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Date _____

PRELIMINARY GEOLOGICAL REPORT

PERMIT 1525

LIARD RIVER AREA, N.W.T.

Abstracted for
Geo-Science Data Index

Date _____

Prepared for
CORDA INVESTMENTS LTD.

by
BULLOCK & HUGHES
Consulting Geologists
October 31, 1958

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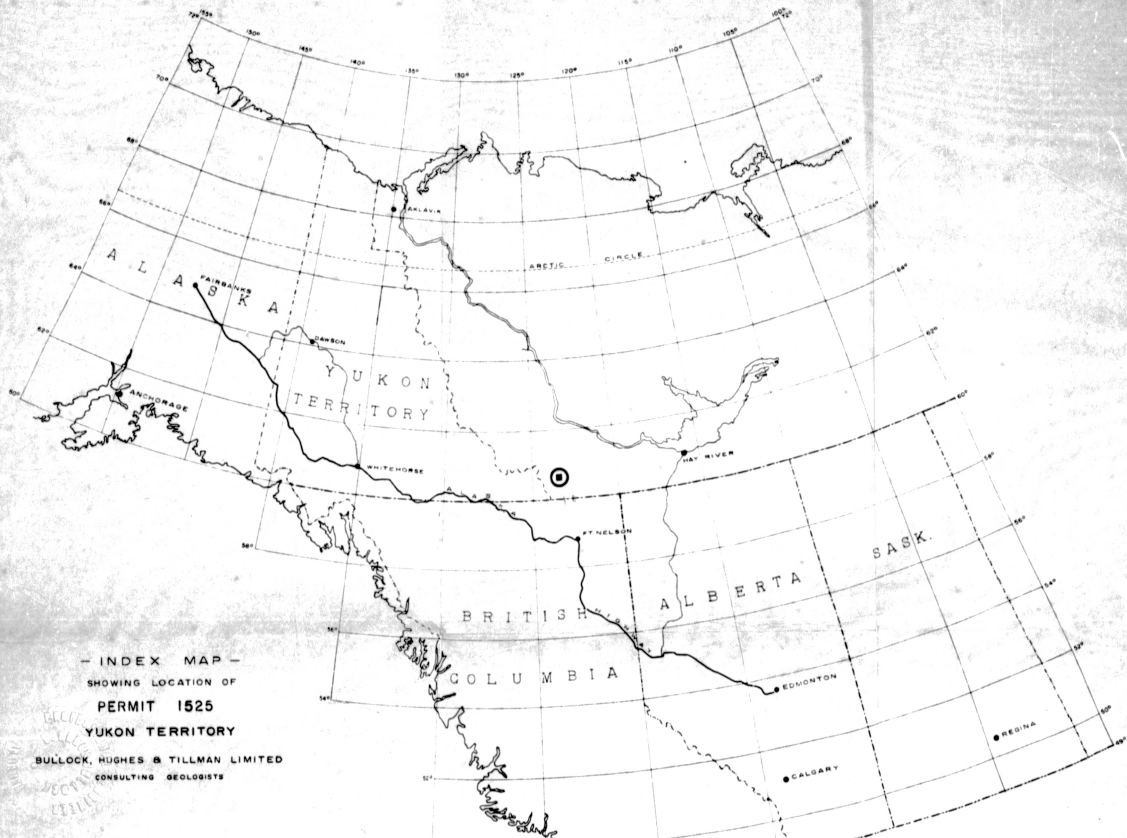
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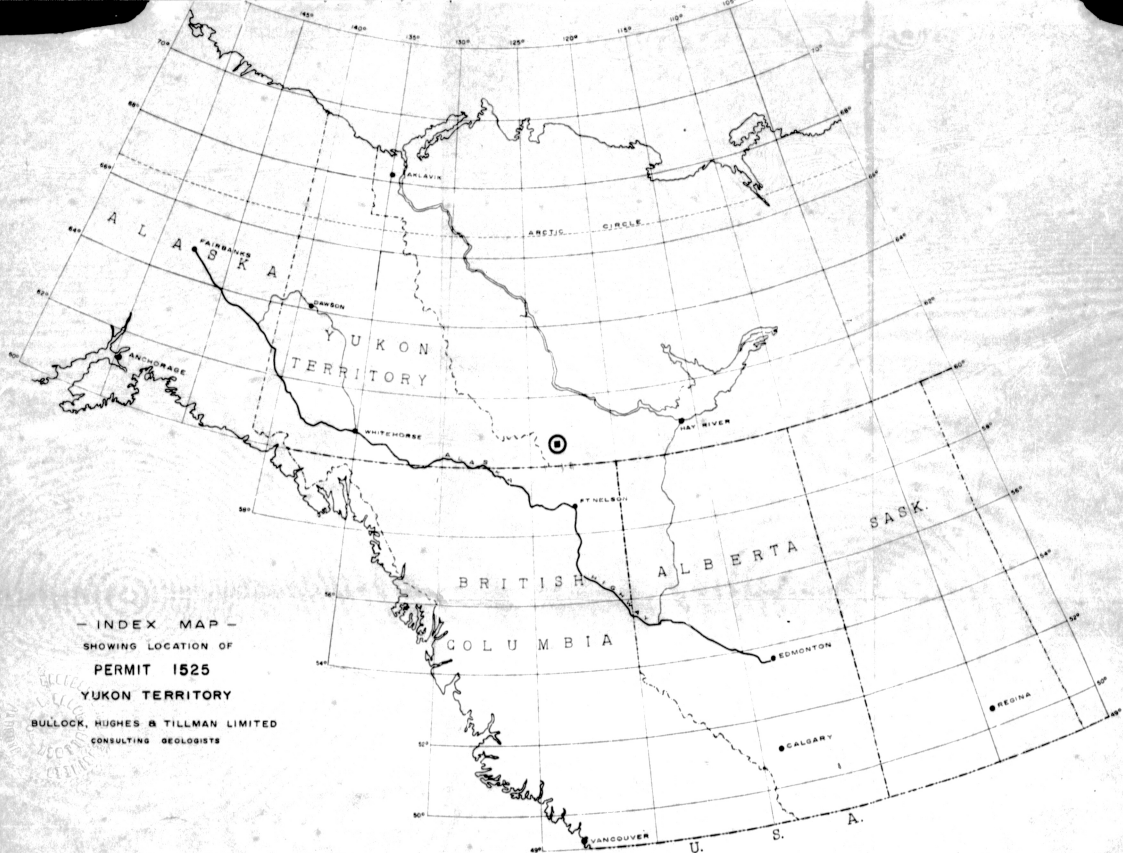


- INDEX MAP -
SHOWING LOCATION OF
PERMIT 1525
YUKON TERRITORY

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- INDEX MAP -
SHOWING LOCATION OF
PERMIT 1525
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SCALE OF MILES
0 100 200 300 400

ABSTRACT

A reconnaissance surface geological survey was carried out on Permit 1525 during the summer of 1958. Data obtained during the survey indicates the presence of a faulted anticline within the permit. Porous zones in Lower Paleozoics underlie the anticline while these and porous zones in the upper Paleozoics underlie the eastern part of the permit. Both the anticlinal flexure and the fault provide potential traps for the accumulation of hydrocarbons. Detailed surface studies to provide stratigraphic detail and geophysical surveys to provide structural detail are warranted and recommended.

INTRODUCTION

General Statement

The area dealt with in this report is located in the southern part of the Northwest Territories in an area of active exploration for oil and gas. Hydrocarbons potential is the main economic value of the acreage and the permit is held for the purpose of exploring for oil and/or gas. The area occupies part of the vast sedimentary basin of Western Canada that is productive in many places to the south.

Location and Area

Permit 1525 is located along part of the Liard River about 16 miles north of the village of Ft. Liard, N.W.T. It is bounded by the following coordinates: on the north by $67^{\circ} 40' N$; on the east by $123^{\circ} 15' W$; on the south by $67^{\circ} 30' N$; and on the west by $123^{\circ} 30' W$. A total of 62,890 acres are contained in the permit.

Accessibility

Permit 1525 borders on a portion of the Liard River which is used as an artery for freight traffic between the Alaska Highway at Ft. Nelson, B. C. and points as far north as Tuktoyaktuk on the Arctic coast. Heavy equipment could be moved by barge down the Liard River to

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the permit area during the early summer months. Seismic and access roads to wells have been constructed from Ft. Nelson as far as Bowie Lake (15 miles east of Ft. Liard). These roads are useable during the winter months only. An extension to these roads would have to be constructed to the permit area, a distance of about 30 miles, to gain access by this route.

Supplies are available from Ft. Nelson or outside points via the Alaska Highway. Ft. Nelson, B. C. is served by regular commercial airlines and an aircraft charter service is available at Ft. Nelson. Float-equipped aircraft are able to land on Liard River near the permit.

Vegetation and Wildlife

Vegetal cover over the area is dense. Predominant tree types are black spruce, poplar, and birch. The area has been burned over and a thick new growth of poplar has grown up on the hilly areas. Spruce growths occupy the lower, damper ground while poplar and birch are to be found on dry ground. Some of the trees which were left standing by the fire have grown to a very large size. The area is difficult to walk through because of the dead fall and the very dense second growth.

Wildlife is abundant in the area. Big game

animals include moose, sheep, and grizzly bear. Fur bearing animals include lynx, martin, beaver, muskrat, fox, bear, and wolf. Arctic grayling, Dollyvarden, and Jack Fish are found in most of the streams and lakes of the region. There are many ducks and a few grouse common to the area.

Drainage

The western portion of the map area is well drained whereas the eastern portion is wet with muskeg. The stream pattern over most of the area is dendritic. There may be some structural control of the stream channels in the western portion of the map area in the vicinity of the mapped fault.

Stream valleys over the entire map area contain an abundance of glacial gravels and boulder clays. In the extreme western part of the map area the stream valleys have cut down through bedrock of shale and limestone to form deep canyons in their lower reaches. Stream valleys in the eastern part of the area are typically muskeg-type with shallow meandering channels.

Type and Method of Survey

The work done on the area was planned to evaluate the hydrocarbon potential of the acreage, using reconnais-

sance surface geological methods. The techniques employed during the survey involved the use of a helicopter-expedited surface geological survey with float-equipped aircraft support. Attitudes of the beds were obtained by either measurement with a Brunton compass or strike and dip estimation from the helicopter. Where it was impossible to land in order to examine outcrops, the helicopter was flown as close as possible to the rock units consistent with safety.

Surface geological studies were supported by photogeological studies and by a compilation of published information. During the period of the field study, the party was based at Ft. Liard. The survey crew consisted of one geologist, helicopter pilot and engineer, fixed wing aircraft pilot, and a cook. Work was under the direction of D. Bruce Bullock, P. Eng.

It is particularly important for the reader to note that this report is of reconnaissance quality and should be regarded as preliminary in value pursuant to detailed studies.

Acknowledgements

The writer wishes to express his appreciation to the members of the survey crew for their excellent cooperation in the field. Special thanks are given to

the residents of Ft. Liard for their kindnesses to the crew in providing accomodation and supplies.

PHYSIOGRAPHY AND TOPOGRAPHY

The area discussed in this report is located along the western edge of the plains area in the zone of transition between plains and foothills physiographic provinces. The Liard Range of mountains borders Permit 1525 on the west.

Elevations within the permit area vary from less than 700 feet in the Liard River valley to over 1500 feet on the top of a hill in the northwest corner of the permit. Relief over the permit area is moderate except for the above mentioned hill which forms a predominant landmark in the area. This hill is rounded in outline and is composed of bedrock. The topography is not severe and would offer little difficulty to the building of access roads across the permit.

GEOLOGY

General Statement

Permit 1525 lies within a portion of the Liard Basin which is underlain by a thick series of sediments. The area encloses part of the outer edge of the tectonic belt which is associated with the Liard Range of Mountains.

Surface exposures are limited to small outcrop areas in the creek and river bottoms. Glacial mantle and vegetal cover obscure much of the surface geology.

STRATIGRAPHY

Surface exposures within the permit area are confined to strata of Mississippian and Cretaceous ages. In the mountains west of the permit, strata of Devonian, Pennsylvanian, and Triassic ages are also present. Stratigraphic descriptions contained in this report are based on published data and the writer's personal knowledge of the sections exposed in the mountains in the general area of the permit.

Middle Devonian

C. O. Hage (1945) proposed the new formational name Nahanni for a Middle Devonian sequence resting disconformably on Silurian beds on Nahanni Butte. The section of Nahanni formation on the Butte has a thickness of 450 feet and is described as "bedded, dark grey, light grey weathering, dense, dolomitic limestones and finely crystalline and dense limestones". The section is profoundly faulted.

Imperial Big Island River No. 1 penetrated 380 feet of Slave Point (Middle Devonian) beds and 931 feet of

Elk Point and older beds overlying the Precambrian basement.

P. R. Kingston (1950) carried out a stratigraphic reconnaissance along the upper South Nahanni River and found sections of Cambrian, Ordovician, Silurian, and Devonian present. He reported that neither the upper nor the basal contact of the Devonian was seen in the area. A total of 4,340 feet of apparently unfaulted Devonian beds were measured. Briefly: the oldest (Devonian) measured beds consist of black fissile shale shot with pyrite concretions and free sulphur. Interbedded with these shales are thin beds of limestone. This sequence grades upwards into cycles of thin-bedded, platy, black, shaly limestone and platy, black shale. Upward the limestones increase until they predominate and shale is present only in rare thin beds. Upwards grey, coralline, reef limestones are introduced and dolomites appear. Kingston described a prominent unconformity within the Devonian 2,140 feet above the base of the measured section. The section above the unconformity comprises cliff-forming massive, irregularly bedded, reef-like limestones. The beds are said to be locally petroliferous as well as porous. Kingston remarks on a similarity between the cliff-forming limestones and the Ramparts formation of the Mackenzie Mountains. It is interesting to note that

W. R. S. Henderson (1954) suggested the possibility that some part of the "Ramparts" formation might be of Lower Devonian age.

Upper Devonian

Mississippian strata are underlain by Upper Devonian beds in the region under discussion. C. O. Hage (1954) measured 800 feet of shales in a partial section exposed on the saddle on Nahanni Butte. These shales range from dark grey to greenish grey in colour, from hard to fissile, are calcareous, and locally friable. Limestones of Wabamun and pre-Wabamun age probably both eventually will be found present within the region of the permit acreage as more detailed surface and subsurface studies are carried out. In Imperial Big Island River No. 1, the nearest well to the permit, Upper Devonian beds measured 4,715 feet thick.

W. R. S. Henderson (1954) states that the Simpson formation, of Upper Devonian age, measures between 3000 and 3500 feet in thickness near Camell Bend on the Mackenzie River.

Mississippian

Mississippian beds on Labiche Range region consist of an interbedded sequence of limestone, cherty

limestone with much shale in the lower section. W. H. H. Patton (1956) delivered a paper on Mississippian Succession in South Nahanni River Area, Northwest Territories to the Alberta Society of Petroleum Geologists. The abstract of this very important contribution follows:

"A thick section of Mississippian rocks is exposed west of Jackfish River in the LaBiche Range of the Mackenzie Mountains near South Nahanni River, N.W.T.

From fossil evidence rocks of Kinderhook, Osage, Meramac, and Chester ages are known to be present.

Strata with a Kinderhook fauna equivalent in age to the Banff formation are present. They are followed by a sequence of rocks with Osage, Meramac, and Chester fossils and consisting of interbedded argillaceous limestones and calcareous shale overlain by a great thickness of sandstone with minor shale and coal beds. Fossil plants, Stigmaria sp. and Lepidodendron sp., and coal were found in sandstones below the Meramesian Spirifer cf. poliensis zone.

Microspores from the coal were identified by P. A. Huguobard of the Coal Research Branch of the Geological Survey of Canada, Sydney, Nova Scotia, and were found to indicate a Lower Carboniferous or Mississippian (Tournasian, partly Viscan) flora. Spores in the coal are unlike those found in Mississippian coal of Utah but

are very similar to those described from the Lower Carboniferous of the Ukraine by geologists of the U.S.S.R."

C. O. Hage (1954) described an 850 foot section measured on the west slope of a small mountain about two miles west of Big Island in Liard River thusly:

<u>Top of section</u>	<u>Thickness</u>
Limestone, grey, bedded; contains dark grey chert in thin beds and irregular discontinuous bodies, fossiliferous	150
Shale, brown; interbedded with brown weathering limestone, fossiliferous	100
Shale, dark grey, fissile; with ironstone concretions; in part concealed	200
Limestone, interbedded with calcareous shale; fossiliferous	200
Limestone, dark grey, finely crystalline; interbedded with minor amount of shale, fossiliferous	100
Shale, calcareous; with some beds of crinoidal limestone	<u>100</u>
TOTAL THICKNESS	850

Two miles farther west younger Mississippian beds are exposed in addition to a repetition of the upper beds of the previous Mississippian sequence. Hage described these:

<u>Top of section</u>	<u>Thickness</u>
Base of later Carboniferous section	
Limestone, crinoidal and crystalline; interbedded with grey shale; some black	

<u>Top of section</u>	11.	<u>Thickness</u>
fissile, shale; fossiliferous		100
Limestone, dark grey, fine crystalline; interbedded with shale; fossiliferous		60
Concealed		140
Limestone, dark grey, fine, crystalline; some black chert; interbedded with some black shale containing selenite		<u>100</u>
TOTAL THICKNESS		400

W. R. S. Henderson (1954) reported the discovery by Dann at Twisted Mountain on the South Nahanni River of "over 1500 feet of beds with the base not exposed, consisting chiefly of limestones and which belong lithologically to the Mississippian section which Hage had described in the region."

Outcrops of Mississippian age strata studied in the permit area are described as follows:

At Map location 24-1 - Limestone, brown, granular to fragmental (possible arenaceous) irregularly bedded, hard, abundantly fossiliferous.

At Map location 24-3-1 - Limestone, grey brown, finely granular to dense, hard, slightly sandy in part, bedded up to 18 inches, interbedded with lenses of dark grey, sandy shale, and bands of black chert.

Pennsylvanian

A section of sandstone interbedded with dark grey shales and overlain by an upper chert member were assigned a Pennsylvanian and/or Mississippian age on the basis of contained faunas by C. O. Hage (1945).

C. O. Hage (1945) describes an upper (614 foot) part of the unit on Pointed Mountain, a lower (640 foot) sequence on Sawmill Mountain, and basal (300 foot) beds on Liard Range five miles west of Big Island. A more pertinent, though incomplete, section was measured by C. O. Hage (1945) on Labiche Range near Labiche River:

<u>Top of section</u>	<u>Thickness</u>
Sandstone, medium-grained (not measured)	Feet
Shale, black, fissile, bituminous fossiliiferous	10
Concealed	40
Sandstone, grey, buff weathering	55
Concealed	75
Sandstone, light buff	10
Sandstone, calcareous, fossiliiferous	10
Shale, thinly bedded, calcareous	45
Concealed	45
Limestone, light grey, bedded, cherty, fossils	18
Sandstone, light grey, crossbedded	29
Limestone, dense, some chert	12

<u>Top of section</u>	<u>Thickness</u>
Sandstone, light buff	30
Limestone, light grey, dense	10
Sandstone, light grey, calcareous	20
Sandstone, medium-grained, cross-bedded	60
Limestone, light grey, beds 1 to 4 feet thick, some sandy, others cherty, fossils	110
TOTAL THICKNESS	607

Hage writes: "The contact between the later Carboniferous beds and those of definite Mississippian age may be at the top of the uppermost limestone bed or at the base of the lowest sandstone."

W. R. S. Henderson (1954) notes: "Hage had been unable to ascertain if Cretaceous shales lie directly on the 650 feet, or more, of sandstones, shales, and chert which he had described at Pointed Mountain about 20 miles northwest of Fort Liard, and which he had referred to the Pennsylvanian and/or Mississippian. Paskevitch had found a few hundred feet of similar beds which he believed to lie below Hage's section." Henderson also reports that Dann measured about 950 feet of quartzitic sandstone at Twisted Mountain about 15 miles above the mouth of the South Nahanni. These beds belong to the lower part of Hage's Pennsylvanian and/or Mississippian division.

This whole late Paleozoic division is overlain by 35 feet of conglomerate on Pointed Mountain. These coarse clastics comprise chert fragments in a sandstone matrix and could be a basal Mesozoic, possible Jurassic, conglomerate. Sandstones of Pennsylvanian age in the vicinity of Pointed Mountain were noted by the writer, during earlier work in the area, to be porous and to contain dead oil residues.

Triassic

The nearest known Triassic beds to Permit 1525 are found on Mount Merrill ($60^{\circ} 02' N$ and $124^{\circ} 30' S$). The recent Geological Map of Yukon published by the Geological Survey of Canada shows Toad and Grayling formation undivided at that locality. E. D. Kindle (1948) wrote: "The Lower and Middle Triassic strata thicken considerably towards the west from the confluence of Liard and Toad Rivers. Near the mouth of the Toad, the Toad formation is about 800 feet thick, and no beds of the Liard formation are present. Eight miles due southwest, the Toad formation has increased to an estimated 1,800 feet in thickness, and overlying beds of Liard formation have made their appearance with a minimum thickness of 600 feet."

Cretaceous

Strata of Cretaceous age crop out on Rabbit Creek and at the mouth of Muskeg River south of Permit 1525. The strata examined at Map location 24-4 are believed to belong to the lower unit (Garbutt formation) of the Ft. St. John Group as outlined by C. O. Hage (1945) in a section measured along the Petitot River east of Ft. Liard. These beds are described as Shales, dark grey, sandy, micaceous with ironstones, nodules, and lenses scattered throughout.

Shales of this age form excellent cap rocks for underlying reservoirs but do not contain any known reservoir rocks.

STRUCTURAL GEOLOGY

Structural deformation of the strata underlying Permit 1525 is similar to that found in the Liard Range of mountains to the west. The main structural feature of the mountains is the presence of large anticlinal folds many of which have reverse faults along part of their east flanks.

The principal structural feature of Permit 1525 is a large doubly plunging anticlinal flexure formed in Mississippian strata at the surface and faulted along the east flank. The anticline strikes roughly N-S, parallel

to the mountain front. Axial trace of the anticline is not well defined by surface outcrop and its position on the accompanying geologic map is largely inferred. Bedding plane attitudes measured during the survey provide proof of the existence of an anticlinal flexure. The extension of the anticline through covered areas is based principally on geomorphic evidence.

The anticline plunges along both its south and north extensions. Crest of the structure is believed to coincide with the topographic high centered near the northwest corner of the permit. Vertical closure of the anticline is estimated to be in excess of 1000 feet. The structure is over 15 miles long and 6 miles wide at its widest spot. The anticline and associated fault may be represented at depth by faulting in the basement. It is expected that the folding in evidence at the surface will effect Devonian strata as well but may not involve beds of earlier Paleozoic age.

The reverse fault, located on the east flank of the anticlinal flexure, was not seen in the field. Its position is inferred from field evidence obtained during the survey. The position of Mississippian strata against Cretaceous beds in the Rabbit Creek area necessitates a fault interpretation. The fault has resulted from continued pressure from the west acting on the anticline and

creating stresses beyond the competency of the strata. In the permit the fault has brought Mississippian age strata over beds of Lower Cretaceous age.

The plane of the fault may provide a seal for porous horizons at depth thus providing trapping conditions for hydrocarbons. Geophysical surveys would be required to map the fault plane and the anticlinal flexure at depth.

CONCLUSIONS AND RECOMMENDATIONS

Permit 1525 lies in an area which is underlain by a thick series of sediment that have been subjected to structural deformation producing a major anticline with a faulted east flank. Porous zones in the lower Paleozoic section underlie the anticline and may provide suitable reservoir rocks for hydrocarbons if the structure continues to depth. Porous sandstones of Pennsylvanian age and porous zones of lower Paleozoic age may have been affected by the fault in such a way as to provide a satisfactory seal of the porous zones giving rise suitable hydrocarbon traps.

Additional information is required to properly evaluate the acreage contained in Permit 1525. Stratigraphic detail could be obtained from surface studies of exposures in the mountains of the Liard Range. Subsurface

detail of the anticline and the fault could be obtained from surface studies of exposures in the mountains of the Liard Range. Subsurface detail of the anticline and the fault could be obtained from reflection and/or refraction geophysical surveys across the area.

Permit 1525 is well located and warrants additional study to prove its potential. Surface work would have to be carried out during summer months and geophysical work during the winter months. Consideration should be given to sharing the cost of geophysical surveys with adjoining permittees.

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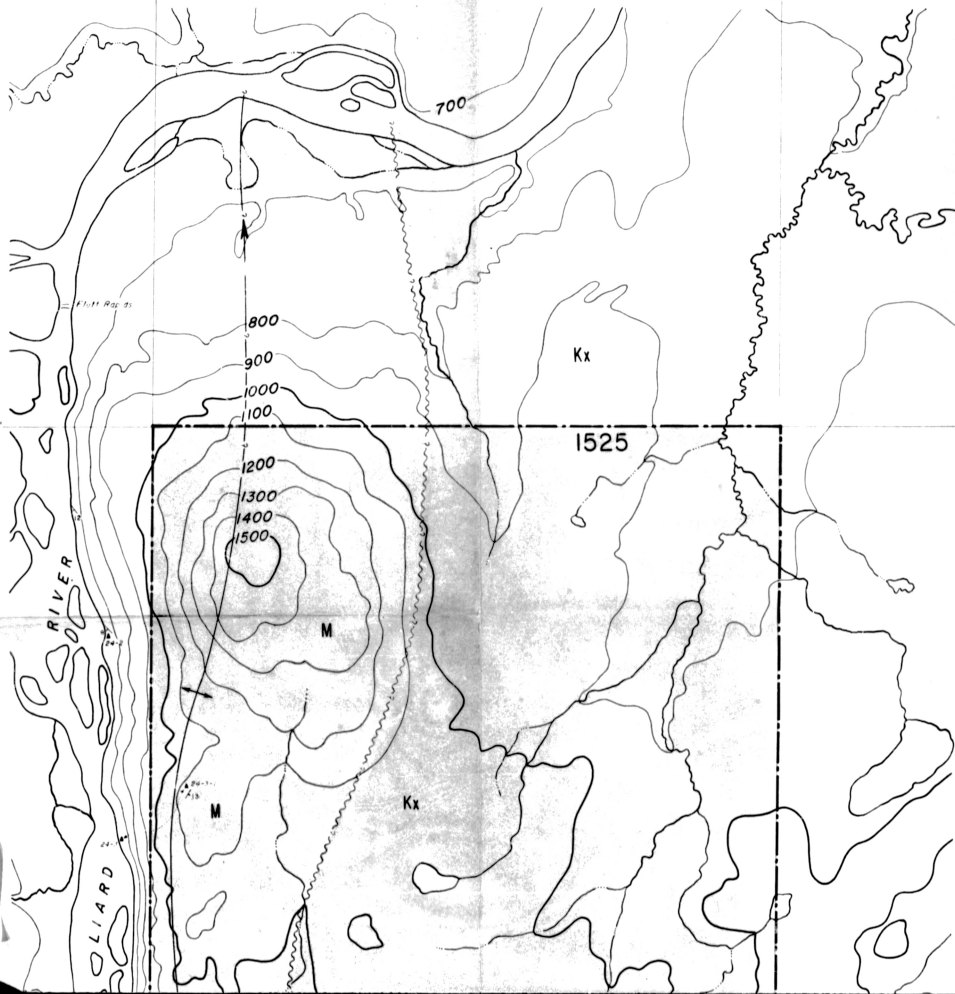
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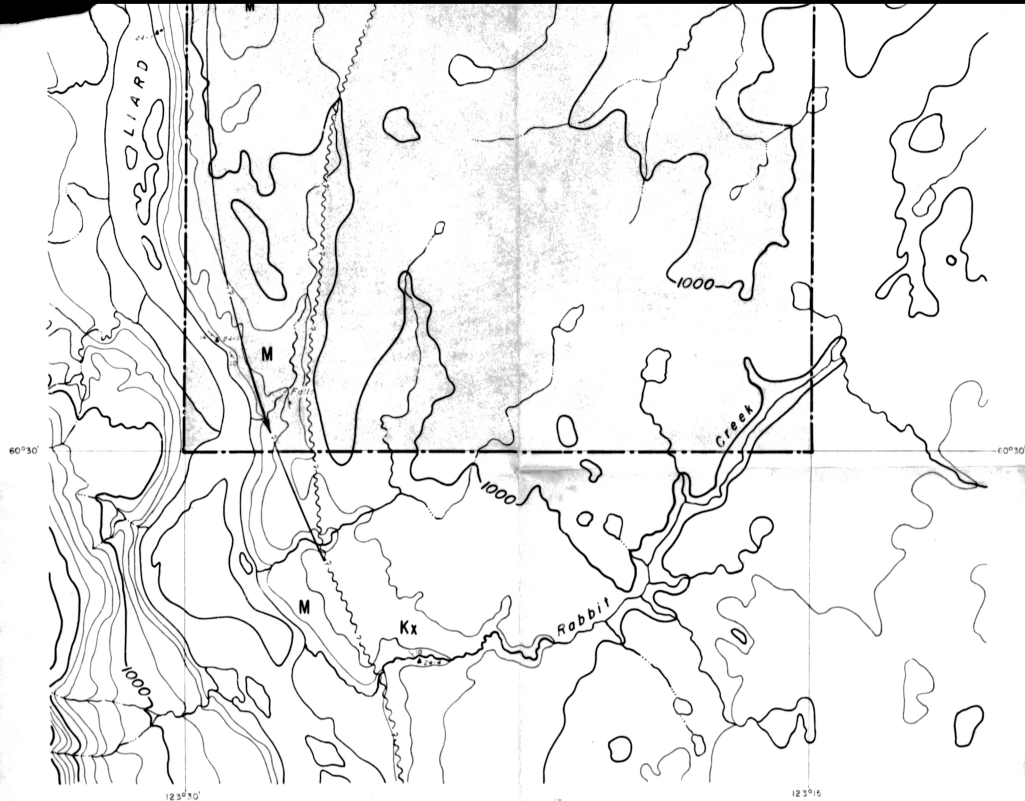
123°15'

60°40'

60°40'



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LEGEND

CRETACEOUS

■ Cretaceous undivided

MISSISSIPPIAN

■ Mississippian undivided

- ▲ Helicopter Landing
- Permit Boundary
- Fault
- Anticline
- Syncline
- OC Observed Dip
- MD Measured Dip
- Ground Traverse

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CALGARY

VANCOUVER

PRELIMINARY GEOLOGICAL MAP

PERMIT 1525

LIARD RIVER AREA, N.W.T.

GEOLOGY BY: D.B. BULLOCK

SCALE: 1 inch to 1 mile

DATE: October, 1958

MAP NO.

CER-4

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