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GEOLOGIC REPORT

SULPHUR PERMIT 108

NORTHERN, ALBERTA

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INTRODUCTION

General Remarks

This report summarizes the economic geology factors of the potential for near-surface sulphur deposits on Sulphur Permit 108, Northern Alberta. Information for this evaluation is based upon a detailed photogeologic study of the permit area and a review of published information. The report was requested by Mr. J.E. Forster, Apex Gravel Limited, and has been produced and written by M.A. Roed, P.Geol.

Location and Access of Permit Area

The permit area is located along the Wabasca River in Tp. 104 and 105, R.9, W4, in Northern Alberta (Map Sheet 84-J), and covers an area of 39,680 acres or 62 square miles (see Index Map on Figure 1). It is situated 30 miles south-east of Fort Vermilion and 300 air-miles north of Edmonton, Alberta. The nearest railroad is the Great Slave Railway located 50 miles to the west. A trail suitable for a four-wheel drive vehicle connects the property to Fort Vermilion and a Siesmic trail is present in the northern part of the permit area. A forestry air-strip is situated 1½ miles to the east of the eastern boundary of the area.

Previous Work

There has been no previous work on the sulphur potential of the permit area to the writer's knowledge. The bedrock geology has been mapped on a reconnaissance basis by Norris (1963). The soils and surficial geology have been mapped on an exploratory basis by Lindsay et al (1959). An oil well, dry and abandoned, was drilled about one mile to the east of the permit area by Hudson's Bay Oil and Gas Ltd.; geologic information of this well has been recorded in Norris (1963).

Physiography

Sulphur Permit 108 is located in the Vermilion Low-land (Bayrock, in Lindsay et al, 1959) of the Great Plains Physiographic Division. The land is very gently rolling with

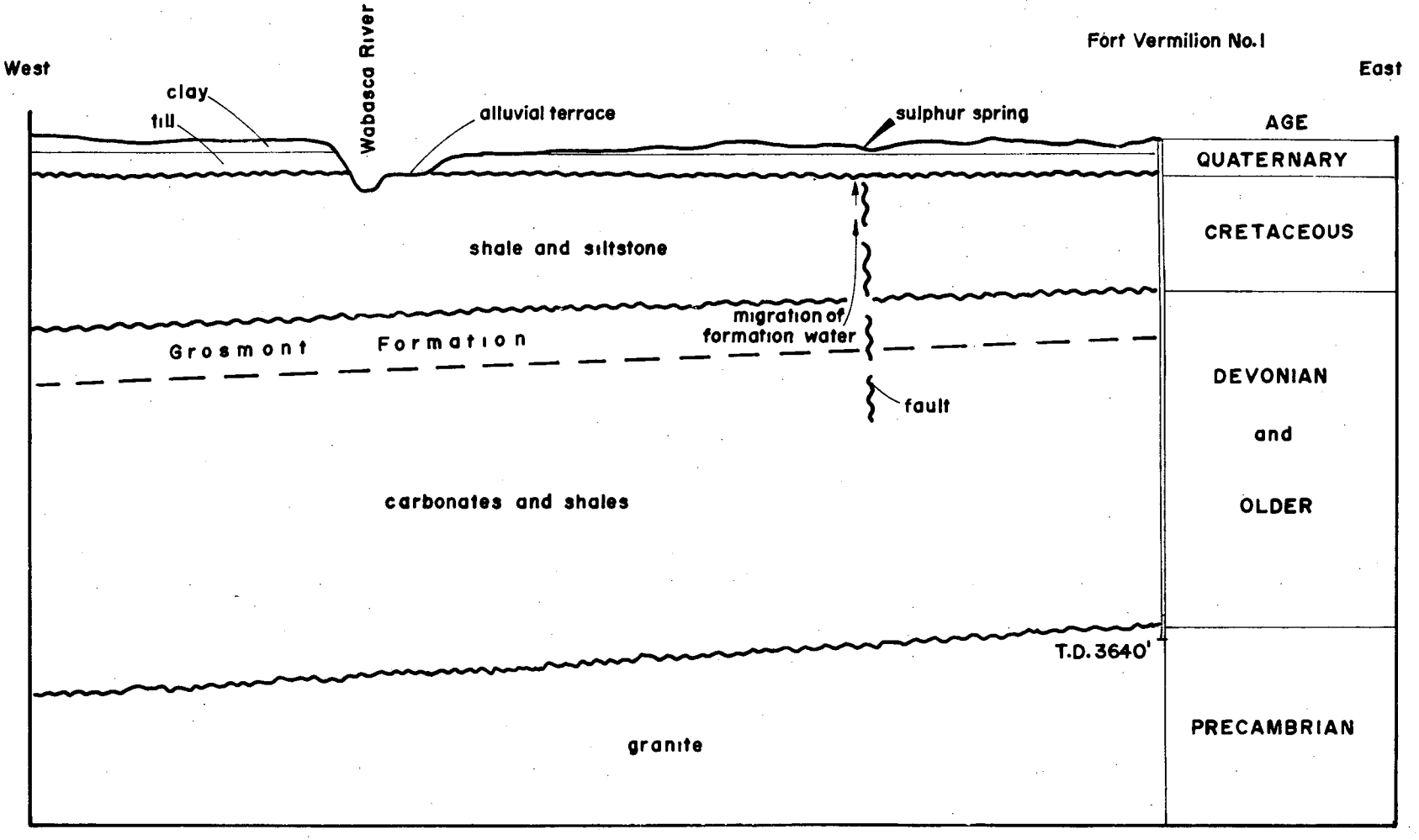

Figure 2 DIAGRAMATIC GEOLOGICAL SECTION - Simplified to show the relationship between faults, cold sulphur springs and the Grosmont Formation.

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a local relief of 50 to 100 feet, and occurs between elevations of 1000 to 900 feet ASL. The Wabasca River flows through the western portion of the permit area and joins with the Peace River 15 miles to the north of the permit. Numerous poorly developed tributary creeks drain into the Wabasca River, but significant erosion has only occured along the valley of the Wabasca River.

The permit area is lightly covered with aspen and a few spruce. Muskeg occupies a minor part of the eastern portion of the permit.

STRATIGRAPHIC GEOLOGY

Two distinct geologic materials occur on the permit; these are surficial deposits and bedrock deposits. These will be discussed separately; a general geologic section showing the relationships between the various units is given on Figure 2.

Surficial Deposits

Surficial deposits of Quaternary age consist of muskeg and bottomland deposits, sand, alluvial sand and gravel, glaciolacustrine clay and till. All units except the till occurs at the surface as shown in Figure 1.

1. Muskeg and Bottomland Deposits: This unit occurs in low-lying, poorly drained depressions and consist mainly of peat but probably contains some alluvial or lacustrine clay and minor aeolian sand. In areas where these poorly drained deposits and sulphur springs coincide there is the possibility of accumulation of near-surface sulphur deposits (Figure 1). The muskeg and bottomland deposit was formed in post-glacial times, probably within the last 10,000 years.

2. Alluvial Sand and Gravel: Alluvial sand and gravel deposits occur on bars and terraces of the Wabasca River. In most places the material is all sand but some terraces are underlain by gravel which provide a potential source of gravel in commercial quantities. The terraces and bars were formed during the course of incision of the Wabasca River in post-glacial time.

3. Dune Sand: Uniform textured sand occurs in scattered localities of parabolic dunes on the permit. These dunes are now stabilized by vegetation and were formed several thousands of years ago in post-glacial time.

4. Glaciolacustrine Clay: Most of the permit area is mantled by a layer of silty and sandy clay deposited in a pro-glacial lake at the end of glacial time. Numerous lineations present in the northeastern part of the permit are interpreted to be strandlines formed upon progressive lowering of the glacial lake, however the lineations may also be a reflection of recessional moraine that underlies the glaciolacustrine clay.

5. Till: Till is a material which was deposited directly from a glacier. This deposit does not form any part of the surface in the permit area but it is undoubtedly exposed in cutbanks along the Wabasca River. It is overlain by glaciolacustrine clay and underlain by bedrock of Cretaceous age.

The glacier that deposited the till came ffom the Keewatin centre of glaciation, west of Hudson Bay, as determined by ice-flow features on the Glacial Map of Canada (1967). The thickness of the glacier was about one mile in this area of Alberta (Bayrock, in Lindsay et al 1959).

Bedrock Deposits

The bedrock of the permit area is made up essentially of horizontally-bedded shales, sandy shales and siltstone of Cretaceous age, and underlying carbonates and shales of Upper Devonian and older age. A representative section is given in Figure 2, which is a summary derived mainly from Hudson's Bay Fort Vermilion No. 1 well (Sec. 32, Tp. 104, R.104, W4) that is located about one mile to the east of the permit area near the airstrip (core description of this well is given in Norris, 1963, p. 161 to 162).

Outcrops of Cretaceous rocks on the permit are restricted to cutbanks of the Wabasca River, whereas the nearest outcrop of rocks of Devonian age is at Vermilion Rapids on the Peace River 20 miles to the northeast. Shales, siltstone and sandstones of Cretaceous age may be up to 500 feet thick in the subsurface of the permit area. The rocks

rest unconformably upon the underlying Upper Devonian rocks. This contact represent a regional unconformity of widespread extent in the plains region of western Canada.

Of special interest within the permit area is the Grosmont Formation of Upper Devonian age. In Hudson's Bay, Fort Vermilion No. 1 well, just east of the permit area, the unit is at least 130 feet thick. Since there is a regional dip to the west of 23 feet per mile, the Grosmont Formation is confidently inferred to underly the entire permit area. The formation is a vuggy, petroliferous dolomite with minor dolomitic limestone. The escape of connate formation water from this unit is believed to give rise to some of the cold sulphur springs in the area, which in turn are genetically related to near-surface sulphur deposits.

The connate formation water may migrate to the surface along one or more porous passages, or escape directly to the surface near exposures of the Grosmont Formation. The most important porous avenues of escape are, firstly, the Cretaceous-Devonian unconformity and, secondly, fractures or faults which are developed in the Paleozoic rocks at depth and extend to the ground surface. Regionally, formation water migration within the subsurface Paleozoic rocks is towards the Vermilion Lowland (Hitchon, in Alberta Society of Petroleum Geologists, 1965) from central and western Alberta. Since the Grosmont Formation is the principal porous member in the permit area, its presence is a prime geologic prerequisite for accumulation of economic near-surface sulphur deposits. The significance of the unit along with related concepts is illustrated in the diagram of Figure 2.

Structural Geology

The regional strike of the Paleozoic sediments in the Vermilion Chutes area is roughly N20° to 30°W; the regional dip is about 23 feet per mile (Norris, 1963, p.74), but there are numerous minor flexures that vary considerably in strike and dip and depart from the regional trend. The only similar structure mapped by Norris (1963, Figure 3) is located on the Clearwater River 200 miles to the southeast of the permit area.

Distinct northwesterly trending lineations that are believed to be structural in origin occur on the permit. These are present mainly to the east of the Wabasca River and are detected on aerial photographs by slight depressions on the ground surface, vegetation patterns and by tonal variations of the surface materials.

ECONOMIC GEOLOGY OF SULPHUR PERMIT 108

The geological aspects which may influence the accumulation of economic near-surface sulphur deposits on Sulphur Permit No. 108 are briefly listed below. This information has been derived from a detailed study of aerial photographs and as a result of experience in other areas.

1. Original finding on Permit No. 8 - presumably a flat-lying bed of native sulphur occuring at and just below the surface. The deposit has been tested with 200 auger drill holes 9 feet deep which indicates an area of the sulphur bed of at least 1400' by 1400'. No tonnages, grade, or geologic description is available but some samples assay better than 70% sulphur. Indicated tonnage estimated from the above information results in a deposit of over one million tons.

2. Some samples are reported to be an earthy material, mainly brown in color with some native sulphur visible; other samples have considerable native sulphur. This information and the near-surface occurrence of the deposits strongly suggest that the sulphur occurs in surficial or glacial deposits.

3. Some of the other sulphur permits cover the area of sub-crop of the carbonate-shale formations of Upper and Middle Devonian age.

4. Other sulphur permits cover the unconformable contact between formations of Cretaceous and Devonian age.

5. Officers of the Research Council of Alberta have reason to believe that the area around Fort Vermilion may be a groundwater discharge area of sulphur-rich waters which have migrated up-dip from the Edmonton area along the Grosmont reef trend.

6. Groundwater springs enriched with sulphur and derived from Devonian formations would be capable of depositing large amounts of sulphuf in an adequate host material and under ideal physio-chemical conditions since the end of glacial time (9000 - 11000 years ago). Favourable host materials would be porous silts and sands of alluvial or glacial origin.

7. Some groundwater springs sustain small lakes; sulphur may accumulate in these lacustrine basins.

8. Some lineations (structural?) are detectable on aerial photographs in the area; fractures and/or faults would offer an avenue of migration for connate waters that are enriched with sulphur, therefore the location of these lineations will help delineate exploration objectives.

Six locations of potential near-surface sulphur accumulations occur on the permit. These locations have been chosen by employing the interpretation that sulphur-bearing formation waters have migrated up to the surface along the faults that have affected the underlying Grosmont Formation. These spots are now marked by muskeg deposits and shallow ponds, especially where the muskeg coincides with a distinct structure. However, the host rock available at these locations appears to be glaciolacustrine silty clay or till, which are believed to be somewhat unfavourable for sulphur deposition - more porous material would present a better recipient of the mineralization. It is unlikely, therefore, that important sulphur accumulations occur within the surficial sediments on the permit, and if such do occur, exploration costs may be very high in order to outline an economic deposit.

Other economic factors which presently discourage further exploration on the permit area include: a) Metallurgical and separation problems of obtaining pure elemental sulphur from surficial materials; b) High transportation and railway rates; c) Uncertain long range prices of sulphur on world markets. An analysis of these factors should be based on a comprehensive feasibility study, which has not been carried out for this report. I feel, however, that these generalizations are presently valid with respect to the indicated potential of sulphur deposits on Permit 108.

CONCLUSIONS AND RECOMMENDATIONS

Due to the cumulative unfavourable geologic conditions for the presence of substantial near-surface exploration targets on Sulphur Permit 108, and because of general economic conditions surrounding the processing and marketing of little known near-surface sulphur deposits, I strongly suggest further exploration expenditure on the permit area be postponed. There is no object in attempting to retain possession of the permit area, therefore, I recommend that Sulphur Permit 108 be cancelled.

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PROFESSIONAL QUALIFICATIONS

1. I, Murray A. Roed, reside at [redacted] Edmonton, Alberta.

2. I have a B.A. (1959) and a M.A. (1961) in Geology from the University of Saskatchewan, Saskatoon. I have a Ph.D. (1968) in Geology from the University of Alberta, Edmonton.

3. I am a Professional Geologist registered with the Alberta Association of Professional Engineers.

4. M.A. Roed Geological Explorations Ltd. was registered in the Province of Alberta May 4, 1966.

5. I possess experience in the following fields of geology: Surficial and glacial geology; groundwater geology; geomorphology; structural and stratigraphic geology; photogeology; geophysics; subsurface drilling in coal, mining and petroleum exploration, and in engineering geology investigations; economic geology; paleontology.

6. I have worked on a variety of exploration projects in the plains and mountainous regions of western and northern Canada.

7. I belong to the following professional societies: Alberta Association of Professional Engineers: Association of Engineering Geologists; Canadian Institute of Mining and Metallurgy; Geological Society of America; Edmonton Geological Society; Association of Professional Engineers of Saskatchewan.

8. I have a 50% interest in Sulphur Permit 108.

Respectfully submitted,

[redacted]

Murray A. Roed, P.Geol.

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Figure 1

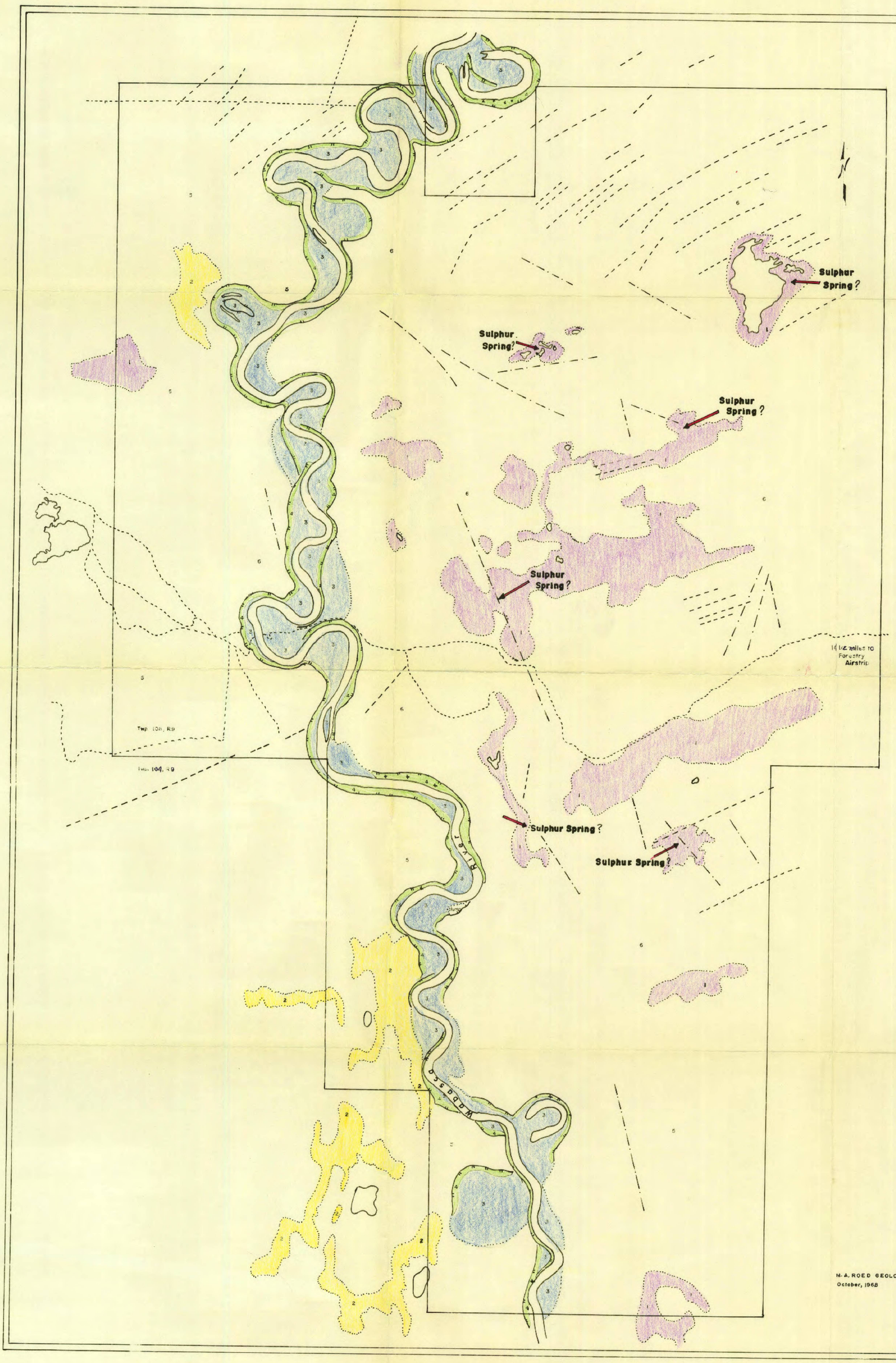


FIGURE 1

SURFICIAL DEPOSITS of SULPHUR PERMIT 108

APEX GRAVEL LTD.

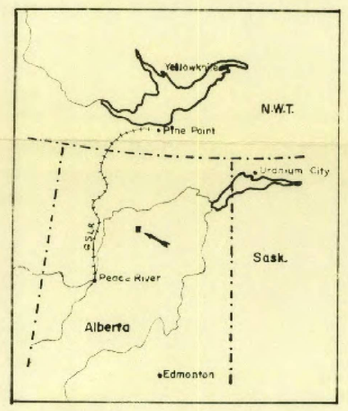
LEGEND

1 Muskeg, bottomland deposits, water ponds
2 Sand, parabolic dunes
3 Sand, minor gravel, alluvial and outwash terraces
4 Colluvium, eroded from slopes
5 Sand, ... some clay, silt; glaciolacustrine
6 Clay, silty and sandy; glaciolacustrine

—·— Lineation, structural, reflected through drift
---- Lineation, glacial, possibly strandlines
·····— Geologic contact, approximate, inferred
Scarp, erosional
Bedrock outcrop
---- Road

SCALE: One inch = 1/2 mile

Source: Photogeology, M.A.Roed
Bayrock, in Lindsay et al, 1959
Norris, 1963



INDEX MAP
One inch = 200 miles

M. A. ROED GEOLOGICAL EXPLORATIONS LTD.
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