial position of the basin the Cretaceous strata are relatively undeformed.

The post-Cambrian sedimentary section present in the project area ranges in thickness from a maximum of 30,000 feet in the west to a minimum of 1,000 feet in the east. This easterly thinning is the result of stratigraphic

convergence, plus overlap of older strata by younger strata. In the extreme west the Ordovician, Silurian, and Middle Devonian section is composed primarily of shale and siltstone, whereas in the east the equivalent section is principally composed of carbonate rock. The exact position of the interface between these two sedimentary facies is unknown, but outcrops in the Mackenzie Mountains suggest that the interface is to the west near the Richardson Mountains. It is presumed that this interface lies along an early Paleozoic hinge line, which separates an eastern relatively thin section of shelf-type carbonate rock from a western very thick section of argillaceous strata. Upper Devonian and Mississippian rocks within the project area are almost entirely clastic, and become thicker and non-marine in the vicinity of the Richardson Mountains. It is believed that the Richardson Mountains were uplifted and deformed prior to the deposition of this Upper Devonian and Mississippian section. The Upper Devonian and Mississippian clastic section is overlain by Mesozoic rock. The Mesozoic section is very thick to the northwest on the east flank of the Richardson Mountains, but thins abruptly to the east and averages less than 1,000 feet over the greater part of the Peel Basin and the Mackenzie Plain Basin. Some non-marine Tertiary rock is present in the Bonnet Plume Basin in the southern Richardson Mountains, and in the northern part of the Mackenzie Plain Basin.

Oil production of approximately 500,000 barrels a year is obtained from a Middle Devonian reef at Norman Wells in the northern part of the Mackenzie Plain Basin. Petroleum residues are found in Middle Devonian strata

at many places and gas seeps have been reported in the Peel Basin. It is believed that petroleum potential exists in the Peel Basin and Mackenzie Plain Basin. Widespread zones of porosity and permeability are present which could provide hydrocarbon reservoirs under suitable structural conditions. These zones include the Lower(?) Devonian Bear Rock Formation, the upper part of the Middle Devonian Hume Formation, parts of the Ordovician and Silurian Ronning Group, and possible sandstones in the Cambrian or Precambrian. Less likely are sandstones in the Upper Devonian and Mississippian Imperial Formation. Thirteen anticlines - three of which are based on geomorphic evidence - which may have economic potential are listed on structure data sheets. The most favorable structures appear to be Slater anticline and Big Bend anticline.

Several geomorphic anomalies are mapped in the Peel Basin which may be indicative of concealed anticlinal structures. Major lineaments in this same area may indicate major faults, which could form fault traps for hydrocarbon accumulation.

Lithofacies boundaries in the Paleozoic section and unconformities in the Mesozoic section could provide hydrocarbon traps, with or without structural control. Specifically, additional production may be expected to be found in Middle Devonian reef limestones. In addition, reef-type reservoirs may be found in Ordovician and Silurian strata in the vicinity of the lower Paleozoic hinge line. To the northwest production may be obtained from the thick Mesozoic section below a mid-Lower Cretaceous unconformity which truncates

this section in an easterly direction.

The position and shape of the facies change in the lower Paleozoic section from easterly shelf carbonate rock to westerly argillaceous rock is of considerable importance to petroleum exploration in the Peel Basin. This interface could possibly be outlined by a study of the fracture system visible on the air photos. A macro-fracture analysis would reveal the gross fault pattern in the subsurface, and possibly indicate hinge lines of deposition. A meso-fracture analysis would more directly reflect the thickness and competency of the subsurface units.

Respectfully submitted,

GEOPHOTO SERVICES, LTD.

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