REPORT ON
THE GEOLOGY
PERMIT 1473
N.W.T.

By:

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INTRODUCTION

Permit 1473 was mapped by A.G. Pentland in July 1958. The adjoining area to the south had been mapped by Pentland and Allen in August 1957.

The search for oil and gas in the Northwest Territories and Yukon Territory has been revived, largely as a result of experience gained in northern Alberta, British Columbia and Alaska, the Norman Wells field, improved transportation, and favorable geology. It is the consensus of opinion that, as the search is continued, sufficiently large fields will be discovered and developed to warrant the capital expenditures necessary to refine locally and deliver by pipeline the products to the Pacific Coast and thence by water to major world markets.

LOCATION

Permit 1473, comprising 52,644 acres is located on the Mackenzie River about 70 miles north of Norman Wells, N.W.T. The northeast corner is at north latitude 65 degrees 50 minutes and west longitude 128 degrees 45 minutes. The Mountain River flows from the west across the southwest corner of the permit and into the Mackenzie at the San Sault rapids. The Donnely River flows across the northeast corner of the permit into the

Mackenzie River.

OWNERSHIP

Permit 1473 is registered in the name of I. Shulman of Shulman, Tupper, Southin and Gray of 404-510 West Hastings Vancouver 2, B. C.

ACCESSIBILITY

Canadian Pacific Airlines operates two scheduled flights per week from Edmonton to Norman Wells, using a DC-3, and three scheduled flights per week from Norman Wells to Aklavik, using an Otter. During the summer there are usually many extra flights to take care of additional freight and passengers.

Much of the heavy freight is shipped into the country by train and barge during the summer months. Freight is shipped from Edmonton to Waterways by train, a distance of 300 miles, and thence by barge down the Athabaska River, Athabaska Lake, Slave River, Great Slave Lake, and Mackenzie River. The only interruption to navigation on this route is the 16-mile portage from Fitzgerald at the northern boundary of Alberta to Fort Smith in the Northwest Territories because of rapids in the Slave River.

Permit 1473 is favorably located near Norman Wells on the Mackenzie River. Thus the transportation problem is greatly simplified.

CLIMATE AND VEGETATION

The rivers and creeks generally open during the latter part of May, but ice may remain on some of the larger lakes until the first or second week in June. Freeze-up comes in September or early October, but occasionally the large rivers remain open until well into November.

During May, June, and July there is almost continuous daylight with warm summer weather. During November, December, and January the sun is below the horizon the greater part of the day. The result is that the length of day varies rapidly during the intervening months. The winter may be severe with temperatures as low as 50 or 60 degrees below zero.

Trees are absent or are stunted over most of the muskeg area. They consist of white spruce, poplar, birch, and tamarack. In a few sheltered places, such as the banks of streams, trees may reach a height of 30 or 40 feet and a diameter of 12 to 18 inches. Here, too, willows and alders grow in thick masses.

The greater part of the area is covered with the various types of moss that is common to the Arctic muskeg.

PHYSIOGRAPHY

Permit 1473 is located near a large bend in the Mackenzie River where it changes direction from westerly to northerly. The land on the west side of the river is low and dotted with numerous small lakes, whereas on the east side a

series of hills rise 1000 to 1800 feet above the river level from East Mountain at the southeast corner to Beavertail Mountain off the northeast corner. At this location the Mackenzie River is 1½ to 5 miles wide, and there are six islands within the permit area. The Mountain River flows across the southwest corner of the permit and enters the Mackenzie a short distance above Sans Sault rapids 2 miles from the south boundary. The Donnelly River flows westerly into the Mackenzie near the northeast corner of permit 1473.

PURPOSE OF THE SURVEY

Geological mapping was undertaken as the first step in a comprehensive program of exploration. It was considered that a study of the formations, with particular attention to their ages, attitudes, and type of rock, was essential and would form a sound basis upon which to outline further work that might culminate in the discovery of oil or gas.

METHODS

The permit area was mapped by A.G. Pentland, July 1958. A Cessna aircraft, model 170B equipped with floats was used for transportation. Full camping equipment was carried. The method used was to fly over the permit at low elevation and at reduced cruising speed in order to observe the general topography and to spot outcrops. Flight lines were along the borders of the permit first and then several passes were made across the central part. In addition, all rivers and streams on the permit or within a radius of several miles of the permit

were flown in order to locate all outcrops that might have a bearing on the structure of the area.

Control of flight lines was by means of maps and aerial photographs. The 8 miles to 1 inch map from the National Topographic Series, which is published by the Department of Mines and Technical Surveys, was found to be accurate and useful for the purpose of determining the limits of the permits and for locating outcrops.

Traverses on foot were made to all outcrops which were located by pace and Brunton compass.

A photographic mosaic was made to the scale of 1 inch to 1 mile on which outcrops were accurately located and the whole was traced in order to make a map from which additional copies could be taken.

REGIONAL GEOLOGY

The Mackenzie River valley and Mackenzie plain, between Fort Good Hope and Fort Norman, are underlain by folded Palaeozoic limestones, sandstones and shales largely covered by flat-lying Lower Cretaceous and Tertiary conglomerate, sandstone and shale. This basin is flanked on the northeast by the Norman Range of the Franklin Mountains and on the southwest by the Canyon and Carcajou Ranges of the Mackenzie Mountains. The southeast and northwest ends are defined by upwarped Devonian strata lying across the long axis of the basin. Permit 1473 is located near the northwest end of the basin where well defined west to southwest trending

anticlinal folds expose Devonian limestones and shales through the flat-lying Lower Cretaceous sediments.

Oil and gas occur in a Devonian reef at Norman Wells. A refinery at the field supplies petroleum products to the Dew Line, Yellowknife, and other localities throughout the north.

Cambrian rocks have been mapped along the southwest side of the Mackenzie Plain. The principal areas of outcrops are on Range Mountain, Sheep and Dodo Mountains, Imperial Creek and Mountain River. The rocks are composed of dark chocolate-colored hard nodular shale at the base; red and green nodular shale and green sandstone; hard scarp forming limestone; black, interbedded, hard sandstone and shale; interbedded greenish-grey and chocolate colored shale and siltstone, and at the top dark grey limestone. The thickness on Macdougal creek is 997 feet. On Rouge Mountain 715 feet of similar rocks are underlain by 800 feet of hard, white-to-black-weathering quartzites which have been tentatively classified as Precambrian (3). On Imperial River 1839 feet of rocks similar to those described above are classified as Cambrian, these being underlain by 125 feet of quartzites which may be Precambrian and overlain by 415 feet of black algal limestone which appear to be Cambrian or Ordovician. (3).

Ordovician shales and argillites have been mapped in the Upper Peel River area but no sediments of this age have been positively identified in sections to the south and east. It is probable that Ordovician rocks are lacking, or if present,

TABLE OF FORMATIONS

Eocene		Imperfectly consolidated sands, clays, and conglomerates with lignite. Contain leaf and plant fragments
	Erosional Unconformity	
Cretaceous	East Fork	Grey shales
	Little Bear	Sandstones and shale with coal
	Slater River	Dark grey to black shales some siltstones and sandstones
	Sans Sault	Fine-grained sandstone with glauconite; grey sandy shales. Sandstone and conglomerate at or near base
	Erosional Unconformity	
Upper Devonian	Imperial	Green, fine-grained sandstone and shale
	Fort Creek	Upper grey shales, thin sandstones; bituminous shales, coral reef and limestones; lower dark platy shales.
	Ramparts	Heavy massive limestone at top with or without coralline beds, limestone interbedded with shales in middle part; limestone in lower part
Silurian or Devonian	Bear rock	Brecciated dolomites and limestones, gypsum and anhydrite.
	Erosional Disconformity	
Silurian Ordovician	Ronning group	Limestone with chert Argillites and shales
Cambrian	Macdougal	Limestone; greenish, grey, and black shales; sandstones gypsum, etc.
Cambrian and/or earlier	Katherine group	Interbedded quartzites and black platy shales

are comparatively thin in the area occupied by Permit 1473.

Silurian strata are widely distributed throughout the Mackenzie River basin. McKinnon (3, p. 18) mapped 1,100 feet of limestone on the Arctic Red River. The lower unit contains 400 feet of chert in dolomite and the upper part 700 feet of limestone carrying a Niagaran fauna. The upper Niagaran coral zone is reported to be quite porous in places and capable of serving as a reservoir.

The name Bear Rock formation is used by Canol geologists to describe the brecciated and non-bedded dolomites and limestones lying below Middle Devonian strata and above a sharp disconformity with well-bedded Silurian limestones below. The Bear Rock formation is reported to be more than 200 feet thick in the Mountain River area where it consists of brecciated limestones and dolomites. In places the beds are gypsum-bearing. The Bear Rock dolomites are generally the most porous rocks in the area except where their position is occupied by gypsum and anhydrite beds. They may be highly bituminous.

Middle Devonian limestone with some shale in the middle of the section outcrops throughout the Norman Wells area. This has been named the Ramparts formation, and is composed of the following, on Mountain River:-

1.) Upper Ramparts limestone member, comprising 180 feet of limy, black to grey-brown petroliferous shale overlain by massive black petroliferous limestone, a black earthy and limy shale bed, and massive dark grey, buff-weathering limestone.

2.) Middle Ramparts shale member, totaling 700 feet of grey to green shales and limy shales with thin limestone interbeds.

3.) Lower Ramparts limestone member, composed of 445 feet of black, hard, petroliferous limestone with thin interbeds of grey to black shale. The log of the Sans Sault No. 1 well recorded 437 feet of Upper Ramparts limestone and 1080 feet of Middle and Lower shale and limestone members.

Upper Devonian rocks throughout the Norman Wells area are divided into the Fort Creek and Imperial formations. The Fort Creek at Norman Wells field is composed of lower shales 385 to 540 feet thick, a reef limestone from which production is taken 0 to 410 feet thick, a bituminous zone 100 to 400 feet thick, and upper shales 700 to 800 feet thick. The type section of the Imperial formation is on Imperial River, 10 miles southwest of the junction with Carcajou River. It is composed of 1988 feet of green sandstone with shale interbeds and thin partings throughout. The Fort Creek Imperial and Ramparts formation have been eroded prior to the deposition of the overlying Lower Cretaceous shale, hence in places throughout the Norman Wells area the Imperial sandstones and Fort Creek shales are removed and only a part of the Ramparts formation is left.

The Devonian rocks are unconformably overlain by Lower Cretaceous shales and sandstones which have been divided (3) from the base to the top as follows:

1.) The Sans Sault group, composed of shales and sandstones of Marine origin, and including all Lower Cretaceous strata from the base to the lowest bentonite bed.

2.) The Slater River formation of thin bedded, black, friable shales with numerous ironstone concretions, and many beds of bentonite 1/8 to 1 inch thick.

3.) The Little Bear Formation, composed of sandstone and some conglomerate, sandy shales and coal seams.

4.) The East Fork formation of well-bedded, grey, conchoidal and plastic marine shale, to date not recognized north of Norman Wells.

Tertiary conglomerate and sandstone occurs in isolated remnants along the Mackenzie River above Norman Wells.

The general structural trend in the Norman Wells area is northwesterly. The Mackenzie River Valley and Mackenzie plain form a structural basin flanked on the northeast by the Norman Range, and southwest by the Canyon Ranges. Near Fort Norman the basin is terminated by cross folding. Similarly, to the northwest, the basin ends in a series of well defined folds. At and near both ends of the basin there is strong faulting. This is most evident on the northeast side of the basin.

LOCAL GEOLOGY

Introduction

Rock outcrops are fairly numerous along the banks of the Mackenzie River on Permit 1473. Devonian and Cretaceous

rocks are exposed in the southeast corner where the river swings around the end of East Mountain. Lower Cretaceous rocks are exposed over a distance of about one and one half miles along the west bank of the river in the south-central part of the permit. Devonian and Lower Cretaceous rocks are exposed on the east bank of the river over a distance of nearly two miles where the river cuts across the west end of the Bat Hills. Lower Cretaceous shales are exposed in small outcrops at some of the sharp bends in the Donnelly River and Devonian limestones are exposed at the extreme northerly edge of the permit where the Mackenzie River cuts the west end of Beavertail Mountain. Thus a fairly continuous north-south cross section can be constructed.

Stratigraphy

The Bear Rock formation does not outcrop on the permit but has been mapped near the crest of the anticlines on East Mountain, Bat Hills, and Beavertail Mountain. In East Mountain it consists of at least 138 feet of brecciated dolomites. The Sans Sault No. 1 well penetrated 366 feet of brecciated dolomitic limestone where it was stopped because of mechanical difficulties.

The Ramparts formation outcrops in three places along the east bank of the Mackenzie River. It is exposed where the river cuts past the west end of three prominent hills. The limestone is generally grey to dark grey in color and weathers to light grey or buff. It is generally massive but may contain minor amounts of thin-bedded limestone. On East Mountain the massive limestone is underlain thin-bedded grey to buff limestones

and shaley limestone and this, in turn, is underlain by dark grey, massive limestone. A fossil found in the southeast corner of the permit was identified by C.R. Stelck of the University of Alberta as Amphipora of Devonian age. Fossils identified by previous workers were Cladopora and Stromatoporoids.

The Sans Sault No. 1 well penetrated 437 feet of the limestone member and 1080 feet of the shale and limestone member. The Sans Sault formation lies unconformably on the Devonian. The amount of erosion varies from place to place. In the area of the permit, all of the Imperial Formation and most of the Fort Creek Formation were removed before the deposition of the Cretaceous took place.

Outcrops of the Lower Cretaceous Sans Sault formation were observed along the Mackenzie River on the north side of East Mountain, along the west bank in the south-central portion of the permit and on the north side of the Bat Hills. The lower part consists essentially of interbedded sandstone and shale. The sandstone beds may be as much as 10 to 20 feet thick and stand out as prominent cliffs. Above this are beds made up essentially of shale.

Near the top of the formation sandstone beds become more prominent. It is these sandstone beds that form the Sans Sault rapids. On the north side of the Bat Hills, several fine conglomerate beds were observed.

A few of the sharp bends in the Donnelly River expose small outcrops of Cretaceous shale, which may belong to the Slater River Formation. They consist of flat-lying, thin-

bedded, black friable shales with numerous ironstone concretions.

Structure

Three, and possibly four, well-marked anticlines are present in the area covered by Permit 1473. They are from south to north, the East Mountain anticline, the Bat Hills anticline, and the Beavertail Mountain anticline. Each of these folds brings Ramparts limestone to the surface in or near to the area covered by the permit.

The extreme southeast corner of the permit covers the west end of the East Mountain anticline. The axis strikes about east-west. The dips on the north limb of the fold are generally steeper than those on the south limb. On the south limb, dips in the Ramparts limestone range from 5° to 20° along the banks of the Mackenzie River. Dips on the north limb are much steeper, ranging up to nearly vertical or even slightly overturned, a short distance east of the permit. The Lower Cretaceous sandstones and shales have dips of from 50° north near the base of the formation to about 10° north at the north end of the outcrop.

The Ramparts limestone has a dip of 43° south on the extreme southerly side of the Bat Hills anticline but flattens within a few hundred feet and continues across the crest of the fold with dips ranging from flat to 5° for a distance of more than one mile along the river bank. Near the northern end of the outcrop, the dips become steeper, ranging from 15° to 25° to the north, and the limestone passes under the overlying beds of Cretaceous shale, sandstone, and conglomerate.

The Beavertail Mountain anticline is exposed in the east bank of the Mackenzie River immediately north of the permit. The projection of its axis would cross the northwest corner. Dips are generally flat with the exception of the extreme southern end of the outcrop where they are as much as 54° to the south.

Folding, that probably represents a fourth anticline, is exposed along the west bank of the Mackenzie River in beds of Lower Cretaceous sandstone and shale. This structure is parallel to the other structures but does not appear to line up with either the East Mountain anticline or the Bats Hills structure. The axis has a general east-west strike and the dips are comparatively flat.

The Sans Sault No. 1 well was drilled on this structure. According to J.S. Stewart (Geol. Survey Paper 45-29, pp. 18-19) a summary of the log is as follows:

Formation or Group	Lithology	Depth in Feet
Sans Sault	Mainly shales	0 - 1,337
Fort Creek	Lower shale member	1,337 - 1,408
Ramparts	Beavertail limestone member	1,408 - 1,845
Ramparts	Shale and limestone member	1,845 - 2,925
Bear Rock	Brecciated dolomitic limestone	2,925 - 3,291

A formation test of the Bear Rock formation yielded water only. Analyses of the water showed sufficient sodium chloride to suggest that it was formation water. It was originally planned to test the more deeply buried formations in this well,

but mechanical difficulties, and the negative results obtained in the prospective horizons penetrated, resulted in the project being abandoned.

ECONOMIC POSSIBILITIES

The formations that are generally considered to be possible oil reservoirs are the sandstones at the base of the Cretaceous and in the Imperial formation, coral reefs in the Fort Creek formation, the upper beds of the Ramparts formation, the Bear Rock dolomites, and the upper beds of the Silurian strata. Of these, the Imperial and a part at least of the Fort Creek formations were removed by erosion before Lower Cretaceous sediments were deposited at the wellsite.

The Sans Sault No. 1 well was drilled on a minor flexure in Lower Cretaceous strata. It failed to encounter gas or oil but this does not, of itself, eliminate production possibilities on the entire permit.

The three larger structures, namely, the East Mountain, Bat Hills and Beavertail Mountain anticlines, which appear to extend into the permit area, warrant further investigation.

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Vancouver, B. C.
September, 1958.

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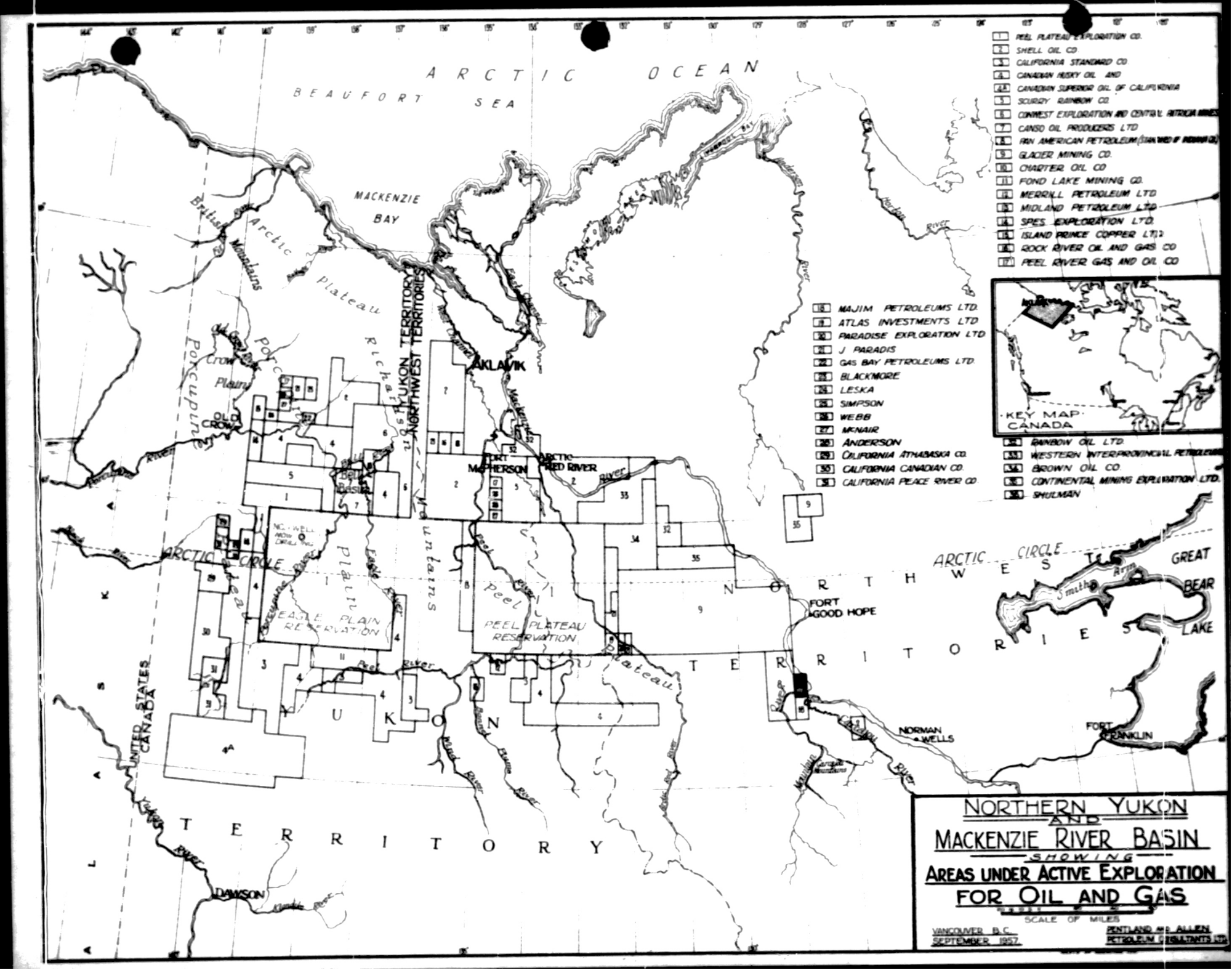


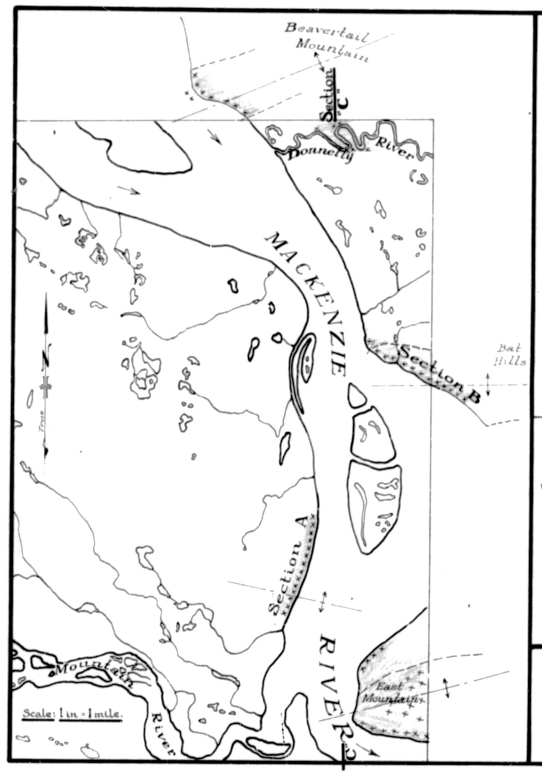
NORTHERN YUKON AND MACKENZIE RIVER BASIN SHOWING AREAS UNDER ACTIVE EXPLORATION FOR OIL AND GAS

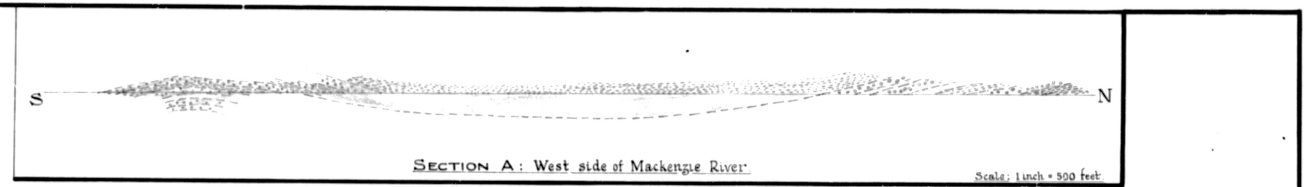
SCALE OF MILES

VANCOUVER B.C.
SEPTEMBER 1957.

PENTLAND and D. ALLEN
PETROLEUM CONSULTANTS LTD.

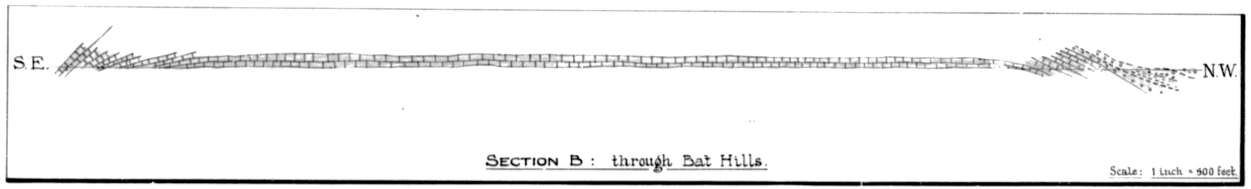

TRUE
PERMIT 1473
Scale 1" = 1 mile
October 1957
Portland & Allen
Petroleum Consultants





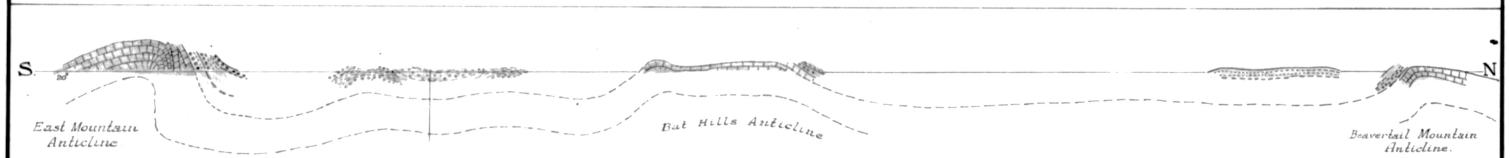
SECTION A : West side of Mackenzie River

Scale: 1 inch = 500 feet



SECTION B : through Bat Hills.

Scale: 1 inch = 500 feet



COMPOSITE SECTION "C - C"
PERMIT 1473

Scale: 1 inch = ½ mile.

LEGEND

Devonian Ramparts Limestone.
Lower Cretaceous Sandstone.
Shale.
Outcrops.
Anticlinal Axis.
Geological Contacts.

P E R M I T ··· 1 4 7 3

September 1958.

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PENTLAND & ALLEN
PETROLEUM CONSULTANTS LTD.