# MAR 19680049: FORT VERMILION

Received date: Dec 31, 1968

Public release date: Jan 01, 1970

# GEOLOGIC EVALUATION

of

# SURFICIAL SULPHUR DEPOSITS

# FORT VERMILION AREA, ALBERTA

Prepared By

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1968

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## INTRODUCTION

### Introductory Statement

Reports of a discovery of elemental sulphur at or near the surface began circulating in western Canada during the late summer of 1967. The location of discovery was unknown, although it was indicated to be in the north country. Nickle's Daily Oil Bulletin dated September 7, 1967 carried the following excerpted report:

"Madison Oils Limited is rumoured to be actively delineating a surface deposit of sulphur that was staked fairly recently. Although the company declined to pin point the exploration project due to its early stage of evaluation, it did state that it was on the south side of Great Slave Lake in the southern sector of the Northwest Territories. Inasmuch as it anticipates additional claim staking in the immediate future, the exact location has been withheld.

Evaluation to date has included the drilling of about 100 ten-foot deep core holes. The core recoveries on many of the holes have been assayed and showed a sulphur content between 70 and 77%. Parties are attempting to prove up a reserve of approximately 1 million tons which it considers would foster an economic mining operation at the discovery location. Apparently the current exploration program involves three separate properties in the same general district."

Some people concluded that the discovery was in the southern part of the N.W.T. and considerable effort was initiated to verify the reports. However, as more concrete information became available the area of interest appeared to center about the Fort Vermilion region of north-central Alberta. Records show that Sulphur Prospecting Permit 8 was issued to J. J. O'Connor on September 29th, 1967 covering some 19,840 acres centered about Tp. 110, R.5 W5M. Permit 8 covers the reported discovery in Section 8 of Tp. 110, R. 5 W5M. Soon thereafter Sulphur Prospecting Permits 9 and 10 were issued to the above holder on October 4th and 6th respectively in Tp. 100, R. 9, W5M and Tp. 103, R. 14, W5M. As interest in the area increased, additional permits were acquired by other parties in November and December. By the end of 1967 approximately 60 Sulphur Prospecting Permits had been issued in the general Fort Vermilion area. The stampede continued and by the 1st of March more than 175 permits had been issued. These covered more than 5-1/2 million acres.

Little hard factual data on the discovery has been released to the public nor have many details been made available. Much of the information has been derived through rumours and innuendo. However, it has been established that Bow Valley Industries Ltd. acquired an option on Sulphur Prospecting Permits 8, 9, and 10 from James J. O'Connor of Calgary. Madison Oils Limited had announced earlier that it had entered into an agreement to obtain a half interest in the permits from the private syndicate which backed the original acquisition venture.

Information released by operators in the area has been meagre. Published reports have appeared periodically in Oilweek, Nickle's Daily Oil Bulletin and the Northern Miner. Study of the information suggests that native sulphur is at or near the surface at several places on Permit 8 and appears to be associated with flat-lying beds. Several pits and 200 9-foot deep auger holes outlined the sulphur deposit over an area measuring 1,400 feet by 1,400 feet closing off only one side of the deposit. The thickness of the deposit has not yet been established. Assay results have indicated a sulphur content ranging up to 90%. However, high grade areas appear small and may not be economically feasible for exploitation under present production techniques.

Reaction to the reports of the sulphur discovery varied. It ranged from complete scepticism to wild-eyed claims which have generated some hysterical publicity (Time, Jan.5, 1968). Fortunately, most people and organizations appear to have maintained an open mind and believe insufficient facts and information are available to make a sound judgment at this time. Considerable evaluation work must be done before any definite conclusions can be reached.

## Sulphur Prospecting Permit Regulations

A copy of a sample Sulphur Prospecting Permit accompanies this report (in map case). Basically it is a document issued by the Province which grants the right for a permitee to explore for and recover sulphur that is the property of the Crown in a permit area. It involves the presentation of an acceptable plan of examination (work program), an application fee of $250.00, and a deposit of $2,500.00 for each 20,000 acres of a permit area, the total acreage not to exceed 100,000 acres. The term of a permit is 1 year, renewable for 4 periods of 6 months each upon payment of $0.10 per acre for each renewal. The $2,500.00 deposit is refundable upon termination of the permit providing the permitee has undertaken a satisfactory work program. The permit may be converted to a 21 year lease, which is renewable, according to terms and conditions which shall be determined by consulation with the Minister of the Department of Mines and Minerals. Lease rentals amount to $0.25 an acre for the first 5 years and escalate to $1.00 thereafter. The lease will reserve a royalty to the Crown at a rate which has not yet been established, but which may be prescribed by the Lieutenant Governor in Council.

## Purpose of the Evaluation

This preliminary investigation has several objectives. It attempts to portray the regional and local geologic setting of some known surficial sulphur occurrences in the Fort Vermilion area, including the reported discovery on Sulphur Prospecting Permit No. 8; it attempts to predict the possible location of other deposits; to co-ordinate a variety of geologic data (surface, subsurface, published and unpublished reports and field observations) in regard to sulphur; to offer some concepts dealing with the origin of the deposits; to serve as a guide and present some recommendations concerning future evaluation work.

## Evaluation Techniques

Several geologic illustrations were prepared to show the geologic setting. They accompany this report. An areal geologic map was prepared in two sheets at the scale 1" to 2 miles to cover Tp. 93 to Tp. 115, R. 1 to 12 W5M. The mapping covers about 9,500 square miles. The base shows a land network, drainage, topography by means of contours and principle elements of culture. The areal geologic interpretation was based on examination and interpretation of vertical air photographs and air photomosaics that were acquired from the Provincial government, topographic maps, and published geologic maps. The maps show the interpreted distribution of bedrock which is mantled at most places by extensive deposits of glacial drift. The mapping also shows several other geologic features such as distinctive alignments (which may be indicating fractures or faults), the location of outcrops of bedrock and exposures of surficial deposits. Other special features are shown which will be discussed later. Structural contours on top of the Paleozoic bedrock surface are superimposed on the areal geology maps. The structural interpretation was based on a co-ordination of surface information, field observations, published geologic information and subsurface data provided by wildcat wells drilled for oil and gas. A geologic cross section further illustrates the geologic setting. A stratigraphic log of Hudson Bay Fort Vermilion No. 1 (located in 15 of 32, Tp. 104, R. 8 W5M.) portrays the stratigraphic section.

One day was spent in the field in January making some geologic observations along Mikkwa River and along Harper and Lambert Creeks. Samples were gathered and a correlation between surface features and anomalies noted on air photographs was established.

## Location and Accessibility

The Fort Vermilion area is located in north-central Alberta about 250 miles north of Edmonton. The area is reasonably accessible. An all-weather gravel road reaches the settlement of Fort Vermilion located on the Peace River about 40 miles west of the discovery in Permit #8. The gravel road is being extended to the east along the north side of Peace River and is planned to be routed through Wood Buffalo Park to reach Fort Smith in the N.W.T. Numerous secondary roads and seismic trails traverse parts of the area. The railroad, which connects Pine Point in the N.W.T. with Peace River and other rail points of Alberta, passes within 50 miles of the town of Fort Vermilion along the Mackenzie Highway to the west. Regularly scheduled commercial airline service by P.W.A. operates three times a week between Fort Vermilion and Peace River.

# REGIONAL GEOLOGIC SETTING

## Physiography

The Fort Vermilion area lies in the Interior Plains located between the Precambrian Shield to the east and the Cordilleran Belt to the west. The Interior Plains have been subjected to multiple continental glaciation. The landscape consists of two main subdivisions. They are made up of a low-lying plain or broad valley, through which the Peace River flows, and three separate plateaus which rise abruptly above the plains: the Caribou Mountains to the north, the Birch Mountains to the southeast and the Buffalo Head Hills to the southwest.

Topographic elevations in the gently rolling plain range from about 775 feet along the Peace River to about 1,800 feet at the foot of the Birch Mountains and Buffalo Head Hills. However, the land stands mainly at levels ranging from 800 to 1,500 feet. Little variation in local topographic relief exists except along some streams which have incised below the level of the plain. Peace River, which is the dominant drainage of the area, follows a preglacial valley and at places has cut through the veneer of glacial drift. The plain is moderately drained although numerous lakes, swamps, muskegs and bogs are common in many parts. Rock outcrops are scarce because bedrock is mantled by a variable thickness of glacial drift. Outcrops occur in some stream cuts, such as near Vermilion Chutes along the Peace River in Tp. 108, R. 5 & 6 W5M and along parts of Wabasca and Mikkwa Rivers and Lambert and Harper Creeks in the vicinity of Tps. 106 and 107, R 2 W5M. Bedrock appears to be formed by flat-lying to gently dipping Devonian carbonates and clastics, which are exposed in the northeast, and unconformably overlain by Cretaceous shale and sandstone.

A variety of glacial drift and surficial deposits is present. Glacial gravels, sands, silts and clays appear widespread. Ground moraine is common, and kame and kettle topography is developed in a few scattered areas. Lacustrine deposits are also present. The thickness of the drift varies. In the north-east part of the area the surficial deposits range in thickness from nil to nearly 200 feet. However, the thickness anticipated at most places would be in the order of 50 to 100 feet.

The plateaus rise rather abruptly above the plains. Crestal elevations in the order of 3,100 feet exist in the Caribou Mountains, 2,500 feet in the Birch Mountains and 2,800 feet in the Buffalo Head Hills. Thus, over 2,000 feet of topographic relief is developed very rapidly along the north side of Peace River valley in the Caribou Mountains. Local relief in the plateaus is moderate at most places; it is rough locally. Although the plateaus appear fairly well drained, muskeg is common and several lakes, both large and small, exist on top of them. Outcrops are more common in the plateaus than in the plains but they are not abundant. The plateaus represent erosional remnants of flat-lying to very gently dipping Cretaceous shale and sandstone. The erosional remnants were formed prior to Pleistocene glaciation. Glacial drift covers bedrock at most places and the plateaus are covered by a moderately to a fully stocked forest of coniferous and deciduous trees.

In summary, the landscape is made up of a simple plains surmounted by erosional remnants of flat-lying Cretaceous beds. The area had reached the mature stage in the erosional cycle before being subjected to multiple continental glaciation during the Pleistocene Epoch. Ice appears to have advanced in a general, southwesterly direction but local variations ranging from south-southeast to northwest are indicated by the presence of drumlinoid features. Development of glacial lakes during deglaciation probably occurred as a result of ice damming. The glacial lakes lapped against the lower flanks of the plateaus. Following the Pleistocene the area was reverted to the initial stage in the erosional cycle. Parts of the area are being actively eroded by streams at present.

## Stratigraphy

Consolidated sediments in the Fort Vermilion area consist of Paleozoic clastics, carbonates and evaporites which are mainly Devonian in age. The Paleozoic assemblage is overlain unconformably by Cretaceous clastics. The Paleozoic section ranges in thickness from about 3,500 feet in the southwest to 2,200 feet in the northeast. Much of the thinning is due to erosional truncation along the sub-Cretaceous unconformity. Subsurface studies indicate that the rate of truncation is about 15 to 20 feet per mile. The Cretaceous System is made up of shale and sandstone which attains a thickness of about

2,200 feet in the Caribou Mountains and Buffalo Head Hills. However, it thins to a thin edge and disappears in the northeast where the ancestral Peace River drainage system removed the Cretaceous cover. This probably occurred during late Tertiary time prior to the Pleistocene Epoch.

A detailed discussion of the stratigraphy is beyond the scope of this report. Several accounts are available in the literature. (Refer to Selected Bibliography at the end of this report.) However, the accompanying stratigraphic log of the Hudsons Bay Fort Vermilion No. 1 well located in lsd. 15, sec. 32, Tp. 104, R. 8 W5M, in the centre of the area, illustrates the stratigraphic nomenclature, age, lithology and thickness of the stratigraphic section. (See Figure 1. in map case). It can be divided into four convenient groups. The basal group rests on Precambrian rock and is composed of a dominantly evaporitic assemblage. It consists of thick deposits of anhydrite and salt with some important clastics and marine carbonates. The sequence is Middle Devonian in age and is possibly older in part. It is made up of the following units: the "Red Beds", Chinchaga, Keg River, Muskeg, Watt Mountain and Slave Point Formations. The second convenient subdivision of the stratigraphic section is a marine fine clastic of Upper Devonian age. It consists of green calcareous shale. It is succeeded by the third subdivision which is also Upper Devonian in age. It is dominantly carbonate made up of the limestones and dolomites of the Mikkwa and overlying Grosmont Formations. The Grosmont Formation is reefoid and probably biohermal in character in places. The formations are exposed in the valley of the Peace River in the vicinity of Vermilion Chutes in Tp. 108, R.5 and 6, W5M, and along Harper Creek in Tp. 106, R. 2 W5M. The fourth subdivision is made up by shale and sandstone of Cretaceous age.

Approximately 60 wells have been drilled for oil and gas within the project area. All of them have been dry and abandoned. Density of the drilling is about one well for every 4-1/2 townships. Thus, control is relatively sparse. Study of the drillstem test reports indicate that the Middle Devonian carbonates have yielded significant amounts of salt water which is occasionally gas cut or oil-flecked and rarely sulphurous. Drillstem tests of the Upper Devonian carbonates, the Mikkwa and Grosmont Formations and their correlatives, are interesting. Although some of the tests indicate a lack of permeability in places, evidence of porosity is abundant. Loss of circulation has been reported. Recovery of significant amounts of salt water, which is commonly sulphurous and occasionally gassy, has been reported. Moreover, the Geological Survey of Canada reports vuggy porosity in the Grosmont Formation at outcrops in the vicinity of Vermilion Chutes and the presence of tar-like bitumen material in vugs. During a few drillstem tests, small amounts of gas have risen to the surface. The Cretaceous section has been drillstem tested in a few wells and has rarely yielded small amounts of gas.

## Structure

The Fort Vermilion area lies in the Interior Plains structural province where beds are relatively undisturbed. Paleozoic strata strike regionally to the north-northwest and dip very gently to the southwest at 20 to 25 feet per mile. Overlying Cretaceous beds are almost flat-lying but dip regionally to the southwest at rates of 5 to 10 feet per mile. The presence of local structures are anticipated and should be confirmed as more control becomes available. One can expect high angle faults, probably related to basement trends, gentle tectonic flexures, compaction folds over reef or irregularities on unconformities, and solution collapse structures. Some erratic dips were observed in the field by officers of the Geological Survey of Canada in the vicinity of Vermilion Chutes. Dips as high as 8° and some gentle folds were reported and are shown upon the accompanying areal geologic map.

Several distinctive alignments were mapped during the evaluation. They are shown on the accompanying areal geologic maps by heavy lines labelled DA. They are based on straight stream segments and topographic, vegetational and/or tonal alignments. They may indicate faults or fractures. Two dominant trends are apparent: northwest and northeast. Two long persistent alignment trends suggest the possibility of basement faults extending from Tp. 101, R 1, W5M southwest toward Tp. 98, R 9, W5M.

Structural contours on top of the Paleozoic bedrock surface are superimposed on the areal geologic maps. The contour interval is 50 feet. The mapping is based on subsurface data afforded by wells and topographic elevations of known and interpreted rock outcrops, such as in the Vermilion Chutes-Harper Creek area. Thus, the map represents the present structural configuration of the Paleozoic surface which at most places is the sub-Cretaceous unconformity. However, in the northeast where Cretaceous strata have been removed, the mapping portrays the post-Cretaceous, pre-Pleistocene to Recent erosional surface.

Examination of the map shows that the Paleozoic surface dips southwest gently at about 10 feet per mile. Well control shows that local variations in the rate of dip are present. Although these could be attributed to local structures such as folds or faults of various origins, they are likely due to topographic relief on the sub-Cretaceous unconformity. Evidence exists to suggest a gentle cuesta was developed on the erosional surface extending from the vicinity of Tp. 96, R 6 W5M northwest toward the settlement of Fort Vermilion in Tp. 108, R 12, W5M. Another erosional high can be interpreted to have extended from about Tp. 103, R 2, W5M northwest through the Vermilion Chutes area toward Margaret Lake in Tp. 114, R 8, W5M. It appears to have been upheld by resistent limestones and dolomites of the Mikkwa and lower Grosmont Formations which overlie the recessive green calcareous shale unit.

Examination of G.S.C. Map 1161A and Figure 3 of G.S.C. Memoir 313 shows that strata of Upper Devonian age are supposed to be exposed along Mikkwa River in Tp. 104, R 7, W5M. According to Norris (1963), these outcrops were not examined during recent surveys and their identification is based on investigations carried out more than 75 years ago and reported by McConnell (1893). Bedrock exposures are probably there although it is more likely they are Cretaceous in age. The area was snow covered when visited in the field during January, 1968. However, if the beds prove to be Devonian in age, an anomalous structural condition exists. Regional considerations suggest that Paleozoic beds should be buried at a depth of 250 feet.

# CHARACTERISTICS, ORIGIN, PRODUCTION and USEAGE of SULPHUR

Sulphur is frequently recognized by and associated with its bright sulphur-yellow color. However, it can be straw and honey-yellow, yellow-brown, yellow-grey and, in fact, greenish and reddish. It is relatively light and rather brittle. It is a nonconductor of electricity and a poor conductor of heat. Sulphur melts at 108° C. and burns at 270° C. with a bluish flame yielding sulphur dioxide gas. It is insoluable in water and not acted on by acids, but is soluble in carbon disulphide.

Elemental sulphur originates in various ways. It is frequently associated with volcanic activity and occurs in gases emanating from fumeroles. Sulphur is deposited directly by sublimation or the incomplete oxidation of hydrogen sulphide gas being given off. Sulphur may also be associated with thermal spring waters and derived either from volcanic sources or by the reduction of sulphates, especially gypsum, which is aided by certain bacterial action. Sulphur may also be formed by decomposition of metallic sulphides. Sulphur is produced by the living action of some bacteria. Some believe sulphur can originate from cold groundwaters carrying sulphate and hydrogen sulphide through certain geo-electro-chemical processes.

Commercial production of elemental sulphur has a long history. Prior to the 1800's most sulphur was derived by hand picking from volcanic deposits and was used in medicines and gun powder. Demand for sulphuric acid in the 1800's accounted for its increased production from the metallic sulphide, pyrite. The recovery of sulphur from natural gas and other hydrocarbon deposits has recently become a very important source of elemental sulphur. Pilot studies in Texas have achieved some encouragement in the production of sulphur from gypsum deposits.

Elemental sulphur deposits are relatively widespread and mainly volcanic or sedimentary in origin. They contain sulphur in varying concentrations up to about 75%. Native surficial deposits usually are worked by normal mining methods and, when not amenable to Frasch techniques, sulphur is recovered by a variety of processes involving either burning, distillation, floatation, melting or solvent extraction. In any case, most processing techniques developed todate eventually require the use of heat. Commercial deposits and production occur in Sicily, Italy, Central and South America, Japan and in the United States. More than three-fourths of the sulphur produced today goes into the manufacture of sulphuric acid which is used largely in the production of fertilizer. Many other uses for sulphur exist.

PLATE I

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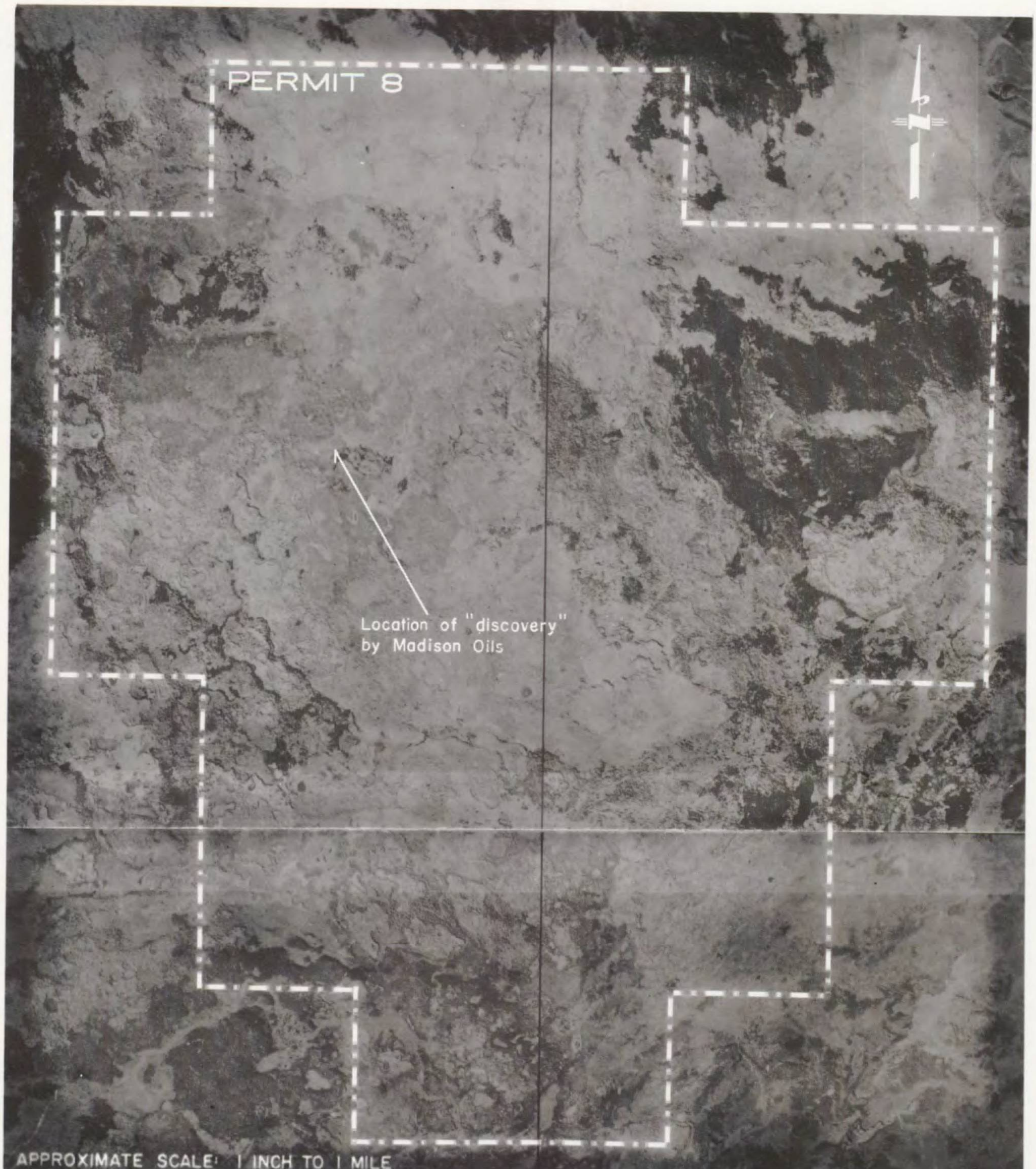


AIR PHOTOMOSAIC

of

Sulphur Prospecting Permit No.8

# SULPHUR OCCURRENCES

in the

# FORT VERMILION AREA, ALBERTA

The presence of sulphur at or near the surface in the Fort Vermilion area has been known for a long time. The Indians were probably the first to have been aware of the presence of sulphur associated with a great number of gassy, salty cool water springs that are known in parts of the area. Some of these were observed during the field work done in January, 1968 along Lambert and Harper Creeks (see Plates 3 and 4). The local population in the Fort Vermilion area have referred for years to Harper Creek as "Stinking River" because it is polluted along part of its course due to the emanation of gassy sulphurous salty waters into it. Stream gravels and boulders are coated with a thin deposit of sulphur. The presence of these deposits have been common knowledge for years to many individuals.

One of the most publicized occurrences is located on Sulphur Prospecting Permit No. 8 in the northeast corner of section 8, Tp. 110, R. 5 W5M. Snow covered much of the area around the "discovery" location during the field work in January. Consequently, details concerning the precise geologic setting of the"discovery" must await investigation in the spring. However, Plate 1. shows the general setting. Plate 1. is part of an air photomosaic at the scale of 1 inch to 1 mile showing the location of the "discovery". It is situated in flat-lying terrain and appears associated with a muskeg-like area. Parts of the land are moderately stocked by trees and bush although scattered bare patches are present. At first glance very little is apparent to distinguish the location of the deposit as it appears on government vertical air photographs. However, its relation to the muskeg is interesting. Closer inspection of air photographs shows several very light-toned patches of ground and potholes and this could be significant.

According to published reports (OILWEEK, Dec. 18, 1967), the "surface deposit about 40 miles northeast of Fort Vermilion was burning in a large pit-like area". The report stated more than 150 shallow auger holes were drilled to a maximum depth of 9 feet in an area covering approximately a quarter section (160 acres). The shallow holes define the limit of the deposit on one side. Assays of samples from the area reportedly showed sulphur content ranging from 35 to 89% with no serious impurities. The deposit was covered with overburden of clay and gravel ranging from approximately 6 inches to 2 feet in depth. The bottom of the deposit was not reached by the holes drilled.

Another area containing known occurrences of sulphur at the surface is located in the Harper and Lambert Creek areas in Tp. 105 and 106, R 3, W5M. The sulphur appears associated with several gassy, sulphurous, salty water springs. The locations of those confirmed in the field during January are shown on the accompanying areal geologic map. Several other suspected locations were observed from a helicopter over a broad area but they could not be verified because of snow cover. A water analysis of a selected spring sample showed the spring water to be salty having an abundance of Na and Cl elements but a low sulphate content. However, some hydrogen sulphide gas appears to bubble to the surface at some springs, as at this locality. The elemental sulphur may have been brought to the surface and derived from the hydrogen sulphide gas. An analysis of a grab sample of surficial deposits associated with the area in section 36 Tp. 105, R 3 W5M can be summarized as follows: it consists of a pale yellow-grey unconsolidated and crumbly assemblage of multisized particles and balls of clay and silty material. The assemblage provides a slight sulphurous odor. When ignited it burns with a rich royal blue flame and gives off a strong acrid sulphurous smell. A microscopic examination and assay carried out by Core Laboratories-Canada Ltd. revealed the presence of chert, mica, quartz and feldspar. These rock minerals are distributed throughout the material from grain to pebble diameters, and the particles show the result of water or glacial erosion. A small amount of deposited calcite was also present. Elemental sulphur present was deposited by water action as a halo effect upon the surface of the rock particles. A screen test on the sample yielded the following:

PLATE 2

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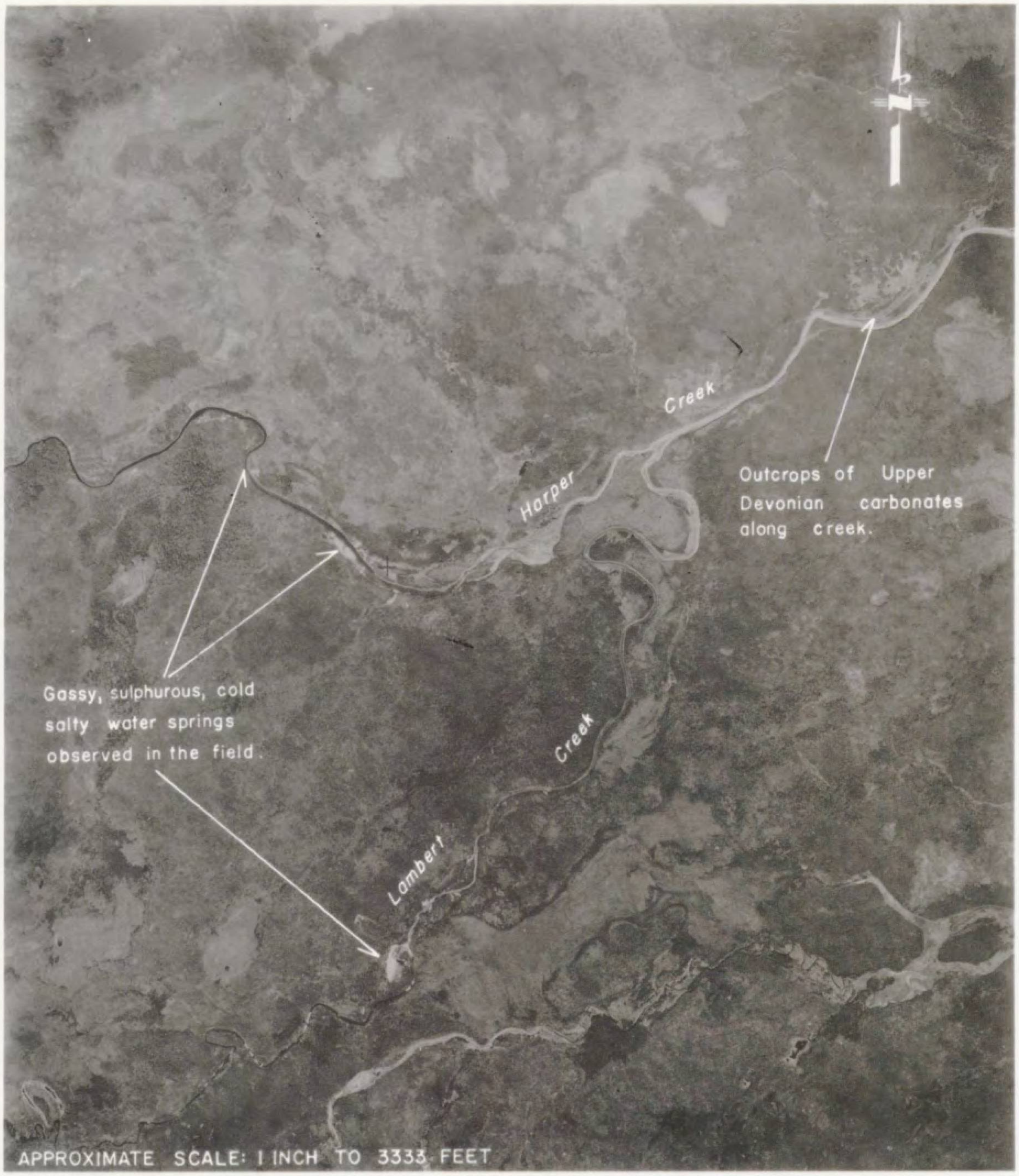


# AIR PHOTOGRAPH

## of

## Harper—Lambert Creeks Area

| | | | |
|---|---|---|---|
| Pebbles | 5.5% (not assayed for S.) | | |
| Plus 20 Mesh | 66.5% | -------------- | 31.9% |
| Plus 40 Mesh | 18.2% | -------------- | 26.9% |
| Minus 40 Mesh | 9.8% | -------------- | 36.1% |

Elemental sulphur content of sample ------- 28.8% (calculated)

Most of the sulphur occurrences visited in the field are circular to the elliptical in shape and from 200 to 1,000 feet in diameter. The associated spring water appears clear, cold and salty. Bubbles of hydrogen sulphide and methane gas are associated with some of the springs; sulphur and bitumen material are deposited around the edges of the springs, and all boulders, pebbles and alluvial particles are coated with sulphur. Other surface features, which probably represent dried-up springs, were seen.

The location of the springs and associated sulphur deposits visited in the field can be recognized on air photographs. (See Plate 2.) They are indicated on the accompanying areal geology map in Tps. 105 and 106, R 3, W5M. The areas appear as very light toned patches on air photographs and are practically devoid of vegetation. Some appear associated with small muskegs or bogs. Several somewhat similar appearing features can be identified on air photographs in the vicinity, but these have not been verified in the field. However, they are shown on the accompanying areal geologic maps by special symbols. Some of these features appear to have game trails leading to them, and it is visualized that animals in need of salt visited these areas. The anomalies should be examined in the field to determine the presence or absence of sulphur. Other surface anomalies which are either unusual or appear to have some of the characteristics similar to known or suspected springs and sulphur occurrences are shown on the map by other special symbols.

Reports of other sulphur occurrences in the Fort Vermilion area have not been accompanied by information describing their nature nor precise location. Consequently, they have not been verified at this time. Inferences indicate they may be located in areas where Cretaceous strata are interpreted to form bedrock. As more data become available, each occurrence should be studied to determine its geologic setting.

Observations todate indicate that some of the surficial sulphur occurrences in the Fort Vermilion area are associated with gassy sulphurous, salty water springs which emanate at the surface. It is conceived that this process has been more or less continuous over a long period of time but has been variable as to geographic location.

Several possible origins for the gassy springs are visualized. It is possible that the waters and associated gas originate from porous zones in Upper Devonian carbonates of the Grosmont and Mikkwa Formations where they rise to the Paleozoic surface in the area where Cretaceous cover has been removed. An allied concept is that some waters could have risen to the sub-Cretaceous unconformity and then migrated updip to the northeast and be emanating in the vicinity of the Cretaceous-Devonian boundary. Another contention is that faults and fractures play a fundamental role and permit the ascent of formation waters, either from Upper Devonian carbonates, Middle Devonian carbonates or the evaporites of the Elk Point Group. Waters that had access to the evaporites of the Elk Point Group could contain large amounts of calcium sulphate.

Insufficient information and facts are available to determine the true cause of the emanations. At present emphasis should be placed on examining the outcrop bands of the Upper Devonian carbonates because two of the known and reported surface sulphur occurrences overlie the outcrop belt of these rocks. Thus, a sulphur producing process, whatever its origin, is currently active, has been confirmed in the field, appears to be operating at various spots over an area of several square miles and is suspected over a much broader area.

If one visualizes that gassy, sulphurous salty waters have been emanating from Upper Devonian beds and principally the carbonates of the Grosmont and Mikkwa Formations, the process could have been going on periodically over a long period of time: ever since the removal of Cretaceous cover during the Tertiary Period. Evidence shows that Cretaceous cover had been removed prior to glaciation. Thus, Upper Devonian strata have been exposed to atmospheric pressure at least since the late Tertiary when the emanation process could have originated. One can visualize sulphur forming at the bedrock surface at that time. As one area became clogged and choked, other gassy springs could have broken through elsewhere. Thus, a thin, patchy, but fairly extensive deposit of elemental sulphur could have formed at the pre-Pleistocene bedrock surface. Pleistocene glaciation could have disturbed and eroded part of the surficial sulphur and dispersed and scattered it depositing sulphur elsewhere intermixed with glacial drift. This could account for small local deposits dispersed in the drift. However, it is highly probable that some protected areas were not subjected to glacial scouring and remnants of the original surficial sulphur rest on bedrock in scattered places along a belt extending from Tp. 103, R 1 to 4, W5M northwesterly to Tp. 110, R 4 to 7, W5M. During and following deglaciation, the process has probably reoccurred more or less continuously but at different geographic locations and at different times. Thus, one could anticipate encountering sulphur deposits in a variety of places not only at the surface but at different levels within the glacial drift and on bedrock itself at depths ranging up to 150 feet.

## CONCLUSIONS and RECOMMENDATIONS

The presence of native sulphur at the surface in the Fort Vermilion area has been verified. Evidence shows that at some places it is widespread and associated with gassy sulphurous salty water springs. Speculation suggests that it could be encountered not only at the surface but at depths up to 150 feet resting directly on bedrock. Thus, field work should be undertaken to examine indicated surface anomalies and exposures. Those surface features which offer some encouragement should be drilled in order to map the distribution, thickness and to determine the grade and concentration of the associated sulphur. Consideration should be given to developing exploration techniques, including both geophysical and geochemical, in an attempt to locate potential sulphur deposits not recognizable at the surface. If sufficient volume of sulphur can be proved, then an economic solution to the recovery and transportation by established or new techniques revealed by research and development is warranted.

Respectfully submitted,

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[redacted]

George M. Collins, P. Geol.

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Plate 3

Plate 4

Gassy, sulphurous, salty cold water springs along Lambert Creek in Tp. 105, R 3 W5M. Yellow cast on alluvium caused by associated sulphur.

Plate 5

Plate 6

Outcrops of nearly flat-lying carbonates of Mikkwa Formation (Upper Devonian) along banks of Harper Creek in Tp. 106, R 2 W5M.

19680049

# SULPHUR PROSPECTING PERMIT NO. 47

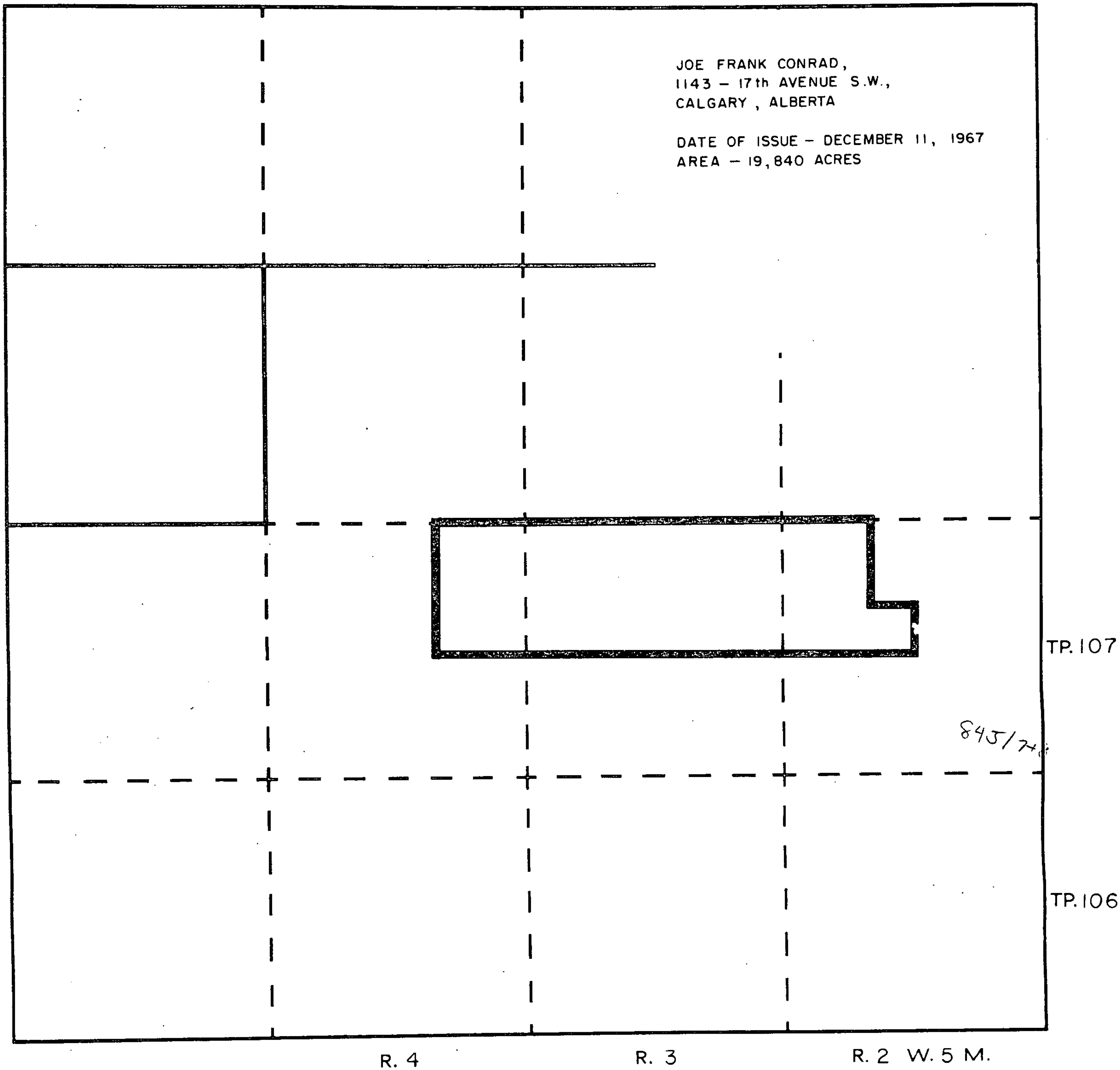

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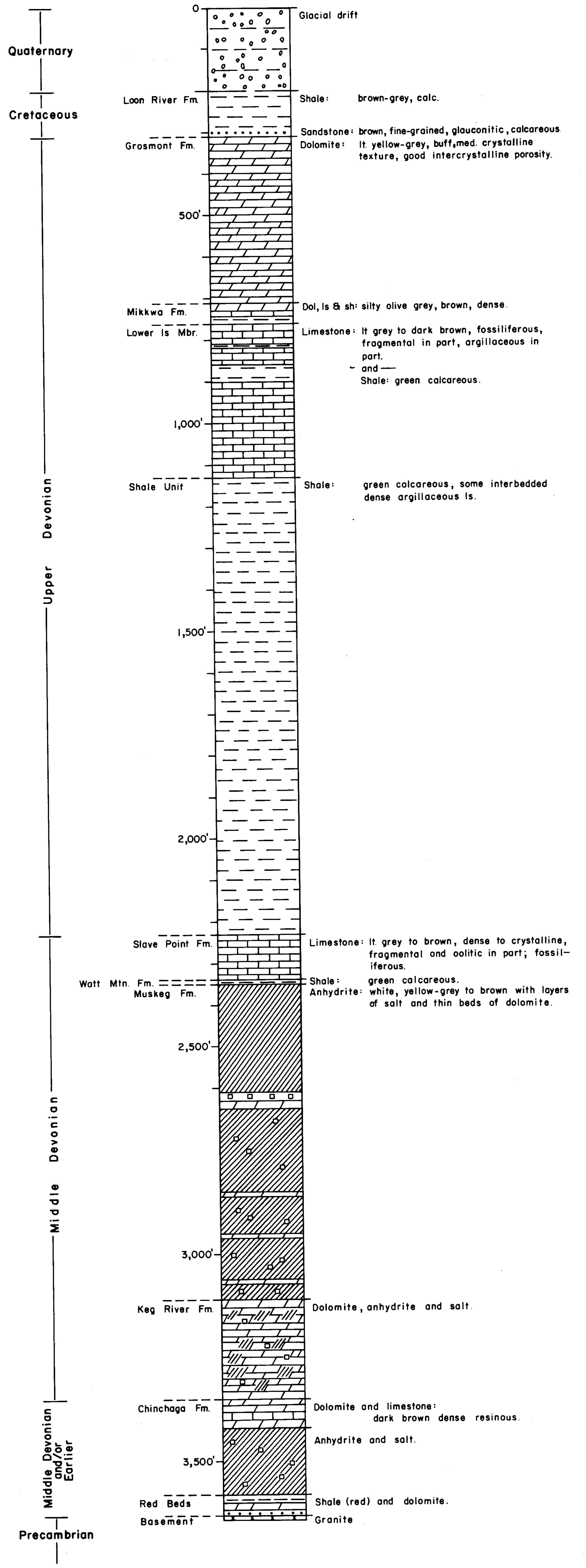
FIGURE 1

# STRATIGRAPHIC LOG
OF
H.B.O. & G. *FT. VERMILION I*

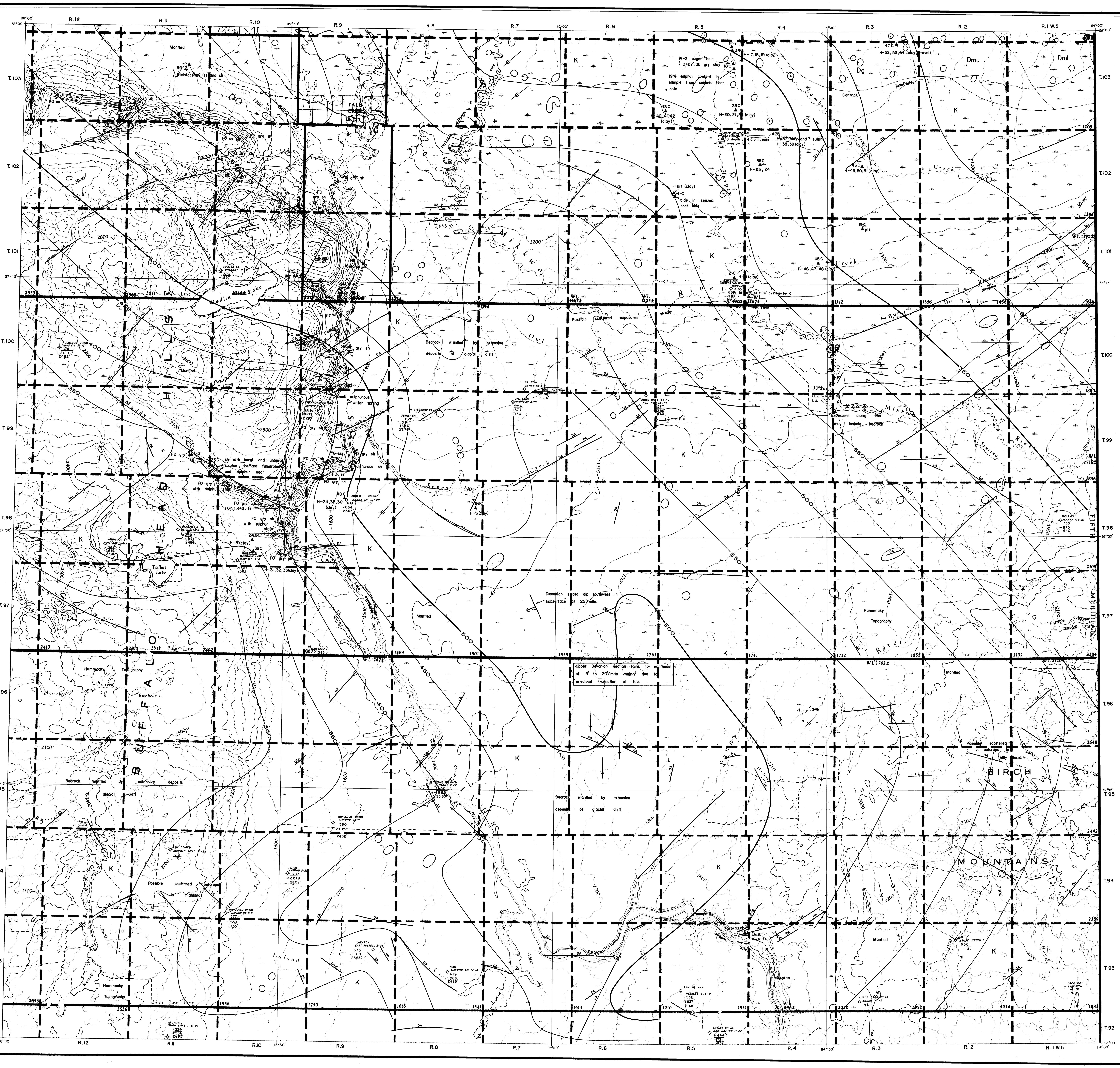
Lsd. 15 S. 32 T. 104 R. 8 W. 5 M.

ELEVATION 1,000' T.D. 3,640' D. & A. JUNE, 1951.

SCALE: 1 INCH TO 200 FEET




V. ZAY SMITH ASSOCIATES LTD.




# LEGEND

## FORMATIONS

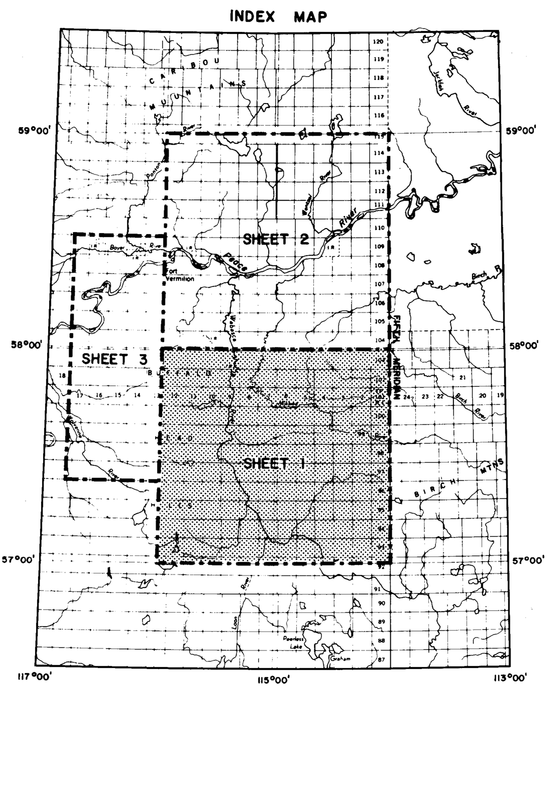
| | | |
|---|---|---|
| CRETACEOUS | K | Loon River and younger; shale and sandstone. |
| UPPER DEVONIAN | Du | Upper Devonian undivided; (may be Cretaceous) |
| | Dg | Grosmont: dolomite. |
| | Dmu | Mikkwa, upper member: limestone and shale. |
| | Dml | Mikkwa, lower member: limestone. |
| | Ds | Shale unit: calcareous shale. |

## GEOLOGICAL SYMBOLS

- Field observed dip; V. Zay Smith Associates, 1968.
- FOP — Field observed published dip.
- Horizontal bedding.
- Gentle dip based on geomorphic evidence.
- FO — Field observed.
- DA — Distinct alignment.
- Glacial lineation indicating direction of ice movement.
- Shore line.
- Formational contact.
- X — Bedrock outcrop.
- X — Exposure of surficial deposits.
- ▲13C — Field station number, may be outcrop or site of auger hole.
- H-15 — Auger hole drilled with Haynes portable power drill.
- W-1 — Auger hole drilled with Winkie portable power drill.
- Active gassy sulphurous salt water spring associated with surficial sulphur deposit.
- Possible active or inactive spring; interpreted from air photographs. No associated sulphur observed during field work.
- Surficial anomaly interpreted from air photographs. No associated sulphur observed during field work.
- +808 — Structural elevation of Paleozoic bedrock surface.
- −684 — Structural elevation of top of Elk Point Group (Watt Mountain Formation).
- 1548' — Thickness of Devonian section preserved above Elk Point Group.
- N.I. — No Information.
- I.U. — Information Uncertain.
- I.D. — Insufficient Depth.
- A—A' — Cross Section.
- 950 — Structural contour on Paleozoic surface. Contour interval: 50'.

## TOPOGRAPHICAL SYMBOLS

- Road or trail
- Town
- Village or settlement
- Lake
- River
- Stream
- Muskeg
- 1900 — Elevation contours




AREAL GEOLOGIC MAP

OF THE

# FORT VERMILION AREA

ALBERTA

SHOWING CONFIGURATION OF

## PALEOZOIC BEDROCK SURFACE

SCALE: 1 INCH TO 2 MILES

Miles 2 1 0 2 4 6 Miles

Note: Well data as of March 1.

— Prepared by —

V. ZAY SMITH ASSOCIATES LTD.

1968

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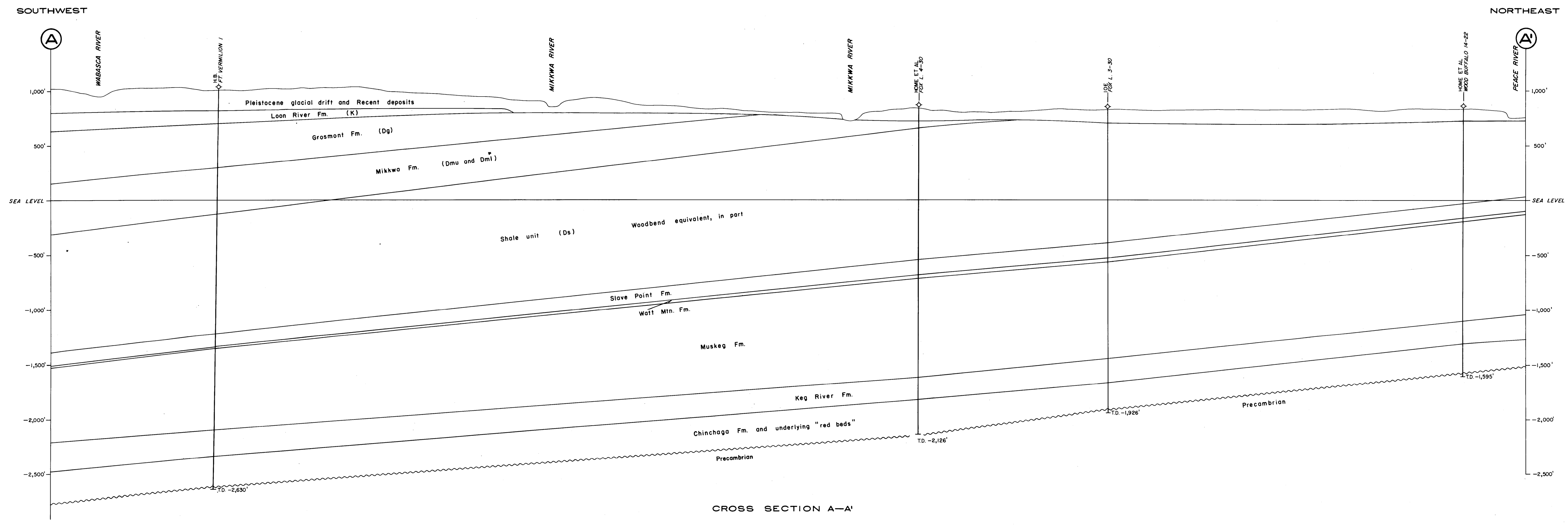
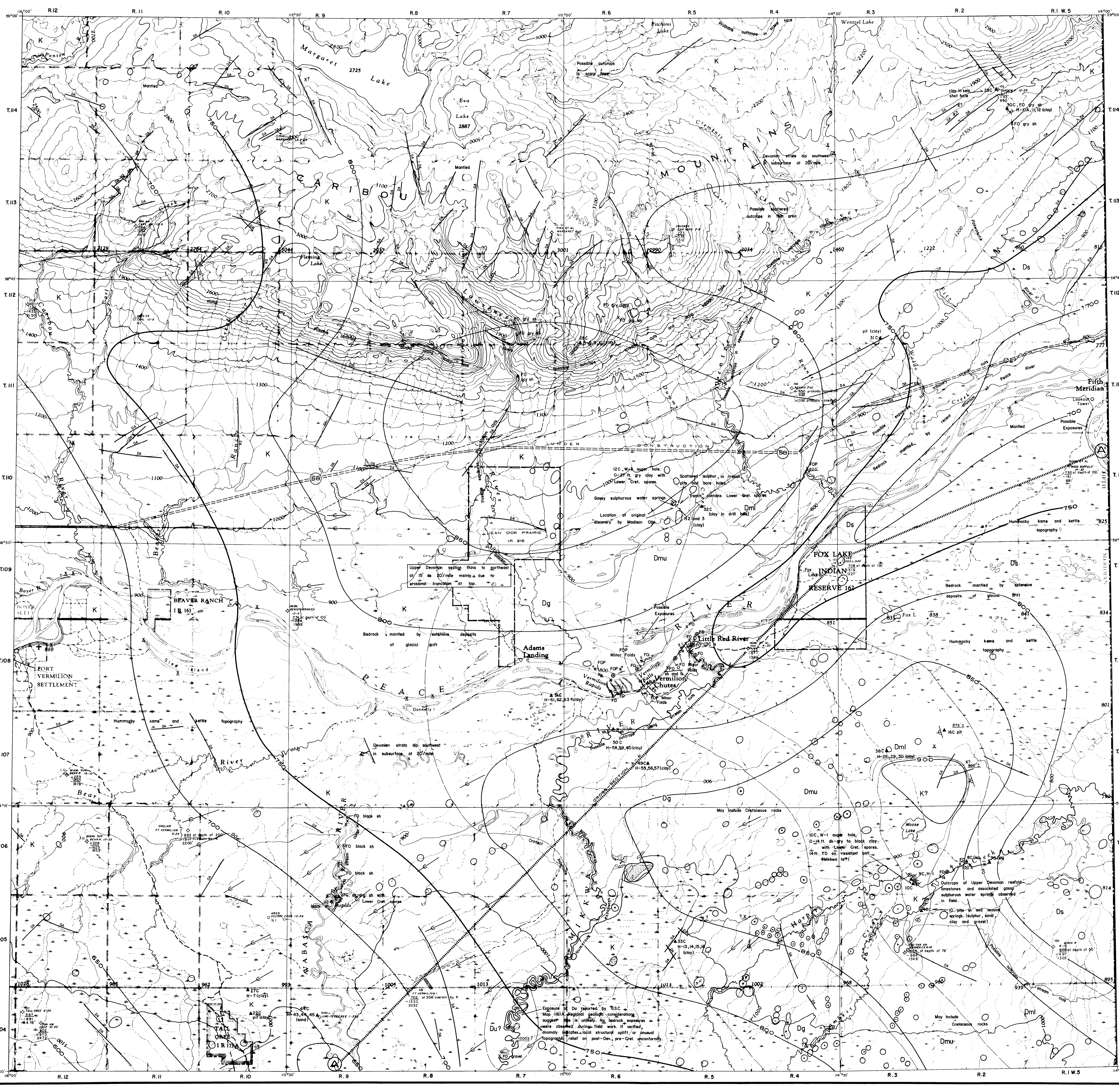
SHEET 1

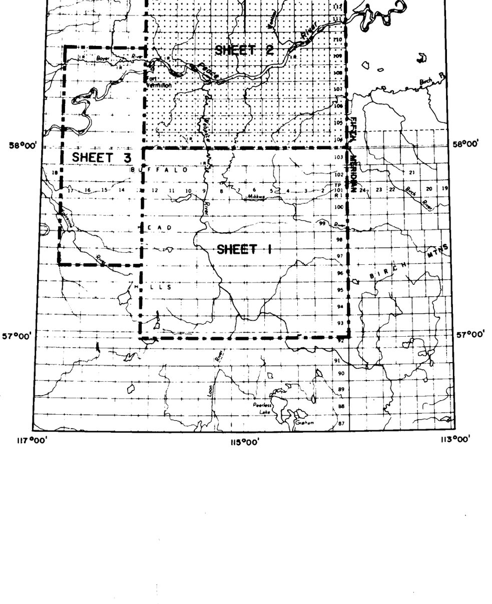



CROSS SECTION A—A'

VERTICAL SCALE: 1 INCH TO 400 FEET
HORIZONTAL SCALE: 1 INCH TO 2 MILES




## LEGEND

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ALBERTA

SHOWING CONFIGURATION OF

PALEOZOIC BEDROCK SURFACE

SCALE: 1 INCH TO 2 MILES

Miles 2 1 0 2 4 6 Miles

Note: Well data as of March 1.

— Prepared by —

V. ZAY SMITH ASSOCIATES LTD.

1968

19680047

SHEET 2

# Disclaimer

This page was inserted by the Coal and Minerals Development Branch, to provide a reference that the map sheet 3 associated with this report is not contained in the assessment report on file.