68°00'
40
30
20
10
139°00'
50
40
30
20
138°10'
67°50'
67°40'
67°30'
67°20'
Old Crow River
Johnson Creek
Old Crow River
Porcupine River
Driftwood River
Dave Lord Cr
A
A
DETAIL B
DETAIL A
Beds folded
Average dip N.W.
Dip N.E.

596-1-2-1

GEOLOGY

PERMIT NO. 1415

SCALE: 1 INCH = 2 MILES.

OCTOBER 1957.

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Alfred P. Allen

A.S. Pentland

DETAIL A ~ Scale: 1 INCH = 50 FEET.

DETAIL B ~ Scale: 1 INCH = 500 FEET.

SECTION ALONG A-A

LEGEND

- Conglomerate
- Sandstone
- Shale
- Limestone
- Tertiary
- Cretaceous
- Paleozoic
- Volcanic
- Granite
- (F) Fossil Location

23

REPORT ON THE GEOLOGY

PERMIT UA15

YUKON TERRITORY

By:

A.G. Pentland
and
A.R. Allen
Vancouver, B.C.
November, 1957.

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1. Location

The northeast corner of Permit 1415 is 68°00' north and 138°30' west. It is in the northern tip of Yukon Territory, about 35 miles northeast of the village of Old Crow.

2. Ownership

Permit 1415 covers 48,202 acres. Mr. Joseph Paradis, 404, 510 West Hastings Street, Vancouver, B. C. is the owner.

3. Accessibility and Transportation

Access to the area is by means of aircraft equipped with floats during the summer and skis during the winter. A few light aircraft on wheels penetrate the area as far as Old Crow where they land on gravel bars along the Porcupine River. A river boat makes two trips each summer from Fort Yukon to Old Crow to bring in supplies. It seems reasonable to assume that this service could be augmented providing there is sufficient demand.

Locally, transportation of heavy equipment could be carried out more easily during the winter months. The country is comparatively flat with large areas of tundra

and lakes. Winter roads for tractor trains could be made quickly and at a comparatively small cost when the lakes and tundra are frozen.

Runways could be prepared and kept open during the winter on many of the larger lakes, thus giving access to the area by means of large aircraft equipped either with wheels or skis.

4. 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 late 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 throughout 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. Residents of the area state that occasionally during the winter a chinook wind causes a very rapid rise in temperature accompanied by melting snow.

The area is situated on the extreme limit of tree growth. Most of the trees grow along the banks of streams

and are usually small and scrubby. They consist mainly of white spruce with minor amounts of poplar and birch. Willow and alders may grow in thick masses along the banks of streams. The greater part of the area is covered with the various types of moss that are common to the Arctic tundra.

5. Physiography

H.S. Bostock (5) has divided the Yukon into a number of divisions based on physiography. Old Crow is in the Porcupine Plain in this classification. The plain is a shallow depression about 200 miles long by a maximum of 60 miles wide. The axis lies in a north-south to northwest-southeast direction. The plain is bounded by Porcupine Plateau on the southwest and by Richardson Mountains, Arctic Plateau, and British Mountains on the east and north. The northern half of the plain consists of a low undulating area that is spotted with ponds and lakes. Here and there throughout this part of the plain, hills protrude to a height of 200 to 500 feet above the general level. The low-lying parts are underlain by soft shales, sandstones, and conglomerates of Tertiary and Cretaceous ages, and the hills by hard, folded, and metamorphosed rocks of an older age.

6. Reasons for the Investigation

The geological investigation of this area was undertaken in order to map the outcrops of rocks, and to determine their ages and attitudes. It was considered that

this information would furnish a sound basis upon which to recommend further investigation aimed at finding oil and gas.

7. Methods of Investigation

The party consisted of A.R. Allen and A.G. Pentland. A Cessna aircraft, model 170B equipped with floats, was used for transportation. The method used was to fly first over the permit at low elevation and 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 find 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 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 permit and for locating outcrops.

The second step was to make traverses on foot to examine all outcrops, collect fossils, and determine attitudes. Generally, a landing was made on the river or a lake, the party separated, one going each direction, and a pace and compass survey was made, or the outcrops were located by means of maps and aerial photographs.

A photographic mosaic was made to the scale of 1 inch to 1 mile and outcrops were accurately located on this. The final map was reduced to 1 inch to 2 miles because of the large area covered.

8. Regional Geology

Cairnes (1) states that formations along the Yukon-Alaska boundary between the Yukon and Porcupine Rivers are dominantly of sedimentary origin but include some intrusives and also a group of metamorphic rocks. The sediments range in age from Recent to Lower Cambrian or possibly Precambrian age. This is one of the most complete sections of Palaeozoic rocks, from the Cambrian to the Carboniferous, known in the Rocky Mountain regions of Canada, or the United States within such a limited area.

The Tindir group is older than Middle Cambrian and may prove to be Precambrian in age. No fossils have been found. The rocks are dolomites, quartzites, shales, phyllites, and associated greenstones.

The Tindir group is overlain unconformably by a thick series of limestones and dolomites which range in age from Cambrian to Pennsylvanian. The entire series of rocks from the Cambrian to the Silurian appears to be conformable. Fossils are rare with the result that it is very difficult to differentiate the beds of different ages. The Devonian limestones resemble very closely the older rocks but they are somewhat more homogenous and darker in appearance, being typically dark bluish grey in color. They generally emit

Period	Formation	Thickness	Lithological character
Recent and Pleistocene	Superficial deposits		Gravels, sands, clays, peat, soil, and ground-ice.
Tertiary			Poorly consolidated conglomerates and sandstone. Buff to grey in color.
Cretaceous		4000±	Shales, sandstones, conglomerates.
Carboniferous	Nation River formation and superjacent beds	2000±	Conglomerates, sandstones, shales, and limestones.
	Racquet group	1500+	Dominantly white to greyish limestones, containing considerable chert in places. Also includes some intercalated dark shales and cherty conglomerate beds.
Devonian	Salmontrout limestone and associated beds	300+	Light to dark grey crystalline limestone.
Silurian Ordovician Cambrian		4000+	Limestones and dolomites, dominantly very siliceous.
Precambrian or Lower Cambrian	Tindir group	5000+	Quartzites, dolomites, shales, slates, phyllites, and some magnesite and greenstone.
Resemble Coast Range intrusives which are Jurassic and Cretaceous in age			Granitic rocks ranging in character from granites to diorites, or possibly even more basic types.
Range in age from probably Devonian to Precambrian			Diabase, diorites, andesites, and other basic intrusives.

a strong oily odor when broken. In places a heavy bed or series of beds of white to light grey, sugar-grained quartzite occurs at the base of this limestone series. The Devonian limestones have an aggregate thickness of from 300 to 500 feet. They lie unconformably over the Silurian rocks.

Members of the limestone-chert group overlie the Devonian limestones. They contain both Mississippian and Pennsylvanian fossils. The rocks consist mainly of limestones and cherts, but include also occasional beds of dark shale, calcareous sandstone, and cherty conglomerate.

These limestones are overlain, in turn, by the Nation River formation which comprise a thick series of sediments composed dominantly of shales, sandstones, and conglomerates with occasional intercalated beds of limestone. The Nation River beds are of Pennsylvanian or Permian age.

The Cretaceous beds consist mainly of shales, sandstones, and conglomerates. The shales are dominantly black, brown, or some shade of grey, and vary in character from hard, firm, finely-bedded rocks to soft friable clays which break into irregular fragments. The shales, in many places, are interbedded with thin sandy layers, and contain ironstone concretions which range in size from a few inches up to six or seven feet in diameter. The conglomerates range in texture from rocks that might be considered coarse sandstone to those containing boulders six to ten inches in diameter.

The Tertiary rocks are typically soft, partially

consolidated sandstones, conglomerates, and interbedded shales. They are usually some shade of grey, buff, or rusty color. Typically, they contain the remains of plants and trees.

The igneous rocks may be divided into two groups. The more basic group, composed of diabases, diorites, and andesites, occur as dikes and small irregular masses. Cairnes found these rocks extensively developed in association with members of the Tindir group and only rarely with more recent formations. He concludes that they are dominantly of pre-Middle Cambrian age. The more acid group include plutonic intrusives of granitic habit. They are very similar to the Coast Range intrusives of British Columbia and the Yukon and are probably of Mesozoic age.

9. Local Geology

The whole of the area covered by this permit is extremely flat and covered by lakes or ponds and muskeg. There are no outcrops. A fairly comprehensive cross section of the region was obtained along the Porcupine River and all of the higher hills within several miles of the permit were traversed in order to fill out the picture as much as possible.

Correlation was difficult because of the dearth of fossils and the complicated structural features where older rocks protrude through the level Cretaceous and Tertiary plane. As a general rule these hills do not show well-defined outcrops, but rather the summits are covered by broken fragments and scree from the underlying rocks. It is possible to determine the type of rock underlying the hill but the exact

contacts, the attitude, and in most cases, the age of the rock could not be determined with any degree of accuracy.

An attempt was made to determine the local geology from all of the information gathered over an area about twenty four miles in a north-south direction and 30 miles in an east-west direction.

The overall picture appears to be that of a large basin in which comparatively flat-lying Cretaceous and Tertiary sediments overlie older sediments that are more highly folded and metamorphosed. The basin is about 24 miles wide at the Porcupine River and extends northwesterly from the river a considerable distance beyond the permit. The basin is bounded by comparatively high plateaus and mountain ranges which, as a general rule, are underlain by older and more highly folded rocks. The hills which here and there protrude above the general level, are situated near the edge of the basin, and may be considered the foothills of the mountains.

Porcupine River Section

The Porcupine River, from about six miles below the mouth of Driftwood River to eight miles above Old Crow, cuts across the basin. The banks expose comparatively flat-lying sediments of Cretaceous and Tertiary ages.

The Cretaceous rocks are essentially dark grey to black shales with occasional sandy or calcareous lenses interbedded. Characteristically they contain ironstone concretions which range in size from a few inches to six feet in diameter. The concretions are more resistant to

weathering than the enclosing shale with the result that they stand out in the banks of the river or accumulate along the river's edge as the bank recedes. Many contain fragments of fossils, which as a general rule are not sufficiently well preserved to allow identification. The shales contain an appreciable amount of sulphur, the odor of which is quite noticeable on a hot afternoon when the sun beats down upon an outcrop. Characteristically, the shales break into irregularly-shaped fragments but in some places they are finely bedded and break along the bedding planes.

The following fossils were collected and sent to C.R. Stelck of the University of Alberta for identification:

1. From the second large bend below the Driftwood River. Alnus sp. (leaf) Late Upper Cretaceous or Tertiary.

2. North bank of Porcupine River opposite Dave Lord Creek. Nucula sp. and a Fucoid. Probably Cretaceous.

3. At the intersection of 139°30' and Porcupine River. Fragments of Inoceramus cf. lundbreckensis and Goniomya n.s. and worm borings. Upper Cretaceous.

The Tertiary rocks are poorly consolidated conglomerates, sandstones, and shales. They are usually buff to a rusty color but contain beds that are white, grey, or almost black. They break readily when struck by a pick. Carbonaceous remains of trees and plants are found throughout the outcrops. In one place, the poorly preserved trunk of a tree about two feet in diameter was observed.

The beds along the eastern half of this portion of the Porcupine River are generally flat-lying or gently

undulating with dips of under five degrees. The beds along the western half are more intricately folded with dips up to 45 degrees. Although much of the folding is of a minor nature with amplitudes of the folds ranging from five to 20 feet, two anticlines were mapped in which the folding is of sufficient magnitude to bring beds of Upper Cretaceous age to the surface in parts that are otherwise underlain by rocks of Tertiary age. The one anticline is near the mouth of Dave Lord Creek and the other at the intersection of longitude 139°30' west with the Porcupine River.

Tertiary beds are exposed on the north bank of the Porcupine River at the mouth of Dave Lord Creek. The average dip is to the west although the beds are folded into a series of minor cremulations. At about one half mile up the river, dark grey shales that have the characteristic appearance of Cretaceous beds are exposed. The outcrop extends 700 feet upstream where the same shales have a dip of ten degrees to the east. Bedrock is covered for a considerable distance from here and the next exposure is composed of rocks of Tertiary age. Thus, there appears to be a gentle arch with minor cremulations on the west flank. The axis crosses the Porcupine River in a general north-south direction about one half mile above the mouth of Dave Lord Creek.

The other fold is very similar. Tertiary beds to the west have a westerly dip and similar beds to the east have an easterly dip. Shales of Upper Cretaceous age are exposed near the axis of the fold.

A major structure crosses the Porcupine River at the first big bend below the junction of Porcupine and Deadwood. Here, buff, dark brown, and black limestones and limy shales are folded into a sharp anticline the axis of which strikes northwesterly. The beds on the west limb of the fold dip about 45 degrees to the northwest, and those on the east limb dip from 65 to 85 degrees to the southeast. In a few places they are nearly vertical or overturned.

Quartzites outcrop on the upstream side of the anticline. They are white to slightly buff in color and range from massive to fine-bedded. They are folded into minor folds but the average dip is to the east or southeast.

The quartzites are overlain by flat-lying, black, fissile shales that resemble very closely the Cretaceous shales which outcrop for several miles along the lower part of the river.

Opposite the mouth of Deadwood River, there is an outcrop of light colored limestone that has a northeasterly strike and a dip of 30 degrees to the southeast. The limestone is overlain by a hard, massive, chert conglomerate. The pebbles range in size from large sand grains to marbles with only a very few having a diameter of one to two inches.

The age of the limestones, quartzites, and conglomerate cannot be determined definitely because no fossils were found. From a lithological point of view, they resemble closely beds described by Cairnes and assigned by him to Carboniferous age.

The flat-lying, black shales are almost certainly of Cretaceous age and represent an embayment of rocks that overlie those of older age unconformably.

Exposures on Isolated Hills

A hill situated two miles northeast of the second major bend in the Porcupine River below its confluence with the Deadwood has a capping of rubble composed of fragments of quartzite. Dip and strike could not be determined because of the poor outcrop. However, its position indicates that it is on the east flank of the anticline described above.

A second hill, situated seven miles east of Permit 1415 has an extensive capping of broken fragments of white quartzite. Here, as in the hill to the south, the attitude could not be determined with certainty. However, the general appearance of the hill and its location with reference to the projection of the axis of the anticline suggests a northwesterly dip. The quartzite resembles very closely that exposed on the Porcupine River.

10. Economic Possibilities

Permit 1415 is near the central part of a large sedimentary basin. The periphery of the basin is underlain for the most part by rocks of Paleozoic age and the basin itself by rocks of Tertiary and Cretaceous ages. The older rocks are folded into broad anticlines and synclines.

The younger rocks are not so highly folded, and in places are flat-lying.

The Tertiary and Cretaceous rocks are underlain by clastic sediments of Permo-Carboniferous age and these in turn by a great thickness of limestones and dolomites ranging in age from Carboniferous to Cambrian. Cairnes (1, p. 56) estimates the thickness to be at least 4,000 feet and states (1, p. 59) that the dolomites in places are more or less porous and contain numerous cavities which are generally quite small, but range in size from microscopic to several inches in diameter. There seems little doubt that a part of these limestones are coralline and contain sufficient porosity to act as an oil reservoir rock. Cairnes (1, p. 76) notes that the Devonian limestones "generally emit a strong oily odour".

Thus it is evident that the area covered by this permit is underlain by a thick sedimentary series that gives promise of oil or gas production. It is known that folding has taken place particularly in the Paleozoic sediments.

Oil has been found in a coral reef in the Norman Wells field and this has given rise to the hope that other discoveries will be made in similar structures. Also, it has been shown that coral reefs give good seismic reflections. This method has been used with considerable success in many parts of Western Canada.

Permit 1415 warrants further investigation. It is recommended that a seismic survey be completed and a study

made of the results in order to give further information regarding the sub-surface geology.

A.G. Pentland

Alfred E. Allen

Vancouver, B. C.
November, 1957.

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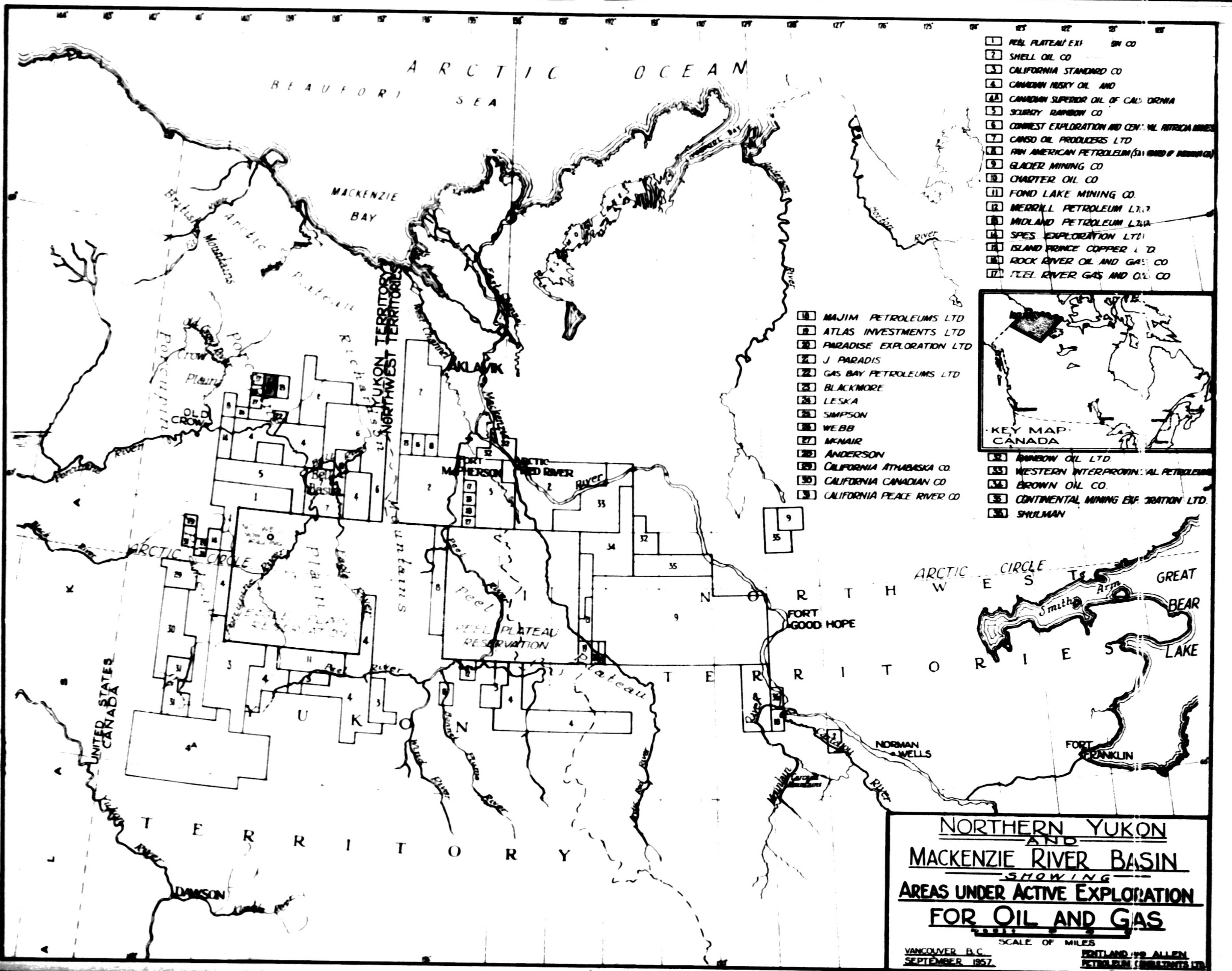
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Richardson Mountains
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Arctic Plateau
Porcupine River
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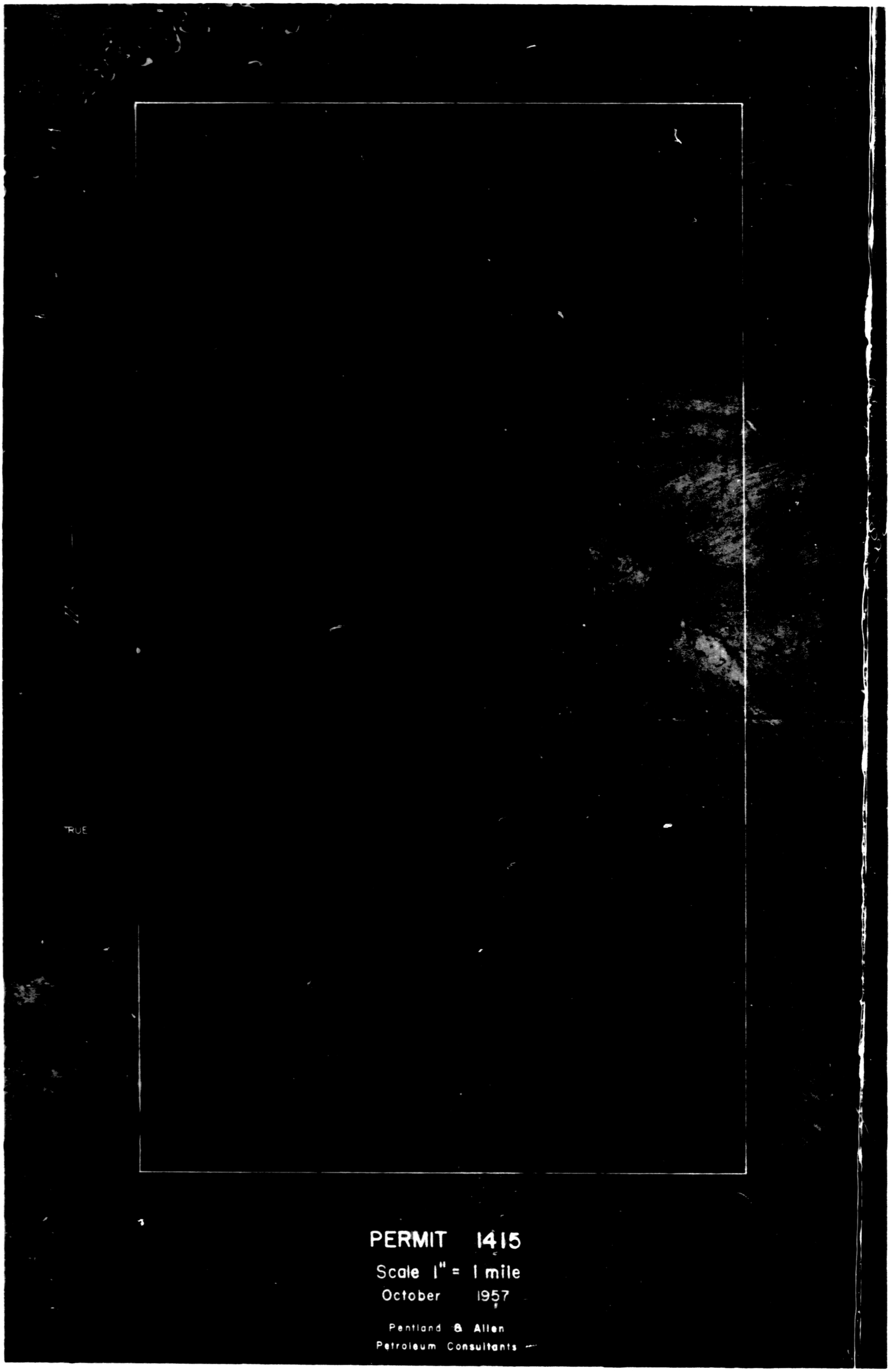
Bell Basin
Eagle Plain
Mackenzie River
West Channel
East Channel
Anderson River
Horton River
Yukon River
Wind River
Bonnet Plume River
Arctic Red River
Carcajou River



PERMIT 1415

Scale 1" = 1 mile

October 1957

Pentland & Allen

Petroleum Consultants