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PRELIMINARY OBSERVATIONS CONCERNING ECONOMIC DEPOSITS ADJACENT TO SULFUROUS SPRINGS, LA SALINE LAKE, NORTH OF FORT MCMURRAY, ALBERTA.

BY

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INTRODUCTION:

A brief examination of the deposits associated with sulfurous springs on the S.E. shore of LaSaline Lake, north of Ft. McMurray was performed on the morning of February 9, 1968. The observations were made in the presence of Mr. E. Bengts and Mr. J. Wan. Detailed sampling and survey work was prohibited by the presence of a thick snow cover.

GEOLOGICAL DESCRIPTION:

The site of the deposits discussed herein is easily recognisable on the Alberta Government vertical aerial photograph (No. 561-5703/2860-45). The deposits examined reveal themselves as a white spot 0.3 x 0.2" across, on the bank of the easternmost abandoned channel of the Athabasca river. The channel is now silted up and partly occupied by the shallow LaSaline Lake. This lake is in part fed by a creek running S.W. - N.E. just to the north of the deposit.

Some 260 feet east of the lake shoreline, a small sulfurous spring issues into an 8 foot - square pool which is approximately 2 feet deep. The pool occupies the apical sector of a thick deposit of calcareous tufa, gypsum and native sulfur extending over an area of some 105,000 square feet. Small surface streams, draining westwards off the cone, carry the spring waters down into LaSaline Lake. Owing to the high concentration of mineral salts in the water, neither the pool nor the streams were frozen, despite the fact that the air temperature was below 0°C.

FIELD OBSERVATIONS:

1. **Spring water:** Flow rate: 5-10 gallons/minute. Temperature circa 40°F. Clear, no visible opalescence. Bubbles of gas constantly issuing from bottom of pool (high H_2S content). Water tastes extremely salty and bitter.

2. **Pool:** A thick deposit of native sulfur, gypsum and some calcite is being deposited continuously on the pool floor. In certain sections of the pool, small calcareous algal growths were observed.

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2. Pool: (Cont'd)

These algal growths are either individual mushroom shaped units or coalesced growths which form a continuous plate-like structure with an undulatory surface.

When broken open, the algal growths had gelatinous green or red algal on their inner surfaces.

3. Stream:

Issuing from the northwest edge of the pool was a small stream of spring water. This water represents run-off from the pool's surface. In the stream bed a thick sulfur-gypsum mud (strong yellow colour) was partly overgrown by calcareous algal. The stream water was identical to that in the pool, being highly saline, bitter and sulfurous.

4. Pits:

A number of shallow pits were examined (1 - 1½ feet deep) which had been dug into the cone surface within a 25 foot radius of the pool. In each case the material encountered was a loose aggregate of sulfur and gypsum with occasional calcite fragments.

A further section was examined some 15 feet above the lake edge, below the pool. This section revealed a poorly stratified calcareous tufa with a very low proportion of yellow sulphur. At the base of the section (which was 6 - 8 feet high) the ground was waterlogged and the material outcropping there was predominantly gypsum with black and red-brown oxidized, iron-rich material.

5. LaSaline Lake:

It is noteworthy that although the lake was predominantly frozen and covered with snow, in a number of places the surface was still unfrozen and marked by yellowish stains. It is possible that these spots represent the upwelling of saline - sulfurous water from springs in the lake bed.

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LABORATORY INVESTIGATIONS (MINERALOGICAL):

Samples collected from the pool-bed, stream-bed and pits on the apical portions and flank sector of the cone, were examined at the University of Alberta.

All samples were studied mineralogically utilizing X-ray powder diffraction photographs to facilitate rapid identification of phases present.

It was found that the predominant constituents of the muds and poorly consolidated materials on the apical portion of the cone were gypsum ($CaSo_4.2H_2O$) and native sulfur. The proportion of native sulfur in the samples was variable, but extremely high in some cases.

In contrast to the predominantly gypsiferous lithology in the upper portions, the lower slopes appear at the surface to be composed of calcareous tufa (ie. calcite: $CaCo_3$) with a low native sulfur content. This tufa is undoubtedly in part of algal origin and analagous to the calcite forming around the stream and pool at present.

LABORATORY INVESTIGATIONS (ISOTOPIC):

Dr. P. Fritz of the Geology Dept., University of Alberta studied oxygen isotopic ratios in water from the pool and in the carbonate occuring in the algal growths and in the tufa. The isotopic ratios point to an origin for both the water and the carbonates in circulating meteoric groundwater. The isotopic values obtained preclude the possibility of any volcanic activity having contributed to the supply of water.

Dr. R. Krause and Dr. A. Sasaki are presently studying the isotopic composition of the sulfur both in the native sulfur and in the dissolved H_2S of the water. This work will indicate whether isotopic fractionation has been effected at depth (i.e. whether bacterial breakdown of gypsum or anhydrite in the bed rock has given rise to this occurrence).

ORIGIN OF THE DEPOSIT:

It is probable that the deposits owe their origin to circulating meteoric waters in depth which became saturated with salts and highly sulfurous in the following manner: -

1. Horizons of evaporites (gypsum or anhydrite) within the Devonian sequence of the bedrock below the LaSaline Lake region were, by fracturing and solution processes, opened up to a flow of meteoric water descending from the surface. This water would then possibly circulate for some distance laterally before rising to the surface again as the spring.

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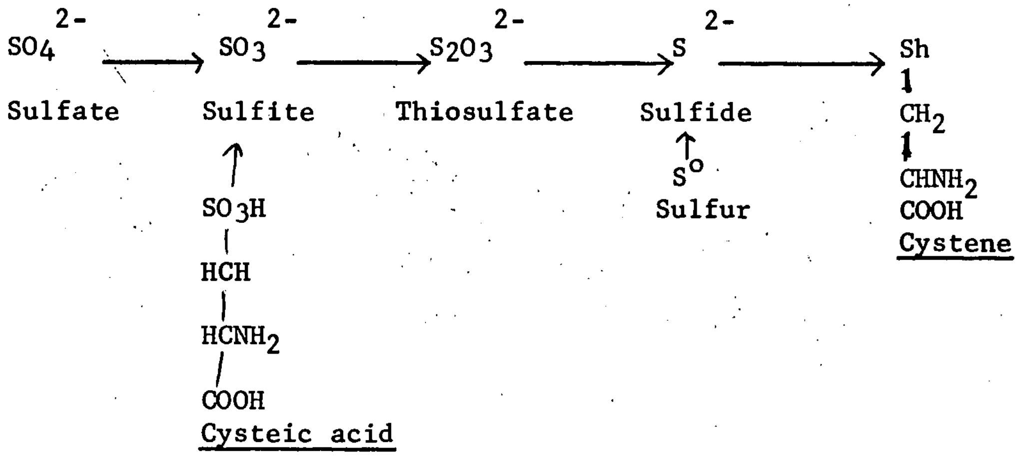
2. The descending meteoric waters carried with them, from the surface, certain dissimilatory sulfate-reducing bacteria, e.g. Desulfovibrio sp. Such bacteria are able to tolerate some of the most extreme terrestrial conditions of heat, cold, salinity and pressure; (see Nicholas J.D., Mineralium Deposita, vol. 2, 1967). Such bacteria are ubiquitous in nature and have the characteristic of utilising sulfate as a terminal hydrogen acceptor during their metabolic protein synthesis instead of oxygen, as in 'normal organisms.

This process of 'sulfate respiration' may be represented by the reactions:

$$\text{Polysaccharide Sulfate} \rightleftharpoons SO_4^{-} \xrightarrow{\text{bacteria}} \text{Cysteine} \rightleftharpoons \text{Methionine};\quad \text{Cysteine} \rightarrow \text{Proteins} \rightarrow \text{Methionine}$$

The cysteine production is represented by:-



During their metabolic utilization of sulfates, the autotrophic bacteria generate large volumes of H_2S gas (hence H_2S in the spring waters) and carbon dioxide.

3. The hydrogen sulfide and the carbon dioxide could then, in part, react with sulfates to produce elemental sulfur, (perhaps with the acid of the bacteria), in a manner analagous to the reaction:

$CaSo_4 + Co_2 + 3H_2S$ ------ $CaCo_3 + 3H_2O + 4S$

This reaction type would also account in part for the presence of calcareous tufa at the surface.

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4. One can then envisage the spring water emerging at the surface in a saline state carrying with it gypsum, sulfur, hydrogen sulfide, calcium carbonate etc. These materials would then be partly precipitated in the pool and stream-bed, perhaps filtered out in part during their passage up through the porous tufa and drift below, and in part carried down to LaSaline lake where they would be deposited.

5. It is also possible that a further precipitation of sulfur might be effected by oxidation (inorganic or bacterial) of the H_2S bubbling through the pool at the surface.

CONCLUSIONS:

It would appear that the LaSaline Lake deposits are of biogenic origin formed principally at depth, within evaporite horizons, by bacterial action and brought to the surface by circulting meteoric waters.

ECONOMIC CONSIDERATIONS:

Sulfur reserves (1) Immediate

Owing to the limited nature of the preliminary sampling program, no accurate forcast can be made. However, the initial showings in the cone-deposit, having a surface outcrop of circa 105,000 square feet and an estimated average thickness of circa 30 feet would yield around 157,500 short tons of raw material (assuming the material to be rather porous). If the average value for sulfur proved to be 30% wt. in this material then one could anticipate a production of circa 38, 000 short tons of sulfur with 80% recovery.

(2) Future reserves and exploration

The following possibilities should be carefully checked:

a) The possible occurrence of considerable quantities of sulfur in the sediments of LaSaline Lake. (This is a distinct possibility, as the process has been going on for a very long period of time. Also there must be quite a high proportion of the spring water feeding this lake to make it saline enough to earn the name LaSaline Lake).

b) The immediate vicinity should be checked for similar deposits to the one examined; (especially the creek area just to the north).

c) The possibility of sulfur impregnations in the glacial drift surrounding such springs should not be overlooked.

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d) The existance of irregular pockets of sulfur within the evaporite horizons in the bedrock below is not unfeasible. If bacterial activity is as strong as the surface deposits indicate, then quite considerable quanities of sulfur might occur replacing the evaporites below.

It is therefore concluded that the LaSaline Lake region could yield deposits of sulfur of considerable magnitude. Therefore it is recommended that the property be extensively sampled and cored at the earliest opportunity.

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