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# GEOLOGIC FIELD WORK and DRILLING PROGRAM

# TO EVALUATE

# SULPHUR PROSPECTING PERMITS 133 and 134

# FORT VERMILION AREA, ALBERTA

#13

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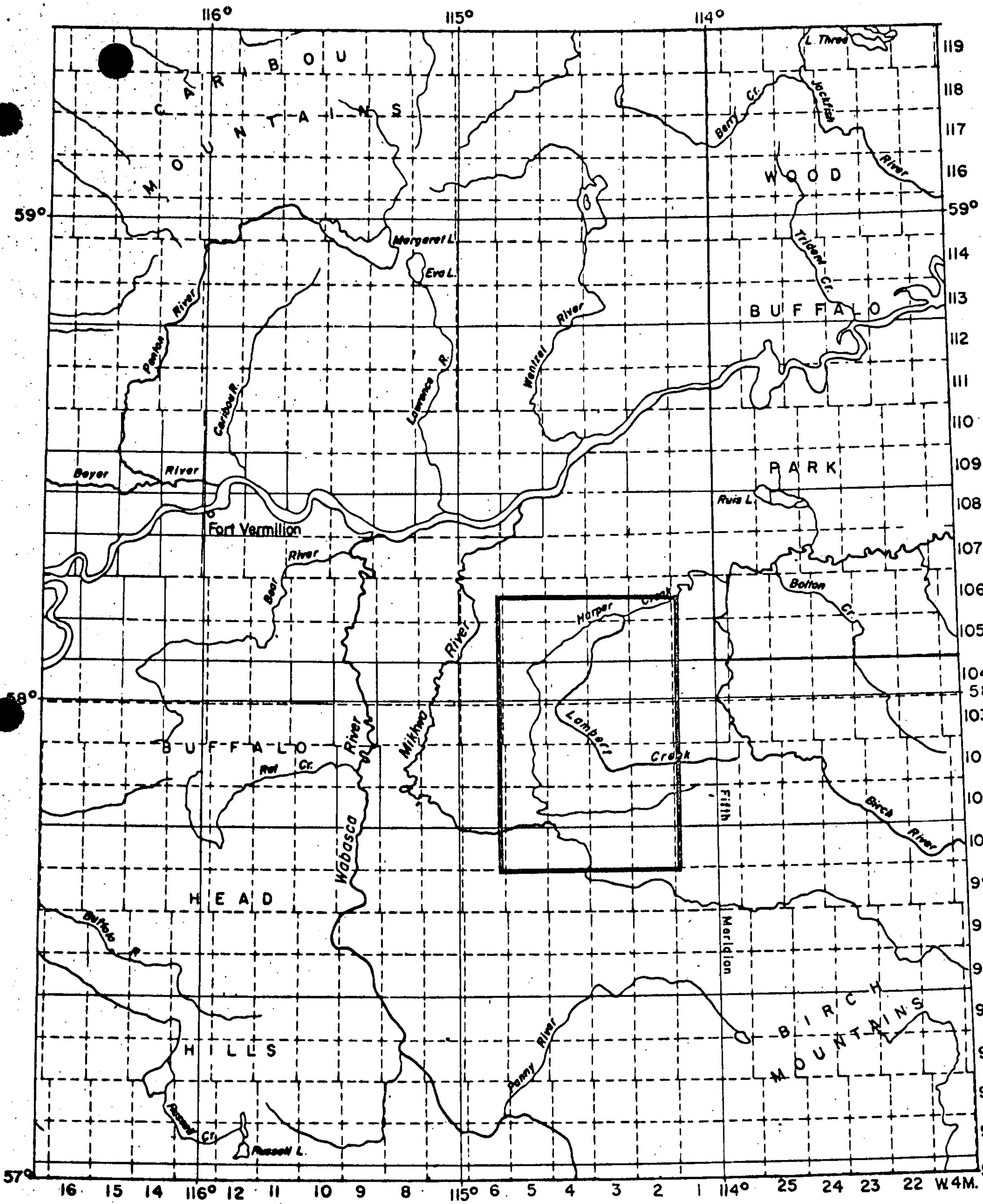


# FORT VERMILION AREA, ALBERTA
## LOCATION MAP

▭ Boundary of photomosaic covering Permits 133, 134

V. Zay Smith Associates Ltd. Calgary, 1968

# GEOLOGIC FIELD WORK and DRILLING PROGRAM

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## INTRODUCTION

Geologic field work and the drilling of a number of shallow auger holes in the Fort Vermilion area of Alberta has been undertaken in an attempt to evaluate several Sulphur Prospecting Permits and the reported discovery of elemental sulphur at or near the surface in the general vicinity. Reports of such a discovery began circulating in western Canada during the late summer of 1967. The location of the discovery was initially unknown. However, as more information became available, the area of interest appeared to center about the Fort Vermilion region of north-central Alberta. At the end of 1967 approximately 60 Sulphur Prospecting Permits had been issued in the Fort Vermilion area. The stampede continued and by May some 192 permits had been issued covering more than 6,500,000 acres.

Little hard factual information on the reported discovery of sulphur has been released to the public. 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

J. J. O'Connor of Calgary. Permit No. 8 is often referred to as the "discovery permit". Published reports and descriptions of exploratory work on Permits 8, 9 and 10, in some cases based on information released by the operators, have appeared periodically in Oilweek, Nickle's Daily Oil Bulletin and the Northern Miner. A review of this information suggests that native sulphur occurs at or near the surface at several localities on Permit 8 and appears to be associated with flat-lying beds. Several pits and 200 auger holes drilled to a depth of 9 feet have outlined a sulphur deposit over an area measuring 1,400 feet by 1,400 feet and 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.

Elsewhere in the Fort Vermilion area the presence of sulphur at or near the surface has been known for sometime. 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 at several localities along Lambert and Harper Creeks in Tps. 105 and 106, R. 3 W5. Moreover, sulphur occurrences at other localities in the Fort Vermilion area are indicated where Cretaceous strata are interpreted to form bedrock.

Accordingly, geologic field investigations and a drilling program were undertaken in the early summer of 1968 to evaluate several Sulphur Prospecting Permits in the area east and generally southeast of Fort Vermilion. The V. Zay Smith Associates Ltd. field party was equipped with a light-weight, protable auger for the drilling of shallow bore holes. Transportation was provided by a 3-place helicopter capable of carrying the portable drill.

A photomosaic covering the permit area and surrounding terrain accompanies this report. It shows areal geology and a terrain analysis and also permit boundaries and surface features such as areas of muskeg, exposures, sites where bore holes were drilled and field stations visited.

## Purpose of the Field Work and Drilling

The main objective of the field work and drilling program was to evaluate Sulphur Prospecting Permits of participating permit holders. The field effort was planned to include the examination and sampling of any rock exposures, surficial deposits, seeps, springs and surface anomalies and the drilling of a number of shallow bore holes. An average of three or four auger holes were drilled on each permit with light-weight portable drilling equipment.

## Field Work and Drilling Equipment

Field geology was undertaken in May and June of 1968 by a V. Zay Smith Associates Ltd. field party consisting of two geologists and supporting personnel. Work was done from Fort Vermilion with transportation being provided by a Bell helicopter chartered from Associated Helicopters, Edmonton. J. F. Conrad served as party chief.

A light-weight, portable power auger was used to drill shallow bore holes at several localities in the Fort Vermilion area. The drill was transported by helicopter and is referred to as the Haynes auger. The drill is capable of drilling to a depth of 9 feet and is comparable in size to a gasoline driven power lawn-mower. The average depth of the holes drilled is between 4 and 5 feet. The locations of bore holes are shown on the accompanying photomosaic.

## 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 extends from the Mackenzie Highway at High Level east to the settlement of Fort Vermilion on the Peace River. An eastern Extension of this road is under construction through Wood Buffalo Park to Fort Smith in the Northwest Territories. Scheduled commercial airline service is available for Fort Vermilion from Peace River by way of High Level each day. Access to remote areas in the summertime is best provided by helicopter.

# REGIONAL GEOLOGIC SETTING

## Physiography

The Fort Vermilion area forms part of the Interior Plains of northern Alberta and contains landscapes of two main types. These are a low-lying plain or broad valley in which the Peace River flows and a series of plateaus which rise abruptly above the plains.

Elevations in the gently rolling plain range from about 775 feet along Peace River to more than 2,000 feet in the higher plateaus. Much of the land surface stands at elevations between 800 and 1,500 feet above sea level and is remarkably flat and featureless. The plain is characterized by numerous swamps, muskeg, bogs and abundant tree cover.

The plateau areas rise abruptly above the plain with crestal elevations between 2,500 feet and 3,100 feet above sea level.

The Fort Vermilion area was subjected to multiple continental glaciation in Pleistocene time. Ice appears to have advanced in a general southwesterly direction. Glacial lakes developed during the ice retreat probably as a result of ice damming. At one time glacial lakes lapped against the lower flanks of the plateaus.

## Stratigraphy

Consolidated sediments in the Fort Vermilion area consist of Devonian clastics, carbonates and evaporites. This assemblage is overlain unconformably by Cretaceous shales and sandstones. The Devonian section ranges in thickness from about 3,500 feet in the southwest to some 2,200 feet in the northeast. Much of this thinning is due to truncation on the sub-Cretaceous unconformity. The rate of truncation is about 15 to 20 feet per mile. Cretaceous rocks attain a thickness of about 2,200 feet in the Caribou Mountains and Buffalo Head Hills.

A detailed discussion of stratigraphy is beyond the scope of this report. Several accounts are available in the literature (see Selected Bibliography). The basal unit of the stratigraphic section rests on Precambrian rock and is composed mainly of thick deposits of anhydrite and salt with some important clastics and marine carbonates. The succession is Middle and/or Lower Devonian in age. It has been separated into the following units: the "redbeds" and the Chinchaga, Keg River, Muskeg, Watt Mountain and Slave Point Formations. The overlying unit is a marine fine-clastic succession of Upper Devonian age. It consists of green calcareous shale. It is succeeded by a third subdivision which is also Upper Devonian in age. This unit is dominantly carbonate, made up of the limestones and dolomites of the Mikkwa and overlying Grosmont Formations. The Grosmont Formation is reefoid and probably biostromal in places. The Mikkwa and Grosmont Formations are exposed on the shores of Peace River at Vermilion Rapids and Vermion Falls. The Mikkwa limestones are also exposed along Harper Creek in Tp. 106, R. 2 W5M. The fourth subdivision of the stratigraphic succession is made of shales and sandstones of Cretaceous age.

The Mikkwa and Grosmont Formations are exposed on the south shore of the Peace River from Vermilion Rapids downstream to the settlement of Little Red River. The lower limestone member of the Mikkwa Formation exposed there consists of some 30 feet of limestones, gray, partly argillaceous, locally dolomitic and aphanitic. The beds contain bulbous stromatoporoids up to 12 inches in diameter and colonial corals including Cladopora(?). The overlying upper limestone member of the Mikkwa Formation is about 55 feet thick and is made up of limestone, brownish-grey with purplish mottling, nodular and thin-bedded to locally massive with abundant colonial corals and brachiopods including Alveolites and Atrypa.

Approximately 60 feet of dolomites of the Grosmont Formation are exposed along the Peace River above and below Vermilion Rapids. The beds are characterized by vuggy, petroliferous, finely-crystalline dolomites with poorly preserved stromatoporoids, colonial corals and brachiopods.

Shales and minor sandstone beds of Cretaceous age are believed to underlie the plateau areas near Fort Vermilion. The beds form part of the Loon River (Spirit River, Clearwater) Formation and are believed to be characterized mainly by black and dark-grey shales.

## Structure

The Fort Vermilion area lies in the Interior Plains structural province where beds are generally undisturbed. Paleozoic strata dip to the southwest at 20 to 25 feet per mile. The eroded Paleozoic surface dips southwest gently at about 10 feet per mile. The overlying Cretaceous beds dip very gently to the southwest at rates from 5 to 10 feet per mile. High-angle faults are anticipated in the sedimentary section and are probably related to basement trends. Other structures probably include gentle tectonic features, compaction folds over reefs or irregularities on unconformities and solution collapse phenomena.

Several distinctive alignments were observed on air photographs during the evaluation. They are indicated on the accompanying mosaic by heavy lines labelled DA. They are marked by straight stream segments and topographic, vegetational and/or tonal alignments. They may indicate faults or fractures.

# CHARACTERISTICS and ORIGIN 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. Pure sulphur is relatively light and 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 is not acted on by acids, but is soluable in carbon disulphide.

Elemental sulphur originates in various ways. It is frequently associated with volcanic activity and occurs in gases emanating from fumaroles. Sulphur is deposited directly by sublimation or by the incomplete oxidation of hydrogen sulphide gas. 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 by metallic sulphides. Sulphur is produced by the living action of some bacteria. Some believe sulphur can originate from cold ground waters carrying sulphate and hydrogen sulphide through certain geo-electro-chemical processes.

According to Parks (1959) there are two main types of native sulphur. One type is associated with volcanic activity where elemental sulphur is formed from the mutual action of hydrogen sulphide and sulphur dioxide which occur in volcanic gases. A nonvolcanic origin is indicated for some deposits of native sulphur which appear to have been liberated from gypsum with the reducing action of bituminous matter found associated with gypsum. Calcium sulphide is probably formed from the calcium sulphate. The action of water and carbon dioxide on the sulphide forms elemental sulphur, calcium carbonate and hydrogen sulphide. Parks reports that hydrogen sulphide and its oxidation products are found in the waters of many sulphurous springs.

Sulphurous water springs and associated gas seeps in the Fort Vermilion area would appear to be of the type described above by Parks and thus may have gypsum as a source for the elemental sulphur.

# SULPHUR OCCURRENCES

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# FORT VERMILION AREA, ALBERTA

The presence of sulphur at or near the surface in the Fort Vermilion area has been known for many years. The Indians were probably the first to be aware of the presence of sulphur associated with a number of gassy, salty, cool-water springs such as those of the Harper-Lambert Creeks area. Several occurrences of burning sulphurous shales are known in the Buffalo Head Hills south and southeast of Fort Vermilion. These localities have also been known for sometime by the native population due to the smoke and sulphurous vapors which they emit.

## Discovery Permit

The most publicized occurrence of sulphur in the Fort Vermilion area is located on Sulphur Prospecting Permit No.8 in Tp. 110, R.5 W5M. This is often referred to as the "discovery permit" and is located in a flat-lying mainly tree-covered plain locally marked by muskeg. In the December 18, 1967 issue of Oilweek magazine it is reported that the "surface deposit about 40 miles northeast of Fort Vermilion was burning in a large pit-like area". The report stated that more than 150 shallow auger holes were drilled to a maximum depth of 9 feet in an area covering approximately 1/4 section (160 acres). The shallow holes define the limit of the deposit on one side. Assays of samples from the area reportedly show sulphur content ranging from 35% to 89% with no serious impurities. The deposit is covered with overburden clay and gravel ranging from approximately 6 inches to 2 feet in thickness. The bottom of the deposit was reportedly not reached by the holes drilled.

## Sulphurous Springs

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. The springs are located in Tps. 105 and 106, R.3, W5M. It is believed that elemental sulphur may have been brought to the surface by the gassy, sulphurous water springs.

The locations of several springs presumed to be associated with sulphur deposits can be recognized on air photographs in the Harper-Lambert Creeks area. These appear as very light-toned patches and are essentially devoid of vegetation. Some appear associated with small muskegs or bogs. Similarly appearing features termed anomalies have been identified on the accompanying photomosaic. They are unusual features which appear to have some characteristics similar to suspected sulphurous springs.

Reports of other sulphur occurrences in the Fort Vermilion area have not been accompanied by information describing their nature or location. Consequently, they cannot be verified from available published information. Inferences indicate that they may be located in areas where Cretaceous strata form bedrock.

## Permits 133 and 134

No significant sulphur concentrations were observed at the surface or in the bore holes drilled in Permits 133 and 134. A low level reconnaissance of the permits reveals they are covered by areas of muskeg, treed muskeg and forest cover. Bedrock exposures are absent. As shown on the accompanying mosaic a number of pits and shallow bore holes were dug within and adjacent to the permits. Shallow bore holes were dug at field stations 42C, 36C, 21C and 45C. The holes were drilled to a depth of 6 feet at stations 42C, 36C and 45C. An auger hole was drilled to a depth of 9 feet at station 21C. The remaining holes were drilled to a depth of 3 feet. Soft brown or greyish-brown clay and sandy clay was encountered in all of the boreholes drilled. The clay extends from immediately below the soil cover to the total depth drilled.

Samples from three of the deeper bore holes and also from a seismic shot hole at station 41C were analyzed for sulphur content by Core Laboratories-Canada Ltd. Sulphur concentrations in these samples are as follows: station 41C 0.32%, station 42C 0.2%, and station 45C 1.95%.

Alluvial deposits are exposed along the channel of Mikkwa River which flows through the southern portion of Permit 134. At field station 20C, in sec.6,Tp. 101, R.4 W5M, approximately 15 feet of brownish-grey shaly sands are exposed and are non-sulphurous. The beds are believed to be Recent river deposits.

No exposures of bedrock are known within the permits. Permits 133 and 134 contain many sub-circular treeless areas interpreted from air photographs as possible inactive springs. They have similar airphoto characteristics to sulphurous springs in the Harper-Lambert Creeks area. They appear as very light-toned patches and are characteristically treeless. Some appear associated with small muskegs or bogs. It is believed that some of these anomalies may be dormant springs, possibly with associated sulphur deposits. They are indicated on the accompanying mosaic with appropriate symbols as defined in the legend.

## CONCLUSIONS and RECOMMENDATIONS

With the presently available meagre information concerning the occurrence and origin of surficial sulphur deposits in the Fort Vermilion area, it can be concluded that some surficial occurrences of sulphur are apparently precipitated from sulphurous water springs and gas seeps such as those in the Harper-Lambert Creeks area. It is believed that this process may have been more or less continuous for a long period of time and has varied as to geographic location. The sulphurous waters and associated gas may originate from porous zones in Upper Devonian carbonates of the Grosmont and Mikkwa Formations and may rise to the surface along faults and fractures.

Alternately Middle Devonian carbonates and evaporites of the Elk Point Group may also be source beds. Waters that have access to the evaporites of the Elk Point Group could contain large amounts of calcium sulphate. One can visualize sulphur deposits forming at the bedrock surface over an extensive area. As one spring became clogged and choked, other gassy springs could have broken through elsewhere. Thus, a thin patchy but fairly extensive deposit of elemental sulphur may have formed at the bedrock surface.

According to Parks (1954) elemental sulphur and hydrogen sulphide are associated with many sulphurous water springs and may have their origin from gypsum. Parks reports that native sulphur appears to have been liberated from gypsum with the reducing action of bituminous matter sometimes found associated with gypsum. Calcium is probably formed from the calcium sulphate. The subsequent action of water and carbon dioxide on the sulphide forms elemental sulphur, calcium carbonate and hydrogen sulphide. Parks reports that hydrogen and its oxidation products are found in the waters of many sulphurous springs. Thus, the sulphurous water springs and associated gas seeps in the Fort Vermilion area would appear to be of the type described by parks as having gypsum as a source for the elemental sulphur.

The anomalies of Permits 133 and 134 and many other anomalies in the Fort Vermilion area were investigated during the field work either by foot-traverse or by low-level helicopter reconnaissance. No associated sulphur accumulations were observed at the surface. However, several of the anomalies mapped in the Lambert-Harper Creeks area were confirmed as sulphurous springs. Elsewhere in the Fort Vermilion area, as in Permits 133 and 134 the anomalies investigated are typical muskeg areas or bogs and do not lend themselves to the drilling of shallow bore holes during the summer months. It is believed that some of the anomalies may have developed over dormant sulphurous springs. If so, exploration of these features can best be accomplished by a winter drilling program when the land surface is frozen.

It should be emphasized that a vast area is involved in Permits 133 and 134. Concentrations of sulphur were not observed at the surface but may occur at depth with no apparent surface indication. Additional exploration should include a winter drilling program, with drillsites located so as to evaluate anomalies and possible springs indicated on the mosaics and also other areas inaccessible during the summer months. Moreover, consideration should be given to developing and employing geochemical and geophysical techniques to locate subsurface sulphur deposits.

Respectfully submitted,

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